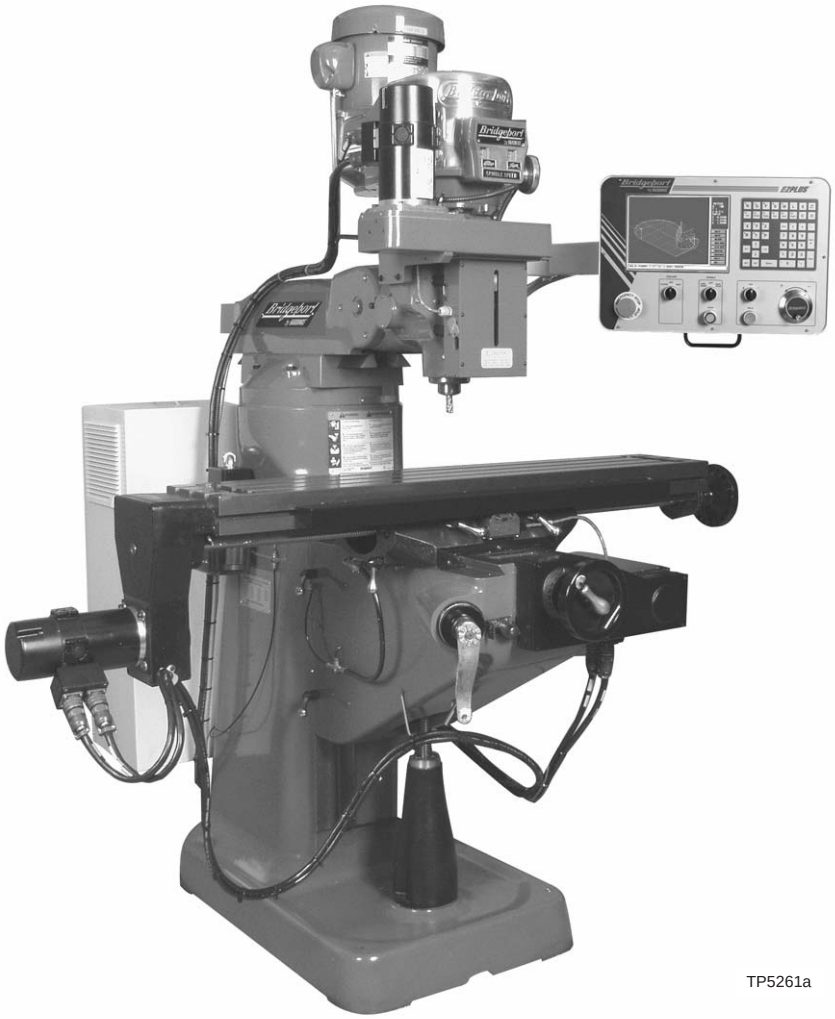
Bridgeport® by HARDINGE®

EZPLUS™ AUTOMATED MILLING MACHINES

INSTALLATION, MAINTENANCE AND PARTS MANUAL



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Information in this manual is subject to change without notice.

This manual covers programming and operation for EZPLUS™ automated milling machines.

In no event will Hardinge Inc. be responsible for indirect or consequential damage resulting from the use or application of the information in this manual.

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Warning, Caution, and Notes as Used in this Publication

- WARNINGS -

Warning notices are used in this publication to emphasize that hazardous mechanical conditions, voltages, currents, or temperatures exist in this equipment which could cause serious personal injury and/or damage to the equipment.

- CAUTIONS -

Caution notices are used where equipment might be damaged if care is not taken.

- NOTES -

Notes merely call attention to information that is especially significant in understanding and operating the equipment.

- NOTICE -

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READ COMPLETE INSTRUCTIONS CAREFULLY BEFORE OPERATING MACHINE, LOAD/UNLOAD AUTOMATION, OR BAR FEED SYSTEM.

When this instruction book was printed, the information given was current. However, since we are constantly improving the design of our machine tools, automation, and bar feed systems, it is possible that the illustrations and descriptions may vary from the machine, automation, or bar feed system you received.

- WARNING -

Occupational Health and Safety Administration (OSHA) Hazard Communication Standard 1910.1200, effective May 25, 1986, and various state "employee right-to-know" laws require that information regarding chemicals used with this equipment be supplied to you. Refer to the applicable section of the Material Safety Data Sheets supplied with your machine when handling, storing, or disposing of chemicals.

Machine should only be used with a bar feed approved by Hardinge Inc.

HARDINGE SAFETY RECOMMENDATIONS

Your Hardinge machine is designed and built for maximum ease and safety of operation. However, some previously accepted shop practices may not reflect current safety regulations and procedures, and should be re-examined to insure compliance with the current safety and health standards.

Hardinge Inc. recommends that all shop supervisors, maintenance personnel, and machine tool operators be advised of the importance of safe maintenance, setup, and operation of Hardinge-built equipment. Our recommendations are described below. BE SURE TO READ THESE SAFETY RECOMMENDATIONS BEFORE PROCEEDING ANY FURTHER.

READ THE APPROPRIATE MANUAL AND/OR INSTRUCTIONS before attempting operation or maintenance of the machine. Make certain that you understand all instructions.

DON'T ALLOW the operation or repair of equipment by untrained personnel.

CONSULT YOUR SUPERVISOR when in doubt as to the correct way to do a job.

WEAR SAFETY GLASSES AND PROPER FOOT PROTECTION at all times. When necessary, wear a respirator, helmet, gloves, and ear muffs or plugs.

DON'T OPERATE EQUIPMENT unless proper maintenance has been regularly performed and the equipment is known to be in good working order.

WARNING OR INSTRUCTION TAGS are mounted on the machine for your safety and information. Do not remove them.

DON'T ALTER THE MACHINE to bypass any interlock, overload, disconnect, or other safety device.

DON'T OPERATE EQUIPMENT if unusual or excessive heat, noise, smoke, or vibration occurs. Report any excessive or unusual vibration, sounds, smoke or heat as well as any damaged parts.

MAKE CERTAIN that the equipment is properly grounded. Consult National Electric Code and all local codes.

DISCONNECT MAIN ELECTRICAL POWER before attempting any repair or maintenance.

ALLOW ONLY AUTHORIZED PERSONNEL to have access to enclosures containing electrical equipment.

DON'T REACH into any control or power case area unless electrical power is OFF.

DON'T TOUCH ELECTRICAL EQUIPMENT when hands are wet or when standing on a wet surface.

REPLACE BLOWN FUSES with fuses of the same size and type as originally furnished.

ASCERTAIN AND CORRECT the cause of a shutdown caused by overload heaters before restarting the machine.

KEEP THE AREA AROUND THE MACHINE well lighted and dry.

KEEP CHEMICALS AND FLAMMABLE MATERIALS away from electrical or operating equipment.

HAVE THE CORRECT TYPE OF FIRE EXTINGUISHER handy when machining combustible material and keep chips clear of the work area.

DON'T USE a toxic or flammable substance as a solvent cleaner or coolant.

MAKE CERTAIN THAT PROPER GUARDING is in place.

MAKE SURE chucks, closers, fixture plates, and all other spindle-mounted work-holding devices are properly mounted and secured before starting the machine.

MAKE CERTAIN all tools are securely clamped in position before starting the machine.

REMOVE ANY LOOSE PARTS OR TOOLS left on machine or in the work area before operating the machine. Always check the machine and work area for loose tools and parts especially after work has been completed by maintenance personnel.

REMOVE CHUCK WRENCHES before starting the machine.

BEFORE PRESSING THE CYCLE START PUSH BUTTON, make certain that proper functions are programmed and that all controls are set in the desired modes.

KNOW WHERE ALL STOP push buttons are located in case of an emergency.

CHECK THE LUBRICATION OIL LEVEL and the status of the indicator lights before operating the machine.

MAKE CERTAIN that all guards are in good condition and are functioning properly before operating the machine.

INSPECT ALL SAFETY DEVICES AND GUARDS to make certain that they are in good condition and are functioning properly before the cycle is started.

CHECK THE POSITION of the tool top plate before pressing the Cycle Start push button.

CHECK THE POSITION of any load/unload automation before pressing the Cycle Start push button.

USE PROPER Point-of-Operation safeguarding.

CHECK SETUP, TOOLING, AND SECURITY OF THE WORKPIECE if the machine has been off for any length of time.

DRY CYCLE a new setup to check for programming errors.

MAKE CERTAIN that you are clear of any “pinch points” created by moving slides before starting the machine.

DON’T OPERATE any equipment while any part of the body is in the proximity of a potentially hazardous area.

KEEP ALL PARTS OF YOUR BODY AWAY from moving parts (belts, cutters, gears, and others).

DON’T REMOVE CHIPS with hands. Use a hook or similar device and make certain that all machine movements have ceased.

BE CAREFUL of sharp edges when handling a newly machined workpiece.

DON’T REMOVE OR LOAD a workpiece while any part of the machine is in motion.

DON’T OPERATE ANY MACHINE while wearing rings, watches, jewelry, loose clothing, neckties, or long hair not contained by a net or shop cap.

NEVER OPERATE A MACHINE after taking strong medication, using non-prescription drugs or consuming alcoholic beverages.

DON’T ADJUST tooling or coolant hoses while the machine is running.

DON’T LEAVE tools, work pieces or other loose items where they can come in contact with a moving component of the machine.

DON’T CHECK finishes or dimensions of workpiece near running spindle or moving slides.

DON’T JOG SPINDLE in either direction when checking thread with a thread gage.

DON’T ATTEMPT to brake or slow the machine with hands or any makeshift device.

ANY ATTACHMENT, TOOL, OR MACHINE MODIFICATION not obtained from Hardinge Inc. must be reviewed by a qualified safety engineer before installation.

USE CAUTION around exposed mechanisms and tooling, especially when setting up. Be CAREFUL of sharp edges on tools.

DON’T USE worn or defective hand tools. Use the proper size and type for the job being performed.

USE ONLY a soft-faced hammer on tooling and fixtures.

DON’T USE worn or broken tooling on machine.

MAKE CERTAIN that all tool mounting surfaces are clean before mounting tools.

INSPECT ALL CHUCKING DEVICES daily to make certain that they are in good operating condition. Replace any defective chuck before operating the machine.

USE MAXIMUM ALLOWABLE gripping pressure on the chuck. Consider weight, shape, and balance of the workpiece.

USE LIGHTER THAN NORMAL feedrates and depth of cut when machining a workpiece diameter that is larger than the gripping diameter.

DON’T EXCEED the rated capacity of the machine.

DON’T LEAVE the machine unattended while it is operating.

DON'T CLEAN the machine with an air hose.

KEEP TOTE PANS a safe distance from the machine. Don't overfill the tote pans.

DON'T LET STOCK project past the back end of the collet closer or machine spindle with out being adequately covered and properly supported.

FOLLOW each bar feed manufacturer's guidelines. For performance and safe application, size and use feed tube bushings, pushers, and spindle liners according to bar feed information.

MAKE CERTAIN that any bar feed mechanism is properly aligned with the spindle. If the bar feed is a floor-mounted type, it must be securely bolted to the floor.

UNLESS OTHERWISE NOTED, all operating and maintenance procedures are to be performed by one person. To avoid injury to yourself and others, be sure that all personnel are clear of the machine before beginning operation.

- WARNING -

Before activating a new program, turn the control off. Wait approximately 10 seconds; then turn the control on. This will set the collet closer timer to the default setting of 4.9 seconds and will assure safe operation of the control.

FOR YOUR PROTECTION - WORK SAFELY.

Some of these precautions and other safety precautions are discussed in the American National Standards Institute Standard entitled Safety Requirements for the Construction, Care, and Use of Drilling, Milling, and Boring Machines (ANSI B11.8-1983).

This publication is available from:

American National Standards Institute
25 West 43rd Street, 4th floor
New York, NY 10036

Safeguarding for protection at the point of operation can only be designed and constructed when the parameters of the particular operation have been determined. As a result, ANSI B11.8-1983, Section 5.1, states that "it shall be the responsibility of the employer to provide, and ensure the use of, a guard, guarding device, awareness barrier, awareness device, or shield..."

To assist machine users in designing point of operation safeguarding for their specific machine applications the Occupational Safety and Health Administration has published a booklet entitled Concepts and Techniques of Machine Safeguarding (O.S.H.A. Publication Number 3067).

This publication is available from:

The Publication Office – O.S.H.A.
U.S. Department of Labor
200 Constitution Avenue, NW
Washington, D.C. 20210

The general purpose point of operation shield provided with this machine and shown in certain illustrations throughout this manual may not be appropriate and cannot be utilized for all possible applications of the machine. Use additional or alternate safeguarding where this shield is not appropriate or cannot be utilized. Note that for purposes of display, the shield has been removed in certain other illustrations in this manual.

- NOTE -

Any unauthorized changing of control parameters is not permitted. Hardinge Inc. will not accept any liability whatsoever for the alteration of any set parameters to those programmed at installation.

-NOTE -

DO NOT attempt disassembly or removal of major components without first contacting the Hardinge Inc. service department for proper procedures.

- NOTES -

Table of Contents

Chapter 4 - Logic Boards

Chapter 5 - Axis Drive System

Chapter 6 - Preventive Maintenance

Chapter 7 - Manual Controls

Chapter 8 - Maintenance

- NOTES -

CHAPTER 1 - SPECIFICATIONS

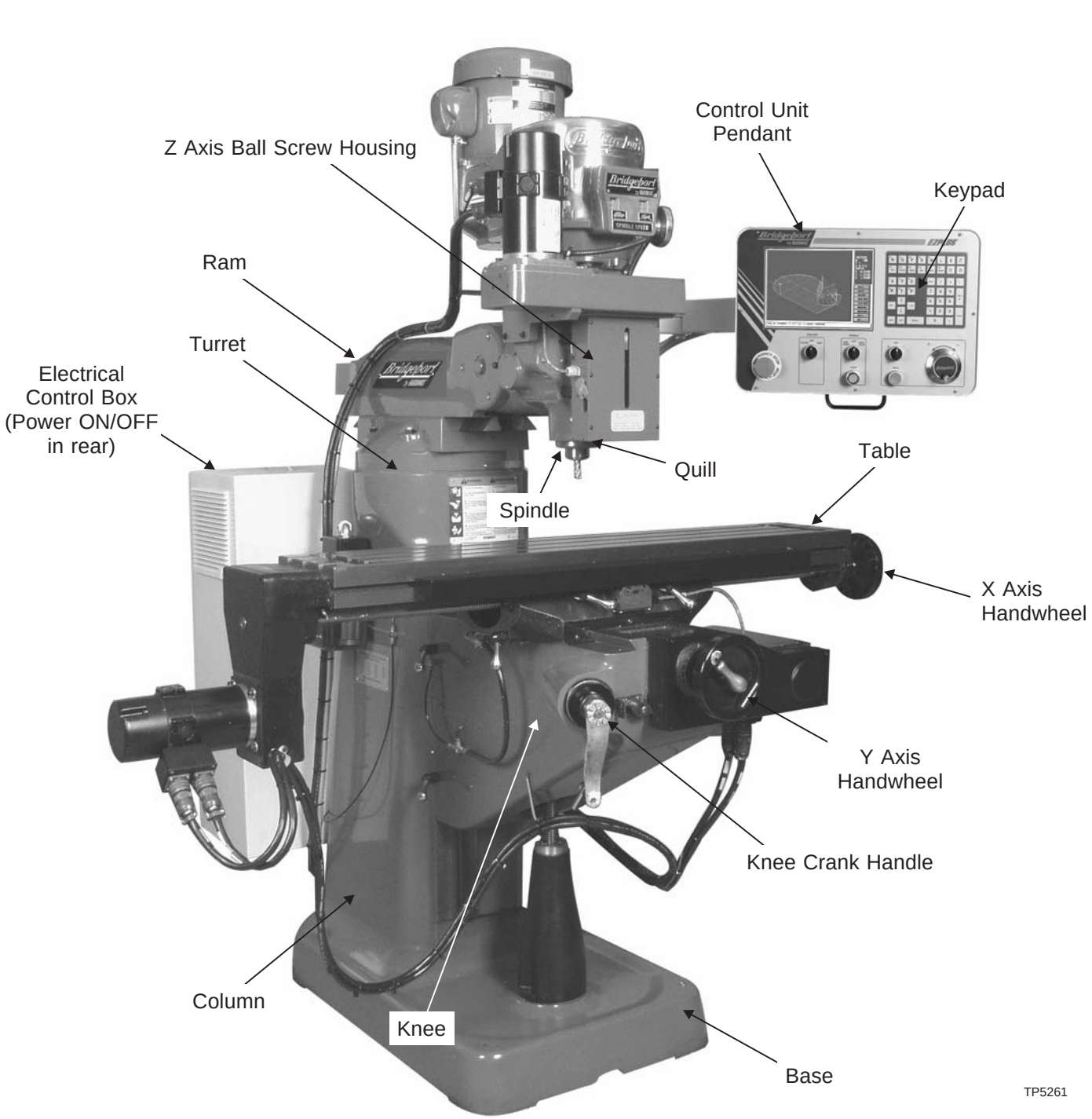


Figure 1.1 - Basic Components of a 3 Axis Milling Machine

SERIES I SPECIFICATIONS

RANGE		
Table travel (X axis)	30 in.	762 mm
Saddle travel (Y axis)	12 in.	305 mm
Quill travel	5 in.	127 mm
Quill travel w/3rd axis	4.5 in.	114 mm
Knee travel* (Z axis)	16 in.	406 mm
Ram travel	12 in.	305 mm
Throat distance (min.)	6.75 in.	171 mm
Throat distance (max.)	18.75 in.	476 mm
Table to spindle nose gage line (min.)	2.5 in.	64 mm
Table to spindle nose gage line (max.)	18.25 in.	463 mm
TABLE		
Overall size	48 x 9 in.	1219 x 229 mm
Working surface	48 x 9 in.	1219 x 229 mm
Height above floor (max.)	47.4 in.	1204 mm
Maximum uniform load	300 lbs.	136 kg
T-slots	3 @ 2.5 in. Cntr	64 mm
T-slot size	.625 in.	16 mm
SPACE AND WEIGHT		
Floor area (door open)	8.2 x 7.3 ft.	2.5 x 2.2 m
Floor area (door closed)	8.2 x 5.3 ft.	2.5 x 1.6 m
Height	6.8 ft.	2.1 m
Net weight	2340 lbs.	1061 kg
Shipping weight	2900 lbs.	1315 kg
SPINDLE		
AC spindle motor rating (continuous)	2 hp	1.5 kw
Power rating	3 hp	2.2 kw
Duty cycle	30 min. duty rated	
Spindle speed Hi	500 – 4200 rpm	
Spindle speed Low	60 – 500 rpm	
Spindle diameter	1.875 in.	48 mm
Quill diameter	3.375 in.	86 mm
Standard Spindle Taper		
Spindle taper	R-8	
Tooling	R-8 collets	
Optional Spindle Taper		
Spindle Taper	#30 ISO	
Tool Holder	Erickson Quickchange #30 ISO	
Spindle Taper	#200 Universal	
Tool Holder	Universal #200 Kwik switch	
BALLSCREWS		
Diameter	1.25 in.	32 mm
Pitch	0.200 in.	5.08 mm

POSITIONING

Auto (X,Y)	100 ipm	2540 mm/min.
Manual (X,Y)	100 ipm	2540 mm/min.
Feedrate range (X,Y)	0.1 – 100 ipm	2 – 2540 mm/min.
Minimum increment	0.0001 in.	0.003 mm

MACHINE AND CONTROL PERFORMANCE

Positioning accuracy over saddle	± 0.001 in.	0.025 mm
Positioning repeatability over saddle	± 0.0008 in.	0.02 mm
Input resolution	0.0001 in.	0.003 mm
Servo resolution	0.0001 in.	0.003 mm
Display resolution	0.0001 in.	0.003 mm

BPC2M PC Control system
Full 3-axis DRO
Simultaneous 2 axis linear or 2 axis circular interpolation
10.5-inch color conversational display
Absolute and incremental programming
Automatic corner rounding
Mathematical help modes
Powerful canned cycles for machining arcs, diagonals, circles, bolt hole patterns, pocket milling and more
Cutter diameter compensation
English/metric conversion
1000 block program storage
Disk storage: (standard) 3.5 in. diskette, HD 1.44 Mb (12,000 ft.)
8MB PC Flashdisk
Maintenance, diagnostic and program error message display
Part program loading: RS-232 bi-directional communication link
Input/Output: 1 RS-232 serial port
Maintenance: Diagnostic routines embedded in system

POWER

Input power: 208/230/460 volts 3 phase, 50/60 cycles
Power capacity: 4kVA

STANDARD FEATURES

Automatic centralized lubrication system
Chrome plated ways
Electrics: NFPA/NEMA-12 Standards, UL Listed.
Color: Machine Tool Gray

OPTIONAL FEATURES

3rd Axis Control
Mist or flood coolant system
4 or 7 inch Riser block
Universal communication software
Power drawbar for R-8 or 30 QC Spindle

* Knee Travel Reduced by 1"with Flood Coolant.

PRINCIPAL DIMENSIONS

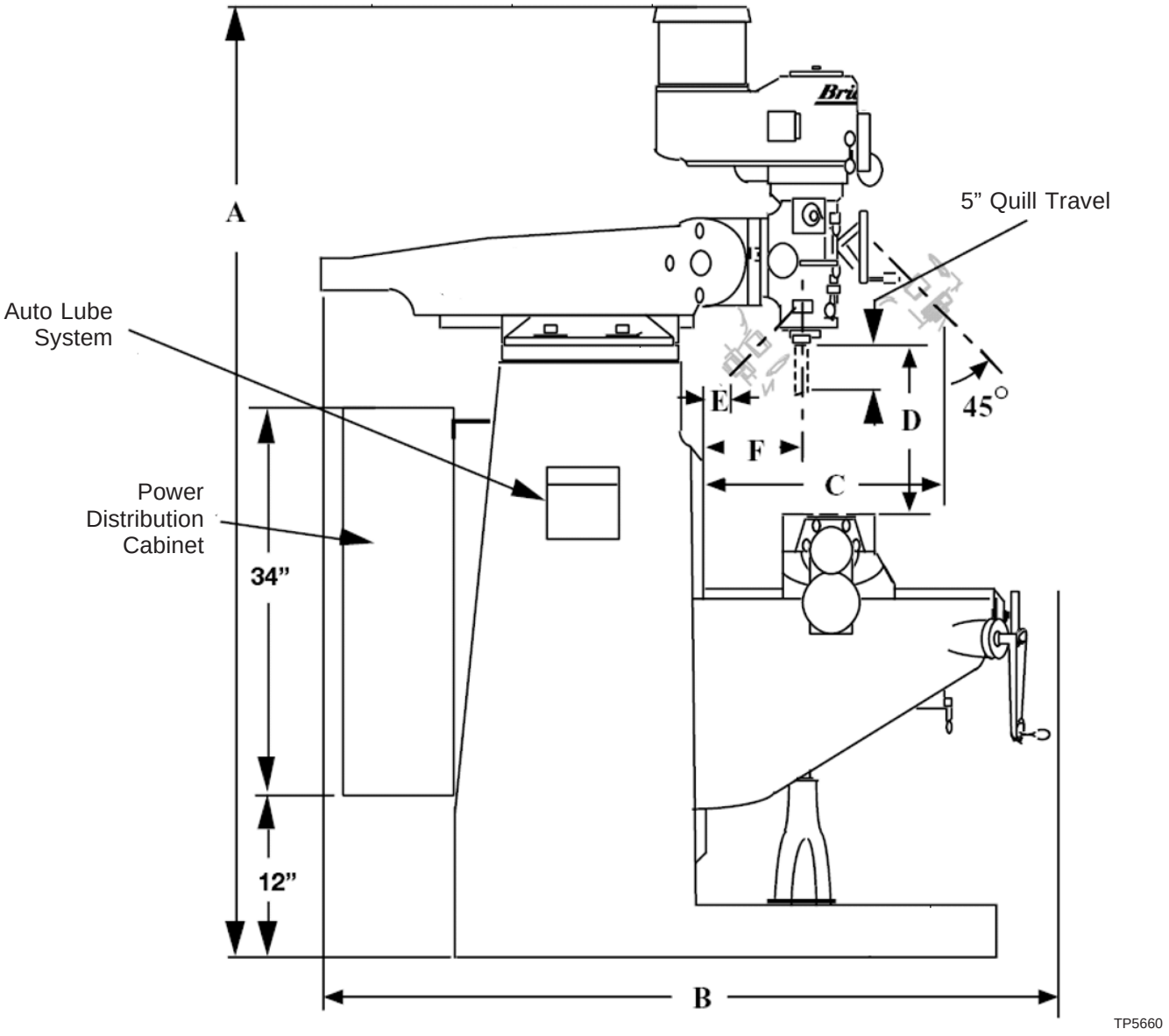


Figure 1.2 - Principal Machine Dimensions

TABLE TRAVEL	30.0 in.	762 mm
TABLE LENGTH	48 in.	1219 mm

	A	B	C	D	E	F
MIN.	82" (2083)	51" (1295)	8.75" (222)	2.5" (64)	0	6.75" (171)
MAX.	84" (2140)	63" (1600)	20.75" (527)	18.25" (470)	12" (305)	18.75" (476)

MACHINE SPECIFICATIONS

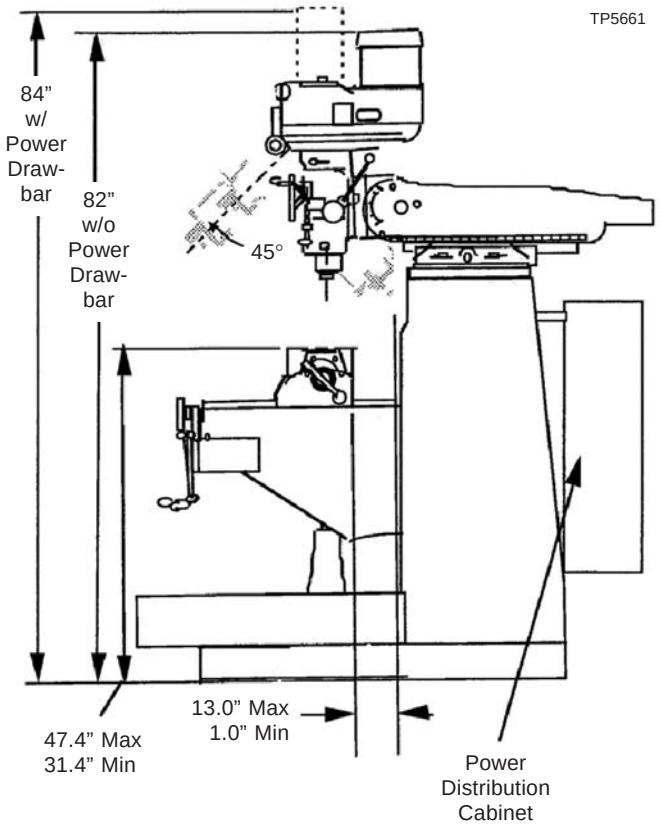


Figure 1.3 - Machine Specifications
Side View

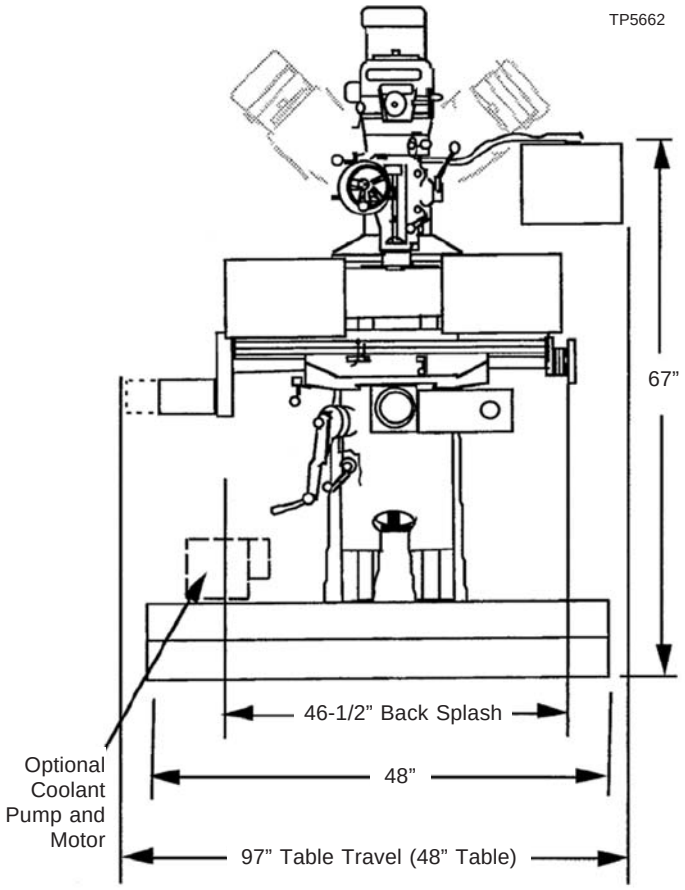


Figure 1.4 - Machine Specifications
Front View

2J-HEAD SPECIFICATIONS

Power	2.0 HP	
Motor RPM	1800 RPM	
Speed Ranges - RPM	Stepless	
LOW	60 - 500	
HIGH	500 - 4200	
Quill Travel	5.0 in.	127 mm
Quill Diameter	3.375 in.	86 mm
Spindle Tapers	R-8	
	#30 Q.C.	
Spindle Diameter	1.875 in.	48 mm
Spindle Feed Rate	0.0015/Rev	0.038 mm
	0.003/Rev	0.076 mm
	0.006/Rev	0.152 mm
Drilling Capacity - Manual	0.87 in.	22 mm dia.
Drilling Capacity - Power	0.37 in.	9.4 mm dia.
Boring Capacity	6.75 in.	152.4 mm dia.
Milling Capacity	2.0 cu. In./min.	32 cc/min.
Spindle to Column - Minimum	6.75 in.	171 mm
Maximum	18.75 in.	476 mm

RECOMMENDATIONS:

Use 2, 3, or 4 flute end mills. Eight flute end mills are usually not satisfactory for general milling. When using shell mills, face mills or any other tooling, proper machining practice should be observed.

Power Feed can be used for drills up to 0.375 in. diameter. Use manual feed for drills larger than 0.375 in.

FEEDS AND SPEEDS

FEED PER MINUTE

MATERIAL TO BE CUT	ROUGH CUT	ROUGH/ FINISH	LIGHT/ FINISH CUT
Cast Iron - Soft - (Under 150 Brinnell)	70	80-90	120
Cast Iron - Med - (150-200 Brinnell)	55	60-70	90
Cast Iron - Hard - (Over 200 Brinnell)	40	50-60	70
Steel (Chrome Nickel 40-45 Shore)	30	40	50
Steel (Stainless)	60	80	90
Steel (Low Carbon)	80	90	140
Steel (High Carbon)	40	50	70
Bronze (Medium)	90	120	150
Bronze (Hard)	65	90	130
Brass (Hard)	100	150	200
Copper	150	200	300
Duraluminum	400	-	600
Aluminum	600	-	1000

CUTTING SPEEDS AND FEEDS IN REVOLUTIONS PER MINUTE

	FEET PER MINUTE										
DIA/In.	**15**	**20**	**25**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1/16”	917	1222	1528	1833	2445	3056	3667	4278	-	-	-
1/8"	458	611	764	917	1222	1528	1833	2139	2445	2750	3056
3/16"	306	407	509	611	815	1019	1222	1426	1630	1833	2037
1/4"	229	306	382	458	611	764	917	1070	1375	1375	1528
5/16"	183	244	306	367	489	611	733	856	978	1100	1222
3/8"	153	204	255	306	407	509	611	713	815	917	1019
7/16"	131	175	218	262	349	437	524	611	698	786	873
½"	115	153	191	229	306	382	458	535	611	688	764
5/8"	91	122	153	183	244	306	367	428	489	550	611
3/4"	76	102	127	153	204	255	306	357	407	458	509
7/8"	65	87	109	131	175	218	262	306	349	393	437
1"	60	76	95	115	153	191	229	267	306	344	382
1-1/8"		67	84	102	136	170	204	238	272	306	340
1-1/4"		61	76	91	122	153	183	214	244	275	306
1-3/8"			69	83	111	139	167	194	222	250	278
1-1/2"			63	76	102	127	153	178	204	229	255
1-5/8"			60	70	94	118	141	165	188	212	235
1-3/4"				65	87	109	131	153	175	196	218
1-7/8"				61	81	102	122	143	163	183	204
2"					76	95	115	134	153	172	191

2J-HEAD SPECIFICATIONS

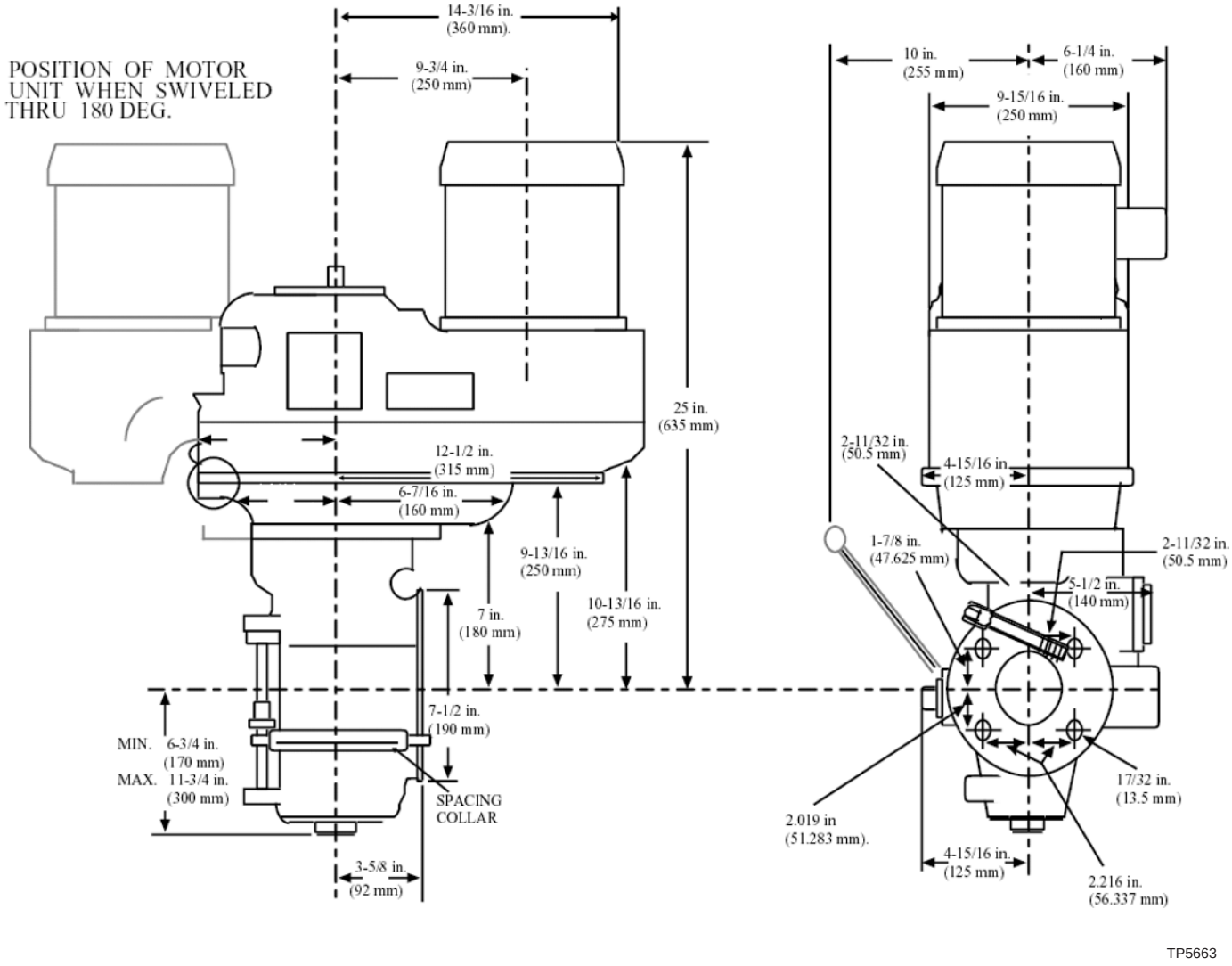


Figure 1.5 - 2J-Head Specifications

Spindle Taper	R8	
Spindle speeds - RPM	60-4200	
Motor	*2 HP	1.5 kw
Quill travel	5 in	127 mm
Power feed of Quill	0.0015 in.	0.04 mm
per rev of Spindle (3 rates)	0.003 in.	0.08 mm
	0.006 in.	0.15 mm
Collet capacity	1/8 - 3/4 in. x 1/16 in.	3-9 mm x 1.5 mm
Weight	196 lb.	89 kg

*2 HP Continuous - 3 HP Intermittent

- NOTES -

CHAPTER 2 - INSTALLATION

UNCRATING

Carefully remove crating and skids so that the machine and parts are not marred, scratched or impaired. In the event of damage in transit, communicate AT ONCE with our representative and the transportation company making delivery.

SHORTAGES

Check shipment carefully against the itemized packing list which is included in the parts box. In the case of shortages, report them IMMEDIATELY to the representative from whom the machine was purchased, indicating parts not received which have been checked on the packing list.

CLEANING AND LUBRICATING

- WARNING -

DO NOT use gasoline or any other flammable cleaning agent for cleaning machine.

1. Thoroughly clean protective coating from machine with suitable cleaning solution.
2. By hand, move table, saddle, and knee to limit stop in one direction.
3. Clean and lubricate the exposed ways and then move each unit to the opposite limit stop and similarly clean and lubricate exposed ways.
4. Loosen bolts to unlock the ram, and move it forward and backward to the full length in order to clean and lubricate.

- NOTE -

Check Way Lube Reservoir and fill if necessary (Sunoco Way Lubricant 1180 or equivalent. See Chapter 10, Auxiliaries System for list of acceptable lubricants).

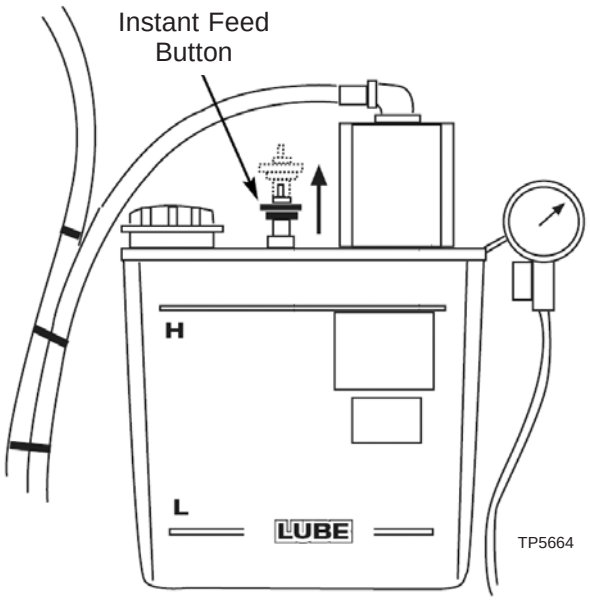


Figure 2.1 - Way Lube Reservoir (Mounted on Left Side of Machine Column)

Pull and release the Instant Feed button on the reservoir several times until oil flows freely on way surfaces and lead screws (see Figure 2.1).

- WARNING -

DO NOT attempt to operate the machine until all ways have been well cleaned and lubricated.

POSITIONING THE HEAD UPRIGHT

- NOTE -

If your milling machine was delivered with the milling head in an upside down position, execute the following steps.

1. Lower the knee (see Figure 2.2) approximately 6 inches. (150 mm).
2. Loosen four locknuts ”A”, Figure 2.3, and pull safety pin ”C”, Figure 2.4 out to detent. Using the swivel bolt ”B”, Figure 2.3, rotate head attachment in either direction until it is within approximately 20% of vertical.
3. Support the head by hand to relieve the weight on the swivel bolt.
4. As a safety precaution, push the stop pin back in after passing the 25° mark.
5. Continue to raise the head attachment to vertical position.
6. Align the indicator on the head attachment with the ZERO line on the ram adapter scale.

- CAUTION -

Over-tightening could cause distortion in the quill movement. Care should be taken to avoid excessive pressure.

7. Retighten all nuts first to 25 ft/lbs. torque in a diagonal sequence and then to 50 ft/lbs, (see Figure 2.5).

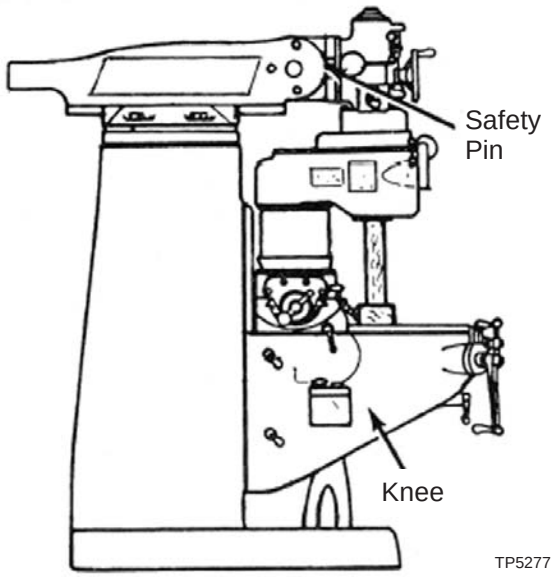


Figure 2.2 - Milling Machine
Left Side View

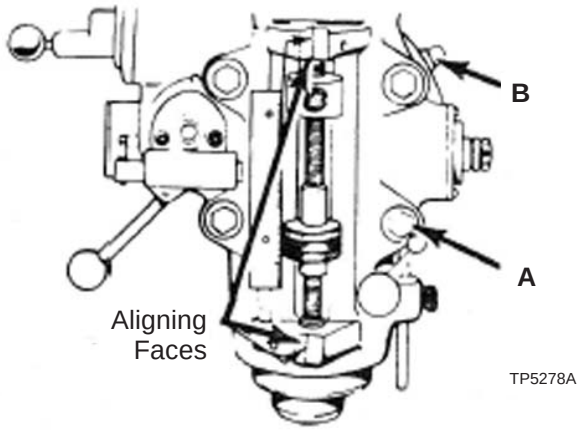


Figure 2.3 - Positioning Head
Front View

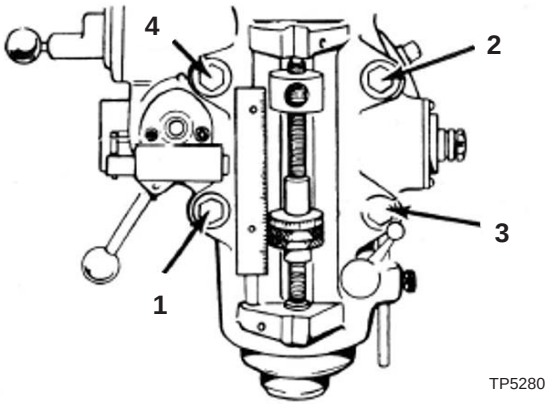


Figure 2.5 - Head Bolt Tightening
Sequence

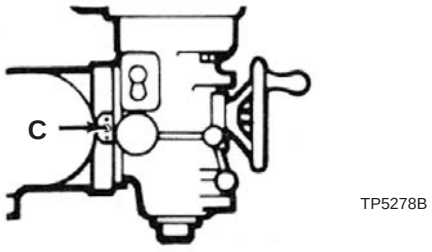


Figure 2.4 - Positioning Head
Left View

LIFTING THE MACHINE

Check the position of ram and table when lifting with sling. Machine should be lifted by placing sling under the ram as illustrated. Be sure to use proper sling when lifting. Improper lifting could cause serious injury.

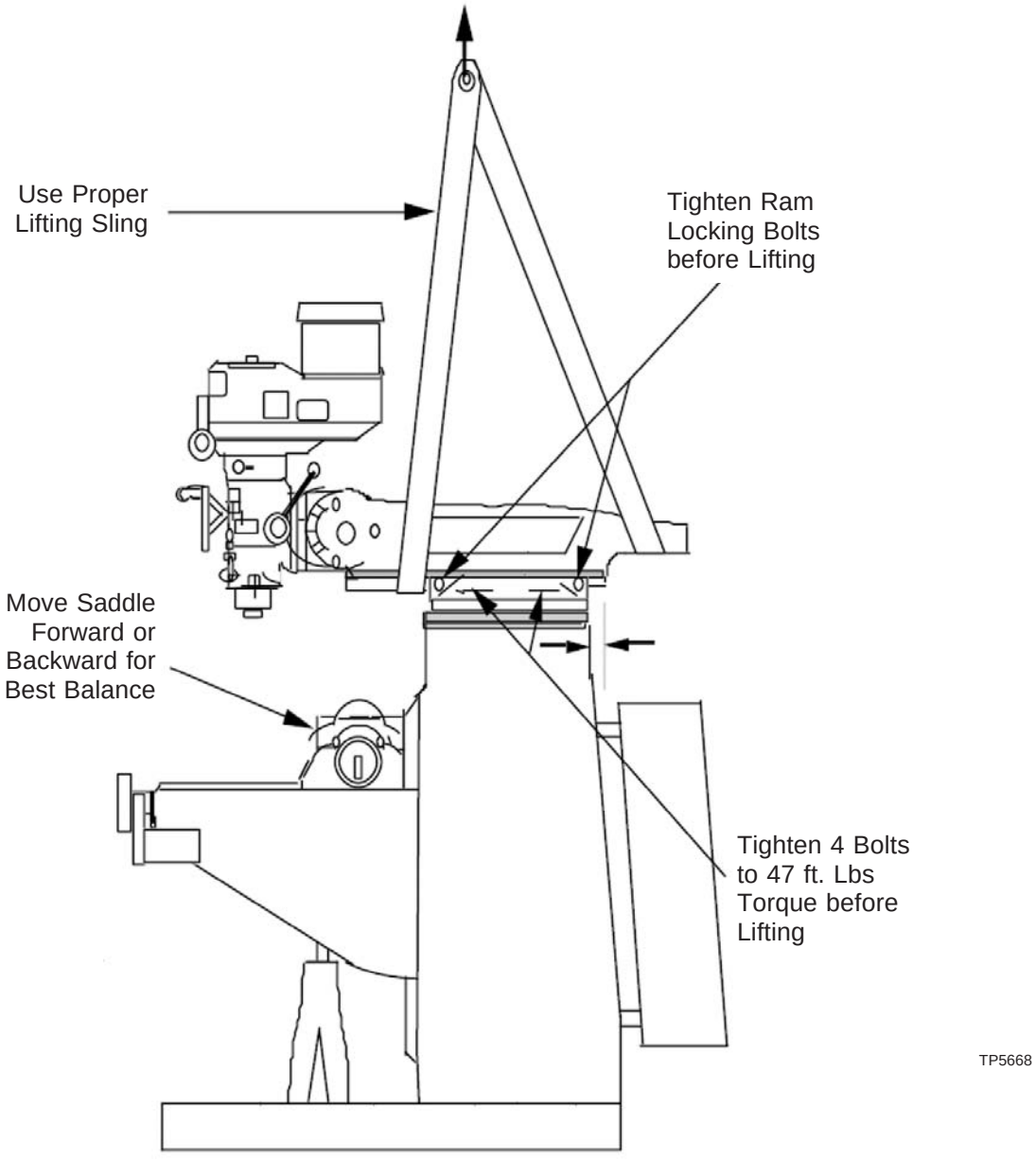


Figure 2.6 - Proper Method of Lifting the Machine

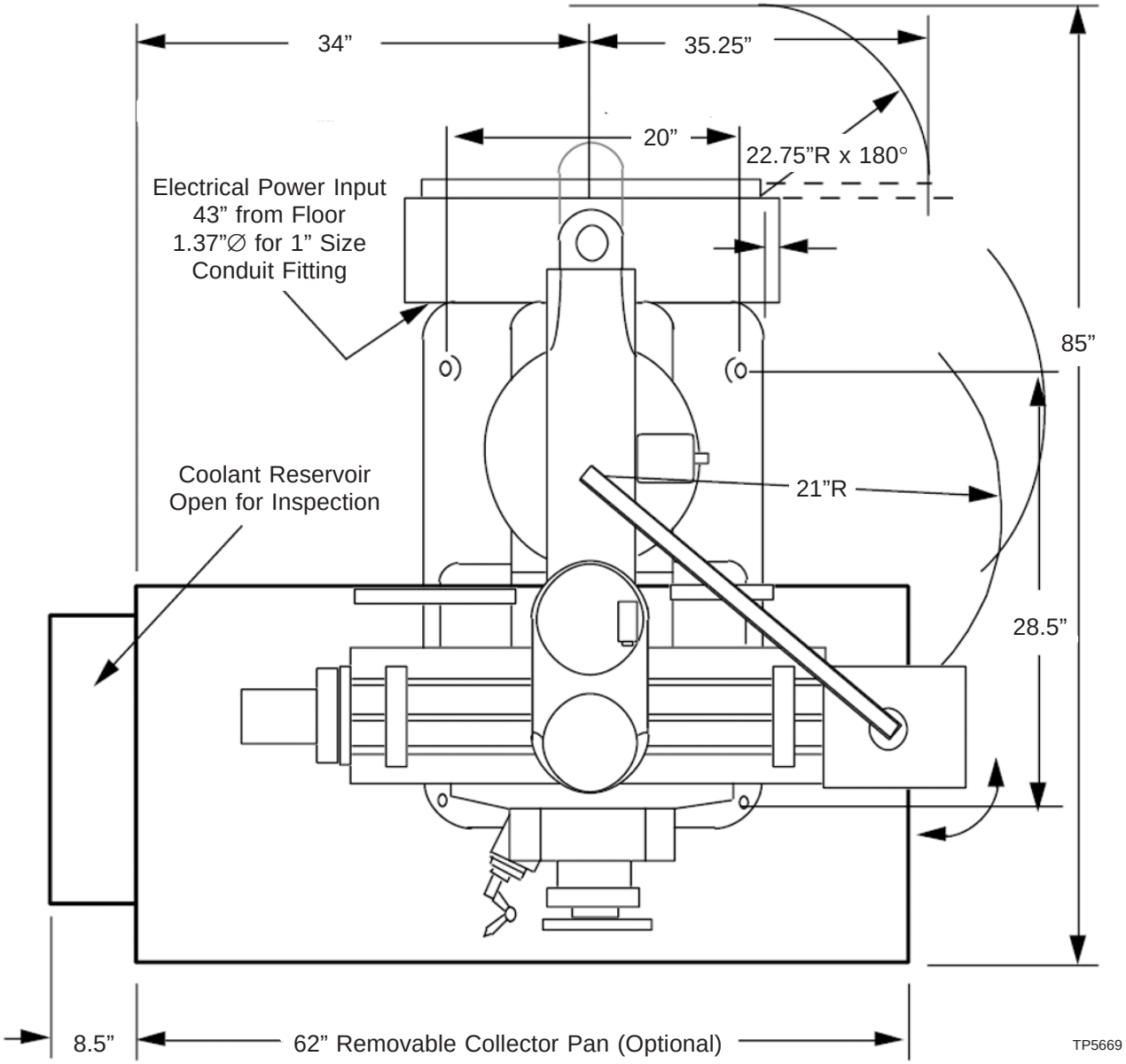


Figure 2.7 - Floor Installation Layout

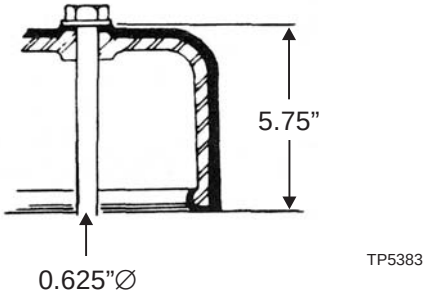


Figure 2.8 - Hold-Down Bolt
Machine Dimension

PLACING MACHINE ON A SOLID FOUNDATION

- NOTE -

The EZPLUS Milling Machine should be placed on a solid level floor with shims or anti-vibration pads to insure machine base is positioned evenly to prevent rocking (see Figure 2.9).

1. When setting machine on a concrete foundation, use a little grout (thin mortar) to take care of any unevenness in the concrete as well as to provide a solid foundation at all points.

2. When setting machine on a floor that has any surface irregularities, use shims to correct this condition to the greatest extent possible.

3. Before securing machine to floor (tighten all hold down bolts), make certain that all four corners are making contact with the floor after machine is leveled. If above condition is not met, it is possible to twist the column and put a bind into the ways.

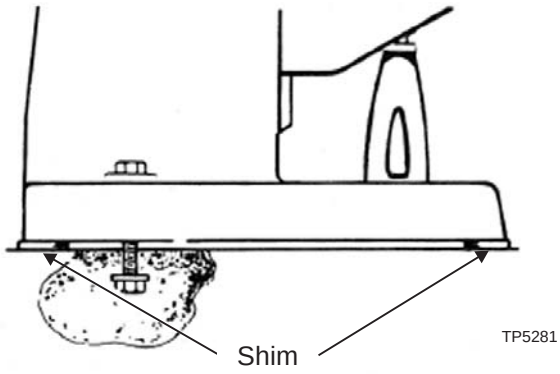


Figure 2.9 - Installation of Shims under the Machine

- NOTE -

It is recommended that the machine be secured to the floor to prevent movement or tipping due to off-center loading.

LEVELING THE MACHINE

Set machine by leveling the work table lengthwise and crosswise with a precision instrument as shown in Figure 2.10.

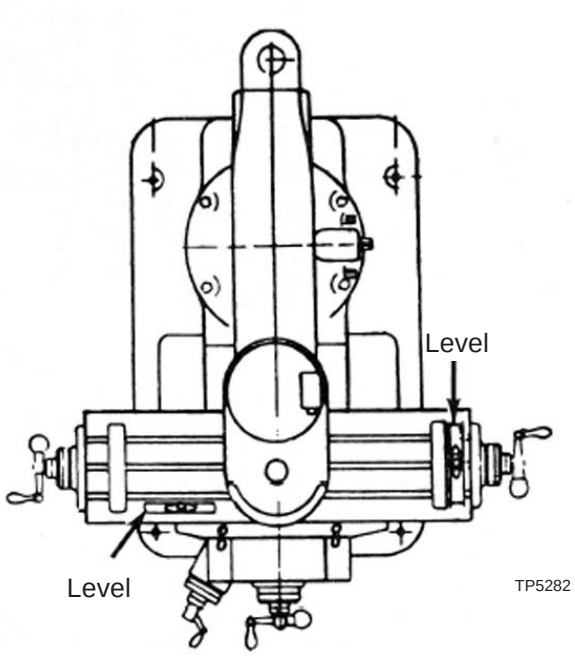


Figure 2.10 - Proper Method of Leveling the Machine

ELECTRONIC CABINET INSPECTION

The Electronic Control Cabinet requires careful inspection for shipping damage. The following is a list of the control elements that should be inspected.

- WARNING -

DO NOT inspect the Electronic Control Cabinet until all power to unit is shut off.

1. Ensure that the customer's electrical service is compatible with the machine's voltage, which is stamped on a plate mounted on the cabinet door. Also, ensure that incoming power is properly grounded. (See Transformer Connections table on Page 2-12.)

2. Check all Control Box connections:

   A. Plug connection on the LCU Unit.

   B. Keypad interface plug of the LCU Unit.

   C. LCU Axis I/O connections.

   D. X and Y axis power amplifiers (AMC drives).

   E. Check the seating of relays and wire termination points on relay sockets for tightness.

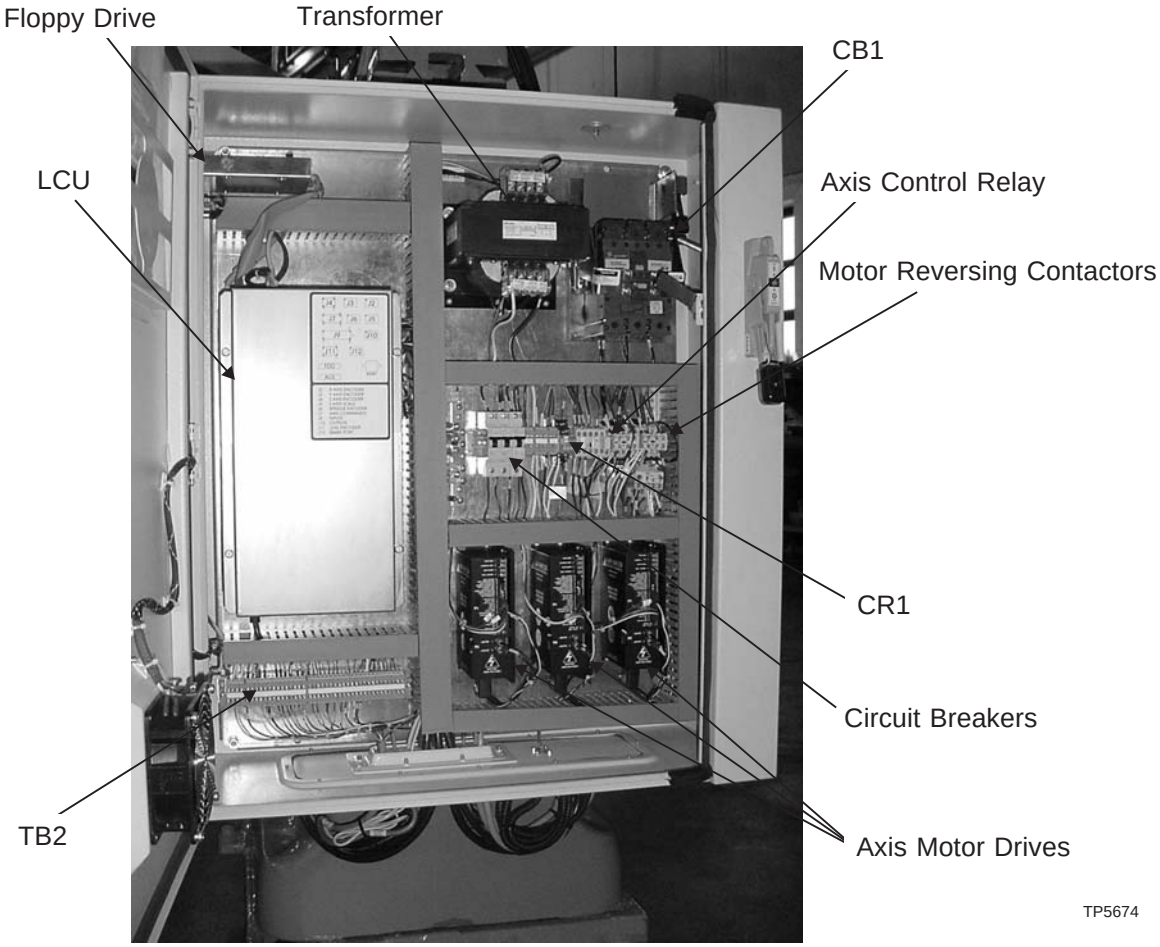


Figure 2.11 - Electronic Control Cabinet

ATTACHING THE LCD DISPLAY

OPERATOR CONTROL STATION

- NOTE -

For safety, two people should perform the installation of the LCD/Operator Control Station.

1. Check all contents for damage.

2. Mounting the control panel requires two people, one to lift and hold the pendant while the other person attaches the pendant to the swivel arm with a bolt and locking nut.

3. Set one of the large washers over the hole on the swivel arm (see Figure 2.12), then place the pendant onto the arm so that the mounting bracket is over the washer and the hole (see Figure 2.13). Slide the small washer onto the bolt, followed by the other large washer, then insert the bolt through the mounting bracket and the swivel arm.

4. Use a 3/8” hex key to turn the bolt until it is all the way through the bracket and arm.

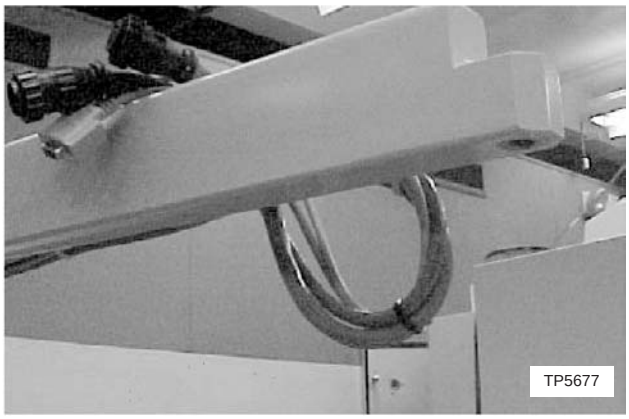


Figure 2.12 - Swivel Arm with Cable Connections

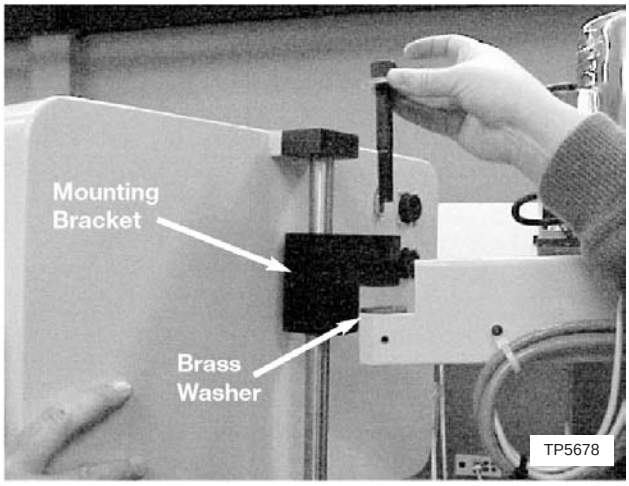


Figure 2.13 - Locating Washer and Bolt

5. Screw the locknut onto the end of the bolt and. tighten with a 3/4” box wrench so that the pendant is secure, but just loose enough to swivel. Use the hex key to hold the bolt and lock the nut with the wrench (see Figure 2.13).

6. Plug existing cables into the back of the control station (see Figure 2.14). Cable connectors are unique so there should be no confusion as to placement.

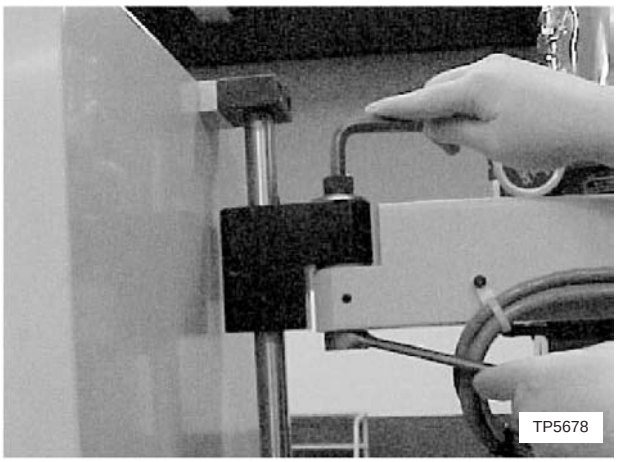


Figure 2.13 - Tighten Washer and Bolt using Allen and hex nut Wrenches

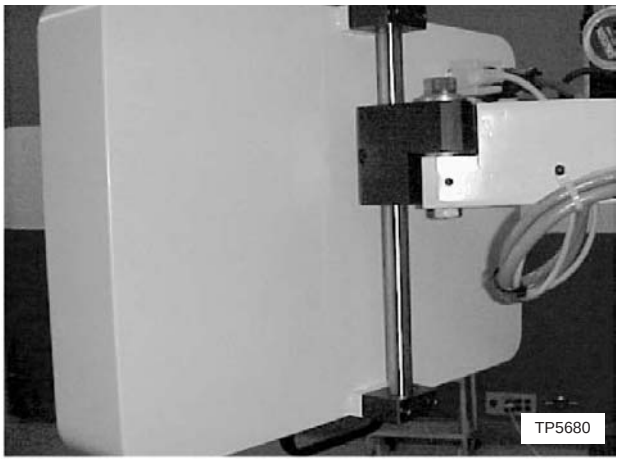


Figure 2.14 - Cables are Plugged into back of Pendant

CONNECTING THE POWER SUPPLY

To connect the machine to the plant supply, have a qualified electrician proceed as follows:

1. Check required voltage against power supply to ensure that they are compatible.
2. Connect machine wiring to power supply, making sure connection is in compliance with safety regulations.
3. Maximum earth loop impedance must not exceed 1.0 Ohm. See Protective Ground on Page 2-9.

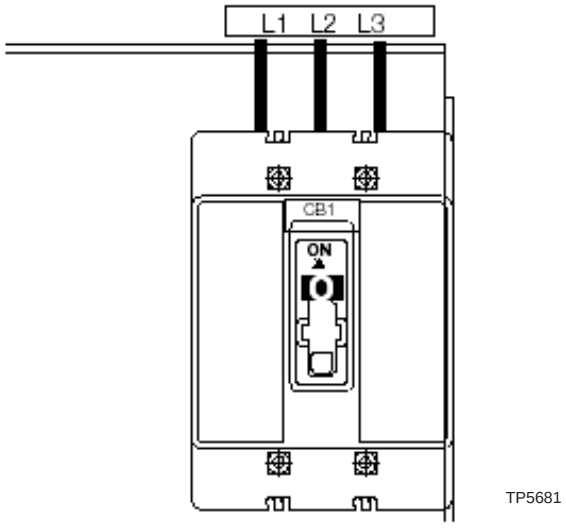


Figure 2.15 - Main Circuit Breaker

PROTECTIVE GROUND

- DANGER -

PROTECTIVE GROUND IS REQUIRED. It minimizes the exposure to personal shocks in the event of circuit shorts or other malfunctions. Failure to ensure protective ground may create electrical shock hazard, causing serious personal injury or death.

Protective Ground (Chassis or Safety Ground) establishes a low impedance path from the equipment enclosure and other mechanical parts of the system to earth ground. Protective Ground assures that all conductive parts of the enclosure are safe. If any circuit inadvertently touches the chassis, the voltage will be reduced to zero and the enclosure will be safe to touch. Because safety requirements vary in different localities, be sure to consult local governing codes.

These codes take precedence over the practical guidelines presented which are based upon:

National Electrical Code;
California “Electrical Safety Orders”; and
Pennsylvania “Electrical Safety Regulations”.

The four methods listed below are commonly used to establish earth ground:

CONTINUOUS METAL WATER PIPE

When properly buried, length is installed below the permanent moisture level, impedance is typically 3 ohms.

COPPER STAKE (3/4 IN. DIA, 6-8 FT. LG

When properly driven into the ground below permanent moisture level, the impedance of this type is typically below 5 ohms.

FOURTH WIRE GROUND

Although a copper ground stake is preferred, an alternative is a fourth wire for ground included with the power wires from the enclosure ground stud to the power company service panel ground bus. (See Note below.)

OTHER METAL ELECTRODES (WELL CASTINGS OR THE LIKE)

Must be well chosen, since they generally exceed an impedance of 5 ohms but are well below 25 ohms.

- NOTE -

The resistance of the earth ground connection is measured from the enclosure ground stud, through the ground wire, to the earth ground connection; then through the earth ground to another earth ground connection (at least 20 feet away), and through its associated wire to another ground stud. The resistance should not exceed 5 ohms. The wire used between the ground stud and the earth ground should be AWG10 or larger and should be braided cable to minimize resistance at high frequencies (cable resistance less than 0.075 ohm). The ground wire should be inspected for mechanical abuse periodically.

PRESTART CHECKS

Make a careful check of the following conditions before applying power.

1. Floor is of sufficient quality to support machine and maintain machine level.
2. Incoming power is within +/- 10% of nameplate voltage.
3. Machine is properly grounded (1 ohm between ground rod and reference point.)
4. Electrical Cabinet components inspected for loose connections, etc.
5. Check the level of lubricating oil; refill it if it is low. See Section 3.13 (below) for lubrication check points.
6. Air pressure level must be adjusted to nominal 80 psi (5.5 bar). This is applicable only if power drawbar is installed.
7. Way areas are cleared, cleaned and lubricated.
8. Fill Coolant Tank with coolant to required level (if optional coolant system is installed).

- NOTE -

For Series I machines, the tank capacity is 50 liters. For Series II machines, the tank capacity is 25 liters.

- CAUTION -

DO NOT use coolant containing the following chemicals: Mono-ethanolamide, Di-ethanolamide, Triethanolamide. These chemicals may degrade the polycarbonate spindle guard.

9. Install Air Filter on Electrical Cabinet Door.

Figure 2.16 - Way Lube Pump and Reservoir

LUBRICATION CHECK POINTS

Do not operate machine until properly lubricated. Refer to Cleaning and Lubricating on Page 2-1.

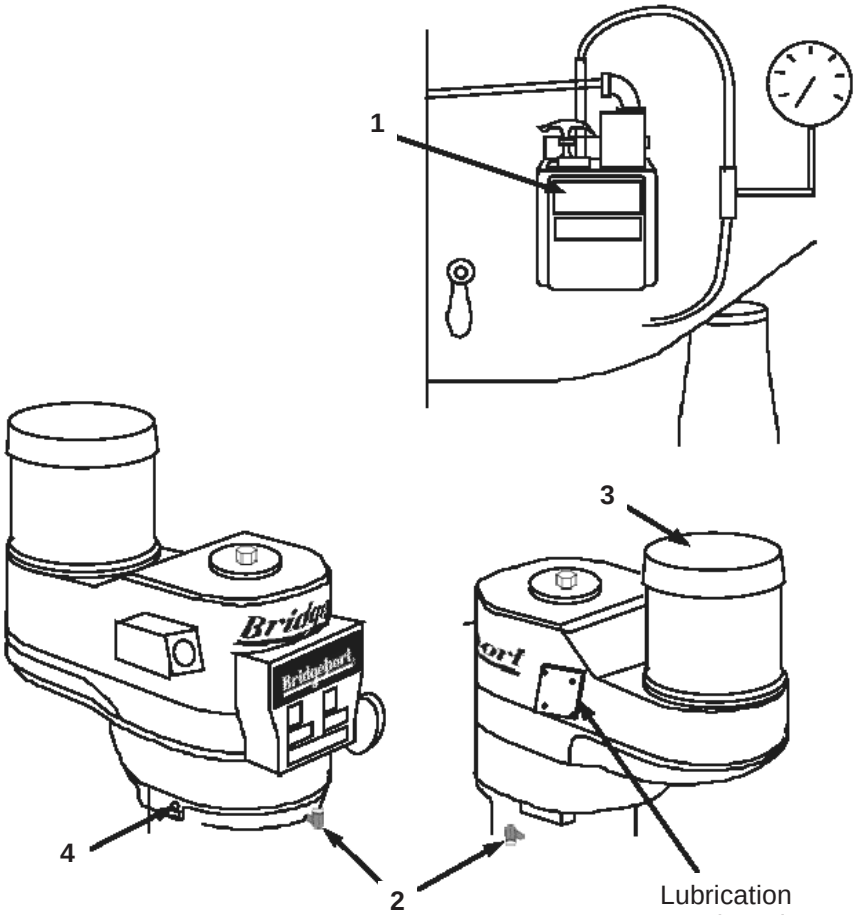


Figure 2.17 - Lubrication Requirements

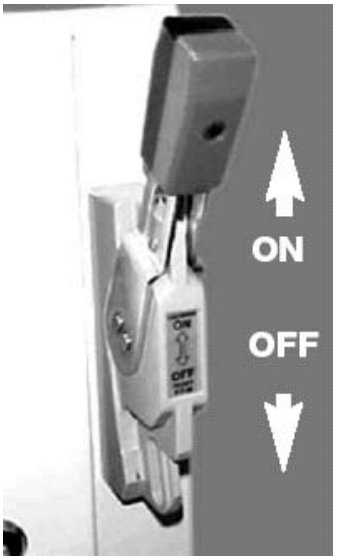
Indicator	Lubrication Area	Type of Lubrication
1	Way Surfaces and Lead Screws	Sunoco Waylube #1180 or equivalent
2	Milling Heads (Spindle Bearings)	S.A.E. 10 or 10W Light Oil (None on grease-packed heads)
3	Motor	None required. Motor greased for life of bearings
4		Grease with lubricate every six months as described on lubrication plate
Not Shown	Power Feed	Oil to sight level with Mobilube No. 46 S.A.E. 140
Not Shown	Shaping Attachment	Mobil 600W Oil or equivalent

APPLYING POWER:

- WARNING -

Ensure that electrical service is compatible with the machine's voltage and that machine is properly grounded before applying power and turning on the main circuit breaker switch (Figure 2.18) on Electronic Control Cabinet.

1. Verify that the correct Cam settings have been made for the machine voltage (see chart below).
2. Perform all voltage checks. Use the Voltage Checklist on Page 2-13 as a guideline.



TP5684

Figure 2.18 - Main Circuit Breaker Switch

TRANSFORMER CONNECTIONS

LINE VAC	INPUT	JUMPER	OVERLOAD CAM SETTING
208	1L1 TO 1 1L2 TO 4	1 TO 3 2 TO 4	7.8A
230	1L1 TO 1 1L2 TO 4	1 TO 3 2 TO 4	7.5A
245	1L1 TO 1 1L2 TO 4	1 TO 3 2 TO 4	7.3A
380	1L1 TO 1 1L2 TO 2		4.5A
415	1L1 TO 1 1L2 TO 2		4.2A
460	1L1 TO 1 1L2 TO 4	2 TO 3	3.7A
490	1L1 TO 1 1L2 TO 4	2 TO 3	3.3A

VOLTAGE CHECKS

AC LINE INPUT VOLTS

PHASE TO PHASE		PHASE TO GROUND	
L1 TO L2	_ _ _ _ _ _ _ _ _ VAC	L1 TO GND	_ _ _ _ _ _ _ _ _ VAC
L2 TO L3	_ _ _ _ _ _ _ _ _ VAC	L2 TO GND	_ _ _ _ _ _ _ _ _ VAC
L3 TO L1	_ _ _ _ _ _ _ _ _ VAC	L3 TO GND	_ _ _ _ _ _ _ _ _ VAC

T1 TRANSFORMER

SECONDARY:

WIRE 1 TO 2	_ _ _ _ _ _ _ _ _ _ _ _	115VAC +/- 10%
WIRE 20 TO 2	_ _ _ _ _ _ _ _ _ _ _ _	115VAC +/- 10%

LCU UNIT VOLTAGE CHECK:

Check Voltage at the Auxiliary Power Connector on the side of the LCU cabinet.	_ _ _ _ _ _
The Center conductors are GND	_ _ _ _ _ _
The End conductors are + 5V and + 12 V and should be:	
+5.00 +/-.25V	_ _ _ _ _ _
+12.00 +/-.6V	_ _ _ _ _ _

STARTUP CHECKLIST

1. Enable drives and reference machine.

- WARNING -

Drum switch and Hi-Neutral-Lo lever must be in HI range when checking spindle rotation. The Hi-Neutral-Lo Lever is located on the right side of head (see Figure 2.19).

2. Check Spindle Rotation. The spindle should rotate clockwise when viewed from the top of the machine.
3. Install Air Filter on the Back Door.
4. Ensure that the Door Fan is blowing air into the cabinet.

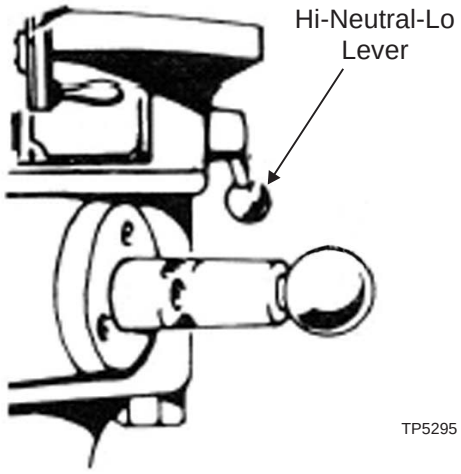


Figure 2.19 - Location of Hi-Neutral-Lo Lever

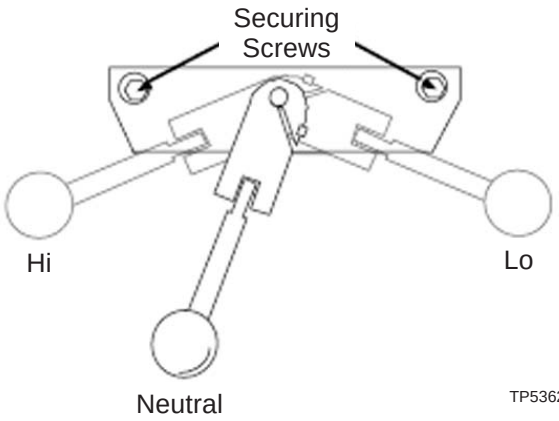


Figure 2.20 - Hi-Neutral-Lo Lever Settings

ALIGNMENT OF HEAD FOR FINE WORK

The spindle has been properly trammeled at the factory, but it is recommended that you check the setting of the head to ensure that it has not moved during shipment.

1. To set head perfectly square with table, adjust ram adapter through vertical adjusting worm shaft with ram adapter on ram.
2. Loosen four locking bolts but leave some drag for fine adjustment.
3. To square head to table in the longitudinal axis, mount indicator as shown in Figure 2.22.
4. Retighten the four head locking bolts in a diagonal order as described at right (Figure B).
5. Retighten the three Ram Locking Bolts to 50 ft. Lbs.

Tighten bolts first to 25 ft/lbs. torque in diagonal sequence shown in Figure 2.21, and then to 50 ft/lbs. Over-tightening could cause bind in the quill movement.

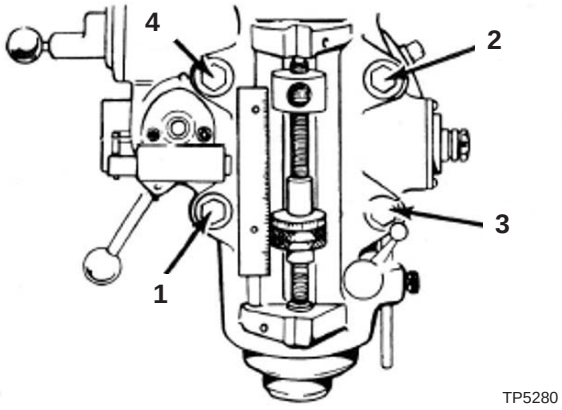


Figure 2.21 - Head Bolt Retightening Sequence

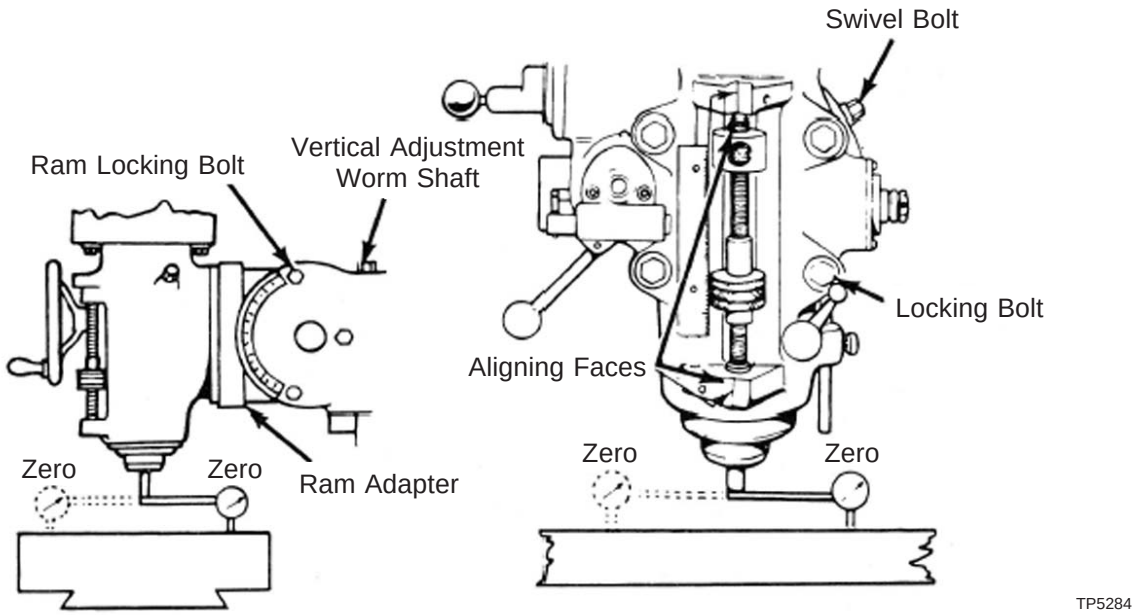


Figure 2.22 - Head Alignment

- NOTES -

CHAPTER 3 - POWER DISTRIBUTION

OVERVIEW

The EZPLUS Milling Machine system consists of an electrical cabinet attached to the back of the column, an LCD display and keypad, an operator station, and two motors, one on the X axis and one on the Y axis. The LCD display shows the operator the control and machine status, and the position of each axis. The key pad permits the operator to input and modify part programs. The operator's station permits direct control of the spindle, coolant, and emergency stop. The electrical cabinet contains all apparatus to control the spindle, coolants, and motors.

Figure 3.1 - Control Panel with Remote Start Switch

POWER DISTRIBUTION SYSTEM

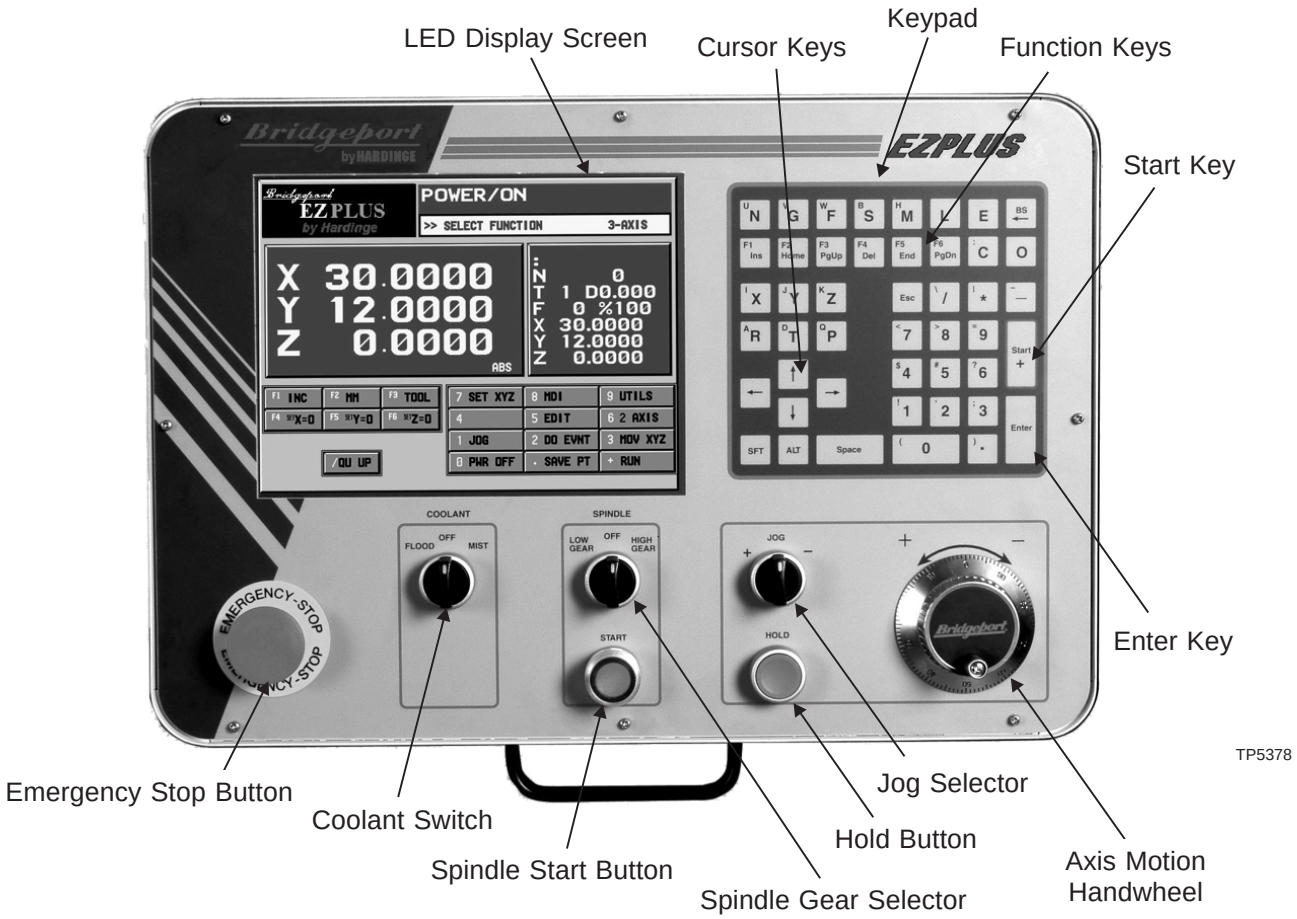


Figure 3.2 - Operator Control Panel

LIQUID CRYSTAL DISPLAY

The front panel contains the LCD and the keypad. The LCD is a 10.5” color display, which is used to interact with the operator, prompting for information and instruction. The screen changes to a new display with each mode as it is selected: input, setup, or edit. Axis positions are displayed as offset from the last established zero.

KEYPAD FUNCTION

The keypad contains 46 keys that make up a full alphanumeric keypad. With the keypad the operator can input part program information or initiate a start. Once the part program has been established, it can be edited through use of the keypad.

FLAT PANEL CONTROLS

LCD Display Screen

The screen on the Control Panel displays all of the information necessary to run the machine system software, such as tool number and diameter, feedrate, and program information.

Emergency Stop

- CAUTION -

Pressing the Emergency Stop button or Spindle Off selector removes power from the spindle motor but does NOT apply the spindle brake. The brake must be activated manually.

This red mushroom pushbutton is used to shut down all power to the spindle and axis drives in the event of an emergency. When the EMERGENCY STOP button is pressed, the computer screen displays an ALARM condition in the top left corner of the screen. To clear the alarm condition, pull out the EMERGENCY STOP button by turning it, then follow the instructions on the screen to continue.

- CAUTION -

DO NOT restart the milling machine before pulling out the EMERGENCY STOP button.

Coolant

This three way switch (FLOOD-OFF-MIST) activates flood or spray mist coolant functions.

Spindle Gear Selector

This three way switch (LOW GEAR-OFF-HIGH GEAR) is used to set the rotation direction of the spindle and to shut the spindle OFF. It should be set the same as the SPEED RANGE SELECTOR located on the lower right side of the spindle housing.

Spindle Start

- CAUTION -

NEVER put hands near the spindle unless the spindle light is ON.

This indicator pushbutton starts the spindle, provided the Spindle Gear Selector is not turned to OFF. When this green light is ON, power to the spindle is OFF.

Jog Selector (+/-)
Axis Motion Handwheel

In JOG mode, these two controls are used to position the table by moving the X and Y axes separately. After selecting the axis you wish to move, turn the JOG SWITCH to plus (+) or minus (-) to jog the axis in the positive or negative direction.

Hold

- CAUTION -

The HOLD switch will not shut off the spindle or coolant. It is not the Emergency Stop.

This pushbutton interrupts automatic operation. The START button resumes operation.

Remote Start Switch

This is a hand held switch attached to a flexible cord at the left side of the operator's control panel (see Figure 3.1). It can be used in place of the START button on the control keyboard when the operator is prompted to press the START button.

CONTROL CABINET

The control cabinet is a large metal box mounted on the back of the column. It contains the following devices:

Incoming Power Disconnect

The Incoming Power Disconnect is mounted on the equipment panel with the handle protruding through the flange. This disconnect is used as the Power On/Off switch. The circuit breaker is rated at 15 amps.

Interface Transformer

The Interface Transformer receives the incoming line voltage and outputs 115VAC to the CRT monitor, the LCU, the 115VAC control circuits, and 115VAC to supply power for the axis drives.

Forward/Reversing Starter

This controls the 3 HP spindle motor. The starter is equipped with a motor overload for motor protection.

LCU Components

PENTIUM PROCESSOR BOARD

This component interfaces with the LCD, the BMDC board, the key pad, the floppy disk reader, and all external communications.

BMDC BOARD

The BMDC Board controls all motion on the X and Y axes when the control is in Auto/Run.

DISK-ON-MODULE

The Disk-On-Module emulates an IDE hard disk.

AXIS I/O CARD

Motor Driver Amplifier

Two motor driver amplifiers control the speed and torque required by the axis motors.

Floppy Disk Reader

A placed in the cabinet that is used at start up to load the machine software and to load part programs.

ELECTRICAL POWER DISTRIBUTION SYSTEM

- NOTE -

The power input to this machine is 4 conductor wires carrying a 3-phase 60-cycle alternating current. The machine wiring can be adjusted to accommodate 208, 230, 240, 380, 416, 460, or 495VAC.

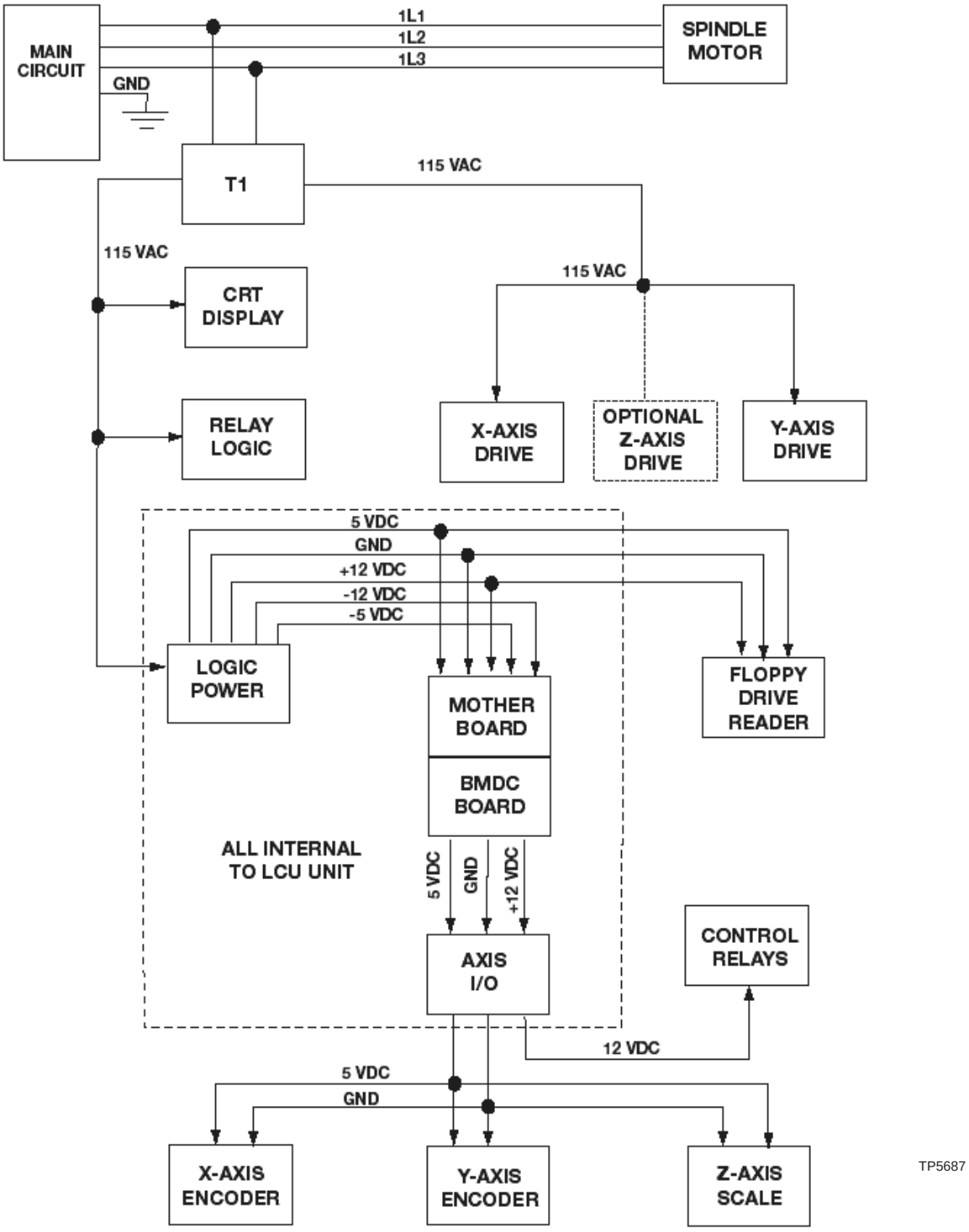


Figure 3.3 - Power Distribution System Block Diagram

VOLTAGE CONNECTION REQUIREMENTS

CONFIGURATION	SUPPLEMENTARY PROTECTION	SPINDLE MOTOR OVERLOAD	TRANSFORMER CONNECTIONS	VOLTAGE PLATE TEXT
208VAC*	Secondary	5.5 to 8.0 Amps (Adjustable) Part # MT03M	1L1 to Terminal H1 1L2 to Terminal H4 Jumper H2 to H4	208VAC Part # 31943395
230VAC*	Secondary	5.5 to 8.0 Amps (Adjustable) Part # MT03M	1L1 to Terminal H1 1L2 to Terminal H4 Jumper H1 to H3 Jumper H2 to H4	230VAC Part # 31943394
240VAC	Secondary	4.55 to 7.4 Amps (Adjustable) Part # C306DN3B	1L1 to Terminal H1 1L2 to Terminal H10 Jumper H1 to H6 Jumper H5 to H10	
380VAC	Secondary	4.55 to 7.4 Amps (Adjustable) Part # C306DN3B	1L1 to Terminal H1 1L2 to Terminal H7 Jumper H2 to H6	380VAC Part # 12598103
416VAC*	Secondary	3.23 to 5.23 Amps (Adjustable) Part # C306DN3B	1L1 to Terminal H1 1L2 to Terminal H6 Jumper H3 to H6	416VAC Part # 31943706
460VAC*	Secondary	2.15 to 3.49 Amps (Adjustable) Part # C306DN3B	1L1 to Terminal H1 1L2 to Terminal H9 Jumper H4 to H6	460VAC Part # 31943391
480VAC	Secondary	2.15 to 3.49 Amps (Adjustable) Part # C306DN3B	1L1 to Terminal H1 1L2 to Terminal H10 Jumper H5 to H6	

*The spindle motor must be wired according to the instructions in the manufacturer's manual or the motor name plate.

The four wire connections are L1 to the top left connection on the Main Circuit Breaker, L2 to the top middle connection, and L3 to the top right connection; the green wire must be connected to the chassis ground terminal.

- CAUTION -

The green wire is a Personnel Safety Device. The green wire must be connected directly to the chassis.

- NOTE -

To determine the correct phasing, put the transmission in HI. Select the high gear position on the spindle switch and press the spindle start switch. If the spindle direction is clockwise, the phasing is correct. If the spindle direction is counterclockwise, reverse any two incoming wires.

The incoming three phases are switched off and on by the Main Circuit Breaker. The output from the circuit breaker energizes the spindle motor through the reversing starter and the motor overload. Phases L1 and L2 are used to energize transformer T1.

The output of transformer T1 supplies the power for the complete control.

The 115VAC output from ground and terminal X1 is used to supply power to the IPC, the CRT Monitor, the Duplex Outlet, Axis Drives, and the cabinet fan through Wire 1.

RELAY LOGIC

The output of CB3 on Wire 5 delivers 115VAC to 3 circuits. The first is to a normally closed contact on the MR relay. On the other side of this relay contact, Wire 17 is connected to a normally closed contact on the MF relay. Wire 18 connects the output on the MF contact to the light on the spindle start switch. Wire 2 completes the circuit. This circuit insures that the spindle safe light is only lit when the spindle is off.

The second circuit, Wire 5 is connected to the Lube Level Switch. Wire 19 from Lube Level connects to CR1. The third circuit is to a normally closed contact on MOL1. Wire 11 on the other side of MOL1 connects to the emergency stop switch. Wire 6 on the output of the emergency stop switch feeds this to several circuits. MOL1 opens if the spindle motor is shut down for an over-current condition. The Emergency Stop circuit opens when the operator depresses the switch activator. This series connection insures that if either the MOL1 or Emergency Stop switch opens, the spindle motor stops, the coolant shuts off, and the axis motors are brought to a halt.

Wire 6 connects to SW2, the Spindle Start Switch. The output of SW2 connects to a normally open CR1 through Wire 7. On the other side of the Low Lube Switch, Wire 8 connects to SW3, the Spindle Select Switch. One output (low gear) from SW3 is connected to a normally closed contact on MF through Wire 9. On the other side of MF contact Wire 10 connects to the MR coil. The other side of MR coil is connected to Wire 2 to complete this circuit. The second output of SW3 is connected to a normally closed contact on MR through Wire 12. The other side of MR contact is connected to the coil of the MF relay through Wire 13. Wire 2 connected to the other side the MF coil completes the circuit. Wire 6 connects to a normally open contact on the MR and MF relay, and to the ACR relay. The other sides of these contacts are connected to Wire 8. This circuit will energize the MR relay when the lubricator is full, low gear is selected on the spindle switch, and the spindle start switch is depressed. The MR contact between Wire 6 and 8 holds the circuit on. Note that the MR contacts between Wire 12 and 13 will open and MF cannot be energized until MR is turned off. A mechanical fail-safe mechanism between contacts also prevents both coils from being picked. Turning the Spindle Selector Switch to off will stop the spindle. The other leg of this circuit will operate if high gear is selected.

Wire 6 also is connected to ACR. The other side of the coil on ACR is connected to Wire 2 to complete the circuit.

ACR applies power to the axis motors.

Wire 8 also supplies power to SW4, the Lube Pump Motor, and the Power Drawbar Switch. The output of SW4 is connected to the flood coolant pump motor through Wire 14. Wire 2 completes the flood coolant circuit. The output of SW4 is connected to the coolant solenoid through Wire 15. Wire 2 completes the circuit to the coolant solenoid.

Wire 8 is energized when the spindle is on. The lube pump will be on and the power drawbar pneumatics will be on.

- NOTE -

If the lube reservoir is close to empty the spindle will not start. If the spindle is running when the pump runs dry, the machine will run until the spindle is shut off but will not start again until oil is added to the reservoir.

The fourth set of contacts on the MR and MF reversing starter is used to signal the control logic that the spindle is running. They are connected to the IPC and Axis I/O through Wires 33 and 34. Wire 34 at J9 Pin 16 supplies 12VDC to a normally open contact on the MR and MF relay. On the other side of the MR and MF relay, contact Wire 33 connects the contacts to J9 Pin 3. When either one of the relays is energized, J9 Pin 3 goes to 12VDC.

Wire 34 also supplies 12VDC to a normally open contact on the Emergency Stop Switch and a normally open contact on MOL relay. Wire 35 connects J9 Pin 4 to the other side of the normally open contact on the Emergency Stop Switch and the normally open contact on the MOL relay. When either the emergency switch or the MOL relay is energized, J9 Pin 4 goes to 12VDC. This signal informs the control that the machine is in the Emergency Stop mode.

FRONT PANEL SWITCHES

The front panel contains three switches for the operator's use. They are Jog Continuous, Axis Motion, and Hold.

Jog Continuous Switch

The Jog Continuous Switch (SW6) is connected to the IPC and Axis I/O board at Connector J9.

Pin 1 is connected to SW6 at Pin 4 through Wire 53.

Pin 2 is connected to SW6 at Pin 3 through Wire 52.

When Jog + is selected J9 Pin 1 goes to 12VDC.

When Jog - is selected J9 Pin 2 goes to 12VDC.

The Jog function will continue as long as the switch is held in that position.

Axis Motion Encoder

The Axis Motion Encoder (P4) is connected to the Axis I/O board at Connector J11.

Pin 9 is connected to P4 at Pin 4 through Wire 54.

Pin 10 is connected to P4 at Pin 5 through Wire 51.

Pin 8 is connected to P4 at Pin 3 through Wire 50.

Pin 7 is connected to P4 at Pin 1 through Wire 48.

The Axis Motion Encoder is a rotary encoder that produces a quadrature signal with 5VDC amplitude. This signal is decoded to determine direction, speed, and distance of the axis selected to jog.

Hold Switch

The Hold Switch (SW7) is connected to the Axis I/O board at Connector J9.

Pin 6 is connected to SW7 at Pin 3 through Wire 55.

Pin 14 is connected to SW7 at Pin 4 through Wire 56.

Pin 14 supplies 12VDC to the switch. When the switch is pressed, Pin 6 is raised to 12VDC.

This signal will halt the axis motion only.

The Remote Start Switch (SW8) is connected to the Axis I/O board at Connector J9.

J9 Pin 4 is connected to SW8 at Pin 2 through Wire 44.

J9 Pin 21 is connected to SW8 at Pin 1 through Wire 45.

Pin 21 supplies 12VDC to the switch. When the switch is pressed, Pin 8 goes to 12VDC.

This stops the machine.

SYSTEM PROTECTION

Signal Ground

Each module, separated device, or separate circuit, is referenced to the System Ground as close as practical to the System Ground Stud. Because these circuits branch out independently from the ground stud, they will not carry current from other modules. The Signal Ground (a zero-volt reference) is connected to the protective ground at only one point.

Shielding

Certain shielded cables for signal purposes are continuous shields grounded at one end only (the point closest to the System Ground Stud).

Noise Suppression

Suitable RC circuits are applied across AC relays and starters as well as at the main 3-phase AC induction motor for the spindle.

PROTECTIVE GROUND

See Chapter 2, Installation.

- CAUTION -

This power supply is equipped with a crowbar circuit that will shut down the output power if the output current exceeds its preset level. When troubleshooting this supply, unload the outputs one at a time to determine if one of the loads are shorted. Shut down the control to disconnect each load. The power supply will not reset with power on. It may take several minutes for the power supply to reset.

CONTROL CIRCUIT FUSE SPECIFICATION

FUSE #	USE	PART NO.	DESCRIPTION	LOCATION
FU1	LCU Logic Unit	1542110	5 Amp GDA	Internal
FU2	CRT Monitor	1508813	1 Amp GDA	Internal
FU3, 4, 5	Motor Drives		16 Amp MDA	Internal

- NOTES -

- NOTES -

CHAPTER 4 - LOGIC BOARDS

INTRODUCTION

This chapter deals with the logic boards in the EZPLUS Milling Machine control system and describes what they do and how they interact with the whole system. Refer to the System Block Diagram, Figure 4.1, for an overview of logic flow and interaction.

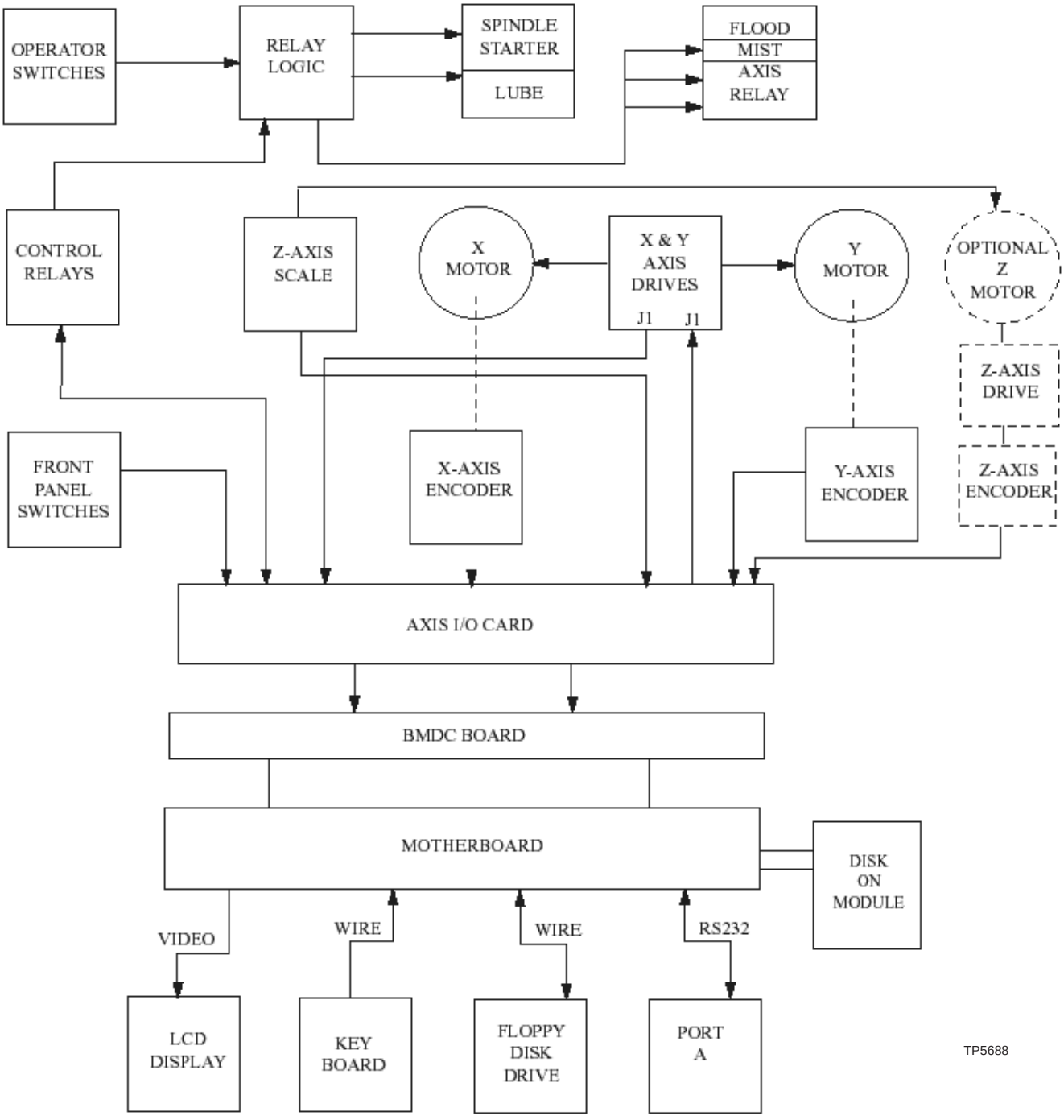


Figure 4.1 - System Block Diagram

LOGIC BOARDS AND COMPONENTS

MOTHER BOARD

This board is a general purpose Pentium digital processor operating at 100 megahertz with 8 megabytes of RAM. This board contains all computer functions necessary to meet the functional requirements of this control. One back plane slot is occupied by the BMDC machine controller board.

The mother board handles all communications related to the part program. It receives information directly from the keyboard. All information to or from the floppy disk, hard disk, and the external Port A is handled by the motherboard. All information displayed on the CRT is ported through the VGA port.

Mother Board I/O Features and Specifications:

SERIAL PORT

- Two RS-232C serial ports
- Supports COM1, COM2, COM3 and COM4 ports addressed at 3F8-3FF, 2F8-2FF, 3E8-3EF and 2E8-2EF
- Supports IRQ2 to IRQ5 Interrupt Request Lines
- Supports DTE/DCE operation
- Equipped with enable/disable function
- Includes a 9-pin to 25-pin connector with cable

PARALLEL PRINTER PORT

- One parallel printer port (25-pin female connector)
- Supports two port addresses: 378-37F and 278-27F HEX
- Supports IRQ5 and IRQ7 Interrupt Request Lines
- Equipped with enable/disable function

FLOPPY DISK CONTROLLER

- Supports up to two standard floppy disk drives
- Supports 360KB, 720KB, 1.3MB and 1.44MB 5.25/3.5-inch floppy disk drives
- Equipped with enable/disable function

IDE HARD DISK INTERFACE

- Interfaces up to 4 IDE hard disk drives
- Equipped with enable/disable function

DISK ON CHIP

- Flash memory array that emulates hard disk
- Type PC-FD (DOS compatible)
- Memory capacity: 8 meg.

PS2 MOUSE PORT

BMDC CARD

The BMDC board is a low-cost, high performance general purpose machine tool controller that is IBM AT bus compatible. The board and its companion software are designed to be a general purpose, five-axes control with the following features:

BMDC Features and Specifications:

- 25 MHZ 32-bit microprocessor (MC68EC030) provides a powerful platform with sufficient computational “horsepower” to allow additional features to be added.
- 25 MHZ Floating Point Coprocessor (MC68882) provides fast and accurate (80-bit) arithmetic.
- 512K bytes of High Speed Static memory for Control software, User data, and/or programs.
- 4096 bytes of Dual Port Memory to facilitate communication between the Host processor (286/386/486) and the 68EC030.
- Five Axis Position Encoder inputs. The encoder inputs may be either single ended TTL/HCMOS compatible, or RS-422 differential. Inputs for each channel include Phase A, Phase B, and Index.
- One Quadrature encoder input for Operator Input such as a “Jog Knob”. The Phase A and Phase B inputs must be single ended TTL/HCMOS compatible.
- Four 12-bit DACs for outputting +-10 Volt commands to the four axes amplifiers.
- One 16-bit DAC for outputting +/-10 Volt commands to a fifth axis, typically a spindle.
- Eight channel 8-bit Analog to Digital converter. Four channels are used to perform diagnostics, four channels are available for operator controls such as joy sticks or feedrate override pots.
- Two Serial I/O communication Ports for auxiliary I/O through optional AUF and/or TLAUF boards, or to control “digital axis drive systems”.
- Twelve bits of general purpose input, typically used for operator switch inputs.
- Two relay driver outputs rated for 60VDC and 1 amp.

The BMDC board is plugged into a standard IBM AT compatible back plane. The system software is divided into two parts. The software that runs on the DOS (286/386/486) is responsible for providing the interface to the machine operator (through the VGA screens and the keyboard), as well as communication capability with other computer based systems. The software for BMDC is responsible for interpreting the user’s part program, controlling the machine’s axes servos, and other auxiliary functions such as coolant, lube, spindle, etc.

The software resides on a floppy or hard disk drive on the DOS machine. On power-up, the software on the DOS machine loads the main memory of the 68EC030 with BMDC software. The DOS software then enables the 68030 to run. The BMDC software then performs its power-up diagnostics and the begins its normal operation. Once the BMDC board is running, all communication between the DOS software and the BMDC software is performed through the dual port memory on the BMDC board.

The BMDC board is compatible with most IBM AT compatible systems. There are two requirements:

- The I/O addresses 1A0 through 1B6 (hex) are reserved for use by the BMDC board.
- The Memory addresses D4000 through D4FFF (hex) are reserved for use by the BMDC board.

In some PC systems, these addresses may be in use for other boards and/or features. Often, conflicts may be fixed by changing addresses on the other boards and/or changing the system configuration information in the battery backed ram on the AT mother board.

The I/O for the BMDC board is through two 50-pin connector.

BMDC Application Notes

The BMDC board requires +5VDC at 3 amps. If the axes encoders are plugged into the encoder I/O board and obtain their power from the BMDC board, then the current requirement for +5VDC will increase. Typically, four axes of encoders requires an additional 1.0 amp of current. The BMDC does not need any positive or negative 12VDC from the AT bus connection, but if an external device such as a “joy stick” is connected, then sufficient +/-12VDC current must be supplied.

The axis encoder line rate (line count times the encoder rotational speed) is limited to a rate of 127,000 lines per second. This limits the axis position counters to 508,000 counts per second.

An example:

A 1,000 line encoder at 3,000 RPM (50 revs/second) will generate a line rate of 50,000 lines per second or 200,000 counts per second.

Diagnostic Software Features

- There are four types of diagnostics that are available for the BMDC board:
- There are software routines that run on the DOS machine that can check the basic functionality of the BMDC by directly accessing the 68030’s bus and its devices.
- The 68030 has its own software routines within BMDC that also check the BMDC board. The 68030’s routines run faster and are more extensive than the DOS based diagnostics.
- There are checks performed by the BMDC software during normal operation that monitor the behavior of the system. If a run time check detects a problem, a note of the problem and the time and date is placed into the Event Queue. The Event Queue may be read with a program running on the DOS machine. The event queue is volatile! If the system is powered down, the information in the queue is lost.
- The fourth type of diagnostic software is called the Window Monitor. The window monitor allows a technician to read and write memory and I/O on the BMDC while normal system operation continues. The Window Monitor consists of software that runs on the DOS machine and software that runs on the 68030. The two parts of the window monitor software communicate with each other through the dual port memory.

A Quick Check for Proper BMDC Operation

At Power-Up, the LED D1 should be ON and LED D10 should be OFF. When the BMDC is loaded with software and started, the LED D1 will turn off and D10 will Blink on and off. At the successful completion of the power up tests, LED D10 will begin to blink! LED D11 (if installed) will glow dimly during normal operation. If D11 is glowing brightly, then the 68EC030 has suffered a DOUBLE BUS FAULT or the board was reset.

Status LEDS

The BMDC boards have three status LEDs, a “RESET” LED, a “HALT” LED, and a “STATUS” LED. The Reset LED is on when the BMDC board is powered up or when the Host computer issues “RESET” command.

The HALT LED is on if the BMDC is in a reset state or if the 68030 has detected a severe fault. Under normal conditions, the HALT LED will glow dimly. The STATUS LED is off at power up or after a RESET command.

The 68030 power test software will blink this LED as it begins its BMDC tests. If the tests are successful, the status LED will blink on and off as the 68030 runs its normal system software.

BMDC3

Reset Led = D1 (next to U2, MC68882)

Halt Led = D2 (next to U2, MC68882)

Status Led = D3 (next to U21, 2681)

Function in the System

The BMDC has the basic function of controlling the position of the motors at all times. It does this by commanding the velocity of the axis motors through the AXSBOB card and receiving the output of the motor encoders and the Z axis scale through the AXSBOB card. This board computes the new commanded position each 500 micro seconds and corrects the velocity of the motors to get there. This board also monitors the front panel switches and issues commands the control relay through the Encoder-I/O card.

DISK ON MODULE

Disk On Module is a computer chip which emulates a hard disk. The card is a memory array of 32 megabyte flash memory components. Disk On Module can read faster, and withstand vibrations better than an ordinary hard drive.

AXIS I/O CARD

The purpose of this board is to break out all the BMDC board connections. The Encoder-I/O board handles the general purpose low current inputs and outputs, Jog Knob, Axis Commands and encoder inputs.

THE ASSIGNED USE OF THESE CONNECTORS:

JP2 returns the encoder signals from the X axis.

JP3 returns the encoder signals from the Y axis.

JP4 returns the encoder signals from the Z axis.

JP7 outputs the velocity command to the X, Y, and optional Z axis.

JP9 returns BMDC inputs.

JP10 BMDC outputs A and B. to X, Y and optional Z axis drive enable inputs.

JP11 Jog Knob input from Front Panel.

The Axis-I/O board delivers to the BMDC board the status of all the main interface switches. Over and above the front panel switches connected to it, as described above, the following signals are also connected to it.

The Axis-I/O has two outputs called Output A and Output B. They are capable of sinking .5 amp of current up to 30VDC. The power transistor for these outputs is located on the BMDC board.

Each axis has an encoder to enable the BMDC to maintain the position on each axis.

- NOTES -

- NOTES -

CHAPTER 5 - AXIS DRIVE SYSTEM

SYSTEM OVERVIEW

The X axis and the Y axis on the machine are driven by two DC servo motors. These motors are equipped with an encoder and tachometer for position and speed control. The power to these motors is controlled by the X and Y axis power amplifier. The DC voltage for the motors is supplied by the amplifier. The control of the motor position, speed, and direction is done in the BMDC card through the Encoder I/O Board.

EZPLUS MILLING MACHINE DRIVE SYSTEM

DC SERVO MOTORS

The servo motors on the machine, when combined with the amplifiers in this design, are capable of producing 19 in/lbs. of torque continuous, 30 in.-lbs. Intermittent, and a peak of 50 in/lbs. for 2.5 seconds. The tachometer output is 7VDC at 1000 RPM. The encoder output is 250 lines of quadrature output with one index mark per revolution. The motors are geared to the lead screws by a 2 revolution of the motor to 1 revolution of the 5 pitch lead screw timing belt. The output of the encoder will be 500 lines for every revolution of the lead screw. The control will decode the quadrature input and multiply it by 4. This will yield a pulse count of 2000 pulses for each revolution of the lead screw, which will be 0.2 inches of linear motion. This enables the control resolution to be 0.0001 inches.

The index mark is used for homing the machine to X0.0 and Y0.0 in machine coordinates. This point is the reference for the software limits. When the machine is requested to HOME, first the Y axis and the X axis will travel in the positive direction until the home trip dog causes the home switch to close. The axis will continue to move until the control finds the next marker pulse on the encoder. At that time the control sets the move dimension to 0.2000 and continues to the home position. In the event that one or both of the axes has already tripped the home switch, that axis will travel in the negative direction until the trip dog clears the home switch. The axis will then return to home by the normal sequence described above.

AXIS POWER AMPLIFIER

The axis power amplifier is rated at 160VDC with a continuous output current of +/- 8 amps and a peak current of +/- 16 amps for 2.0 seconds. They are located on the bottom right side of the equipment panel. These amplifiers have 4 potentiometers to adjust their performance. Refer to the following information on AMC drive amplifiers. To adjust these potentiometers in this control, execute the following steps:

1. The current limit potentiometer (Pot 2 if it is present) should be adjusted fully clockwise. Some models may not have this potentiometer. In this case, the potentiometer has been replaced by a fixed resistor and no adjustment is necessary.
2. The reference in gain potentiometer must be adjusted before the current gain potentiometer is adjusted. To adjust this potentiometer, request the control to run the axis at 100 IPM. In the system terminal adjust the AT for 0 following error on the screen.
3. The current gain potentiometer must be adjusted for minimum overshoot on the axis. Many times, this potentiometer can be turned clockwise until the motor hums and backed off 2 turns.
4. The balance potentiometer is adjusted with the axis at rest. Go to the system terminal and adjust the DAC offset number for 0.
5. After the above settings have been completed, the following error must be set. To accomplish this, input the FERROR program following the instructions on the screen to set up the axis. Set the machine in motion in the automatic mode. Go to system terminal and select the screen that displays the following error on both axis. Determine which axis has the least following error. Adjust that axis with the velocity gain potentiometer to make the following error the same for each axis.

- CAUTION -

Wires 25 and 2 must be connected correctly or the drive cards will be destroyed.

The output of the amplifier at J3 Pin 2 is connected to Terminal A- of the drive motor. The output at J3 Pin 1 is connected to Terminal A+.

The tachometer output of the motor at Terminal T+ is connected to the amplifier at terminal J1 Pin 3. Terminal T- is connected to the amplifier at Terminal J1 Pin 4. These signals are phased with the signals that are going to the armature. If these signals are connected incorrectly the motor will be come unstable.

The command voltage to the amplifiers is 0 to +/-9 volts DC which is equal to 0 to 3000 RPM at the motor shaft. This system is limited to a maximum table speed of 120 IPM, which equates to 1200 RPM on the motor shaft. This will correspond to a maximum command voltage of +/-3.6 volts DC. The X-axis command voltage output is from the AXIS I/O card on connector J7. Pin 1 is connected to the amplifier at J1 Pin 2 through Wire 31. Pin 9 is connected to the amplifier at J1 Pin 1 through Wire 32. The Y-axis command voltage output is from the AXIS I/O card at connector J7. Pin 2 is connected to the amplifier at J1 Pin 2 through Wire 30. Pin 10 is connected to the amplifier at J1 Pin 2 through Wire 29. Pin 3 on each connector grounds the shield on the command cables. If any of these wires are connected incorrectly the motor will run in reverse. If the shield is not connected correctly, the motor will become noisy and high temperatures will develop quickly.

The X-axis encoder signals are connected to the AXIS I/O card at connector J2. The Y-axis signals are connected to the AXIS I/O card at connector J3. The signal wires must be connected in the order that is shown on the System Wiring Diagram. If any wire is not connected correctly, the motors will be unstable. If any connections are loose, the axis will shut down when it is requested to make a move. Improper connection of the cable shields will result in noisy motors.

- CAUTION -

To reverse the direction of an axis, the command signal wires must be reversed and the A+ and A- signals on the encoder feedback must be reversed.

The Z-axis scale is connected to the AXIS I/O card through connector J4. These terminations are prewired at the factory and should not be changed.

- NOTE -

Though all these wires terminate on the AXSBOB card, the signals terminate or originate on the BMDC card.

The axis fault signal from the X and Y axis amplifier is “ORed” together and brought into the AXIS I/O card on connector JP9. Pin 5, the active signal, is connected to the X and Y-axis amplifier at J1 Pin 8 through Wire 71. The signal ground at Pin 13 is connected to J1 Pin 5 through Wire 70. The signal voltage on Wire 71 is pulled up to 12 volts DC through a 1 kohm resistor when the axis is clear to run. If an axis goes to fault, this signal goes to zero volts. It should be noted that two signals are ORed together and either axis can pull this signal to ground.

- NOTE -

To complete this chapter, review the following information on Advanced Motion Controls Servo Amplifiers.

- WARNING -

AVOID human contact with the power connector (J2), the high voltage area of the amplifier, and the PC board any time power is applied. Electrical shock can result.

WAIT at least 3 minutes after power has been turned off before contacting the motor output leads.

DO NOT apply power with unterminated leads attached to the motor output terminals on J2.

Amplifiers MUST be operated in enclosures where access by personnel unfamiliar with the warnings contained in this manual is restricted.

Incorrect servo phasing can result in erratic motor motion. Servo phasing should be established before mounting the motor in the mechanism.

- CAUTION -

EXERCISE caution during maintenance and troubleshooting. Potentially lethal voltages exist within the amplifier and auxiliary assemblies. Only qualified technically trained personnel should service this equipment.

SERIES 30A-AC SERVO AMPLIFIERS

Models 30A20AC, 16A20AC

FEATURES

- 120VAC, 50-60 Hz Single Supply Operation
- Surface-Mount Technology
- Small Size, Low Cost, Ease of Use
- Built-In Optical Isolation (see Figure 5.1)
- Shunt Regulator (30A20AC only)
- DIP Switch Selectable: Current, Voltage, Velocity, IR Compensation, Analog Position Loop
- Four Quadrant Regenerative Operation

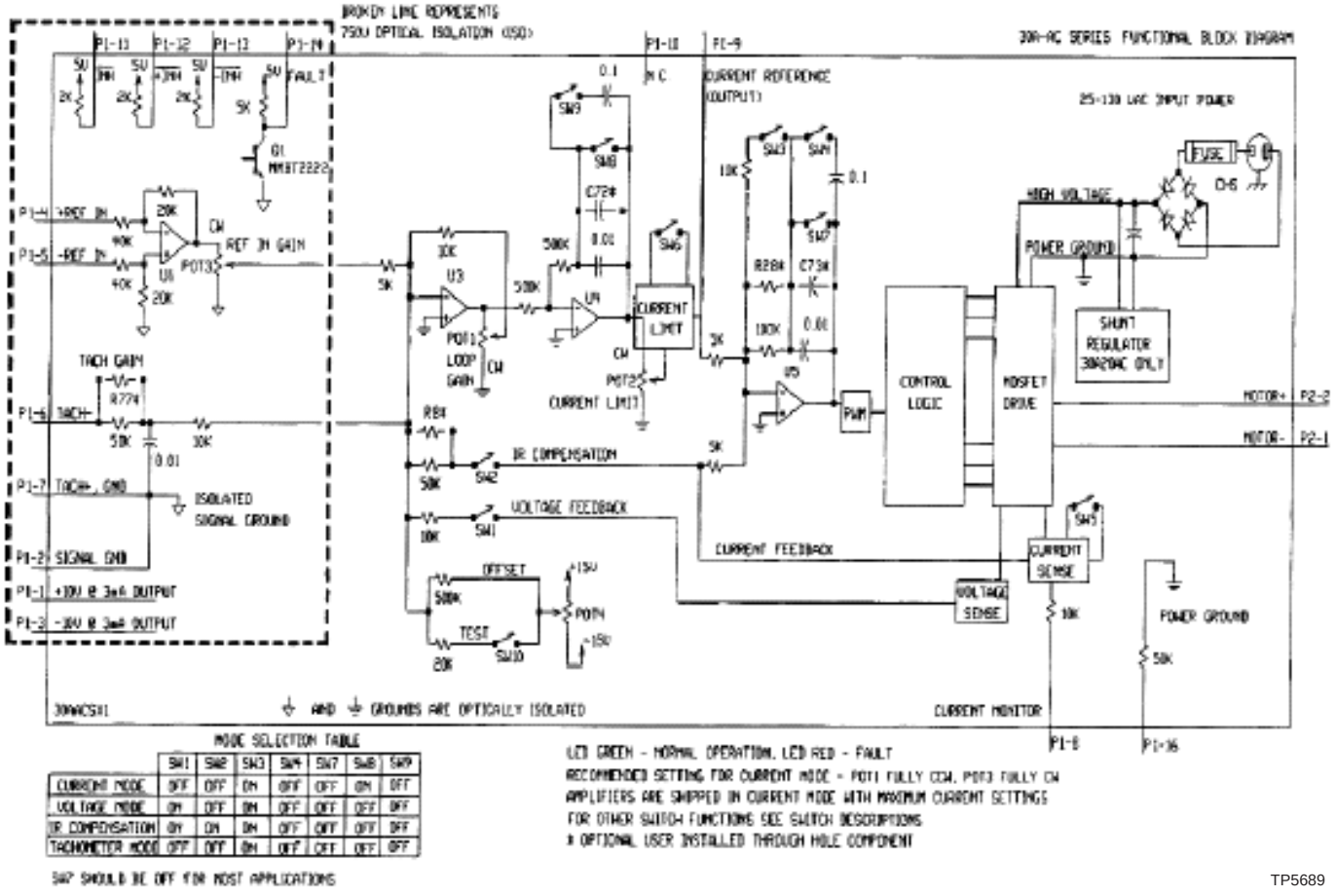


Figure 5.1 - Functional Block Diagram

Description

The 30A-AC Series PWM Servo Amplifiers are designed to drive brush-type DC motors at a high switching frequency. A single red/green LED indicates operating status. All models are fully protected against over-voltage, over-current, overheating and short-circuits across motor, ground and power leads. These models interface with digital controllers or can be used as a stand-alone system. They require only a single AC power supply. Loop gain, current limit, input gain and offset can be adjusted using 14-turn potentiometers. The offset adjusting potentiometer can also be used as an on-board input signal for testing purposes when SW10 (DIP switch) is ON.

POWER STAGE SPECIFICATIONS	MODELS	
	30A20AC	**16A20AC**
Single Phase AC Supply Voltage*	30 - 125VAC @ 50 - 60 Hz	
Peak Current (2 Second Maximum, Internally Limited)	± 30 A	± 16 A
Maximum Continuous Current (Internally Limited)	± 15 A	± 8A
Minimum Load Inductance**	250 µH	250 µH
Switching Frequency	22 kHz ± 15%	
Heatsink (Base) Temperature Range	-25 to +65° C, Disables if < 65° C	
Power Dissipation At Continuous Current	150 W	80 W
Over-Voltage Shutdown (Self-Reset)	195VDC	
Bandwidth (Load Dependant)	2.5 kHz	
Shunt Regulator Trip Voltage (30A20AC)	185 V = On, 180 V = Off	N/A
Shunt Resistor	10 Ω @ 50 W	N/A
Bus Capacitance	3600 µF	
Bus Fuse	15 A, Slow-Blow Rated @ 250VAC	

MECHANICAL SPECIFICATIONS	MODELS	
	30A20AC	**16A20AC**
POWER CONNECTOR	Screw Terminals	
SIGNAL CONNECTOR	Molex Connector	
SIZE	7.35” x 4.23” x 2.45” 186.6mm x 107.4mm x 62.2mm	
WEIGHT	2.5 Lbs. 1.14 Kg.	

* Do not exceed 125VAC input.

** Low inductance motors (”pancake” and “basket-wound” require external inductors.

These amplifiers contain a rectifier bridge and filter capacitors to generate the DC bus internally from the AC input power. The DC bus voltage is 1.4 times AC voltage (RMS). During braking much of the stored mechanical energy is fed back into the power supply and charges the output capacitor to a higher voltage. If the charge reaches the amplifier's over-voltage shutdown point, output current and braking will cease. To ensure smooth braking of large inertial loads, a built-in shunt regulator is provided in model 30A20AC. The shunt regulator will switch on the internal power resistor when the bus voltage reaches 185VDC. This resistor then dissipates the extra energy of the DC bus.

PIN FUNCTIONS

CONN.	PIN NO.	NAME	DESCRIPTION/NOTES	I/O
P1	1	+10 V OUT	Outputs regulated voltages of ±10 V @ 3 mA for customer use. Short-circuit protected. Pin P1-2 is signal ground.	O
	2	SIGNAL GND		SGND
	3	-10V OUT		O
	4	+REF IN	Differential analog input, maximum ±15 V, 40K input resistance.	I
	5	-REF IN		
	6	-TACH IN	Maximum ±60VDC, 60K input resistance.	I
	7	+TACH (SGND)		
	8	CURRENT MONITOR OUT	This signal is proportional to the actual current in the motor leads. Scaling is 4A/V (2A/V when SW5 = OFF) for 16A20AC; and 8A/V (4A/V when SW% = OFF) for 30A20AC. See current limit adjustment information below.	O
	9	CURRENT REFERENCE OUT	Command signal to the internal current-loop. The maximum peak current rating of the amplifier always equals 7.25V. See current limit adjustment information below.	O
	10	NC	Not connected.	
	11	$\overline{\text{INHIBIT}}$	Inhibit TTL; turns off all 4 power devices of the "H" bridge drive when pulled to ground. Will cause high FAULT and red LED. For inverted inhibit inputs, see Page 5-40.	I
	12	$\overline{\text{+INHIBIT}}$	Inhibits the motor for "+" direction only. This function can be useful to remove power to the motor using a "limit switch". Will not cause high FAULT or red LED.	I
	13	$\overline{\text{-INHIBIT}}$	Inhibits the motor for "-" direction only. This function can be useful to remove power to the motor using a "limit switch". Will not cause high FAULT or red LED.	I
	14	FAULT OUT (Red LED)	TTL compatible output. It becomes high during output short-circuit, over-voltage, overheating, inhibit, and during "power-on reset". Fault condition indicated by a red LED.	O
	15	NC	Not connected.	N/A
	16	NON-ISO GND	Connected to power ground and can be used as ground with P1-8 and P1-9.	PGND

SWITCH FUNCTIONS

SWITCH	FUNCTION DESCRIPTION	SETTING	
		ON	OFF
1	Internal voltage feedback	On	Off
2	Internal current feedback for IR compensation	On	Off
3	Current loop gain	Decrease	Increase
4	Current loop integration	Increase	Decrease
5	Current scaling. When OFF, increases sensitivity of current sense thus reducing both peak and continuous current limit by 50%.	Full-Current	Half-Current
6	Can be used to reduce factory preset maximum current limit.	Cont/Peak Ratio 25%	Cont/Peak Ratio 50%
7	It is recommended to leave SW7 in the OFF position.	Shorts out the current loop integrator capacitor.	Current loop integrator operating.
8	This capacitor normally ensures “error-free” operation by reducing the error-signal (output of summing amplifier) to zero.	Shorts out the outer velocity/voltage loop integrator capacitor.	Velocity/Voltage integrator operating.
9	Adjusts the value of the integrator capacitor. It is recommended to leave SW9 in the OFF position for most applications.	Increase	Decrease
10	Offset/test. Controls sensitivity of the “offset” potentiometer. Used as an on-board reference signal in test mode.	Test	Offset

POTENTIOMETER FUNCTIONS

POTENTIOMETER	DESCRIPTION	TURNING CW
Pot 1	Loop gain adjustment in voltage and velocity modes	Increases loop gain
Pot 2	Current limit. It adjusts both continuous and peak current limits by maintaining their ratio (50%).	Increases current limit
Pot 3	Reference gain. It adjusts the ratio between input signal and output variables (voltage, current, velocity).	Increases reference input gain
Pot 4	Offset/test. Used to adjust any imbalance in the input signal or in the amplifier. When SW10 (DIP switch) is ON, the sensitivity of this pot is greatly increased, thus it can be used as an on-board signal source for testing purposes.	N/A

Standard Input Signal Isolation

These amplifiers feature an internally installed analog isolation amplifier, which optically isolates the inputs from the rest of the amplifier circuitry. See Functional Block Diagram, Figure 5.1.

Operating Mode Selection

These modes can be selected by the DIP switches according to the chart in the functional Block Diagram:

CURRENT MODE

VOLTAGE MODE

IR COMPENSATION MODE

TACHOMETER MODE

- NOTE -

See Page 5-16 for more information on Analog Position Loop Mode.

Current Limit Adjustments

These amplifiers feature separate peak and continuous current limit adjustments.

The current limit adjusting Pot 2 adjusts both peak and continuous current limit at the same time. It has 12 active turns plus 1 inactive turn at each end and is approximately linear. Thus, to adjust the current limit, turn the potentiometer counterclockwise to zero, then turn clockwise to the appropriate value. If the desired limit is, for example, 15 amperes, and the servo amplifier peak current is 30 amperes, turn the potentiometer 7 turns clockwise from zero.

Pin P1-9 is the input to the internal current amplifier stage. Since the output current is proportional to P1-9, the adjusted current limit can be easily observed at this pin. Note that a command signal must be applied to the reference inputs to obtain a reading on P1-9. The maximum peak current value equals 7.25V at this pin and the maximum continuous current value equals 3.625 at this pin. If SW5 = On, peak rated amplifier current = 7.25V. If SW5 = OFF, ½ peak rated amplifier current = 7.25V. Example: using the 30A20AC with SW5 = ON, 30A = 7.25V and with SW5 = OFF, 15A = 7.25V.

The actual current can be monitored at Pin P1-8.

SW6 (DIP switch) will reduce the continuous current limit to 50% of the maximum value, when switched ON. SW5 (DIP switch) will reduce the current feedback (monitor) scaling by 50% thereby reducing both the peak and the continuous current limit by 50%, when switched OFF.

ORDERING INFORMATION

Model Numbers:

16A20ACX, 30A20ACX (X indicates the current revision letter)

MOTION CONTROL SYSTEMS

Motion control technology (sometimes also referred to as “robotics”) is used in industrial processes to move a certain load in a controlled fashion. These systems can use either pneumatic, hydraulic, or electro mechanical actuation technology. The choice of the actuator type is based on power, speed, precision, and cost requirements. Electro mechanical systems are typically used in high precision, low power, and high-speed applications. Such systems are flexible, efficient, and very cost-effective. The actuators used in electro mechanical systems generate power through the interaction of electromagnetic fields and create either rotary or linear motion. Typically, a complete system consists of the following components:

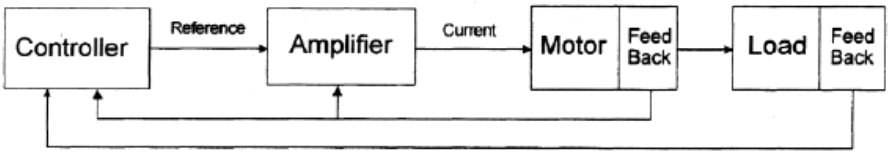


Figure 5.2 - Typical Motion Control System

The above figure shows the components typically used in a servo system. The controller contains the algorithms to close the desired servo loop and also handles machine interfacing (inputs/outputs, terminals, etc.). the motor(which can be of the brushed or brushless type, rotary, or linear) is the actual electromagnetic actuator, which generates the forces required to move the load. Feedback elements are mounted on the motor and/or load in order to close the servo loop.

SERVO AMPLIFIERS

Servo amplifiers are used extensively in motion control systems where precise control of position and/or velocity is required. The amplifier basically translates the low-energy reference signals from the controller into high-energy signals (motor voltage and current). These reference signals can be either of an analog or digital nature. An analog +/-10VDC signal is the most common. This signal can represent either a motor torque or velocity demand (see amplifier modes below).

Pulse Width Modulation (PWM)

Although there exist many ways to “amplify” electrical signals, pulse width modulation (or PWM) is by far the most efficient and cost-effective approach. At the basis of a PWM amplifier is a current control circuit that controls the output current by varying the duty cycle of the output power stage (fixed frequency, variable duty cycle). A typical setup is as follows (here for a single phase load):

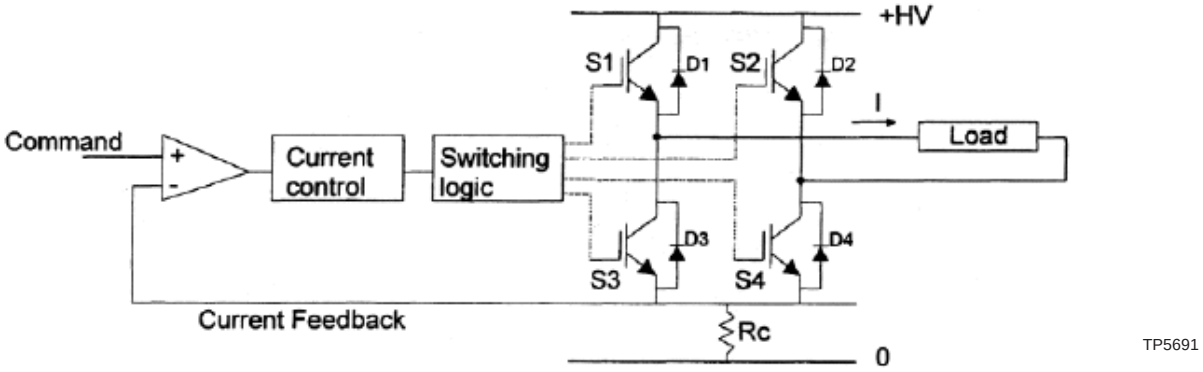


Figure 5.3 - PWM Current Control Circuit

S1, S2, S3 and S4 are power devices (MOSFET or IGBT) that can be switched on or off. D1, D2, D3 and D4 are diodes, which guarantee current continuity. The bus voltage is depicted by +HV. The resistor Rc is used to measure the actual output current. For electric motors, the load is typically inductive (due to the windings used to generate electromagnetic fields). The current can be regulated in both directions (+ and -) by activating the appropriate switches. When switch S1 and S4 (or S2 and S3) are activated, current will flow in the positive (or negative) direction and increase. When switch S1 is off and switch S4 is on, (or S2 is off and S3 is on) current will flow in the positive (or negative) direction and decrease (via one of the diodes). The switch "ON"-time is determined by the difference between the current demand and the actual current. The current control circuit will compare both signals every time interval (typically 50 usec or less) and activate the switches accordingly (this is done by the switching logic circuit, which also performs basic protection functions). The picture below shows the relationship between the pulse width (ON-time) and the current pattern. Note that the current rise time depends on the bus voltage (+HV) and the load inductance. Therefore, certain minimum load inductance requirements are necessary depending on the bus voltage.

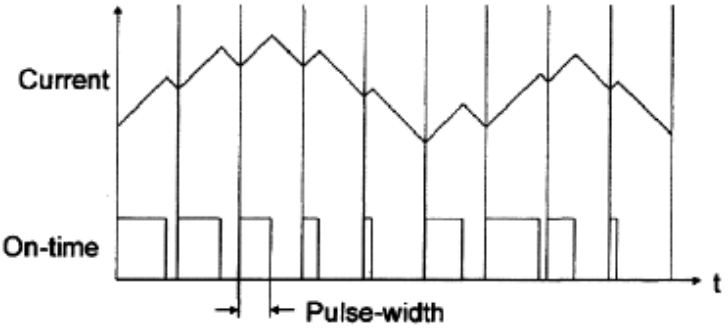


Figure 5.4 - Output Current and Duty Cycle Relationship

DC Brush-Type Amplifiers

DC brush-type amplifiers are designed for use with permanent magnet brushed DC motors (PMDC motors). The amplifier construction is basically as shown in figure 2 (single phase H-bridge). PMDC motors have a single winding (often called the armature) on the rotor, and permanent magnets on the stator (no field winding). Brushes and commutators maintain the optimum torque angle. The torque generated by a PMDC motor is proportional to the current, giving it excellent dynamic control capabilities in motion control systems.

Brushed DC amplifiers can also be used to control current in other inductive loads such as voice coil actuators, magnetic bearings, etc.

Brushless Amplifiers

Brushless amplifiers are used with brushless servo motors. These motors typically have a three-phase winding on the stator and permanent magnets on the rotor. Brushless motors require commutation feedback for proper operation (the commutators and brushes perform this “commutation” function in brush-type motors). This feedback consists of rotor magnetic field orientation information, which can be supplied either by magnetic field sensors (Hall effect sensors) or position sensors (encoder or resolver). Brushless motors have better power density ratings than brushed motors because heat is generated in the stator (shorter thermal path to the outside environment), not on the rotor. Also, the absence of brushes allows them to used in any environment. A typical system configuration is as follows:

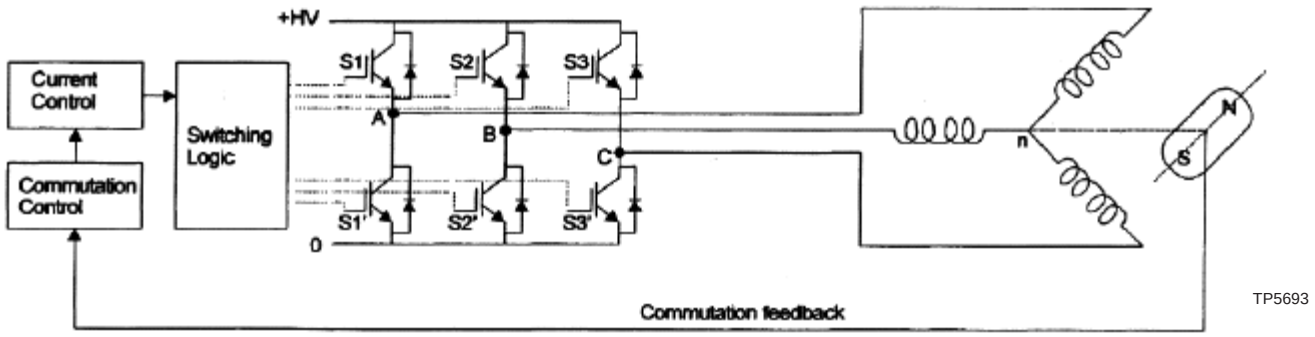


Figure 5.5 - Brushless Servo System

DC BRUSHLESS AMPLIFIERS

DC brushless amplifiers use Hall effect sensor signals for commutation feedback. The Hall effect sensors (typically three) are built into the motor to detect the position of the rotor magnetic field. These sensors are mounted such that they each generate a square wave with 120° phase difference, over one electrical cycle of the motor. The amplifier drives two of the three motor phases with DC current during each specific Hall sensor state:

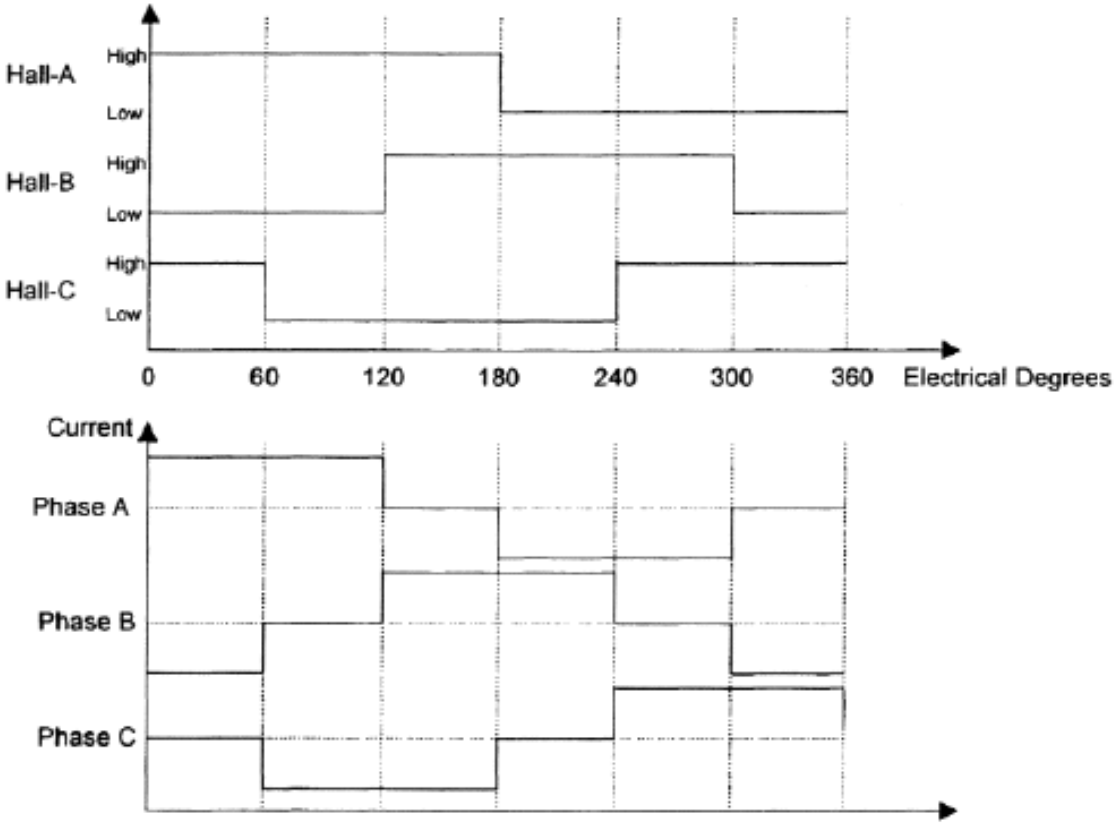


Figure 5.6 - Hall Sensor-Based Commutation

This commutation technique results in a very cost-effective amplifier. When used with motors with sinusoidal back-EMF, the torque ripple is about 13.4%. the average torque is 5% lower compared to a sinusoidal (or AC brushless) system, the peak torque however is 10% higher.

AC BRUSHLESS AMPLIFIERS

AC brushless amplifiers use encoder or resolver signals for commutation feedback. The amplifier drives the motor with sinusoidal currents, resulting in smooth motion (no torque ripple). The amplifier is more complex since it needs to accept high-resolution position feedback. Such amplifiers use a micro-controller implementation for the sinusoidal commutation.

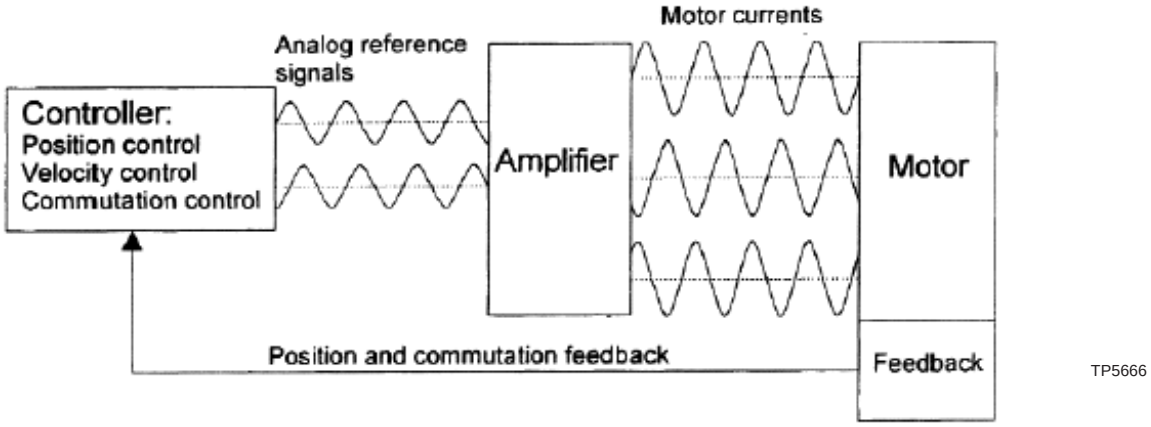


Figure 5.7 - Controller-Based Commutation

AMPLIFIER MODES

Servo amplifiers can operate in most of the following modes:

AMPLIFIER MODE	CONTROLLED VARIABLE	FEEDBACK SOURCE
Open-Loop Mode	Motor Voltage	Duty Cycle (Internal)
Voltage Mode		Voltage (Internal)
IR Compensation Mode		Voltage and Current (Internal)
Tachometer Velocity Mode	Motor Speed	Tachometer
Hall Velocity Mode		Hall Sensors
Encoder Velocity Mode		Encoder
Current (Torque) Mode	Motor Current	Current (Internal)
Analog Position Mode	Motor Position	Potentiometer

The “controlled variable” means the physical parameter controlled by the input reference signal (±10VDC).

Open-Loop Mode

In this mode the input reference signal commands a proportional motor voltage (by changing the duty cycle of the output power stage). This mode is not a closed loop configuration (unlike the other modes described); therefore the average output voltage is also a function of the power supply voltage.

Voltage Mode

In voltage mode, the input reference signal commands a proportional motor voltage regardless of power supply voltage variations. This mode is recommended for velocity control when velocity feedback is unavailable and load variances are small.

IR Compensation Mode

If in voltage mode there is a load torque variation, the motor current will vary, as torque is proportional to motor current. Hence, the motor terminal voltage will be reduced by the voltage drop over the motor winding resistance (IR), resulting in a speed reduction. Thus, motor speed – which is proportional to motor voltage (terminal voltage minus IR drop) – varies with the load torque.

In order to compensate for the internal motor voltage drop, a voltage proportional to motor current can be added to the output voltage. An internal resistor adjusts the amount of compensation. Use caution when adjusting the IR compensation level. If the feedback voltage is high enough to cause a rise in motor voltage with increased motor current, instability occurs. Such result is due to the fact that increased voltage increases motor speed and thus load current which, in turn, increases motor voltage. Is a great deal of motor torque change is anticipated, it may be wise to consider the addition of a speed sensor to the motor.

Tachometer Velocity Mode

The addition of a DC tachometer to the motor shaft produces a voltage proportional to speed. With this addition, the tachometer output voltage replaces the motor terminal voltage as the controlled variable. Since this voltage is proportional to the motor speed, this operating mode truly controls motor speed in a closed loop fashion.

Hall Velocity Mode

The frequency of Hall sensors is proportional to the motor speed. In most brushless amplifier series, an internal circuit decodes velocity information from the motor mounted Hall sensors. This analog signal is available for closed loop velocity control. This mode does not provide good velocity control at low speeds (below 300 rpm for a six-pole motor, 600 rpm for a four-pole motor, or 900 rpm for a two-pole motor) since the resolution of Hall sensor signals is not very high.

Encoder Velocity Mode

The frequency of a motor mounted encoder is proportional to the motor speed. An internal circuit can decode velocity information from such encoder feedback. This analog signal is available for closed loop velocity control. Since the resolution of an encoder is much higher than of Hall effect sensors, much better low speed regulation can be obtained.

Current (Or Torque) Mode

The current mode produces a torque output from the motor proportional to the input reference signal. Motor output torque is proportional to the motor current. Torque mode is recommended if the servo amplifier is used with a digital position controller (under this condition, a movement of the motor shaft from the desired position causes a large correcting torque, or “stiffness”). Therefore, this mode may produce a “runaway” condition if operated without a digital position controller.

Analog Position Loop Mode

In this mode the feedback device is an analog potentiometer mechanically tied to the positioned object, thus providing position feedback. The wiper of the potentiometer is connected to one of the differential input terminals (-REF). The command is an analog signal, which is connected to the other differential input terminal. It is recommended to use a tachometer to close the velocity loop. The input reference gain can be increased for the analog position mode by ordering the –ANP extension. The following figure is a typical wiring diagram example of the analog position mode:

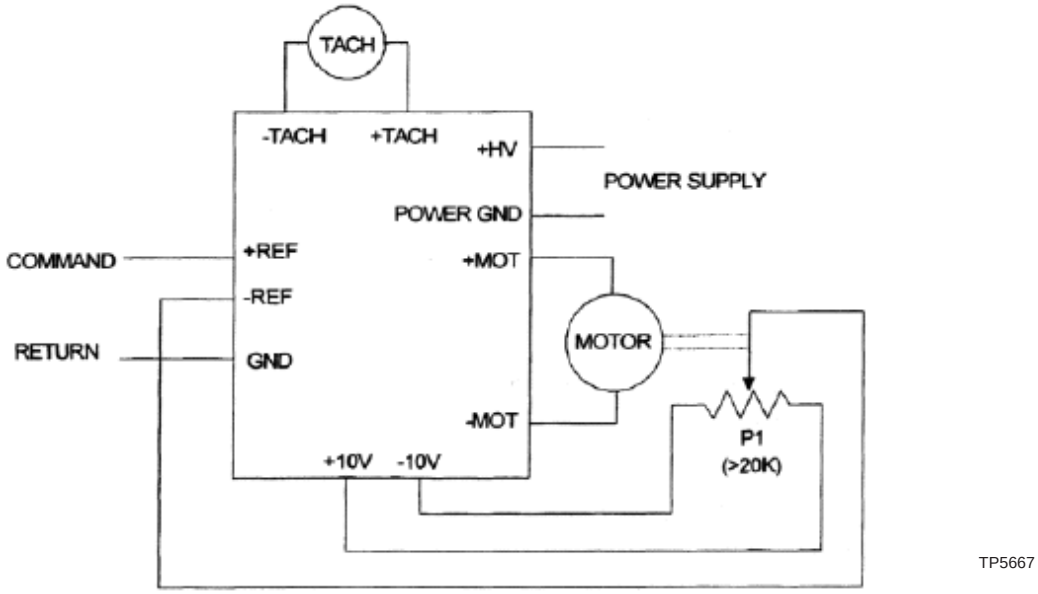


Figure 5.8 - Analog Position Loop Mode

COMPONENT SELECTION

Motor Type

The type of motor used depends on the application characteristics. Brushed DC motors are cost-effective, simple to use and install, and provide high power density. Drawbacks are brush wear and arcing (explosive environments). Brushless motors provide the same advantages as brushed DC motors. The absence of brushes reduces maintenance and allows them to be used in any type of environment. Brushless motors may require more wiring due to the commutation feedback requirements.

Determine motor voltage and current requirements, based on the maximum velocity and torque. Torque and velocity can be derived from the application move profiles. Both maximum torque and RMS (root mean square) torque need to be calculated. Rms torque can be calculated by plotting torque versus time for one move cycle.

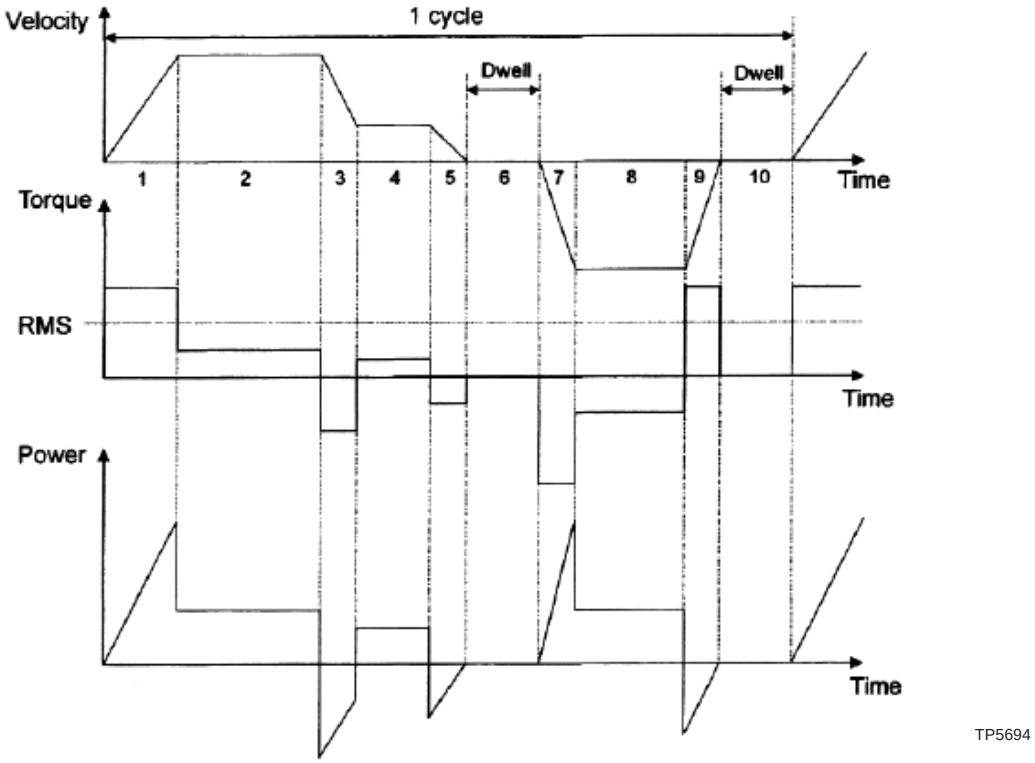


Figure 5.9 - Torque, Velocity and Power Curves

RMS torque is calculated as follows:

Here, T_i is the torque and t_i the time during segment I. In the case of a vertical application, make sure to include the torque required to overcome gravity.

In general, the motor voltage is proportional to the motor speed and the motor current is proportional to the motor shaft torque. Linear motors exhibit the same behavior, except that in their case force is proportional to current. These relationships are described by the following equations:

$V_t = I_m * R_m + E$
$E = K_e * S_m$

$T = K_t * I_m$ for rotary motors or
$F = K_f * I_m$ for linear motors

With:

V_t	Terminal Voltage [V]
I_m	Motor Current [A]
R_m	Motor Winding Resistance [Ω]
E	Back-EMF Voltage [V]
T	Motor Torque [Nm or in/lb]
F	Motor Force [N or lb]
K_t	Motor Torque Constant [Nm/A or in/lb/A]
K_f	Motor Force Constant [N/A or lb/A]
K_e	Voltage Constant [V/Krpm or V/m/s]
S_m	Motor Speed [rpm or m/s]

The motor manufacturer's data sheets contain K_t (or K_f) and K_e constants. Pay special attention to the units used (metric vs. English) and the amplitude specifications (peak-to-peak vs. RMS, phase-to-phase vs. phase-to-neutral).

The maximum motor terminal voltage and current can be calculated from the above equations. For example, a motor with a K_e = 10V/Krpm and required speed of 3000 rpm would require 30V to operate. In this calculation the IR term (voltage drop across motor winding resistance) is disregarded.

Maximum current is maximum torque divided by K_t. For example, a motor with a K_t = 0.5 Nm/A and maximum torque of 5 Nm would require 10 amps of current. Continuous current is RMS torque divided by K_t.

In the above equations, the motor inductance is neglected. In brushless systems, the voltage drop caused by the motor inductance can be significant. This is the case in high-speed applications, if motors with high inductance and high pole count are used. Please use the following equation to determine motor terminal voltage (must be interpreted as a vector):

$V_t = (R_m + j * \omega * L) * I_m + E$

Where:

L	phase-to-phase motor inductance [Henry]
ω	maximum motor current frequency [rad/s]

Amplifier

The amplifier voltage and current ratings are determined from the maximum voltage and the maximum and continuous motor current. It is recommended to select an amplifier with a voltage rating of at least 20% higher than the maximum voltage to allow for regenerative operation and power supply variations. The amplifier peak (and continuous) current rating should exceed the maximum (and continuous) motor current requirements.

Power Supply

It is recommended to select a power supply voltage that is about 10 to 50% higher than the maximum required voltage for the application. This percentage is to account for the variances in K_t, K_e and losses in the system external to the amplifier. The selected margin depends on the system parameter variations. Sometimes a power supply is not available with the required voltage. In these cases it is necessary to choose a higher value. Make sure not to select a supply voltage that could cause a mechanical over-speed in the event of an amplifier malfunction or a runaway condition.

- CAUTION -

Brushed motors may have voltage limitations due to the mechanical commutators. Consult the motor manufacturer's data sheets.

The average DC power supply current is not the same as the motor current. See Figure 5.10 and 5.11.

The power supply current is a pulsed DC current: when the MOSFET switch is on, it equals the motor current; when the MOSFET is off it is zero. Therefore, the power supply current is a function of the PWM duty-cycle and the motor current, meaning 30% duty cycle and 12 amps motor current will result in 4 amps power supply current. 30% duty cycle also means that the average motor voltage is 30% of the DC bus voltage. Power supply power is approximately equal to amplifier output power plus 3 to 5%.

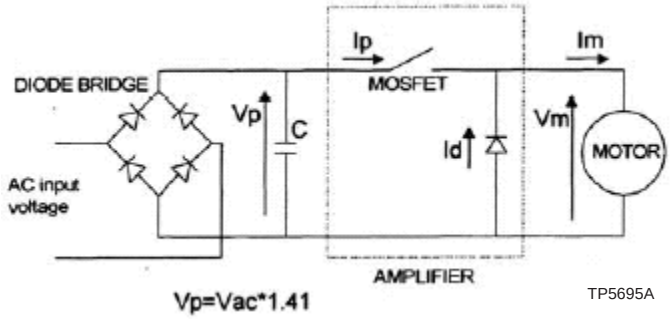


Figure 5.11 - Unregulated Power Supply Current

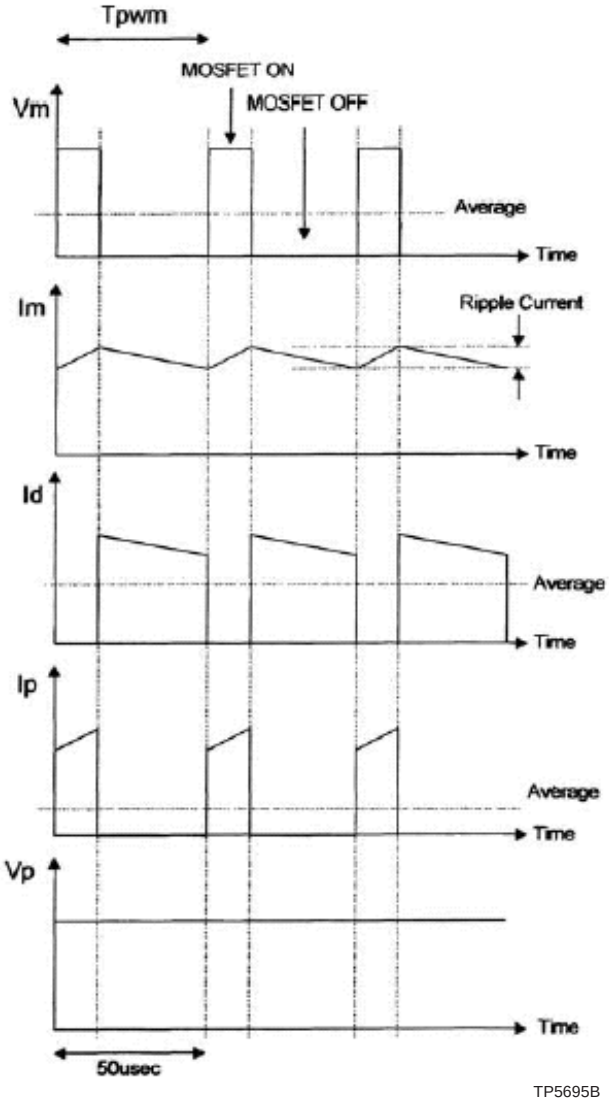


Figure 5.10 - Unregulated Power Supply Current

Regenerative Operation

During braking (deceleration or a downward vertical move), the amplifier returns the system's kinetic and potential energy (motor + load) to the power supply capacitor and in the process can charge the capacitor to potentially dangerous voltages or voltages that may cause an amplifier over-voltage shutdown condition. Consequently, power supplies should have sufficient capacitance to absorb this energy without causing an over-voltage fault. For applications with extremely large inertial loads, use of a "shunt regulator" may be necessary to dissipate the kinetic and potential energy of the load. The shunt regulator is connected to the DC bus to monitor the voltage. When a preset trip voltage is reached, a power resistor R is connected across the DC bus by the shunt regulator circuit to discharge the bus capacitor. The electric energy, stored in the capacitor, is thereby transformed into heat (I^2R).

The kinetic energy of a rotating system is $1/2J\omega^2$ (Joule) where J is the total system inertia (motor + load, kg-m^2) and ω is the motor speed (rad/s). The potential energy is m*g*h, where m is the mass (kg), g is the gravity constant (9.81 m/s^2), and h is the vertical displacement (m). during regeneration this energy will be stored in the power supply's capacitor. The voltage increase caused by this regeneration can be calculated as follows:

At the nominal bus voltage the energy stored in the capacitor is $1/2CV^2$ nom. Regeneration will increase this energy level by $1/2J\omega^2$ + m*g*h. The new bus voltage V can be calculated from this new energy level.

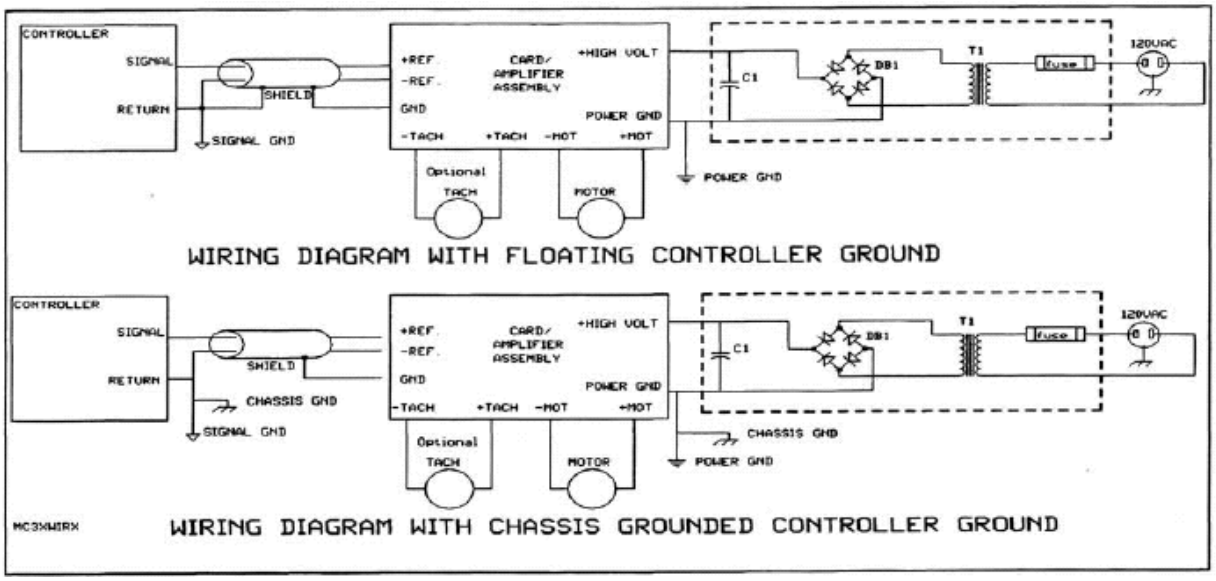
This new bus voltage must be below the power supply capacitance voltage rating and the over-voltage limit. If this is not the case, a shunt regulator is necessary. A shunt regulator is sized in the same way as a motor or amplifier; continuous and RMS power dissipation must be determined. The power dissipation requirements can be calculated from the application move profile (see Figure 5.9).

WIRING INSTRUCTIONS

Typical Wiring Diagrams

the following schematic show typical amplifier wiring configurations:

BRUSH TYPE AMPLIFIER



TP5696

Figure 5.12 - Brush Type Amplifier Typical Schematic

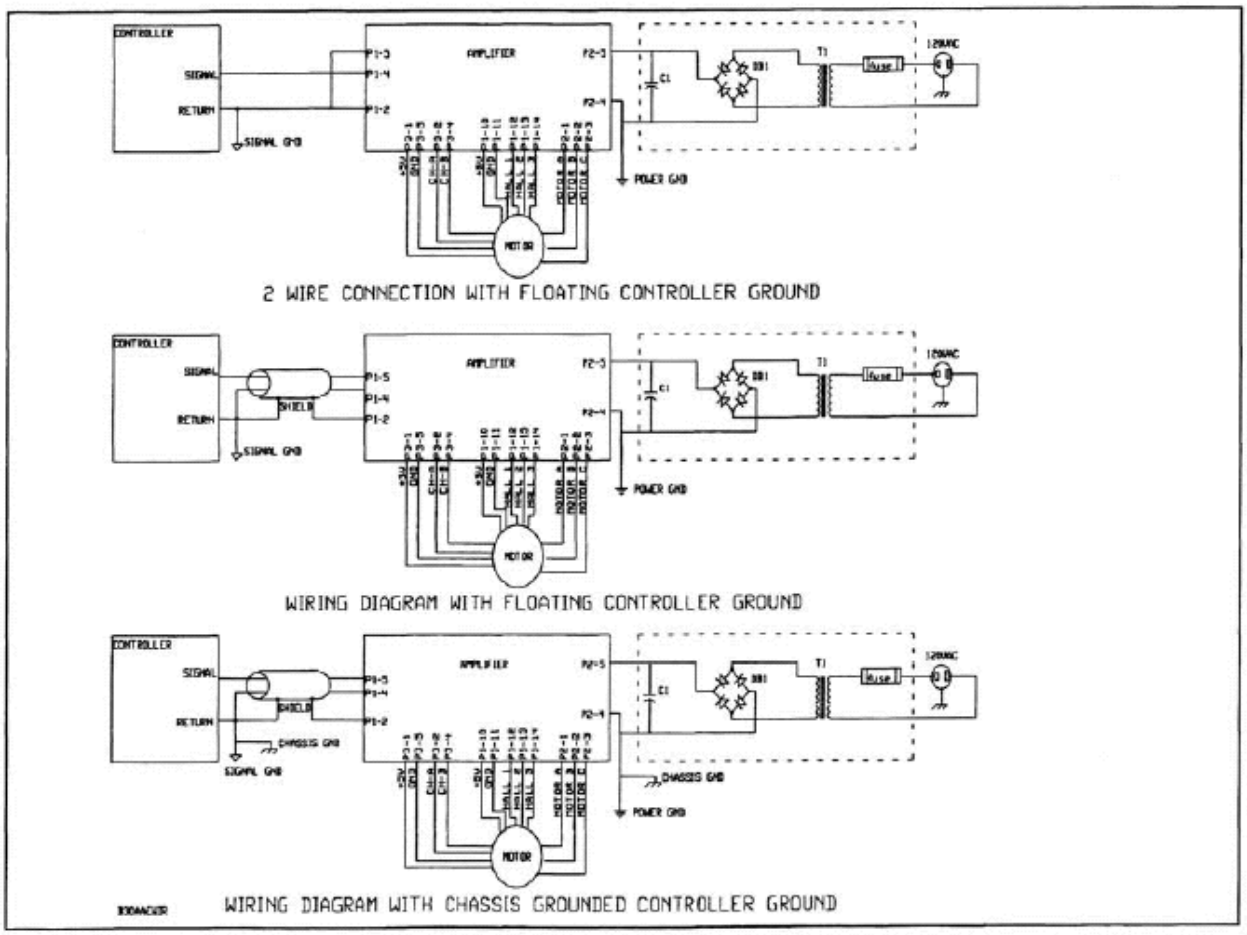
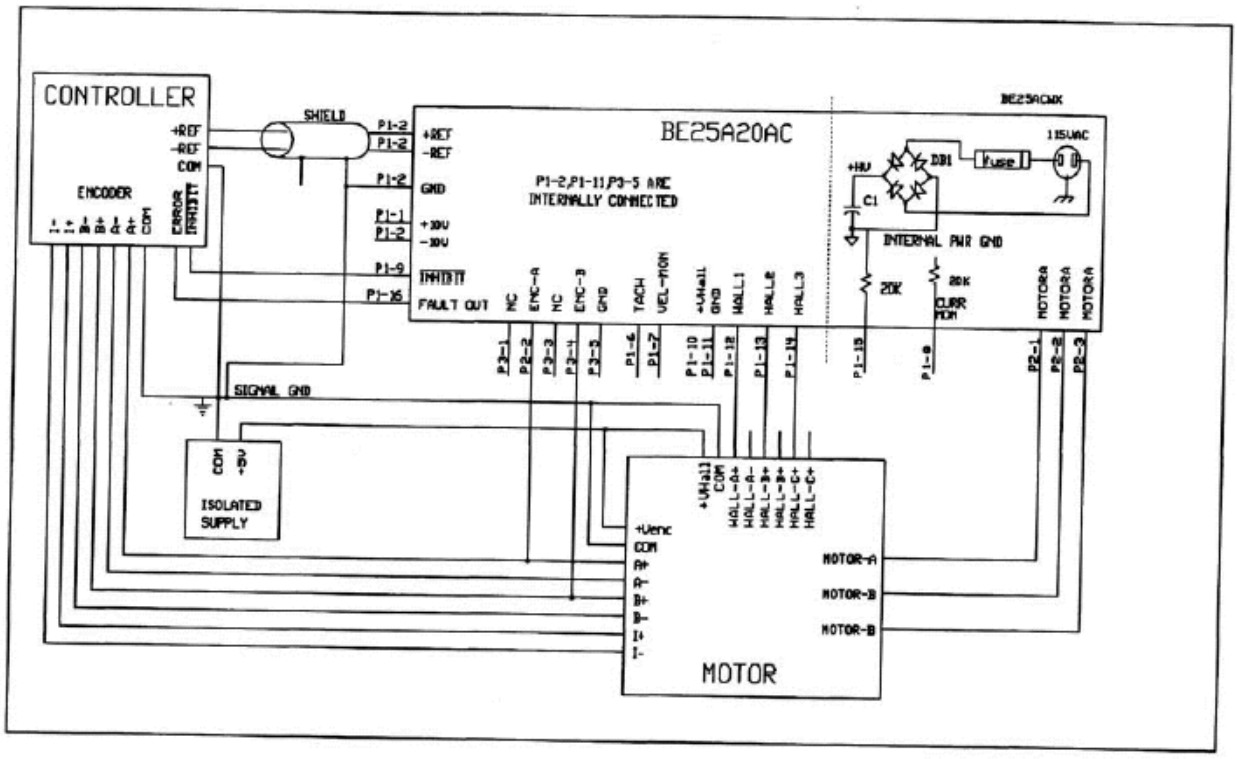


Figure 5.13 - Brushless Amplifier Typical Schematic



TP5698

Figure 5.14 - Brushless Amplifier with Encoder Typical Schematic

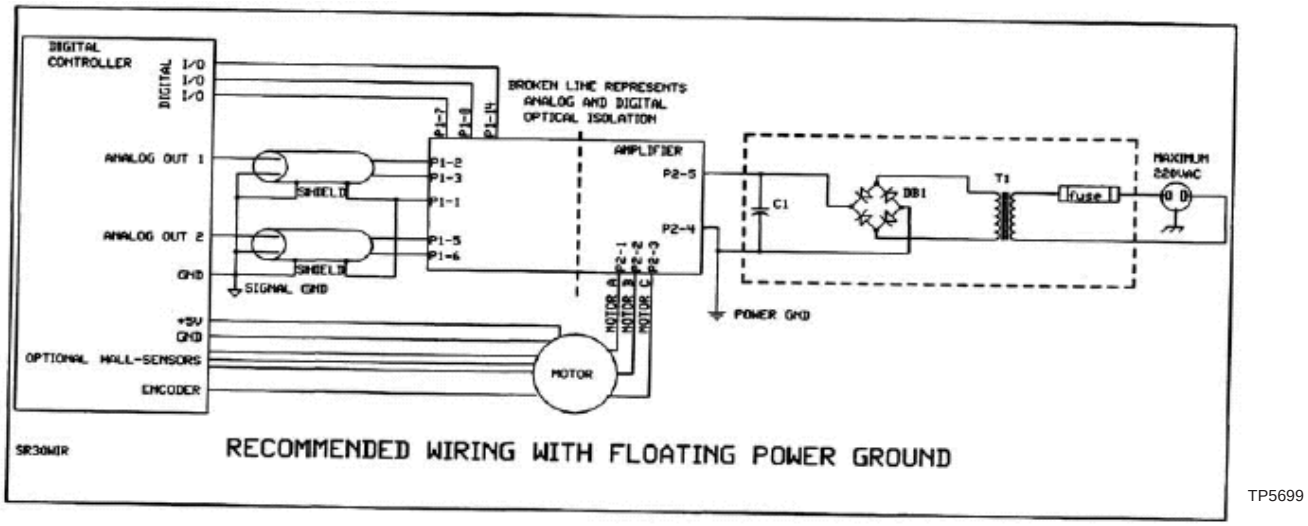


Figure 5.15 - S Series Brushless Amplifier Typical Schematic

Noise Considerations And System Grounding

“Noise” In The Form Of Interfering Signals Can Be Coupled:

Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).

- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.

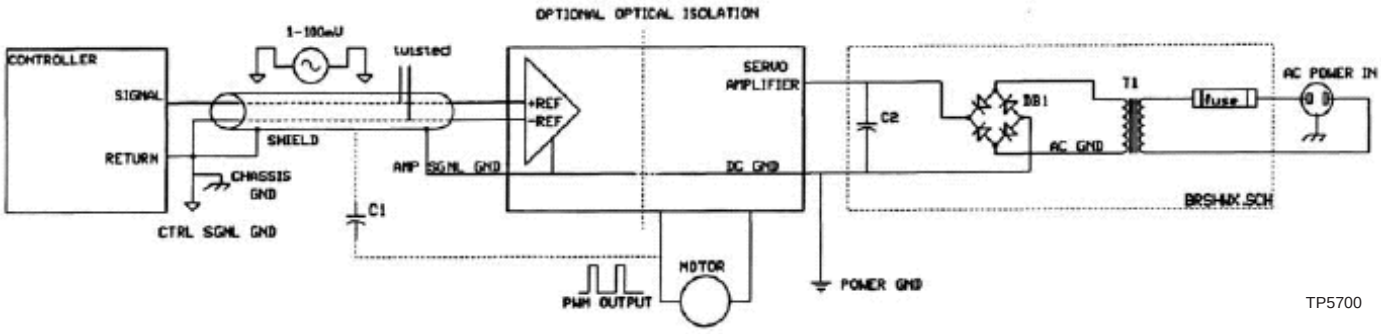


Figure 5.16 - Typical Servo System Wiring Diagram

The preceding wiring diagram shows a typical servo system using an advanced motion controls servo amplifier.

Experience shows that the main source of noise is the high DV/DT of the amplifier’s output power stage. This PWM can couple back to signal lines through straight capacitance “C1” between output and input wires. The best methods are to reduce capacitance between the offending points (move signal and motor leads apart), add shielding and use differential inputs at the amplifier. For extreme cases use of a filter card is recommended (see section E).

Unfortunately low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power supply and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

Aside from overall shielding, the best way to reduce radio frequency coupling is to keep leads short.

The voltage source shown between the amplifier and controller grounds typically consists of some 60Hz voltage, harmonics of the line frequency, some radio-frequency signals, IP drops and other “ground noise”. The differential inputs of the servo amp will ignore the small amount of “ground signal”.

Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OPAMP output. Due to the inductance and capacitance of the wire the OPAMP output can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the amplifier with an oscilloscope to make sure that the signal is noise free.

Servo system wiring typically involves wiring a controller (digital or analog), a servo amplifier, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed.

The signal ground of the controller (CTRL SGNL GND) must be connected to the signal ground of the servo amplifier (AMP SGNL GND) either directly or through chassis ground, to avoid noise pickup due to the “floating” differential servo amplifier input.

It is recommended that the signal and power wires are routed in a separate cable harness.

In most servo systems all the grounds are connected to a single chassis ground (normally the same as earth ground). In the power section there are two grounds, “DC GND” and “AC GND” (see wiring diagram). Either of these grounds can be connected to “CHASSIS GND”. If the system design requires that “AC GND” is connected to “CHASSIS GND” then the servo amp must have internal optical isolation in order to connect “CTRL SGNL GND” or “AMP SGNL GND” to “CHASSIS GND”. This optical isolation is required to avoid a short across the diode-bridge “DB1”, through “DC GND”.

For servo amplifiers without optical isolation, if “DC GND” and “AMP SGNL GND” are connected to “CHASSIS GND” then it is not necessary to connect the signal wire shield to “AMP SGNL GND” because these grounds are then connected through the chassis.

- WARNING -

The grounding design is ultimately the responsibility of the user.

DC Power Supply Wiring

All advanced motion controls servo amplifiers operate from a single polarity unregulated DC power supply. Reservoir capacitance of 2000 μF/ampere of maximum output current will reduce ripple to 4Vp-p at 120 Hz (single phase AC input).

The PWM current spikes generated by the power output stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. If the power supply leads exceed three feet then the amplifier must be bypassed by a capacitor of at least 1000 μF within one foot of the servo amp. Reduce the inductance of the power leads by twisting them.

When multiple amplifiers are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced into the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. Run separate power supply leads to each amplifier directly from the power supply filter capacitor.
2. Use the differential input to the amplifier to avoid common mode noise.
3. Never “daisy-chain” any power or DC common connections. Use a “star” connection instead.

Motor Wiring

Use of a twisted, shielded pair for the motor power cables is recommended. Ground the shields to the amplifier’s chassis ground and to the motor’s frame. The motor power input leads are connected to the amplifier’s output.

- CAUTION -

DO NOT use wire shield to carry motor current or power.

Tachometer Wiring

Use of a twisted, shielded pair for the tachometer wires is recommended. Ground the shield at one end only to the amplifier’s + tach input (tachometer ground).

Input Reference Wiring

Use of a twisted, shielded pair for the input reference wires is recommended. If the reference source can float (remain ungrounded), connect the shield to both the reference source common and the amplifier’s signal ground. It is recommended that the input be connected directly to the amplifier’s differential input (if applicable). Connect the reference source “+” to “+ ref input”, and the reference source “-“ to “- ref input”. If the reference source ground and the amplifier power ground are connected to the master chassis ground, leave the source end of the shield unconnected. The servo’s reference input circuit will attenuate the common mode voltage between signal source and amplifier power grounds. In case of a single ended reference signal, connect the command signal to “+ ref” and connect the command return and “- ref” to the signal ground.

Reference Potentiometer Wiring

An external potentiometer can be used in conjunction with the amplifier's onboard signal voltage (±10V @ 3 mA or ±5 mA @ 3 mA) to supply a command signal to the amplifier. A 50 KΩ potentiometer is recommended. The potentiometer used should not be less than 20 KΩ. This potentiometer should be wired between the +10V (or +5V) and the –10V (-5V) output with the wiper wired to the "+ Ref" or "- Ref" input. The other reference input can remain floating or can be tied to the signal ground. To have a single polarity command source use only the +10V (or +5V) or the –10V (-5V) output and wire the other lead of the potentiometer to the signal ground.

Mating Signal Connectors

The mating connector part number for the 16-pin I/O connector part number 22-12-2164 is:

Molex plastic body: 22-01-3167insert terminals: 08-50-0114

The mating connector part number for the 5-pin I/O encoder connector part number 22-12-2054 is:

Molex plastic body: 22-01-3057insert terminals: 08-50-0114

Standard crimping hand tool part number 11-01-0185

See amplifier data sheets for appropriate D-shell connectors.

CE-EMC Wiring Requirements

Additional installation instructions are necessary for meeting EMC requirements. The instructions are as follows:

GENERAL

1. Shielded cables must be used for all interconnect cables to the amplifier and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.
2. The amplifier's metal enclosure must be grounded to the closest ground point with the least amount of resistance.
3. The amplifier must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable, there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.

ANALOG INPUT AMPLIFIERS

4. A Fair Rite model 0443167251 round suppression core must be fitted to the low-level signal interconnect cables to prevent pickup from external RF fields.

PWM INPUT AMPLIFIERS

5. A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.

MOSFET SWITCHING AMPLIFIERS

6. A Fair Rite model 0443167251 round suppression core must be fitted to the motor cable connector to reduce electromagnetic emissions.
7. An appropriately rated Schaffner 2080 series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply of any MOSFET amplifier system in order to reduce conducted emissions fed back into the supply network.

IGBT SWITCHING AMPLIFIERS

8. An appropriately rated Schaffner 2070 series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply of any IGBT amplifier system in order to reduce conducted emissions fed back into the supply network.
9. A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the motor cable connector to reduce electromagnetic emissions.

FITTING OF AC POWER FILTERS

10. The above mentioned AC power filters should be mounted flat against the enclosure of the product using the two mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal-to-metal contact. The filter should be mounted as close to the point where the AC power enters the enclosure as possible. Also the AC power cable on the load end of the filter should be routed as far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

- NOTE -

The technical construction file number is TCF# J97001250.007 (Rev. 1).

Below is contact information of filter and torroid suppliers:

Schaffner
Schaffner Elektronik AG
CH-4708 Luterbach
Switzerland

Ph: +41-65-802-626
Fax: +41-65-802-641

USA (East Coast)
Ph: 201-379-7778
Fax: 201-379-1151

USA (West Coast)
Ph: 714-457-9400
Fax: 714-457-9510

Fair Rite
P.O. Box J
One Commercial Row
Wallkill, NY 12589

Ph: 914-895-2055
Fax: 914-895-2629

CE-LVD Wiring Requirements

The servo amplifiers covered in the LED reference report were investigated as components intended to be installed in complete systems that meet the requirements of the machinery directive. In order for these units to be acceptable in the end user's equipment, the following conditions of acceptability must be met:

- European approved overload and over-current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.
- A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.
- All amplifiers that do not have a grounding terminal must be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.
- A disconnecting device that will prevent the unexpected startup of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.
- European approved over-current protective devices must be installed in line before the amplifier. These devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over-current protection rating value as low as possible, but taking into consideration inrush currents). Amplifiers that incorporate their own primary fuses do not need to incorporate over-current protection in the end user's equipment.

These items should be included in your declaration of incorporation as well as the name and address of your company, description of the equipment, a statement that the amplifiers must not be put into service until the machinery into which they are incorporated has been declared in conformity with the provisions of the machinery directive, and identification of the person signing.

CAUTIONARY NOTES

- CAUTION -

DO NOT reverse the power supply leads. Severe damage will result.

- CAUTION -

Use sufficient capacitance.

Pulse width modulation (PWM) amplifiers require a capacitor on the high voltage supply to store energy during the PWM switching process. Therefore, a 1000 μF capacitor is needed within one foot of wire length, in parallel with the high voltage supply of the amplifier module.

Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the amplifier's over-voltage shutdown point, output current and braking will cease. At that time, energy stored in the motor inductance continues to flow through diodes in the amplifier to further charge the power supply capacitor. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

A two mH motor at 20 amperes can charge a 2000 μF capacitor an additional 30VDC. An appropriate capacitance is typically 2000 μF/A maximum output current for a 50V supply.

For battery supplied bus voltages, contact factory for capacitance requirements.

- CAUTION -

Make sure minimum inductance requirements are met!

Pulse width modulation (PWM) servo amplifiers deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different amplifier types are shown in the individual data sheet specifications. If the amplifier is operated below maximum rated voltage, the minimum load inductance requirement may be induced. Most servo motors have enough winding inductance. Some types of motors do not have a conventional iron core rotor, so the winding inductance is usually less than 50 μH.

If the motor inductance value is less than the minimum required for the selected amplifier, use of an external filter card is necessary (see Section F).

- CAUTION -

DO NOT rotate the motor shaft without power supplied to the amplifier!

The motor acts as a generator and will charge up the power supply capacitors through the amplifier. Excessive speeds may cause over-voltage breakdown in the output power devices. Note that an amplifier having an internal power converter that operates from the high voltage supply will become operative.

- CAUTION -

DO NOT short the motor leads at high motor speed.

When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the amplifier peak current. The short itself should not damage the amplifier but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the amplifier (due to stored energy in the motor inductance) and may damage the amplifier.

SETUP INSTRUCTIONS

- CAUTION -

DO NOT install the amplifier without first determining that all chassis power has been removed for at least 10 seconds. Never remove an amplifier from an installation with power applied.

- CAUTION -

To ensure reliable operation, the wiring and cautionary notes must be reviewed prior to setup.

Brush-Type Setup Instructions

Advanced Motion Controls amplifiers are designed to operate in a self-test mode, using the “offset” potentiometer to control an onboard signal source.

This test can be used to confirm that the amplifier is functionally operational. Read the setup instructions before applying power:

1. Review cautionary notes and wiring section before proceeding.
2. It is recommended to reduce the amplifier output current to avoid motor overheating during the setup procedure.
3. Connect power. Do not connect the motor yet!
4. Check that the LED indicates normal operation (green).
5. Set mode according to data sheet for voltage mode.
6. Set offset/test switch ON. Measure the voltage across motor output with a DC voltmeter, turn the “test” potentiometer. Voltage should vary between +/- bus voltage. Set the output voltage with the “test” potentiometer to a low value before connecting the motor leads.
7. Set current limit according to motor specifications. See amplifier data sheets for current limiting options.
8. Verify that the load circuit meets minimum inductance requirements and that the power supply voltage does not exceed amplifier rated voltage or 150% of the nominal motor voltage.
9. Turn the power off. Connect the motor. Turn the power back on. “tweak” the “test” potentiometer to change motor speed in both directions. Set the offset/test switch to OFF.
10. Ground both reference inputs and then using the offset pot, set motor for zero speed.
11. Set mode suitable for your application.

Brushless Amplifier Setup Instructions

TRAPEZOIDAL AMPLIFIERS

Read the setup instructions before applying power:

1. Review cautionary notes and wiring instructions prior to setup.
2. It is recommended to reduce the amplifier output current to avoid the motor overheating during the setup procedure.
3. According to mode selection table, select “open-loop mode” and set offset/test switch to ON.
4. Set current limit according to the motor specifications. See amplifier data sheets for current limiting options.
5. Check power and connect it to the amplifier. Do not connect motor lead wires.
6. Set 60/120° phase switch. Connect Hall sensor inputs. LED should be green. Manually turn motor shaft one revolution. Led should remain green. If LED turns red or changes color:
   a. Check 60/120° phase switch setting.
   b. Check power for Hall sensors.
   c. Check voltage levels of Hall inputs (see commutation sequence table below).
   d. Using 60° phasing, interchange Hall 1 and Hall 2.
7. Remove power. Connect the 3 motor wires. There are 6 ways to connect the 3 wires to the Motor-A, Motor-B, and Motor-C pins. Try all 6 combinations (remove power prior to changing connection) and choose the best one. The motor should operate and reverse smoothly in both directions. If the motor runs slower in one direction or if you have to move the shaft to start the motor, the combination is incorrect. The speed should be approximately the same in both directions if the combination is correct. Motor speed can be verified by using the velocity monitor or by measuring the frequency of the Hall sensors or the encoder. See below for velocity calculation equations.
8. To verify smooth operation, turn test/offset pot with test/offset switch in ON position. Set offset/test switch OFF, ground both reference inputs and then adjust offset/test potentiometer for zero speed.

9. Select mode suitable for your application.

COMMUTATION SEQUENCE TABLE

60 DEGREE			120 DEGREE			MOTOR		
HALL 1	**HALL 2**	**HALL 3**	**HALL 1**	**HALL 2**	**HALL 3**	**HALL 1**	**HALL 2**	**HALL 3**
1	0	0	1	0	0	H	X	L
1	1	0	1	1	0	X	H	L
1	1	1	0	1	0	L	H	X
0	1	1	0	1	1	L	X	H
0	0	1	0	0	1	X	L	H
0	0	0	1	0	1	H	L	X
1	0	1	1	1	1	X	X	X
0	1	0	0	0	0	X	X	X

1 High Level Hall Sensor Input
0 Low Level Hall Sensor Input
H High Or Switching Motor Input
L Low Motor Output
X Motor Output Is Off (Floating)

To change direction, interchange Hall 1 and Hall 3, then Motor A and Motor B.

Calculating motor speed:

Hall sensor cycle / Mechanical revolution = Poles/2
Motor-speed [RPM] = Hall sensor frequency [Hz]* 60 / (Poles/2)
Motor-speed [RPM] = Velocity monitor [V]* Scale factor [Hz/V]*60 / (Poles/2)
Motor-speed [RPM] = Encoder frequency [Hz]* 60 / (Encoder resolution)
Motor-speed [RPM] = Velocity monitor [V]* Scale factor [Hz/V]*60 / (Encoder resolution)

- NOTE -

Read the setup instructions before applying power.

1. Review cautionary notes and wiring instructions prior to setup.
2. According to mode selection table, select current mode and set offset/test switch to ON.
3. Set current limit to 10% of motor current to avoid high speeds. See amplifier data sheets for current limiting options.
4. Check power and connect it to the amplifier. Do not connect motor leads.
5. Set 60/120° phase switch. Connect Hall sensor inputs (the encoder can be connected as well without affecting correct setup). The LED should be green. Turn the motor shaft manually one revolution. The LED should remain green. If the LED turns red or changes color:
   a. Check 60/120° phase switch setting.
   b. Check power for Hall sensors.
   c. Check voltage levels of Hall inputs (see commutation sequence table below).
   d. Using 60° phasing, interchange Hall 1 and Hall 2.
6. Remove power. Connect the three motor wires. There are 6 ways to connect the three wires to the Motor A, Motor B, and Motor C pins. Try all 6 combinations (remove power prior to changing connection) and choose the best one. The motor should operate and reverse smoothly in both directions. If the motor runs slower in one direction, or if you have to move the shaft to start the motor, the combination is incorrect. The speed should be approximately the same in both directions if the combination is correct. Motor speed can be verified by using the velocity monitor or by measuring the frequency of the Hall sensors or the encoder. See above for velocity calculation equations.
7. When the Hall sensor phasing is correct the amplifier will automatically switch to sinusoidal commutation. This can be verified by monitoring the “phase” output.
8. To verify smooth operation, turn test/offset pot with test/offset switch in ON position. Set the offset/test switch to OFF, and then adjust offset/test potentiometer for zero speed.
9. Select mode suitable for your application.

Brushless Amplifier With Brush-Type Motor (Trapezoidal Only)

To drive a brush-type motor, disconnect all Hall sensor inputs, set phase setting switch to 60°, and use the Motor A and Motor B terminals. See Brush-Type Setup Instructions, Page 5-32. Follow instructions except for Step No. 5; configure the amplifier for open-loop mode instead of voltage mode.

AMPLIFIER ADJUSTMENT (TUNING) PROCEDURE

Command Signal

The command signal is a reference voltage which is applied to the amplifier to control the motor direction and speed. Depending on the amplifier mode, the command signal controls current, voltage or speed.

Feedback Elements

The feedback element can be any device capable of generating a voltage signal proportional to velocity, position or any parameter of interest. Such signals can be provided directly by a tachometer or potentiometer or indirectly by other feedback devices such as resolvers, Hall sensors or encoders. These latter devices must have their signals converted to a DC voltage by an external converting circuit or by the amplifier.

The feedback element must be connected for negative feedback. This negative feedback will cause a difference between the command signal and the feedback signal. This difference is called the error signal. The amplifier compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero.

Initial Power-On Test

- CAUTION -

These initial adjustments should be performed with the motor uncoupled from its mechanical load.

With a zero speed command applied, momentarily apply power to the amplifier. If upon application of power the motor rapidly accelerates, a runaway condition exists due most likely to polarity reversal of either the motor or the feedback element. If the motor and feedback elements are properly connected, and the amplifier is functioning normally, the motor shaft will remain stationary or drift slightly in either direction with power supplied. If the motor does not run away, but emits a high-pitched squeal, turn loop-gain potentiometer counter-clockwise until squeal stops.

Potentiometer Adjustments

OFFSET ADJUSTMENT

Before offset adjustment is made, reference inputs must be grounded or commanded to 0 volts. Put the test/offset switch in the OFF position (offset mode), and trim the “offset” potentiometer for minimum amplifier output current by observing motor drift. Offset adjustment is complete.

LOOP GAIN ADJUSTMENT

This potentiometer adjusts the gain in the forward portion of the closed loop (velocity or voltage mode). Starting from the counterclockwise position, turn clockwise until motor shaft oscillates. Then back off one turn.

- NOTE -

This potentiometer should be set completely counterclockwise in current mode. Use the reference gain potentiometer for scaling.

REFERENCE GAIN ADJUSTMENT

This potentiometer adjusts the ratio between the input signal and the output variable (voltage, current, or velocity). Turn this potentiometer clockwise until the required output is obtained for a given input signal.

CURRENT LIMIT ADJUSTMENTS

It is critical to set the current limit such that the instantaneous motor current does not exceed the specified motor peak current rating. Should this occur, the motor permanent magnets may be de-magnetized. This would reduce both torque constant and torque rating of the motor and seriously affect system performance.

Most Advanced Motion Controls servo amplifiers feature peak and continuous current limit adjustments. The maximum peak current is needed for fast acceleration and deceleration. Most amplifiers are capable of supplying the maximum peak current for two seconds and then the current limit is reduced gradually to the continuous value. The purpose of this is to protect the motor in stalled condition by reducing the current limit to the maximum continuous value. Current limiting is implemented in the amplifier by reducing the output voltage.

The current limit adjustment potentiometer (50kΩ) has 12 active turns plus 1 inactive turn at each end and is approximately linear. Thus, to adjust the current limit, turn the potentiometer counterclockwise to zero (using ohmmeter between appropriate ground and potentiometer wiper, see amplifier block diagram), then turn clockwise to the appropriate value. If the peak current reference does not reach the set peak limit, the time for peak current will be longer than 2 seconds. The actual time will be a function of RMS current.

A selection of amplifiers feature separate peak and continuous current adjustments. This can be achieved by connecting an external resistor between the continuous current limiting pin and the signal ground. In addition, many amplifiers have the option of current limiting using the dip switches. If this is an option, it will be indicated in the switch function section of the particular amplifier.

Compensation Adjustments

Servo system performance can be judged by the following three characteristics:

- Stability
- Accuracy
- Responsiveness without overshoot

Using advanced motion controls servo amplifiers provides a short and straightforward process to meet all three of these criteria. The process involves obtaining a stable servo using the compensation adjustment while optimizing the response of the system.

For this purpose, it is necessary to be able to feed a small step at the reference input, and observe the appropriate feedback signal on an oscilloscope. Set the compensation adjustment to obtain a properly compensated response. This will be the fastest response without overshoot. If the system is undercompensated (slow response without overshoot), turn the compensation potentiometer clockwise. If the system is overcompensated (overshoot and oscillation), turn the compensation potentiometer counterclockwise.

Practical hints about loop compensation:

- NOTE -

In most velocity control applications, the compensation can be adjusted by rotating potentiometer Pot 1 (loop gain) clockwise until the motor oscillates audibly and then backing off until it stops. This simple procedure also applies to voltage mode.

Except for model 10A8, all Advanced Motion Controls amplifiers feature optional user installed through-hole components for custom compensation. These components can be used to implement custom compensation. For most applications the standard built-in compensation is satisfactory. The amplifier block diagrams show the built-in SMT component values for every user installed through-hole component. These built-in SMT components can be removed easily by a regular fine tip soldering iron by heating up both sides of the component alternatively, then gently lifting the component.

- NOTE -

Contact factory for custom compensation application help.

CURRENT LOOP (INTERNAL)

The current loop gain resistor determines the current loop response. A larger resistor value results in a faster response. Typically the 10k setting is recommended for load inductors less than 3 mH and the 100k setting is recommended for a load inductance of more than 3 mH. This may be accomplished by either switching in the extra resistor with the dip switch or installing a through-hole resistor. For load inductor values higher than 5 mH a 200k or larger through-hole resistor value can be installed for faster response. If the resistor value is too high for the inductance then overshoot or oscillation occurs in the current loop. A through-hole capacitor can be added to the current loop to increase the capacitance if the system is oscillatory. This should not be done to counter the effects of choosing a resistance value in the current loop that is too high for the inductance.

VOLTAGE LOOP

Compensating the voltage loop requires the least amount of effort. Turn Pot 1 clockwise and backoff if oscillation occurs.

VELOCITY LOOP

The velocity loop response is determined by the loop gain potentiometer P1. A larger resistor value (CW) results in a faster response. The velocity integrator capacitor can be used to compensate for large load inertia. Large load inertias require larger capacitor values. This may be accomplished by either switching in the extra capacitor with the dip switch or installing a through-hole capacitor. The need for an extra capacitor can be verified by shorting out the velocity integrator capacitor with the dip switch. If the velocity loop is stable with the capacitor shorted out and unstable with the capacitor in the circuit then a larger capacitor value is needed.

IR FEEDBACK

Start with a very high (or open) IR feedback resistor with an unloaded motor shaft. Command a low motor speed (about 20-200 RPM). Without the IR feedback the motor shaft can be stalled easily. Decreasing the IR feedback resistor will make the motor shaft more difficult to stop. Too much IR feedback will cause motor runaway when torque is applied to the motor shaft.

ANALOG POSITION LOOP

Use of a tachometer is recommended to obtain a responsive position loop because the position loop is closed around the velocity loop. First, the velocity loop must be stabilized (or voltage loop for undemanding applications). The position loop gain is determined by the fixed gain of the input differential amplifier of the servo amplifier. For best results the servo amplifier can be ordered with a higher differential amplifier gain. Extension ANP must be specified (example: 25A8-ANP).

Test Points For Potentiometers

After the potentiometer adjustments in the compensation section are complete, the resistance values can be measured for future adjustments or duplication on other amplifiers. Test points for the potentiometer wipers are provided and are located under all four potentiometers. Make sure the power is off, then measure the resistance between the test point and the outer leg of the potentiometer or between the test point and an appropriate ground. See the amplifier's functional block diagram to determine which ground should be used for each potentiometer. The potentiometers are all approximately 50k. Resistance measurements are only to be used to duplicate amplifier settings since some potentiometers have other resistors in series or parallel.

INVERTED INHIBIT INPUTS

Inputs INH and +/-INH can be inverted by removing “J1” jumper (0 ohm SMT resistor marked on PCB). Removing J1 jumper requires that all inhibit lines be brought to ground to enable amplifier. Most amplifiers except the 10A8 can be ordered with this option. Part number example would be B30A8X-IN. IN stands for inverted inhibit inputs. Some amplifiers such as the B30A40 have a dip switch to invert the inhibits. This option will be listed on the amplifier data sheets if it is available.

TROUBLESHOOTING/FAULT CONDITIONS

A red LED can indicate any of the following fault conditions: over-temperature, over-voltage, under-voltage, short-circuits, invalid communication, status and power on reset. All fault conditions are self-reset by the amplifier. Once the fault condition is removed the amplifier will become operative again without cycling power. Please see amplifier data sheets for protection features included.

HEAT-SINK TEMPERATURE

Verify that the heat-sink temperature is less than 65°C. If this temperature is exceeded the amplifier will remain disabled until the temperature at the base plate falls below 65°C.

OVER-VOLTAGE SHUTDOWN

1. Check the power supply voltage for a value in excess of those listed in the data sheets. If a larger than listed value is observed, check the AC power line connected to the power supply for proper value.
2. Check the regenerative energy absorbed during deceleration. This is done with a voltmeter or a scope monitor of the amplifier bus voltage. If the bus voltage increases above specified values, additional bus capacitance is necessary. Additional capacitors must be of the electrolytic type and located within a one foot lead distance from the amplifier. See also regenerative operation section.

UNDER-VOLTAGE SHUTDOWN

Verify power supply voltages for minimum conditions per specifications. Also note that the amplifier will pull the power supply voltage down if the power supply cannot provide the required current for the amplifier. This could result in a flickering LED when high current is demanded and the power supply is pulled below the minimum operating voltage required by the amplifier.

SHORT CIRCUIT FAULT

1. Check each motor lead for shorts with respect to motor housing and power ground. If the motor is shorted, it will not rotate freely when no power is applied while it is uncoupled from the load.
2. Measure motor armature resistance between motor leads with the amplifier disconnected.

INVALID HALL SENSOR STATE (BRUSHLESS AMPLIFIERS ONLY)

See the “commutation sequence” table for valid commutation states. If the LED is red or if it is changing between red and green as the shaft rotates, check the following:

1. Make sure that the 60° or 120° phasing switch is in the correct position per motor data sheets. When driving a brush-type motor with a brushless amplifier, use the 60° phase setting.
2. Check the voltage levels for all the Hall sensor inputs.
3. Make sure all Hall lines are connected properly.

STATUS

Check all inhibit inputs for correct polarity (pull to ground to inhibit or pull to ground to enable). Inhibit configuration depends on whether J1 is installed or on the position of the inhibit/enable switch if this is a feature on the particular drive you are using. Please note that the master inhibit will cause a red LED but the plus and minus inhibits (+INH and -INH) featured on some amplifiers will disable the amplifier in the plus or minus direction without causing a red LED. Also, keep in mind that noise on the inhibit lines could be a cause for false inhibit signals being given to the amplifier.

POWER-ON RESET

All amplifiers will have a brief licker of a red LED during power-up. This is the power-on reset and is built into the amplifier to ensure that all circuitry on the board is functional prior to enabling the amplifier.

OVERLOAD

Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the amplifier and thus it might cause the short circuit fault to trip. Excessive heating of the amplifier and motor is also characteristic of the minimum inductance requirement not being met. See amplifier data sheets for minimum inductance requirements.

OVER-CURRENT

All Advanced Motion Controls amplifiers incorporate a “fold-back” circuit that protects them against over-current (except for PWM and sinusoidal input amplifiers, which have different protection features). This “fold-back” circuit uses an approximate “I^2t” algorithm to protect the amplifier. All amplifiers can run at peak current for a maximum of 1 second (each direction). Currents below this peak current but above the continuous current can be sustained during a time period of approximately $(\text{peak current}/\text{current})^2$ seconds. If such a current is commanded for a longer time period, the amplifier will automatically fold back to the continuous current. An over-current condition will not cause the LED to be red.

- CAUTION -

Sustained maximum current demand, when switching between positive and negative maximum current without fold-back, will result in amplifier damage. Amplifier RMS current should be below the continuous current setting.

Causes of Erratic Operation

- Improper grounding (amplifier signal ground is not connected to source signal ground).
- Noisy command signal. Check for system ground loops.
- Mechanical backlash, dead-band, slippage, etc.
- Excessive tachometer noise.
- Noisy inhibit input lines.
- Excessive voltage spikes on bus.

PRODUCT LABEL DESCRIPTION

The following is a typical example of a product label as it is found on the amplifier:

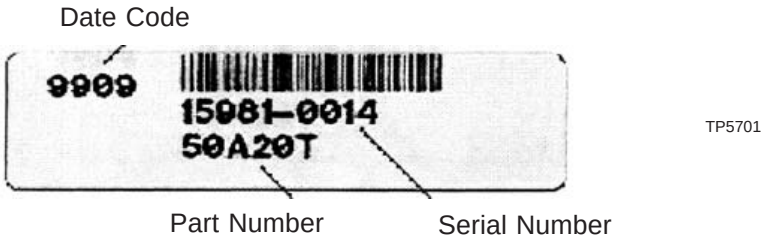


Figure 5.17 - Typical Product Label

DATE CODE

The date code is a 4-digit number signifying the year and week that the amplifier was built. The first two digits designate the year and the second tow digits designate the week.

SERIAL NUMBER

The serial number is a 5-digit number followed by a 4-digit number. Some of the older amplifiers have a 6-digit serial number.

PART NUMBER

Refer to the amplifier data sheets for typical part numbers. The last letter refers to the revision (in the above example it is T). The part number can be proceeded by an X, which means the amplifier is a prototype unit. The part number can also have a suffix which designates a special version of the standard amplifier.

FACTORY HELP

Fax service: (805)389-1165
E-mail: techsupport@a-m-c.com

For aid in troubleshooting with amplifier setup or operating problems please gather the following information and fax or e-mail directly to Advanced Motion Controls:

- DC bus voltage and range
- Motor type, including inductance, torque constant, and wiring resistance
- Position of all dip switches
- Position of all potentiometers
- Length and make-up of all wiring and cables
- If brushless, include Hall sensor information
- Type of controller, plus full description of feedback devices
- Description of problem (instability, runaway, noise, over/undershoot)
- Complete part number and serial number of Advanced Motion Controls product (original purchase order is helpful, but not necessary)

WARRANTY

- NOTE -

All returns (warranty or non-warranty) require that the customer first obtain an RMA number from the factory.

RMA number requests may be made by telephone at (805) 389-1935 or by fax at (805) 389-1165.

Advanced Motion Controls warrants its products to be free from defects in workmanship and materials under normal use and is limited to replacing or repairing at its factory any of its products which within one year after shipment are returned to the factory of origin, transportation charges prepaid, and which are determined to be defective. This warranty supercedes all other warranties, expressed or implied, including any implied warranty or fitness for a particular purpose, and all other obligations or liabilities on Advanced Motion Controls' part and it neither assumes nor authorizes any other person to assume for the seller any other liabilities in connection with the sale of the said articles.

The original warranty period is not extended by the above-mentioned provisions for any replaced or repaired articles. This warranty shall not apply to any of advanced motion controls' products that have been subjected to misuse, negligence, accident, or modification by the user.

- NOTES -

CHAPTER 6 - PREVENTIVE MAINTENANCE

INTRODUCTION

This chapter is written for operators or designated customer representatives. The operator must know how to operate the machine, monitor the levels of pneumatic oil, lubricating oil and coolant reservoirs, and recognize problems that require Dealer or Field Service maintenance. Most operator tasks deal with the external machine; however, the operator should be able to locate the overload heater reset in the Power Equipment Enclosure if necessary.

The operator is not authorized to make adjustments or replace components.

OVERVIEW

Maintenance procedures required for proper upkeep of the machine are included in the following pages. The charts in this section are geared to two types of operating conditions. Follow the chart that applies to your operating conditions. Section 7.4 explains each procedure in detail.

OPERATING CONDITIONS ARE DEFINED AS:

REGULAR SHIFT

The machine is used eight hours a day, five days a week.

MULTIPLE SHIFT

The machine is used in a three-shift operation, five or more days a week.

A third operating condition is DRY CUTTING. In this case, the machine is used to cut materials such as cast iron, magnesium or carbon that produce unusually large amounts of dust in the air. This cutting could take place in either Regular or Multiple Shift conditions. This is considered to be a Hostile environment which requires more than the average amount of care.

- CAUTION -

If the workpiece is cut dry, you must take extraordinary precautions, both while cutting and in cleanup to prevent dust and contaminated air from entering the system. Follow the maintenance procedures recommended for your shift conditions. In addition, use the following guidelines:

- Check the cooling system for proper operation. The air inlet should be filtered. This filtering system is not standard equipment supplied by the machine manufacturer and must be constructed by the machine owner.
- Use an industrial vacuum cleaner and clean the exterior of the machine frequently. Do not use compressed air hoses to clean the machines.
- Use specially designed vacuum systems at the cutting tool.
- Use electrostatic filters if clean air cannot be directed to the head or the control cabinet inlets.

EQUIPMENT AND SUPPLIES

You will need the following items in order to conduct a satisfactory maintenance check on your machine:

- Dry rags or paper cleaning cloths.
- Brush to sweep chips from the tables and ways.
- Industrial vacuum cleaner.
- Mobil DTE 24 or DTE light oil (for pneumatic system filter regulator)
- Coolant fluid. The recommendation is for Trim Sol or comparable antibacterial emulsified cutting oil.
- Lubricant for the way lubrication system. The following way lubricants are approved for use in this system:
  - Gulfway 68
  - Sunoco Way Lubricant 1180
  - Mobil Vactra Oil No. 2
  - Way Lubricant 68 (Texaco)
  - Tonna 68 (Shell)

MAINTENANCE PROCEDURES

1. Check lube system oil level; fill if necessary. The most convenient course of action is to keep the level of oil to the top of the tank. Check it every day. If the reservoir is allowed to empty, a liquid level switch at its base will not allow the spindle to start.
2. Clear dirt and chips from the ways at the end of the day. Use a brush and/or an industrial wet or dry vacuum cleaner, then wipe carefully to remove damage-causing abrasive material.

- WARNING -

DO NOT use compressed air to clean the ways or around the cabinets. Using compressed air could blow chips and other foreign material into the interlocking parts, control system, or at the operator, resulting in extensive damage or serious personal injury.

3. Clean machine exterior; clear intakes and exhausts. Clear dirt and chips from machine at the end of the day Use an industrial wet or dry vacuum cleaner, then wipe carefully to remove damage-causing abrasive material. Do not use compressed air to clean the machine.

- NOTE -

Check the air intakes and exhausts; clear any obstructions. Foreign materials in these areas can cause damage to the machine by entering the Control Power Enclosures.

4. Clean and apply a light coat of oil to the way covers once a week to keep them pliable.
5. Check coolant level; fill if necessary.
6. Check the Flood Coolant. Keep hose joint areas free of chips and dirt. The coolant will come out of the nozzle in spurts when the level is too low. Fill with Trim Sol or comparable antibacterial emulsified cutting oil.
7. Check the Mist Coolant. Wipe off excess grime from the top of the coolant reservoir periodically. It is recommended that the Mist Coolant be filled only with the amount to be used in one operation.

- NOTE -

If mist coolant is used on this or on nearby machines, it will be necessary to change the filter frequently.

8. Clean the air filters. Replace the air filters when you can no longer see light through them. Dirty shop air can cause damage to the control system if not filtered properly.

- NOTE -

Keep the air filters clean to help prevent problems. Watch the air filters for the first few months of operation in order to get an idea of how often they should be replaced.

The time between filter changes cannot be predicted because it depends on many things, including the hours of operation per day and the nature of materials being machined in the vicinity.

9. Check pneumatic regulator system bowls; fill lubricator bowl if necessary. When the level drops below the EMPTY line, fill to FULL with Mobil DTE 24 or direct equivalent.

   A. Shut off the air pressure.

   B. Remove the screw from the fill hole at the left rear of the lubricator.

   C. Fill the bowl to the FULL line. Do not overfill.

   D. Replace the fill hole screw.

10. Drain and clear refill pneumatic regulator bowls. The bowl should be drained whenever it fills up with sludge. The bowls should be cleaned semiannually.

    To drain, clean and refill the bowls:

    A. Put a dry rag under the regulator to catch the drips.

    B. Drain the filter bowl by pressing up on the drain valve.

    C. Drain the filter bowl.

    D. Gently unscrew both bowls.

    E. Rinse them with WARM WATER only.

- WARNING -

DO NOT use soap. Use only warm water to clean the filter bowls. Using soap, solvent, or chemicals may weaken the bowl and cause it to burst, resulting in serious personal injury.

    F. Replace the bowls. Fill the lubricator with Mobil DTE 24 or direct equivalent. (Refer to step 9 for proper procedure.)

11. Check the spindle motor for dirt; wipe if necessary. The spindle motor can become overheated if excessive grease and dirt are allowed to build up on it.

    A. Remove spindle motor hood.

    B. Inspect the motor for dirt.

    C. Wipe the motor with a rag and remove as much of the build-up as possible.

    D. Replace the hood.

12. Check spindle drive belt for dirt and wear. Notify Dealer Service to replace it if necessary. If the housing itself is excessively dirty, the belt may be worn or weak.

    A. Remove the spindle drive belt cover.

    B. Inspect the belt for wear, cracks, or damage.

    C. If the belt looks worn, call Dealer Service to replace it.

    D. Replace the cover.

13. Remove and clean the automatic oil system pump filter.

14. Clean the dirt and chips from inside the Power Equipment Enclosure and around the card frame. Metal chips can come into contact with the boards and disrupt the electronic signals of the PC boards.

Check each item listed in the checklist in the appropriate Operator Daily Maintenance Requirements Table, Pages 6.6 and 6.7, on a regular basis. Refer to the Maintenance Procedures listed in sequence above for a detailed explanation of each numbered item on the checklist.

OPERATOR MAINTENANCE

REQUIREMENTS

Refer to Operator Maintenance Requirements, Regular Shift and Multiple Shift, respectively.

PERIODICITY CODES:

D = Daily, performed on a daily basis during a 24-hour period.
W = Weekly, performed on a weekly basis.
M = Monthly, performed on a monthly basis.
S = Semiannually, performed twice a year.
AS REQ. = Depends on working environment.

OPERATOR MAINTENANCE REQUIREMENTS CHECKLIST - REGULAR SHIFT

REF NO.	REQUIREMENT	PERIODICITY				
		D	W	M	S	AS/REQ
1	Check lube system oil level. Fill if necessary.	X				
2	Clean dirt and chips from ways.	X				
3	Clean machine exterior. Clear intakes and exhausts.			X		
4	Clean way covers and lightly oil.		X			
5	Check coolant level. Fill if necessary.		X			
6	Check air filters. Replace if necessary. Use electrostatic filters if dry cutting.			X		
7	Check pneumatic lubricator bowl. Fill if necessary.				X	
8	Drain, clean and refill pneumatic filter bowl.				X	
9	Check spindle motor for dirt. Wipe clean if necessary.				X	
10	Check spindle drive belt for wear. Notify Dealer Service to replace belt if necessary.				X	
11	Clean lube system pump filter.					X
12	Clean inside of control cabinet.			X		

Check each item listed in the checklist on a regular basis. Refer to Maintenance Procedures for an explanation of each numbered item on the checklist.

OPERATOR MAINTENANCE REQUIREMENTS CHECKLIST - MULTIPLE SHIFT

REF NO.	REQUIREMENT	PERIODICITY				
		D	W	M	S	AS/REQ
1	Check lube system oil level. Fill if necessary.	X				
2	Clean dirt and chips from ways.	X				
3	Clean machine exterior. Clear intakes and exhausts.					48 Hrs
4	Clean way covers and lightly oil.					48 Hrs
5	Check coolant level. Fill if necessary.		X			
6	Check air filters. Replace if necessary. Use electrostatic filters if dry cutting.					48 Hrs
7	Check pneumatic lubricator bowl. Fill if necessary.				X	
8	Drain, clean and refill pneumatic filter bowl.				X	
9	Check spindle motor for dirt. Wipe clean if necessary.	X				
10	Check spindle drive belt for wear. Notify Dealer Service to replace belt if necessary.			X		
11	Clean lube system pump filter.				X	
12	Clean inside of control cabinet.					48 Hrs

Check each item listed in the checklist on a regular basis. Refer to Maintenance Procedures for an explanation of each numbered item on the checklist.

- NOTES -

CHAPTER 7 - MANUAL CONTROLS

HEAD CONTROLS

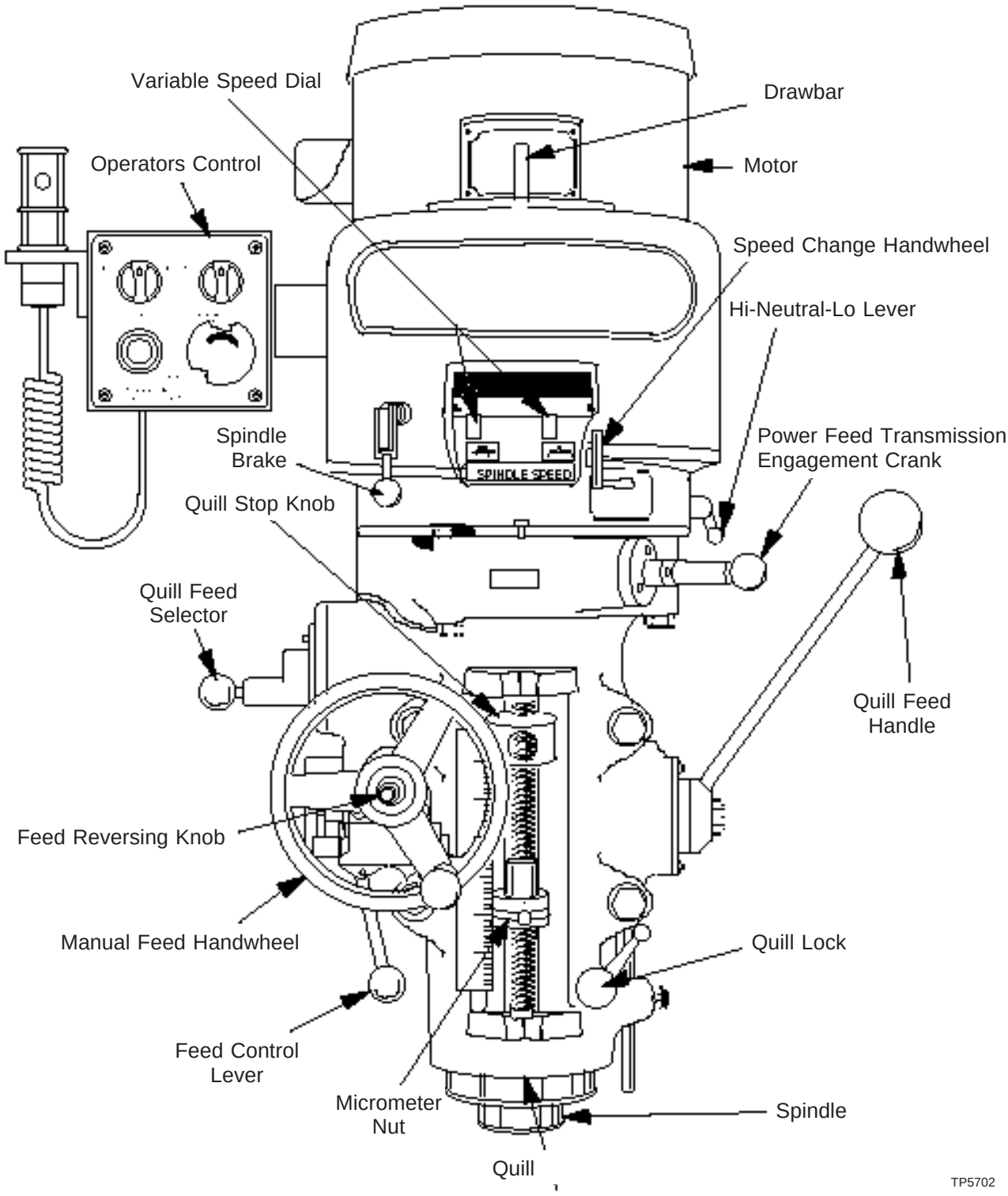


Figure 7.1 - Head Controls and Components Assembly

OPERATOR'S CONTROL STATION

The Operators Control Station (see Figure 7.2) includes two control switches and two pushbuttons.

The EMERGENCY STOP pushbutton "A" will remove power from the spindle, coolant, and the axis motors. This pushbutton is maintained ON when activated by pushing it in towards the panel and will not release until it is manually pulled out.

The OFF, HIGH GEAR, LOW GEAR selector switch "B" permits the operator to select the clockwise direction of the spindle by having the gear selector agree with this switch selection. The OFF position shuts the spindle off. When the attachment is in direct drive (HIGH GEAR) the motor and spindle are turning in a clockwise direction as viewed from the top of machine. When the attachment is in "Back Gear" (LOW GEAR) the spindle will run backwards (counterclockwise) unless the motor direction is reversed by moving switch to low.

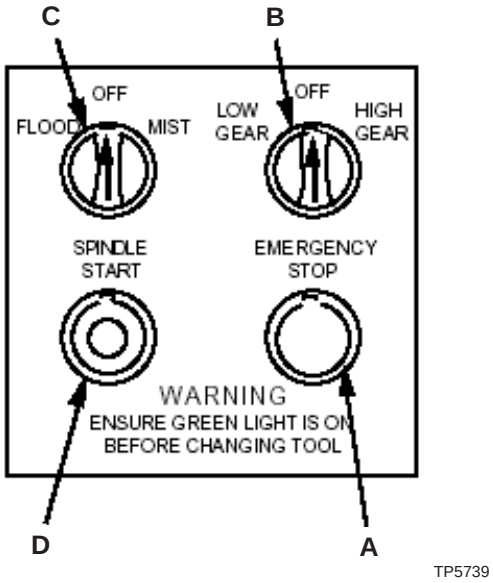


Figure 7.2 - Operator's Control Station

- NOTE -

Spindle should run in clockwise direction.

- CAUTION -

The back-gear lever (Figure 7.13, Page 7-7) is marked HILO. This will indicate the proper switch position. The back gear lever and the OFF, HIGH GEAR, LOW GEAR selector switch should be set in the same position or the spindle will run backwards.

The coolant OFF, MIST, FLOOD selector switch "C" will select the desired coolant. The coolant will turn on and off with the spindle.

- CAUTION -

Pressing the Emergency Stop button or spindle off selector removes power from the spindle motor, but does not apply the spindle brake. The brake must be activated manually.

The SPINDLE START switch "D" will start the spindle when the lighted portion of this switch is pressed. The light will go out after the spindle is started.

- CAUTION -

NEVER put hands near the spindle unless the spindle light is ON.

VARIABLE SPEED DIAL

The Variable Speed Dial (Figure 7.3) visibly indicates, in windows “E”, the speed range that the machine is operating in: 60-500 RPM (low range), 500-4200 RPM (high range).

Rotate handwheel “F” to increase or decrease spindle speed.

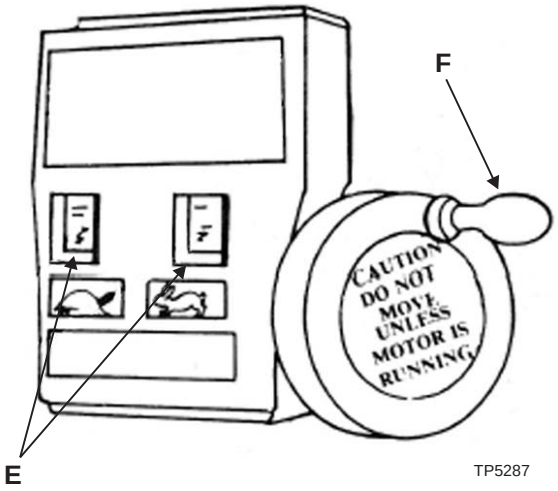


Figure 7.3 - Variable Speed Dial

SPINDLE BRAKE

The Spindle Brake lever (Figure 7.4) can be moved in either direction to stop spindle; however, when locking spindle, lever should be moved either by pulling it toward the operator or pushing it away from the operator, and then raising the lever. When the brake is worn out it has to be replaced. There are no adjustments to be made.

- CAUTION -

BE SURE that the spindle brake is released before starting the motor. The motor can be damaged if switch is turned ON with the brake in locked position.

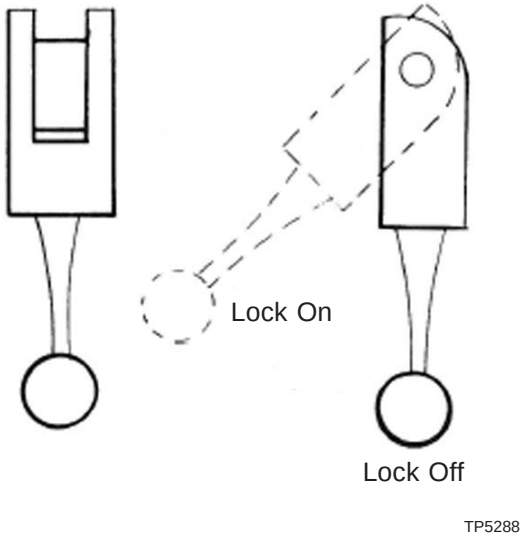
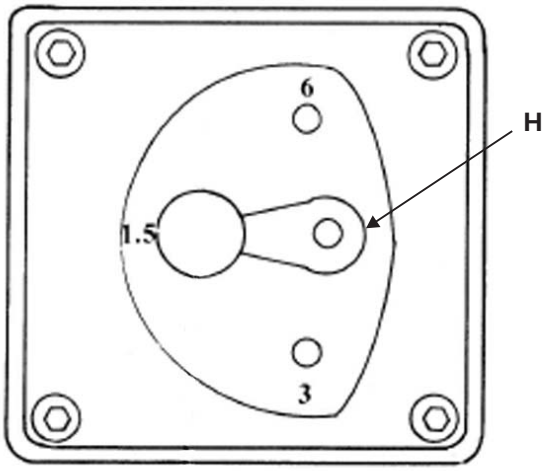


Figure 7.4 - Spindle Brake

QUILL FEED SELECTOR

The Quill Feed Selector “H” (Figure 7.5) is used for selecting the three feeds: 0.0015”, 0.003”, and 0.006” inch per revolution. It is shifted by pulling knob out and turning from one position to the other. Feeds are stamped on cover below indentation hole. Feed is more readily engaged when spindle is running.



TP5289

Figure 7.5 - Quill Feed Selector

QUILL STOP KNOB

The Quill Stop Knob “I” (see Figure 7.6) is used to disengage automatic feed in either direction as well as the stop point setting working depths.

MICROMETER NUT

The Micrometer Nut “J” (see Figure 7.6) is used for setting depths. Each graduation on nut indicated 0.001” of depth. It reads directly to scale mounted along the side of it. Depths may be obtained by setting micrometer nut in conjunction with quill stop.

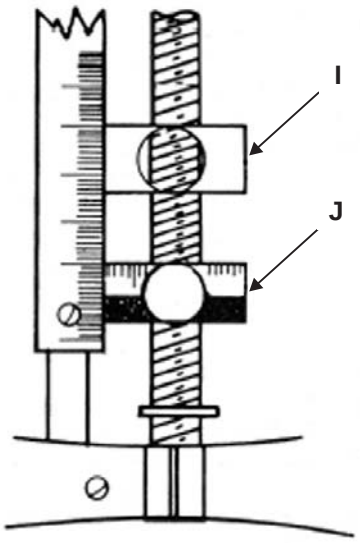


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Figure 7.6 - Quill Stop Knob and Micrometer Nut

FEED REVERSE KNOB

The position of the Feed Reverse Knob “K” (Figure 7.7) depends upon the direction of spindle rotation. If boring (quill feed down) with right hand cutting tools, push feed knob away from operator until clutch becomes engaged. To engage clutch to feed up, pull knob to OUT position. NEUTRAL position is between IN and OUT position. It is recommended that the handle be left in neutral position when not in use.

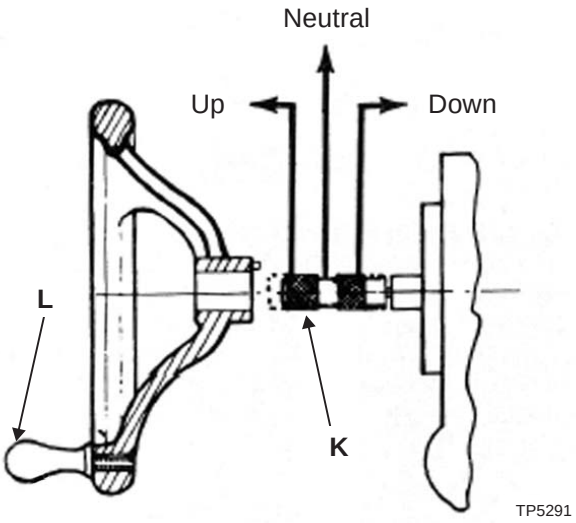


Figure 7.7 - Feed Reverse Knob and Manual Feed Handwheel

MANUAL FEED HANDWHEEL

- NOTE -

The Manual Feed Handwheel may be removed when not in use.

The Feed Reverse Knob “K” should be in neutral position and Manual Feed Handwheel “L” engaged. Clockwise rotation of handwheel moves quill down. The manual feed handwheel and the quill feed handle may be disengaged by moving them outward about 1/8”.

QUILL FEED CONTROL LEVER

The Feed Control Lever “M” (Figure 7.8) engages the overload clutch on the pinion shaft when positioned left and will stay engaged until either quill stop comes in contact with micrometer adjusting nut, forcing feed control lever to drop out automatically, or released manually by moving lever to right.

- NOTE -

The Quill Feed Control Lever must be engaged in order to use manual feed controls.

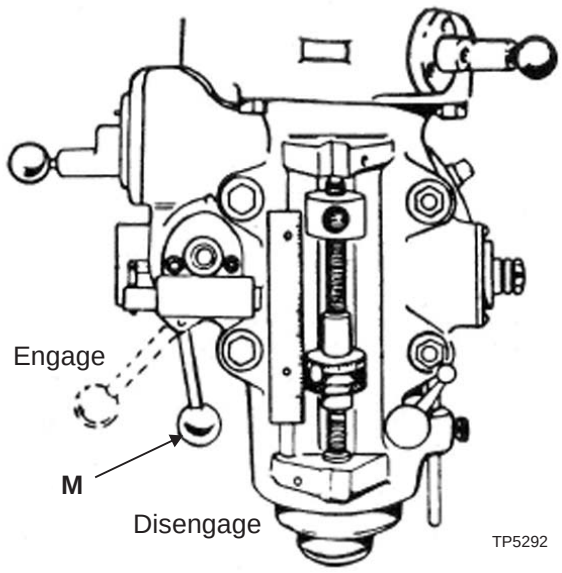


Figure 7.8 - Quill Feed Control Lever

FEED CONTROL OVERLOAD CLUTCH

The Feed Control Overload Clutch is set at the factory to hold up to 200 lbs. Of down pressure on the quill, which will accommodate drills up to 0.375” diameter in mild tool steel.

- CAUTION -

DO NOT tamper with the Feed Control Overload Clutch in the field.

QUILL

The Quill “N” (Figure 7.8) contains the spindle assembly and can be raised or lowered by using the Quill Feed Handle “Q” (Figure 7.10).

SPINDLE

The Spindle “O” (Figure 7.8) performs the actual rotation and also retains the machine tooling.

QUILL LOCK

The Quill Lock “P” (Figure 7.8) is a friction lock used when quill is in stationary position such as milling operations. It is recommended that this lock be used whenever quill movement is not desired.

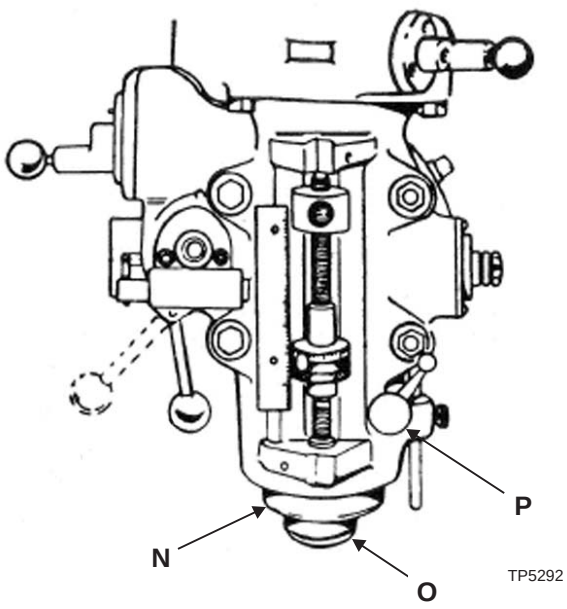


Figure 7.9 - Quill, Spindle and Quill Lock

QUILL FEED HANDLE

The quill feed handle “Q” (Figure 7.10) may be removed by simply pulling the handle off. It is recommended that handle be disengaged when using Power Feed. This handle is used to raise and lower the quill manually.

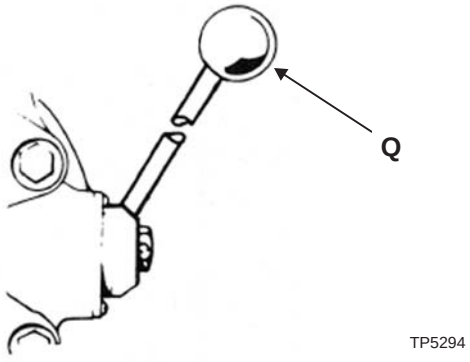


Figure 7.10 - Quill Feed Handle

POWER FEED TRANSMISSION ENGAGEMENT CRANK

The Power Feed Transmission Engagement Crank “R” (Figure 7.11) engages the Power Feed Worm Gear. When the lever is in right hand hole, the Power Feed Worm Gear is engaged. To disengage worm gear, pull knob out and crank handle in clockwise or down direction and move to opposite position (see Figure 7.12).

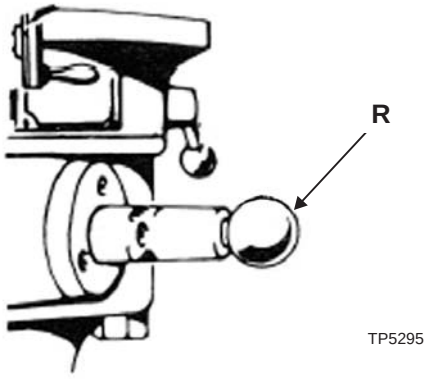


Figure 7.11 - Power Feed Transmission Engagement Crank

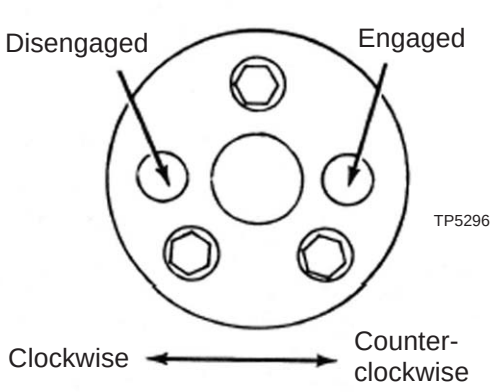


Figure 7.12 - Power Feed Worm Gear Disengagement

HI-NEUTRAL-LO LEVER

The HI-NEUTRAL-LO Lever “S” (Figure 7.12) is used to put the attachment into either back gear or direct drive. Rotate the spindle by hand to facilitate meshing of clutch or gears.

Neutral is provided to permit free spindle rotation for indicating and set-up work.

In the high speed position (direct drive) the spindle is driven by tapered tooth clutch. If the clutch is not meshed tightly, clutch rattle will be heard. This can be corrected by loosening the two securing screws on the lever while in high speed position. The clutch spring will automatically adjust the clutch. Tighten the two securing screws on the lever.

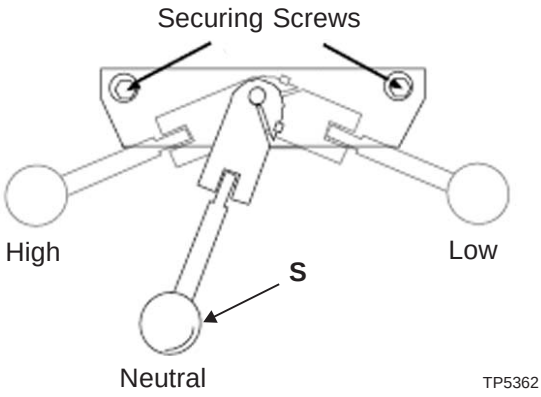


Figure 7.13 - HI-NEUTRAL-LO Lever

- CAUTION -

DO NOT shift HI-LO Lever while motor is running.

SPEED CHANGE HANDWHEEL

- CAUTION -

DO NOT attempt to change spindle RPM unless the motor is running.

- NOTE -

Dial indicator speeds will only be approximate. Belt wear will cause a slight variation in speeds from what is indicated on the dial.

Spindle speeds are adjusted by turning the Speed Change Handwheel “T” (Figure 7.13) on the front of the belt housing. There are two ranges: 60 to 500 RPM and 500 to 4200 RPM.

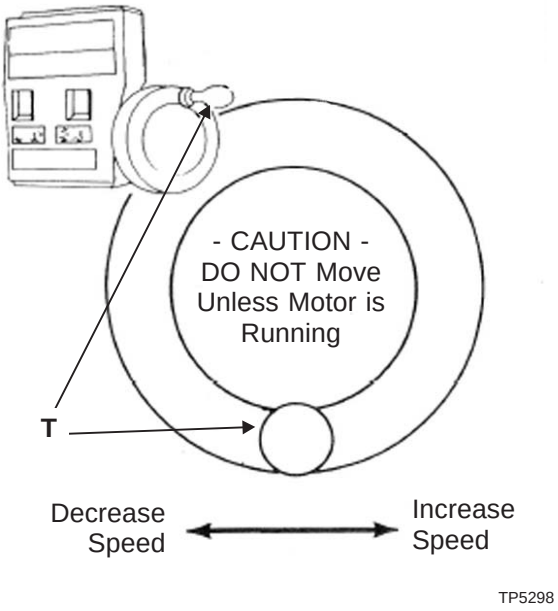


Figure 7.14 - Speed Change Handwheel

60 to 500 RPM is obtained through the back-gear drive and is referred to as the low range. To engage the back gears, use the lever marked HI-NEUTRAL-LO on the right rear side of the attachment. Move this lever to the “LO” position and use the low range on the drum switch.

When shifting to “LO,” DO NOT force the lever if the back gears do not mesh. Hold the lever so the gears are clear of one another, rotate the spindle nose by hand until the gears line up, then put the unit in “LO” (back gear).

500 to 4200 RPM is obtained through direct drive and is the high range. The same lever and switch as above are used selecting the “HI” range.

When shifting to “HI”, DO NOT force the lever if the clutch teeth do not mesh. It is a simple matter to engage the brake and rotate the spindle nose by hand until the clutch engages.

- CAUTION -

AVOID shifting the Hi-Lo lever when the feed gear is engaged.

MOTOR

The Spindle Motor “U” (Figure 7.15) is 2 HP (continuous) variable speed with a 3 HP power rating (30 minute duty rated).

DRAWBAR

When tightening or loosening the Drawbar “V” (Figure 7.15), it is necessary to lock the spindle. To accomplish this, use the spindle brake (Figure 7.4, Page 7-3) which is located on the left side of the belt housing; pull the lever or push it away until it binds, then raise the quill feed handle to lock it in place (Figure 7.10, Page 7-6).

The Drawbar has a 7/16”-20 right-hand thread and should be tightened by hand with a normal amount of pressure using the wrench furnished with the machine. To loosen the collet, back off the drawbar; if collet does not open immediately, give the knob on top of the drawbar a slight tap. The spindle has a non-sticking taper and the collet should release readily.

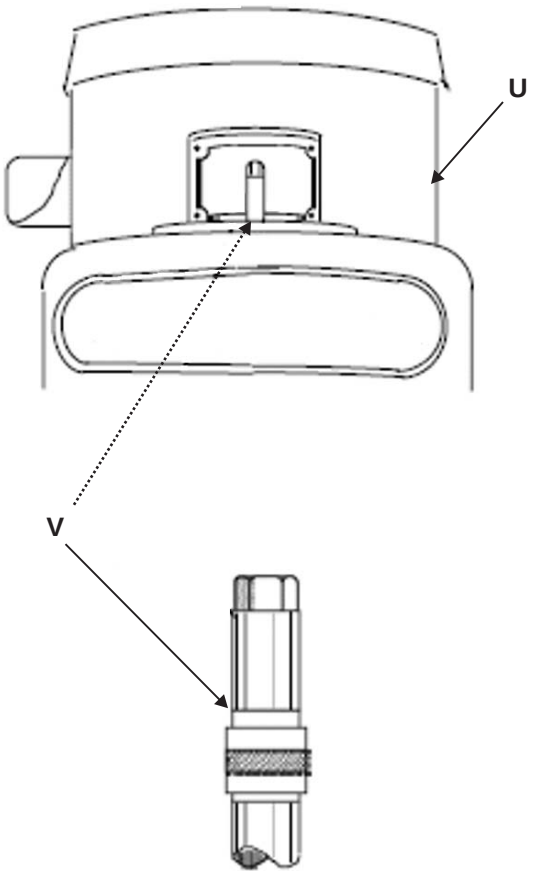


Figure 7.15 - Motor and Drawbar

SPINDLE SPEED

- CAUTION -

DO NOT change spindle speed when spindle is stationary. Change speed only when spindle is running.

TO CHANGE SPINDLE SPEED WITHIN RANGE:

1. Start spindle.
2. Turn handwheel “W”, Figure 7.16 to select required speed.

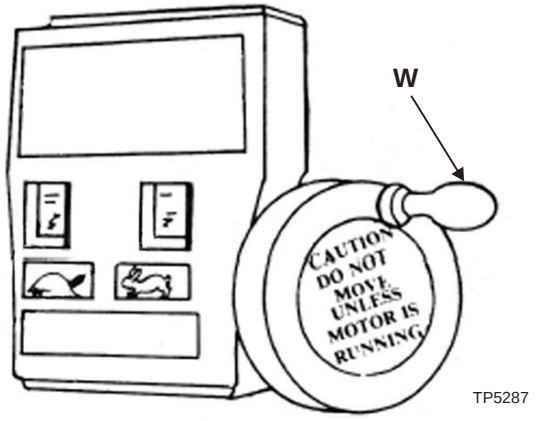


Figure 7.16 - Speed Change Handwheel

TO CHANGE RANGE FROM DIRECT DRIVE TO BACK GEAR DRIVE:

1. Switch “X”, Figure 7.17, to OFF (stop spindle rotation).
2. Move lever “Y” through neutral to LO (this reverses the spindle rotation).
3. Switch “X” to LOW GEAR.

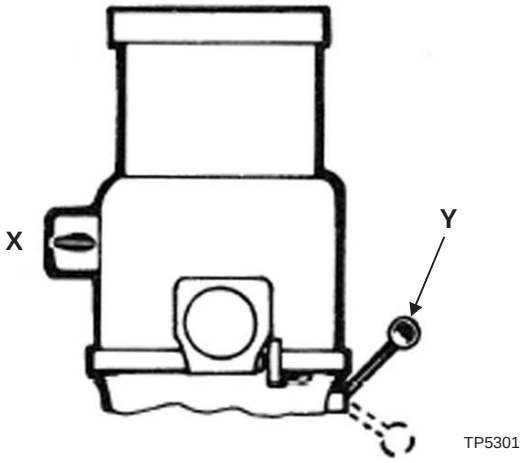


Figure 7.17 - HI-NEUTRAL-LO Lever

TO CHANGE RANGE FROM BACK GEAR DRIVE TO DIRECT DRIVE

1. Switch “X” to OFF (stop spindle rotation).
2. Move lever “Z”, Figure 7.18, through neutral to HI.
3. Rotate spindle by hand until the clutches are felt to engage.
4. Switch “Y” to HIGH GEAR.

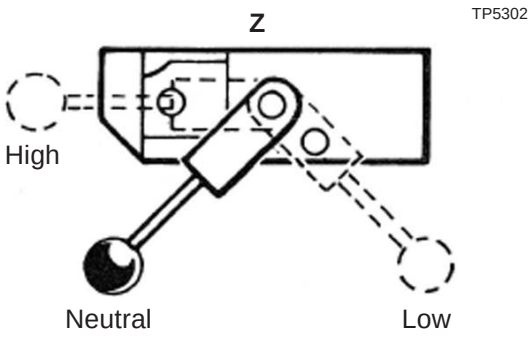


Figure 7.18 - Direct Drive Lever

QUILL FEED

AUTOMATIC FEED

- NOTE -

Do not engage auto quill feed “A”, Figure 7.19, over 3,000 RPM.

- CAUTION -

Maximum loading for auto quill feed is 3/8” (9.5mm) diameter drill steel.

1. Ensure quill lock “D” is off.
2. Set micrometer dial “E” to required depth.
3. Engage auto quill feed “A” when motor is stopped.
4. Select feed rate “F”.
5. Select feed direction “C”.
6. Engage feed trip lever “B”.
7. The feed will automatically trip out to depth setting within 0.010” (0.25mm).
8. Hand feed to dead stop for repeating accuracy 0.001” (0.025mm).

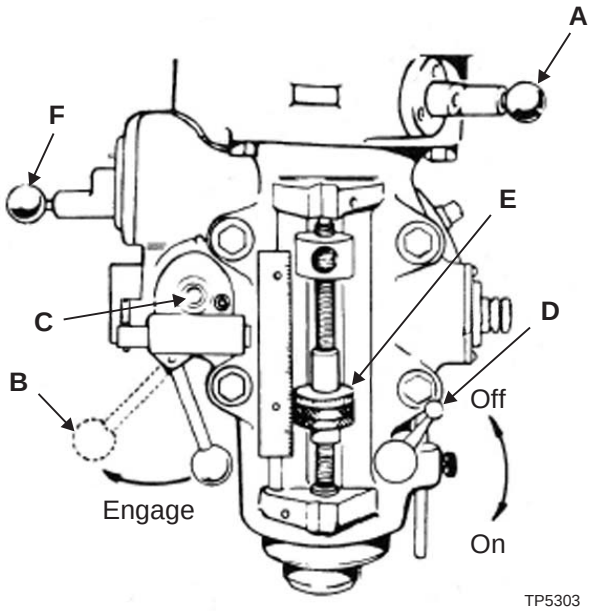


Figure 7.19 - Automatic Quill Feed

FINE HAND FEED

1. Disengage auto quill feed “A”.
2. Locate “C”, Figure 7.20, in mid (neutral) position.
3. The quill is now under handwheel control.

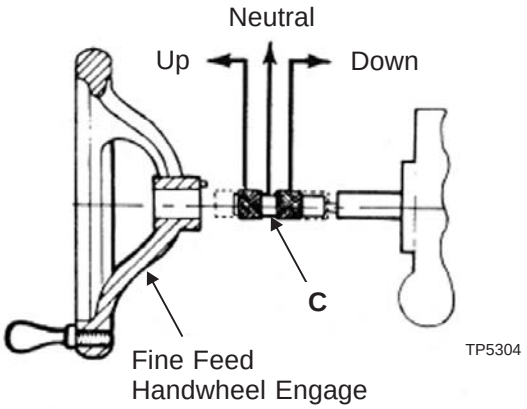


Figure 7.20 - Fine Hand Quill Feed

SWIVEL BELT HOUSING

- WARNING -

To prevent personal injury or damage to machine, DO NOT remove the three locking nuts after loosening.

1. Loosen the 3 locking nuts “A”, Figure 7.21.
2. Swivel to required angular setting.

- CAUTION -

Incorrect spline alignment can be caused by unequal tightening of the locking nuts, causing fluctuation of the quill feed which can be felt through the sensitive feed handle. It is advised to call Hardinge Service Department before attempting this procedure.

3. Tighten 3 locking nuts “A” snugly before final tightening of locking nuts. Run spindle to give correct spine alignment, then retighten locking nuts securely.

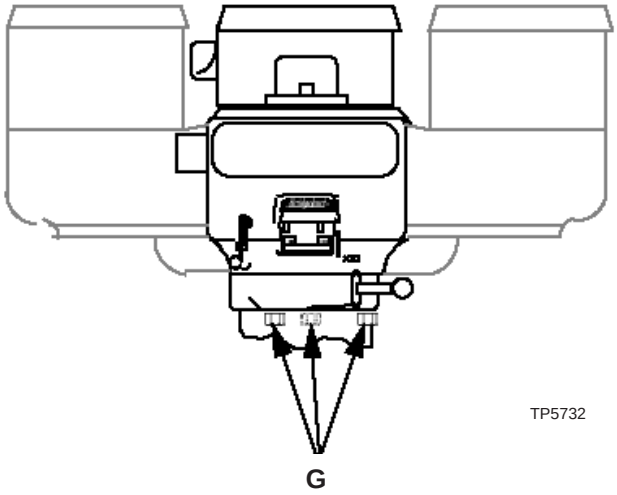


Figure 7.21 - Swivel Belt Housing

SPINDLE BRAKE

Brake lever “H”, Figure 7.22, has the capability to rotate in either direction to brake and lock. Cam upwards to lock and prevent movement of spindle.

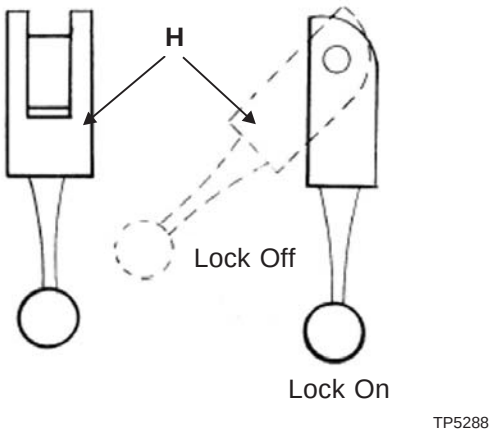


Figure 7.22 - Spindle Brake

QUILL SENSITIVE HAND FEED

1. Place the handle “I”, Figure 7.23, on the quill feed shaft.
2. Select the most suitable position
3. Push home until the locating pin engages.

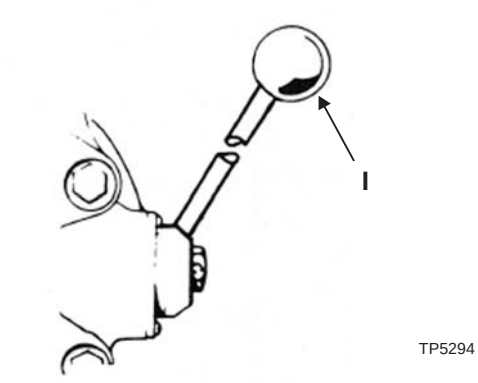


Figure 7.23 - Quill Sensitive Hand Feed

SWIVEL TURRET

- WARNING -

DO NOT remove bolts.

1. Use wrench supplied with machine and loosen the 4 bolts “J”, Figure 7.24.
2. Index to the required setting.
3. Lock the 4 bolts to 47 ft. lbs.

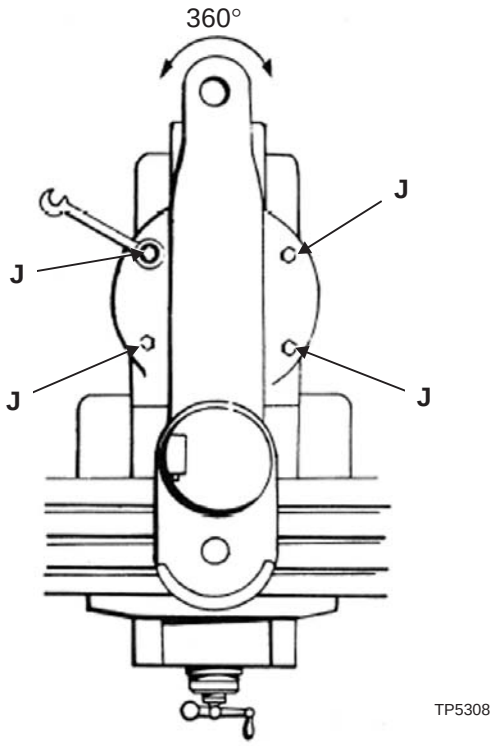


Figure 7.24 - Swivel Turret

MOVE RAM SLIDE

1. Use wrench provided with machine to loosen bolts “K” and “L”, Figure 7.25.
2. Use wrench to move the slide to the desired position using bolt “M”..
3. Retighten bolts “K” and “L”, beginning with the rear bolt.

- NOTE -

It is recommended that on heavy milling work, head should be kept as close to the column as possible, where maximum rigidity is obtained.

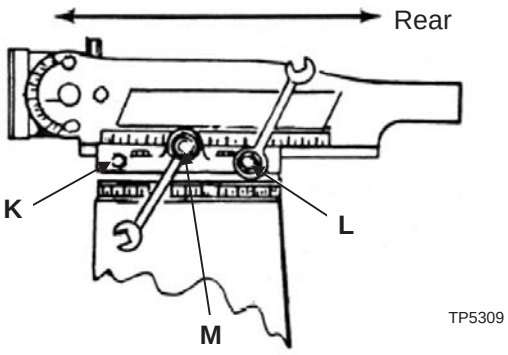


Figure 7.25 - Move Ram Slide

SADDLE CLAMPING

When milling with longitudinal table feed only, it is advisable to clamp the knee to the column (see Figure 7.28) and the saddle to the knee to add rigidity to these members and provide for heavier cuts with a minimum of vibration. The saddle locking lever is located on the left-hand side of the saddle (see Figure 7.26).

Excessive pressure can cause slight table bind. Use moderate clamping pressure, as this will hold saddle sufficiently.

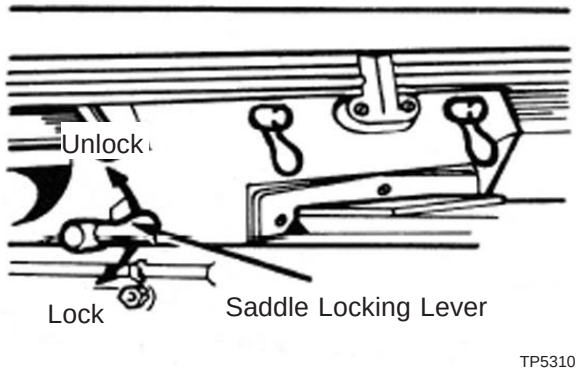


Figure 7.26 - Saddle Clamping

TABLE CLAMPING

The table clamping levers are located on the front of the saddle (see Figure 7.27) and should always be clamped when longitudinal movement is not required.

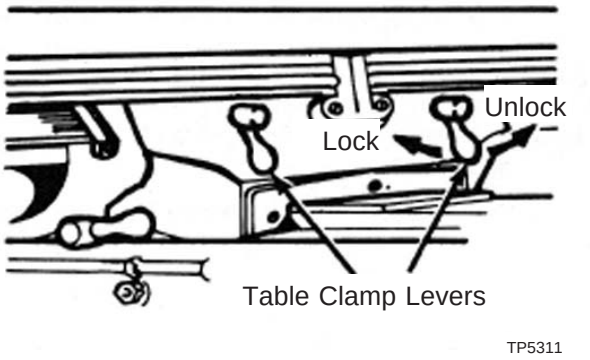


Figure 7.27 - Table Clamping

KNEE CLAMPING

The knee clamping levers are at the left side of the knee and front of knee. Leave clamped at all times unless raising or lowering the knee.

KNEE CLAMPING (Before April 2002):

The knee clamping levers are at the left side of the knee and front of knee (see Figure 7.28). Leave clamped at all times unless in operation.

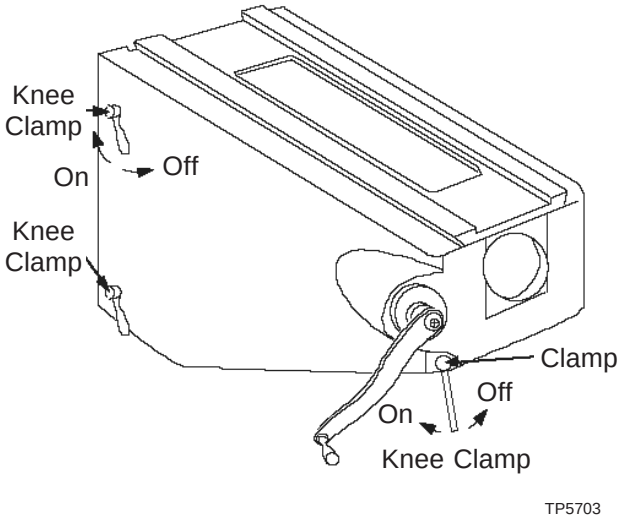


Figure 7.28 - Knee Clamping

KNEE GIB ADJUSTMENT
(Starting April 2002):

The two levers at the left side of the knee have been replaced by the Knee Gib (see Figure 7.29).

LOAD ADJUSTMENT SCREWS:

These screws not only lock the knee in place against downward movement but also adjust the tension on the knee gib to prevent rocking.

1. Loosen jam nuts with a 3/4” wrench.
2. Use a 1/4” Allen wrench to adjust screws to desired pressure.
3. Back off approximately 1/4 turn on each screw.
4. Re-tighten and torque each screw to 40 in/lbs.
5. Hold the set screws in place with the Allen wrench while tightening the jam nuts.

Use enough force to keep the set screws from over-tightening.

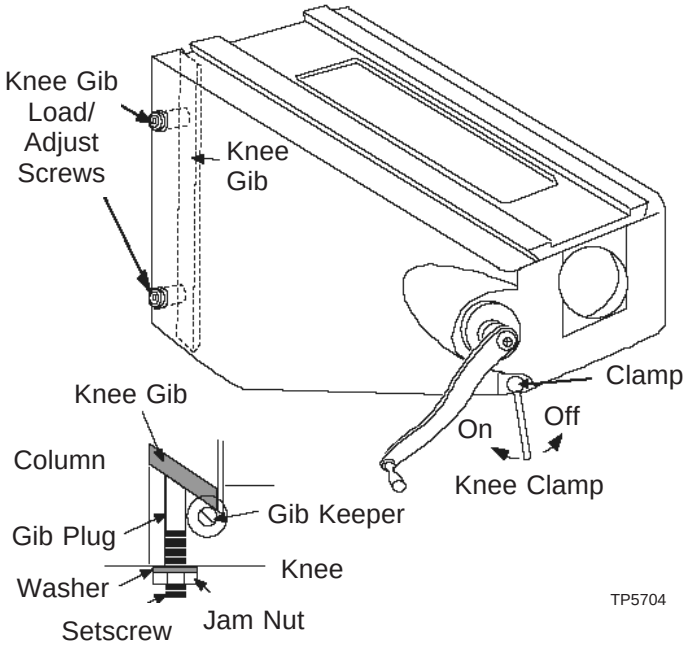


Figure 7.29 - Knee Gib Adjustment

- NOTES -

CHAPTER 8 - MAINTENANCE

MAINTENANCE PROCEDURES

Motor Removal

1. Run head to adjust to lowest speed.
2. Disconnect power.
3. Remove three screws “A” and cover “B”, Figure 8.1.
4. Using two of the three screws “A”, compress spring “C”.
5. Rotate the speed changer to the highest speed.
6. Remove the reversing switch from the belt housing.
7. Remove the two securing screws “D”.
8. Lift the motor and rest the case on stud “E”, Figure 8.2.
9. Ease the belt over the lower drive disc and remove the motor.

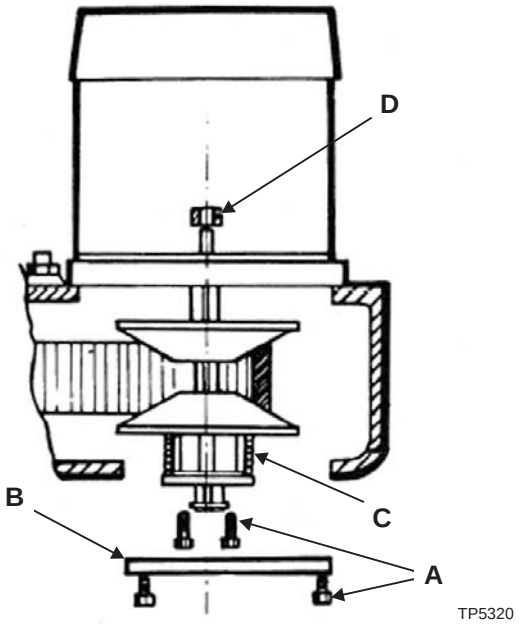


Figure 8.1 - Motor Removal
Front View

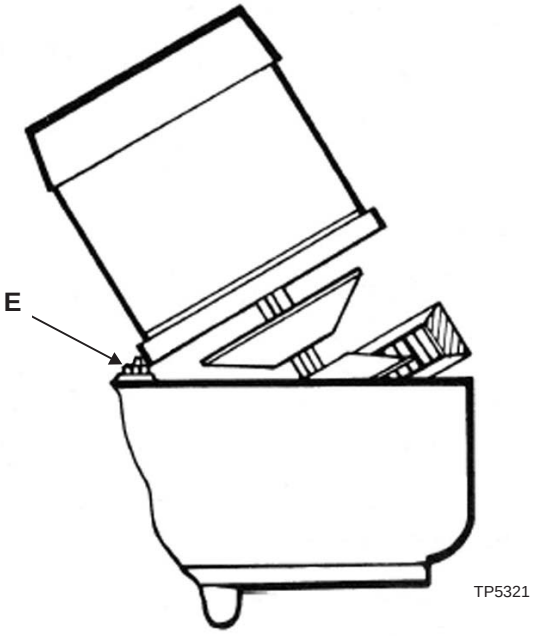


Figure 8.2 - Motor Removal
Side View

Drive Belt Replacement

1. Remove the motor as described on Page 8-1.
2. Remove the three screws “F”, Figure 8.3. Insert them into the adjacent tapped holes and withdraw bearing housing “G”.
3. Remove the two screws and the bushings “H”.
4. Remove four screws “I” and one screw “J”.
5. Remove four screws securing speed changer “K”.
6. Remove top housing “L”. Tap to clear the dowels.
7. Replace the belt.

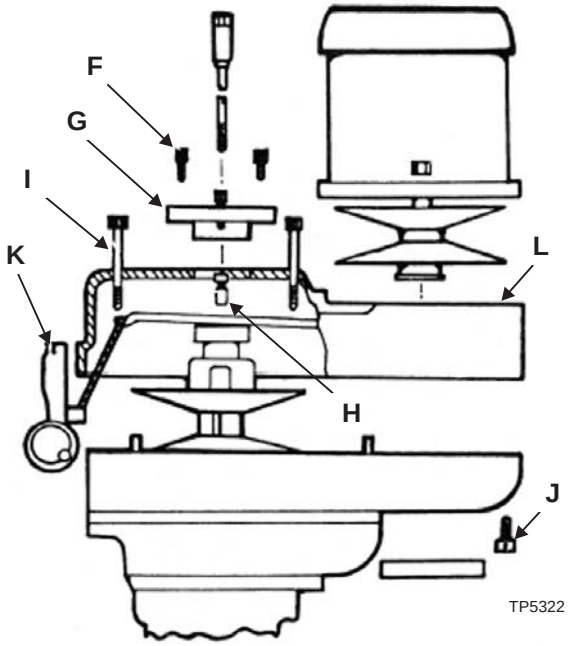


Figure 8.3 - Drive Belt Replacement

Timing Belt Replacement

1. Remove the motor.
2. Lower the quill to full extent.
3. Remove the two lower cap screws “M”, Figure 8.4, from the speed changer housing.
4. Remove the four cap screws “N”.
5. Remove the top assembly “O”, and tap to clear dowels.
6. Replace the belt.

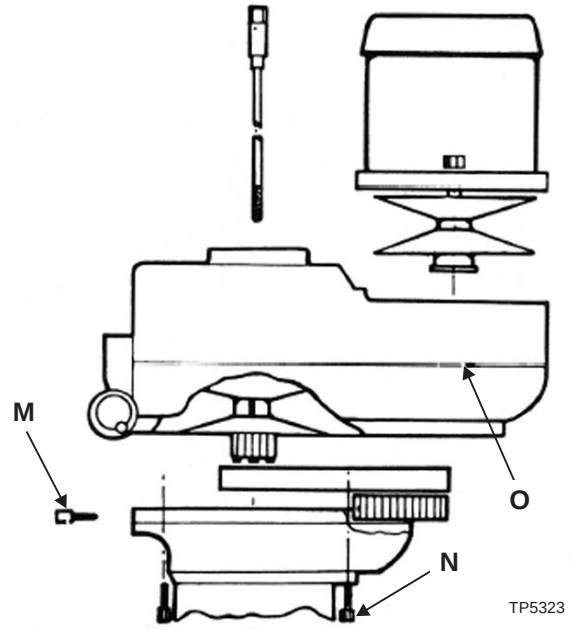


Figure 8.4 - Timing Belt Replacement

Brake Shoe Replacement

1. Remove the top housing (refer to Motor Removal on Page 8-1, and Timing Belt Replacement on Page 8-4).
2. Remove the two screws “P”, Figure 8.5.
3. Remove the clutch hub assembly “Q”.
4. Replace the brake shoes “R”.
5. Remove the bearing, drive discs and circlips from the hub assembly “Q”.
6. Replace the bearing and housing “S”.
7. Thread the hub through the bearing and reassemble the discs. Replace top housing and motor.

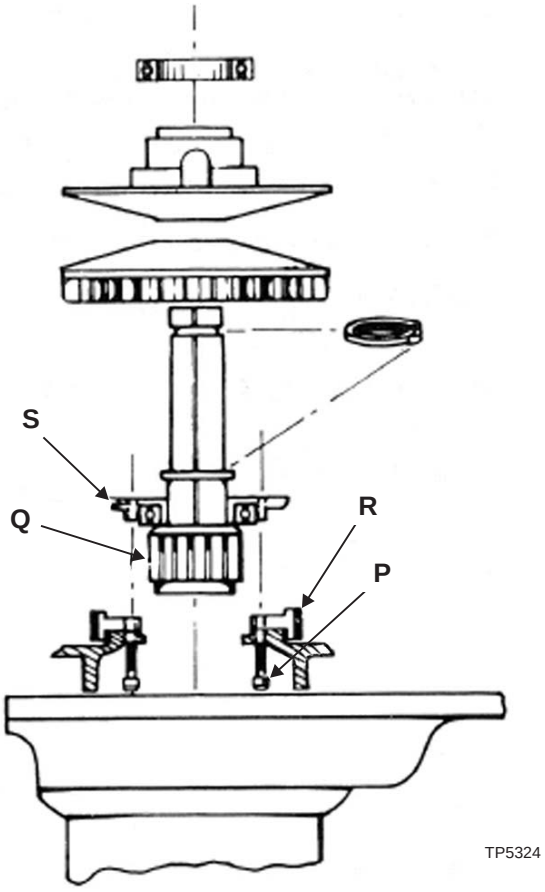


Figure 8.5 - Brake Shoe Replacement

Micro Feed Trip Assembly And Quill Removal

1. Remove screw “A” and ball reverse lever “B”, Figure 8.6.
2. Remove retaining ring “C”, screw “D” and arm “E”.
3. Thread shaft “F” through micro nuts and remove.
4. Remove screw “G” and stop “H”.
5. Remove quill.
6. Clean all areas, oil liberally and reassemble.
7. Check correct operation of micro feed trip assembly together with feed trip linkage as per feed tripping adjustment (see Figure 8.8).

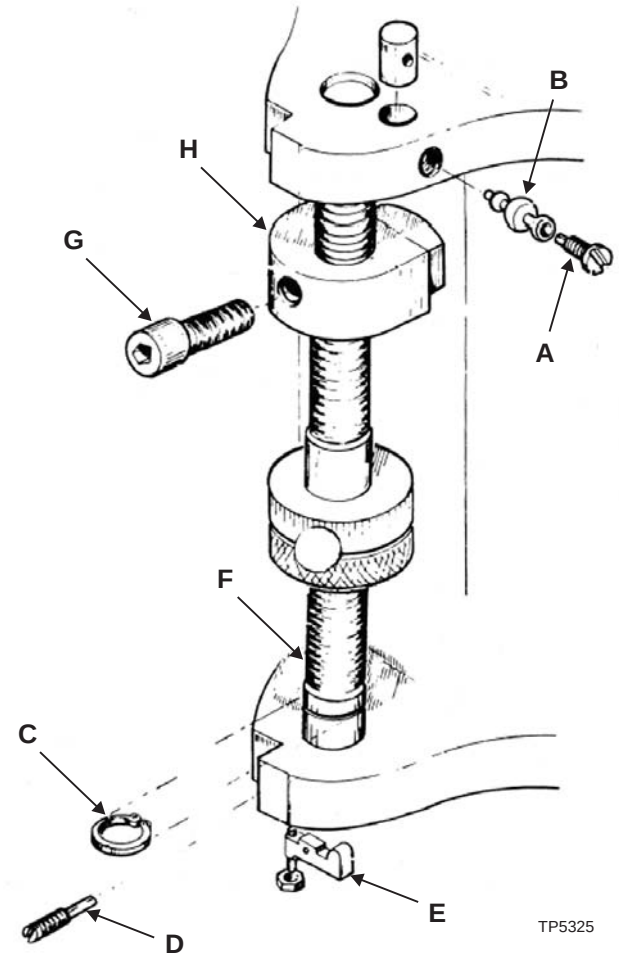


Figure 8.6 - Micro Feed Trip Assembly and Quill Removal

Balance Spring Replacement

1. With quill at maximum UP position, apply quill lock.
2. Remove screw “I”, hub “J”, and key “K”, Figure 8.7.
3. Remove screws “L”, allowing housing to rotate slowly, releasing spring tension.
4. Lift end of spring from pin on the pinion shaft.
5. Rotate housing “M” counterclockwise from head casting.
6. Remove spring from housing and replace.
7. Refit spring to main housing casting. Turn housing clockwise until spring locates on pin in pinion shaft.

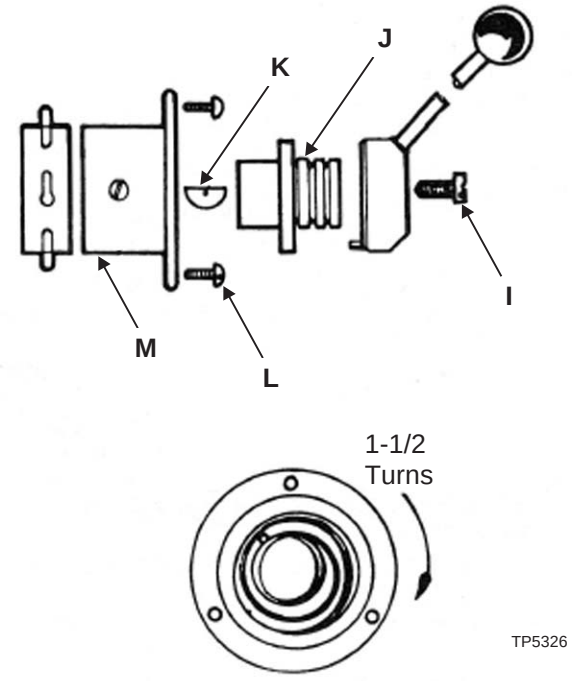


Figure 8.7 - Balance Spring Replacement

Feed Trip Adjustment

1. Release locknut “N”, Figure 8.8.
2. Engage trip handle “P”.
3. Adjust micro nuts against quill stop “O”.
4. Slowly turn adjusting screw “Q” until lever “P” trips. If “Q’ is set too light the machine will not be able to drill.
5. At this point, secure locknut “A”.
6. Check for quick action response.

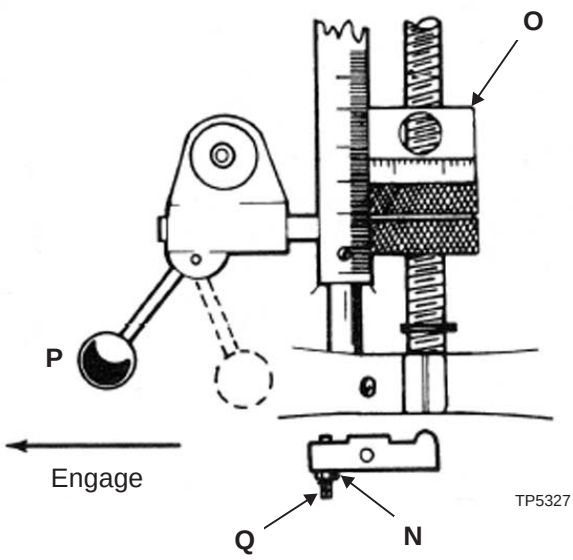


Figure 8.8 - Feed Trip Adjustment

Collet Aligning Screw Replacement

1. Use felt pen, mark reference line on quill and nose cap “S”, Figure 8.9.
2. Remove set screw “R”.
3. Unscrew nose cap “S”.
4. Remove lock screw “T” and collet aligning screw “U”.
5. Replace “U”; insert collet and check that the dog on the end of the screw does not interfere with the bottom of the guide slot.
6. Replace lock screw “T”.
7. Replace nose cap “S”; check felt pen markings for correct alignment.
8. Replace set screw “R”.

- CAUTION -

DO NOT over-tighten as this will cause distortion.

9. Check gap “V” 0.003 in. (0.08 mm).

- CAUTION -

DO NOT attempt to remove nose cap before removing set screw “R”. Doing so will cause serious damage.

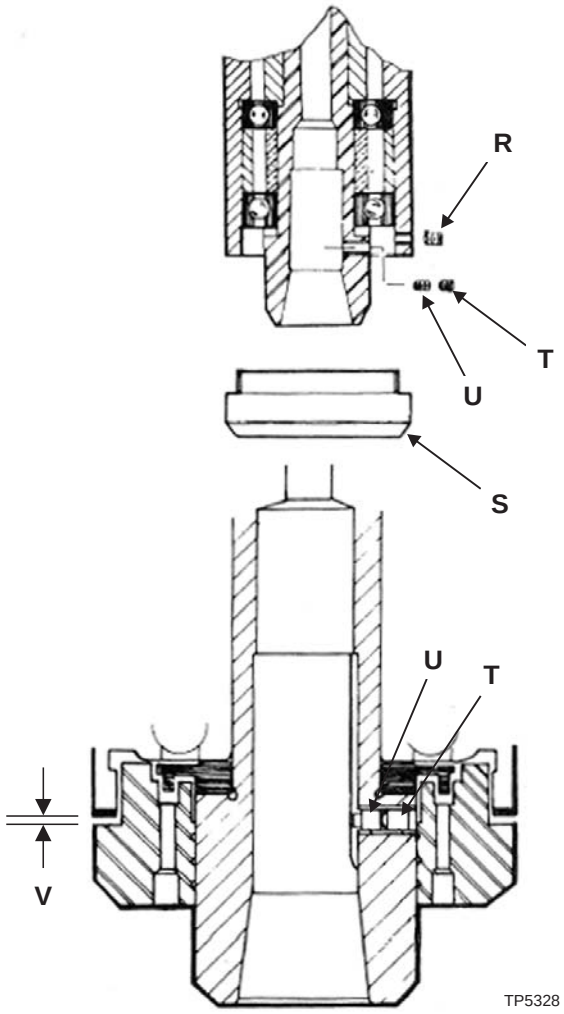


Figure 8.9 - Collet Aligning Screw Replacement

Adjustment Of Table Gib

The table is provided with a full length tapered gib in the saddle, and an adjusting screw on the left side.

To take up gib, tighten gib adjusting screw slightly and repeat until a slight drag is felt when the table by hand.

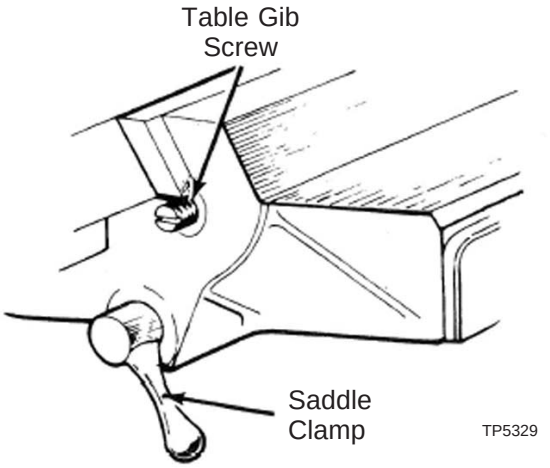


Figure 8.10 - Table Gib Adjustment

Adjustment Of Saddle And Knee Gibs

A tapered gib is used for adjusting the saddle bearing on the knee. This forms a guide for the saddle.

To tighten gib, the same principle as described above is used; however, the chip wiper has to be removed first.

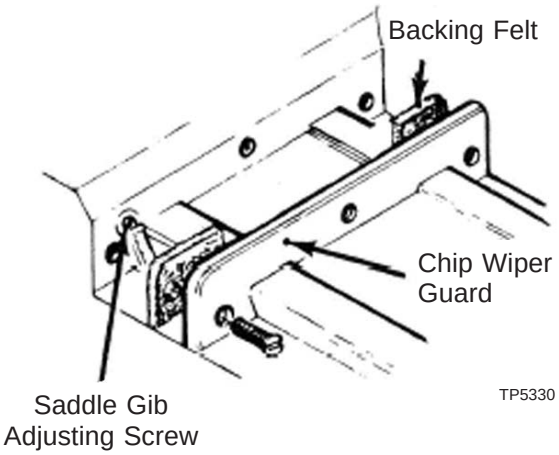


Figure 8.11 - Saddle and Knee Gib Adjustment

Adjustment Of Knee Gib

Remove chip wiper guard and adjust screw until smooth movement is attained.

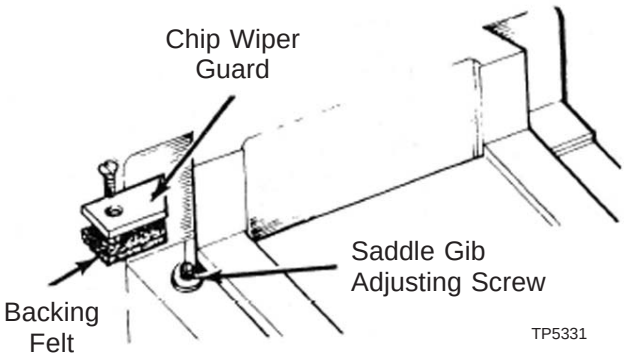


Figure 8.12 - Knee Gib Adjustment

Home Switch Adjustment

The home switches should be adjusted to permit equal travel in the plus and minus direction about the centerline of the spindle.

X AXIS SWITCH ADJUSTMENT

1. Establish the center of the table to the center line of the spindle with the hand crank.
2. Power up the control.
3. Crank the table to the left until the read out is reading 14.815 inches. This is the point that the home switch trip dog should make the home switch close.
4. Remove the cover plate from the bottom of the home switch enclosure. Attach a voltmeter to Wire 59 and ground. Set the voltmeter to the 12 volt range.
5. Move the X axis trip dog from the center of the table over to the home switch plunger and slowly adjust the dog toward the right until the meter reads 12 volts. Lock up the trip dog.
6. Crank the table to the right until the switch is clear.
7. Remove the X axis motor and set it on the floor so that the shaft end can be observed. Leave the motor functional.
8. Home the control. When the X axis starts to move, manually push the home switch plunger down. When the motor stops, the motor is home.
9. Set the X axis read-out to zero.
10. Jog the X axis to read -0.285 on the readout. The motor is now set to the point where the control will be expecting to see the home switch close.
11. Carefully crank the table to the left until the switch just closes, 12 volts on the meter.
12. Carefully install the motor onto the machine.

- NOTE -

Loose gibs will cause loss of machine's accuracy.

13. Manually crank the trip dog off of the home switch and slowly crank it back on to the switch.
14. At the time the meter changes to 12 volts the read out for the X axis should be -0.280 to -0.290 inches.
15. If the readout is out of the above range, carefully adjust the trip dog until the reading is within that range when steps 13 and 14 are repeated.

Y AXIS SWITCH ADJUSTMENT

1. Establish the center of the table to the center line of the spindle with the hand crank.
2. Power up the control.
3. Crank the table forward until the read out is reading 5.715 inches. This is the point that the home switch trip dog should make the home switch close.
4. Remove the cover plate from the bottom of the home switch enclosure. Attach a voltmeter to Wire 58 and ground. Set the voltmeter to the 12 volt range.
5. Move the Y axis trip dog from the center of the knee over to the home switch plunger and slowly adjust the dog forward until the meter reads 12 volts. Lock up the trip dog.
6. Crank the table to the back until the switch is clear.
7. Remove the Y axis motor and set it on the floor so that the shaft end can be observed. Leave the motor functional.
8. Home the control. When the Y axis starts to move, manually push the home switch plunger down. When the motor stops, the motor is home.
9. Set the Y axis read out to zero.
10. Jog the Y axis to read -0.285 on the readout. The motor is now set to the point where the control will be expecting to see the home switch close.
11. Carefully crank the table forward until the switch just closes, 12 volts on the meter.
12. Carefully install the motor onto the machine.
13. Manually crank the trip dog off of the home switch then slowly crank it back on to the switch.
14. At the time the meter changes to 12 volts the read-out for the Y axis should be -0.280 to -0.290 inches.
15. If the read-out is out of the above range, carefully adjust the trip dog until the reading is within that range when steps 13 and 14 are repeated.

- NOTES -

CHAPTER 9 - TROUBLESHOOTING

INTRODUCTION

Troubleshooting consists of locating faults by starting with obvious things and moving to the less obvious. Field diagnosis of machine problems can be divided into 3 sets of checks which are listed below. The Troubleshooting Flow Chart (see Figure 9.1 on Page 9-2) is provided to assist in following the steps correctly. This flow chart indicates which subsystem is likely to be at fault, and directs the technician to the proper section in this chapter.

PROCEDURE

Follow the Troubleshooting Flow Chart to determine the best place to begin troubleshooting the system. The three major sets of checks are:

1. INCOMING POWER
2. POWER SUPPLIES
3. SPINDLE FAILURE

Additional checks for axis stalling and spindle problems are presented in Overload (see Page 9-5), and the Axis Troubleshooting Table (see Page 9-7).

Use the Power Distribution Block Diagram (see Figure 9.3, Page 9-6) to follow the electrical checks, and to perform any additional electrical checks if necessary.

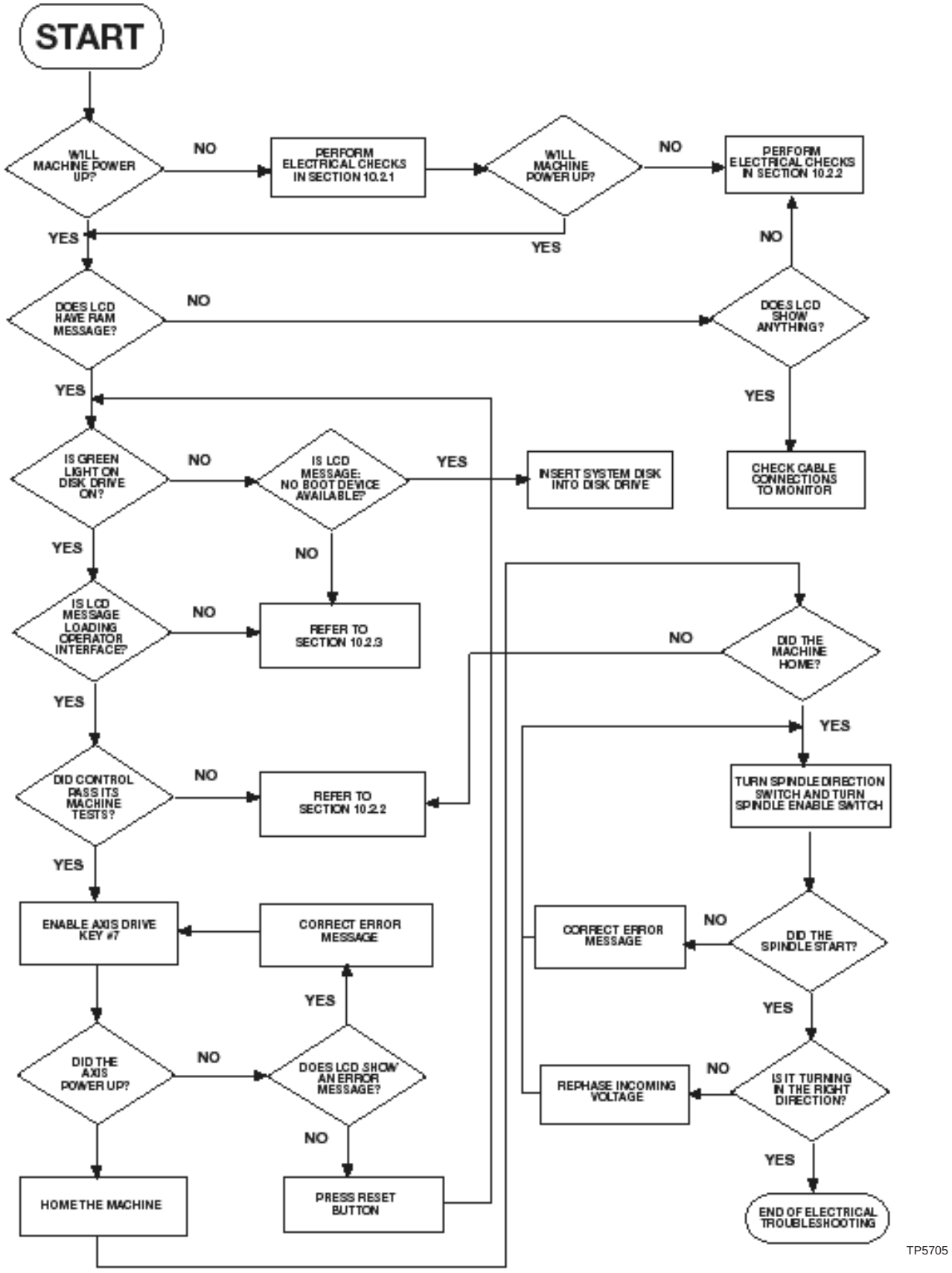


Figure 9.1 - Troubleshooting Flow Chart

ELECTRICAL POWER TEST

- DANGER -

Lethal voltages are present in the Equipment Panel Assembly, even when the Main Disconnect switch is off. Use EXTREME CAUTION whenever working in the Equipment Panel Assembly. Failure to do so may cause electrical shock, resulting in serious personal injury or death.

INCOMING POWER

Power enters the machine at the Main Circuit Breaker on the Equipment Panel Assembly. Then it goes to the Interface Transformer. The proper AC power voltage requirement is indicated on the label outside of the Equipment Power Assembly. Execute the following steps to begin troubleshooting the electrical system:

1. Insure that the correct voltage is supplied to the machine. If not, refer to the Power Distribution Block Diagram (see Figure 9.3, Page 9-6) for the proper jumper configuration.
2. Turn on the Main Circuit Breaker at the Equipment Panel Assembly. Measure the incoming power at the main pairs of terminals 1L1, 1L2, and 1L3.

Machine	Reading
208VAC	187 - 229VAC
230VAC	220 - 240VAC
460VAC	415 - 506VAC

3. Measure the input voltage of transformer T1. The voltage should be the same as between the fuses (1L1, 1L2, and 1L3). Make sure the transformer jumpers agree with voltage input. See Jumper Chart for T1 on System Wiring Diagram (see Figure 9.16).

The inputs to T1 are:

Wire Number	Machine
1L2, 1L3	208/230/460VAC, 60Hz

4. Measure the output voltage from T1:

Wire Number	Machine
1, 2	110 - 120VAC

If the output voltage is not correct, repair the connection(s) or replace T1.

POWER SUPPLIES

1. Turn on the power and locate the terminal strip for the Drive Power Supply. Measure the following voltages:

Wires	Readings
20 to 2	115VAC
21 to 2	115VAC

If the 72VAC is present, but the 105VDC is not, check Fuses 9 and 10.

- NOTE -

This power supply will not work without a 10% load on the +5VDC output. Insure that a hard drive is plugged in when taking readings.

2. The LCD monitor in the front panel is self-contained; the only supply voltage is 115VAC on the power cord at the back of the unit. If this voltage is present and the LCD is still black, check to insure that the power OFF-ON switch is in the ON position. Also, this unit contains a fuse on the 115VAC line. Insure that the fuse is in good working order.

Troubleshooting Suggestions:

if:

MONITOR IS DEAD

- Check voltages
- Check power-on switch
- Check internal fuse
- Check power cord
- Insure brightness thumbwheel is turned up

MONITOR HAS RASTER BUT NO VIDEO

- Check LCU for power
- Check that video cable is plugged into monitor

MONITOR IS DARK

- Adjust the brightness control

MONITOR WILL NOT SYNCHRONIZE

- Adjust the horizontal or vertical hold control

MONITOR DISPLAY MESSAGE: NO BOOT DEVICE AVAILABLE.

- Check voltage on the floppy disk drive
- No system disk in the drive unit
- Check the signal cable from the Pentium to the floppy disk drive

THE MACHINE DID NOT PASS THE START-UP TEST

- BMDC hardware check failed
- BMDC software load failed

SPINDLE FAILURE

- DANGER -

Lethal voltages are present in the Equipment Panel Assembly, even when the Main Circuit Breaker is off. Use EXTREME CAUTION whenever working in the Equipment Panel Assembly. Failure to do so may cause electrical shock, resulting in serious personal injury or death.

1. If the spindle has stopped abruptly, check to see if the spindle overload (MOL) has tripped. If it has, give the heaters in the device a chance to cool and reset it by pushing the red RESET button. Make sure that all connections from the power line to the spindle motor are tight.
2. If the spindle will not start after a move has been completed, check the lubricant level. If the machine has enough lubricant, then the lube level float switch may be bad.
3. If the spindle stops turning as soon as the Spindle Control Switch is released, the reversing contactor may be at fault.
4. Check all contacts to the logic boards and terminal strips.
5. If the spindle motor still will not turn, check the power coming into the motor at the motor terminals, T1, T2, and T3 (assuming that the electrical power test has been completed). The spindle motor itself may be at fault.
6. The spindle motor cannot reverse direction if the reversing contactor is defective.

OVERLOAD

Relay Tripout

Power to the motors may be disabled by a break in the overload relay. This may be restored by pushing the blue RESET switch located to the right of the relay in the Equipment Panel Assembly. Follow this procedure:

1. Turn the power OFF.
2. Wait 5 minutes.
3. Try the RESET by pushing in the switch. If it doesn't work, wait another 5 minutes and try again.
4. Insure that all connections from the power line to the spindle motors are tight.
5. Power should be restored to the motors. If the relays trip out more than twice, make sure the feedrate matches the type of material you are cutting.

Axis Preventive Maintenance Procedures

ITEM	PROCEDURE	TIME
Motor Brushes and Commutator	Check the brushes for wear and arcing. Replace brushes, if necessary. Check the commutator for wear and arcing (Wear is greatly dependent upon application).	Semiannual
Positioning Accuracy	As a normal manufacturing procedure, check the parts made. Check the electrical positioning accuracy and the mechanical machine accuracy.	As Required
Voltage Checks	Check voltages as listed in INCOMING POWER, Page 9-3, and perform steps 1 through 4. After completion, check voltages as listed in POWER SUPPLIES, Page 9-4, and perform steps 1 and 2.	Semiannual

Axis Troubleshooting Table

SYMPTOM	POSSIBLE CAUSE
Brush Or Commutator Failure	Current limit is inoperative or improperly set
	There is high current due to injected electrical noise at the transducer input to the servo.
	The motor is over-speeding.
Power Transistor Failure	The fault sensor is defective.
	Switching logic is defective on the printed circuit board.
Contouring Inaccuracy	Gains of all axes are not identical.
	There is servo current limiting in contouring speed range.
Inadequate Performance	The required accelerating current is not available.
	There is excessive lost motion such as backlash or windup.
	There is low frequency mechanical resonance (check by observing open loop response).
Position Overshoot	The current limit is too low, or the tachometer gain is too low.
Poor Surface Finish	The position loop gain is too high.
	The tachometer is noisy.
	There is a defective feedback device or device excitation.
	A machine drive member is defective.
	Machine tooling is defective.
No Motion (All Axes)	The customer's protective interlocks are set.
	The main circuit breaker is tripped.
Over-Current Fault (1 Per Axis)	There is an armature circuit fault.
	The current limit is inoperative or set too high.
	The armature is shorted to ground.
Instability During Power Enable	The position or velocity transducer signal is reversed or the armature wires are reversed.
	The velocity command is not correct.
	The position or velocity transducer signal is lost.
	A printed-circuit board is defective.
Instability	The axis is not tuned properly.
	The position loop gain is too high.
	The lag capacitor is too small.
	The high frequency gain is improperly set.
	Multiply position loop gains are improperly adjusted (if they are used in the controller).

SYMPTOM	POSSIBLE CAUSE
Instability Manifested By Low Amplitude And/Or Frequency Oscillation	There is high static to running friction action.
	Backlash or deadband is present in the machine or transducer.
Positioning Accuracy	High friction is present.
	Position loop gain and/or low frequency gain of velocity loop is low.
	There is backlash or wind-up in the position transducer/motion connection.
	The tool reaction forces are too high to be consistent with high accuracy.
	Pulley is loose on motor shaft.
	Encoder output not accurate.
Positioning Cycle Time Too Long	The final position is overshot.
	The speed is low.
	Current limit is set too low.
Excessive Machine Wear	Current Limit is set too high or is inoperative.
	The ripple current in the motor is too high due to noise injected from the transducers.
Motor Overheats	The friction level is too high.
	Current limit is set too high or is inoperative.
	There is a noise from the transducers that is being injected into the servo.
	The duty cycle is too severe.
	The inertia is high.
	There are high tool reaction forces requiring high motor current.
	Permanent magnet fields have been demagnetized, causing high armature current to develop torque.
Poor Speed Regulation Top Speed	Friction is too high.
	The motor is incapable of operating at the speed being commanded.
Axis-To-Axis Speed Interaction	Power supply capacitance is too small, allowing voltage to dip during motor acceleration.
	Incoming AC line voltage is dipping during acceleration of the motor and allowing the DC volt bus to drop.
	High friction of inertia load is pulling the DC volt bus low.
	Poor ground connection.
	The rectifiers are bad or there is some other problem causing the rectification in the power supply to be half wave rather than full wave, creating a low voltage +128 volt bus under load.
Erratic Motor Operation	Noise is manifested in the motor current introduced into the servo by transducers.
	There is poor grounding or there are loose connections.
	There is a jump on startup or shutdown due to improper interfacing.

- NOTES -

- NOTES -

CHAPTER 10 - AUXILIARIES SYSTEM

INTRODUCTION

The first section of this chapter supplies general information concerning the EZPLUS Milling Machine auxiliaries system. The following pages provide adjustment procedures and parts replacement information for the pneumatic and lubrication systems in the milling machine. Vendor information, specifications and replacement part numbers are also included.

LUBRICATION SYSTEM

OVERVIEW

The bearings in the spindle, the spindle drive transmission, and the ballscrew mountings have antifriction angular contact bearings greased for life.

The moving members are all fed from a central lubricating tank, which contains a filter and motorized timed plunger pump.

Approved Lubricants

(The viscosity range is 150 to 8000 SUS at operating temperature.) The following lubricants or equivalents are approved for use in the automatic lubrication system.

Gulf Oil Corp.	Gulfway 52 and subsidiaries
Mobil Oil Corp.	Mobil Vactra Oil No. 2
Shell Oil Company	Tonna 68
Sun Oil Corp.	Sunoco Way Lubricant 1180
Texaco Inc.	Way Lubricant D

LUBRICATOR UNIT

- NOTE -

When starting a new machine, fill reservoir. It has a 1 quart (1 liter or 1000 cu cm) refill capacity (see Figure 10.1). Pull and release the “Instant Feed” button at the top of the reservoir several times until the oil flows freely on all bearing surfaces.

Figure 10.1 - Lube Unit Mounted on Left Side of Machine (1 Qt Capacity)

MAINTENANCE

1. Check the oil level daily and refill the reservoir when required.
2. Check the system periodically for loose or broken tubing, worn hoses, and loose fittings and connections.
3. Check the bearing surfaces daily. If there is too little oil, check the following and repair as necessary:

   A. Low oil level

   B. Broken, cracked tubing

   C. Loose connections

   D. Flattened lubricator outlet tube

   E. Clogged filter

MOTOR REPLACEMENT

1. Remove the motor cover and the two screens holding the motor to the top of the reservoir.
2. Replace the motor (Code No. 1-141-7850).
3. Upon reassembly, ensure the slot in the motor shaft is engaged with the pin in the drive shaft before replacing the screens.

SPECIFICATIONS

- NOTE -

When ordering, Specify Lubricator Type and Part Number such as: Lubricator Type TM-5, Part Number D-2994.

Operation

Lubricator is a motor-driven piston pump, spring-discharge type. Pump cycle time is controlled by an integral gear reduction in the motor. Lubricator can be actuated manually by raising and releasing the Instant Feed Button. Available cycle times are shown in the above table.

Discharge Volume Per Cycle

Adjustable from 2.5CC minimum to 5.0CC maximum. The lubricator is supplied at the maximum stroke setting. To reduce oil delivery, remove the lockscrew, measure “A” (see Figure 10.2), and turn adjusting screw clockwise, increasing “A” in the increment (corresponding to the desired discharge), as shown below.

INCH	DISCHARGE
0.400	2.5CC
0.320	3.0CC
0.240	3.5CC
0.160	4.0CC
0.080	4.5CC
0.000	5.0CC

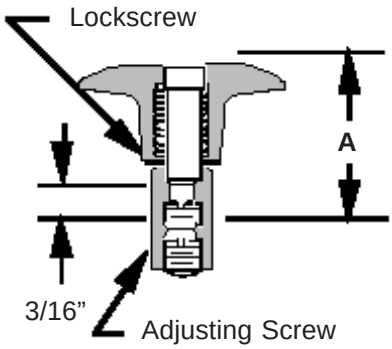


Figure 10.2 - Setting Discharge Volume

Discharge Pressure

60 PSI maximum. Peak system pressure will decrease when the discharge volume decreases, the number of Meter-Units in system increases, or the oil viscosity decreases.

Oil Viscosity Range

150 to 8000 SSU at operating temperature.

Lubricator Filter

40 micron particle separation. It should be inspected periodically and cleaned or replaced as required.

Distribution System

Use Type F Meter Units limitations. The maximum number of meter units possible is 70. For system flow value (t) limitations, refer to the table below.

		CC'S PER CYCLE				
		2.5	3.0	4.0	5.0	
NUMBER OF METER-UNITS	5		700	800	800	MAXIMUM PERMISSIBLE SYSTEM FLOW VALUE, t
	10		550	680	750	
	15		440	520	650	
	20		360	460	520	
	25		320	400	450	
	30		275	325	390	
	40		210	245	290	
	50		155	185	220	
	60		110	135	160	
	70		70	85	96	
		MAXIMUM PERMISSIBLE FLOW VALUE				

Motor

Continuous duty, single-phase, synchronous induction timing motor for 50/60 Hz, dual wound for 115/230VAC. Power consumption is 3 watts.

For correct wiring, see instruction tag attached to the lubricator.

Bijur reserves the right to change motor size, mounting dimensions, and/or manufacturer.

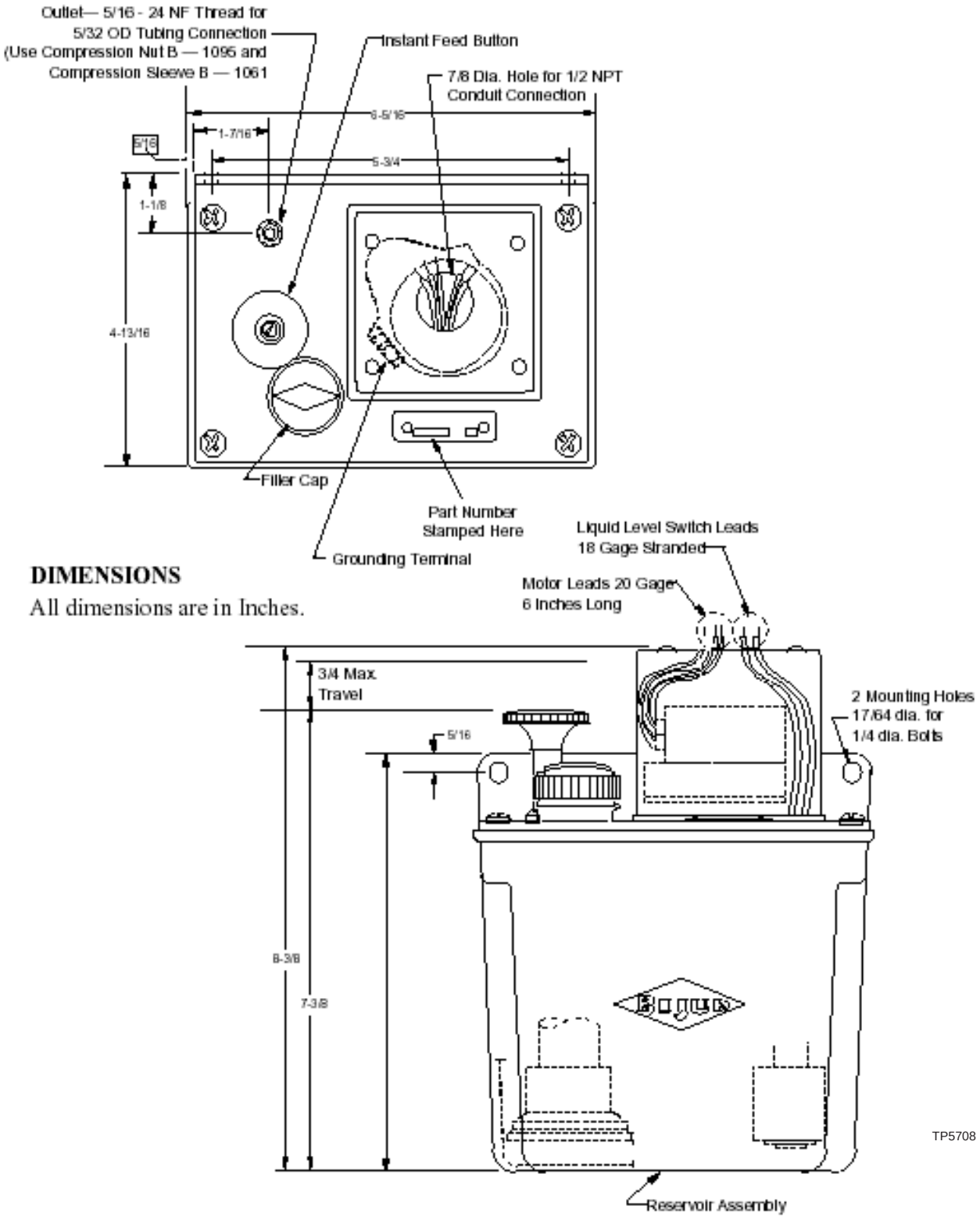
Liquid Level Switch

The liquid level switch will close an electrical circuit whenever the oil in the reservoir is above the minimum operating level. Thus, when connected to a light or other indicating device, the liquid level can be monitored.

Customers may reverse the operation when desired by inverting the float. When the float is reversed, the switch will close an electrical circuit whenever the oil level is below the minimum operating level.

- NOTE -

Switch contact rating is 10 watts maximum (light or indicating device not supplied by Bijur).



DIMENSIONS

All dimensions are in Inches.

Figure 10.3 - Bijur Lubricator Unit, Type TM-5, Part Number D-2988

Lube Specification

GENERAL DESCRIPTION

Waylube - must contain tackiness additives; must not contain lead or chlorine compound additives

USES

Machine tool way, heavy loaded journals, and screws

Lubricant specifications listed here are minimum standards which must be met by all lubricants recommended for use on the machine. For specific applications to the machines, see lubrication sheets for individual machines.

LUBRICATION SPECIFICATIONS			
			WAYLUBE
ASTM OR ABLE LUBE NUMBER			315
VISCOSITY S.U.S.		100° F	283 / 347
		210° F	-
V.I. - MINIMUM			-
FLASH POINT - ° F MINIMUM			350
POUR POINT - ° F MAXIMUM			0
MAXIMUM OP. TEMPERATURE - ° F			150
ADDITIVES OR INHIBITORS			R.F.S.
TEST REQUIREMENTS			
TIMKIN O.K. LD. - MINIMUM			
OXIDATION	ASTM D-943	MINIMUM HOURS	-
		NEUTRAL NUMBER CHG.	-
	ASTM D-943 MODIFIED		-
CU. CORROSION - ASTM - D-130 STAIN			-
ABLE ACCELERATED BREAKDOWN TEST			5
FOAM - ASTM D-892			2
EMULSION - ASTM - D-1401			-
BIJUR DIFFERENTIAL FILTRATION TEST			PASS
EVAPORATION ROCKWELL TEST			6
STICK SLIP RATIO - CMM TEST - MAXIMUM			.85
RUST - ASTM D-665A			PASS

- NOTES -

- NOTES -

CHAPTER 11 - OPTIONAL EQUIPMENT

INTRODUCTION

The following optional equipment is available for the EZPLUS Milling Machine system:

TOOL KIT

These options contain a basic tooling package composed of collets and corresponding tool holders, a locking fixture for assembly of cutters in the holder, and appropriate wrenches. Consult with a sales representative for full details.

COOLANT SYSTEM - FLOOD

With the coolant system option, the coolant will be turned ON/OFF with the spindle. A separate coolant switch is provided.

All coolant systems must be ordered as Coolant Tank Kits and as Nozzle Assemblies, either separate or installed. The tank units are designated as 115/1/50 or 115/1/60 units, and all heads will have one flood nozzle.

FLOOD COOLANT RATINGS

Electrical	Transformers 115V secondary and Triac (4ASB fuse)
Motor	115 volts, 1-phase, 50/60 Hertz, 3450 RPM
Flow	3 GPM at 6 ft. head (water soluble oil)
Tank Capacity	15 Gallons

MACHINE OPTIONS

DESCRIPTION

*Erickson #30 Quick-Change Spindle (Installed) (*Not available with 3rd Axis Option)

*Universal #200 Kwik-Switch Spindle (Installed) (*Not available with 3rd Axis Option)

Export Crating

Chip Floor Pan and Splash-Back Mist Coolant System

Flood Coolant System (Includes Chip Floor Pan and Splash Back)

Machine Work Light

Collet Tray

MISCELLANEOUS OPTIONS

CODE	DESCRIPTION
12570575	2 Axis Power Drawbar Kit for R-8 Spindle
12570990	3 Axis Power Drawbar Kit for R-8 Spindle
12570578	Power Drawbar Kit for Erickson #30 Quick-Change Tooling
12490000	R-8 Collet Kit (11 collets, 1/8 to 3/4)
11570003	#30 Tool Holder Kit
11570550	H-1 Erickson #30 Quick-Change Tooling Kit
11570551	H-10 Erickson #30 Quick-Change Tooling Kit
11576093	Erickson #30 Quick-Change Wrench Kit
11749046	Full Table Chip and Coolant Shield
11680000	Kurt Plain D-60 Vice
11680002	Kurt Swivel Base for D-60 Vice
13380000	Special Paint

MANUALS

- NOTE -

One set of manuals is included with each machine.

CODE	DESCRIPTION
11042909	Operating and Programming Manual
11042910	Installation, Operation, Maintenance, and Parts Breakdown Manual

- NOTES -

- NOTES -

CHAPTER 12 - EZPLUS THIRD AXIS OPTION

INTRODUCTION

With an optional attachment, the Z axis on EZPLUS Milling Machines may be fully automated while still allowing the operator the choice of manual control. The Third Axis Option basically consists of a Z axis motor and ballscrew which mount on the front of the quill (See Figure 12.1).

This chapter describes the parts breakdown and retrofit installation procedure for the Third Axis Option.

- NOTE -

Retrofit can only be done by a qualified service technician.

Retrofit can only be done on controls with Third Axis capabilities, consisting of a Third Axis equipment panel and a knockout in the electrical cabinet for Z Axis power cable.

Installation of the Third Axis Option will alter the following specification:

Quill travel is reduced by 0.5 inches for a total of 4.5 inches.

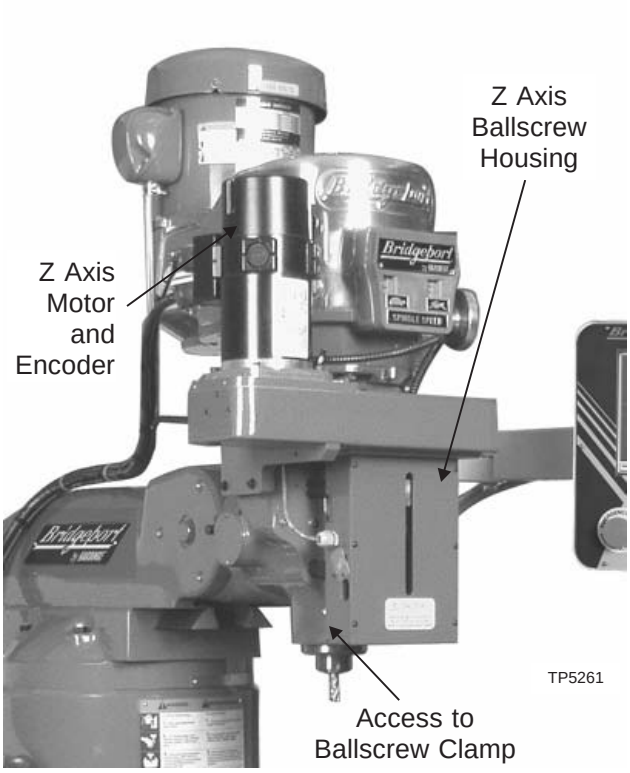


Figure 12.1 - Mounted Third Axis Option

Retrofit requires modifications in the mechanical and electrical configurations of the machine. The basic steps in the retrofit procedure include: assembly of the Third Axis unit, assembly of the unit on the machine, rewiring the control in the electrical cabinet, and installation of the proper software.

OPERATION

The Third Axis Option enables the machine to be operated in either 2 axis or fully automated 3 axis mode. Changing the operating mode of the machine from 2 axis to 3 axis, or vice versa, is done by adjusting a clamp on the Z axis ballscrew inside the boxlike housing. Access to the clamp is through a small hole on the left side of the box, covered by a hinged metal flap. The clamp must be torqued to 22 ft/lbs using a torque wrench provided with the machine. The operator is prompted to make this adjustment by messages on the control panel screen.

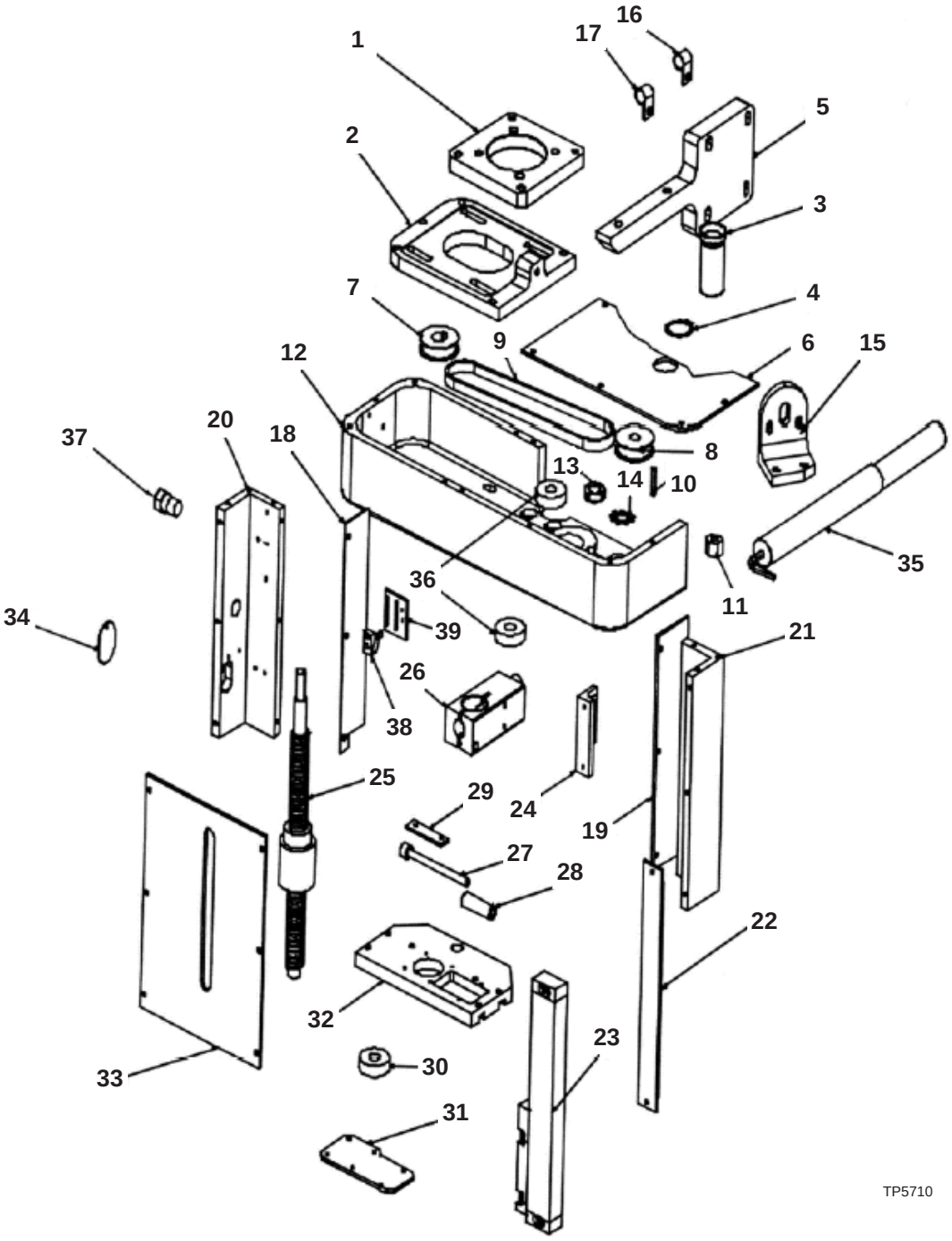


Figure 12.2 - Exploded View of Third Axis Option Assembly

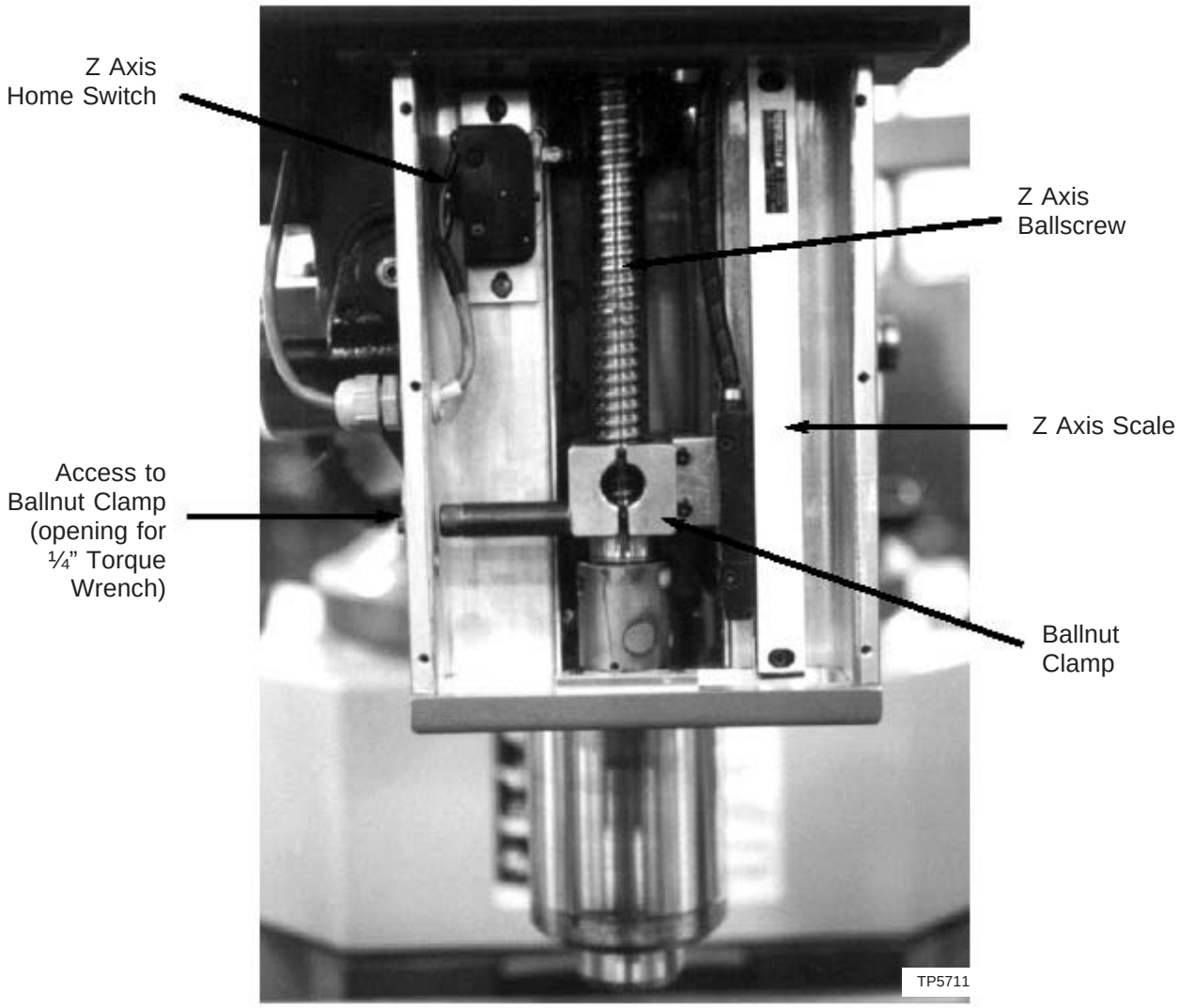


Figure 12.3 - Z Axis Ballscrew Housing with Front Cover Removed

THIRD AXIS OPTION ASSEMBLY, MODEL # BPQUIC, ITEM # 11749400

ITEM#	DESCRIPTION	QTY
1	Plate, Adaptor, Nema 42	1
2	Plate, Motor Mount	1
3	Tube, Cable Scale	1
4	Tube, Circlip	1
5	Plate, Left Mount	1
6	Cover, Top	1
7	Motor, Pulley	1
8	Ballscrew, Pulley	1
9	Belt	1
10	Key, Square, 1/8”	1
11	Nut, Front, 3/8”-16	1
12	Casting, Top	1
13	Nut, Lock	1
14	Washer, Lock	1
15	Angle, Right Mount	1
16	Clamp, Cable	1
17	Clamp, Cable	1
18	Cover, Left Chip	1
19	Cover, Right Chip	1
20	Angle, Left	1
21	Angle, Right	1
22	Spar, Scale	1
23	Scale, Fagor	1
24	Carrier, Reader Head	1
25	Ballscrew, with Ball Nut	1
26	Block, Ballnut	1
27	Screw, Socket Hd Cap, 5/16”-24 with 1/4” E Clip	1
28	Tube, Spacer	1
29	Block, Spacer	1
30	Bearing, Radial	1
31	Plate, Access	1
32	Plate, Bottom	1
33	Cover, Front	1
34	Plate, QD Access	1
35	Wrench, Torque with Holder	1
36	Bearing, Thrust	2
37	Relief, Strain	1
38	Switch, Limit	1
39	Plate, Limit Switch Mount	1
40	Screw, Socket Hd Cap, #6-32 x 5/8”	3

ITEM#	DESCRIPTION	QTY
*	Screw, Socket Hd Cap, 3/8”-24 x 1-1/2”	1
*	Nut, 1/4”-20	5
*	Screw, Pan Head, 1/4”-20 x 2-1/2”	1
*	Screw, Socket Hd Cap, 1/4”-20 x 1-1/2”	4
*	Screw, Socket Hd Cap, #10-24 x 1-1/4”	6
*	Screw, Button Hd Cap, #10-32 x 3/8”	5
*	Screw, Socket Hd Cap, #10-32 x 5/8”	2
*	Screw, Socket Hd Cap, #10-32 x 3/4”	17
*	Screw, Socket Hd Cap, #10-32 x 1”	8
*	Screw, Hex Hd, #8-32 x 3/8”	6
*	Screw, Flat Hd Cap, #8-32 x ½”	3
*	Screw, Socket Hd Cap, #8-32 x 3/4”	2
*	Set Screw, #10-32 x ½”	1
*	Screw, Button Hd Cap, #8-32 x 3/8”	8
*	Screw, Socket Hd Cap, #4-40 x 1/4”	6
*	Screw, Socket Hd Cap, #4-40 x 3/8”	6
*	Screw, Button Hd Cap, #2-56 x 3/8”	2
*	Screw, Socket Hd Cap, #6-24 x 3/4”	4
*	Screw, Socket Hd Cap, 5/16”-18 x 1-1/2”	2
*	Washer, Flat, #10	11
*	Washer, Hard, #10	6
*	Washer, Hard, ½”	1
*	Nut, 7/16”-14	1
*	Screw, Flat Hd Cap, 7/16”-14	1
*	Window, Plexiglass, 1/16” Thick	1

* Item location not specified in illustration of Exploded View of Third Axis Option Assembly.

MECHANICAL INSTRUCTIONS FOR MACHINE PREPARATION

1. Put the quill feed engagement lever in the disengaged position.
2. Remove the quill feed handle.
3. Leave the spindle in the disengaged position.
4. Remove the (3) socket head cap screws on the feed disengage boss.
5. Remove the reverse trip ball lever on the top of the stop screw. (This is the part that looks like an hour glass with a tapped hole in the end.)
6. Remove the engagement lever on the bottom of the same rod.
7. Remove the circlip on the bottom of the screw and slide it out through the bottom while screwing the depth ring off from the top.
8. Remove the original depth stop block from the quill.
9. Slide the feed kick-out rod out.
10. Remove the quill feed transmission cover on the left side of the head. This is the cover that is used to adjust the quill feed.
11. Tram the head of the mill.
12. Change the brake handle position from the round knob at the bottom to the round knob at the top.
13. Remove the front swivel belt housing nut that fastens the top belt housing to the lower quill housing and replace it with the longer nut provided. (This nut is up and to the left if the retrofitter is standing in front of the head.)
14. Remove the paint from the bottom of the flange where the depth rod was removed from and also the wall that is perpendicular with it (see Figure 12.4).
15. Using an indicator, rotate the turret and indicate using the X axis until this wall is parallel with the X axis (see Figure 12.5).
16. Retighten the turret.

Figure 12.4 - J-Head Housing

Figure 12.5 - Indicating off of Dovetail of Ram

QUILL UNIT INSTALLATION

1. Locate the ballnut block and the socket head cap screw (3/8”-24 x 1-1/2”) that fastens it to the quill. Insert the screw into the block and measure the length of its protrusion on the opposite end of the block. The screw should not protrude any longer than .465” out of the block. If it does, file or grind the end of the screw until this dimension is obtained.
2. Fasten the supplied ball nut block to the quill using the supplied socket head cap screw. The tapped hole is at the bottom. Torque to 35 ft/lbs. (see Figure 12.6).
3. Install the left chip cover on the inside of the left angle on the lower assembly. The correct placement is with the large notch to the bottom. Use (3) of the (6) hex head bolts (#8-32 x 3/8”) supplied.
4. Place the lower assembly underneath the flange you scraped.
5. Place the flat head cap screw (7/16”-14 x 2”) through the lower assembly and the lower flange.
6. Place the supplied hard washer and nut on the exposed end of the screw and tighten it just enough to hold it in place.
7. Place the quill in the middle of its travel.
8. Place the installation tool in the bottom of the ball nut block and tighten the socket head cap screw (5/16”-24 x 3-1/4”) firmly to hold it in place.
9. Roll the quill down until the installation tool is close to the bearing bore in the bottom assembly (see Figure 12.7).
10. Remove the bearing access plate in the bottom of the lower assembly.

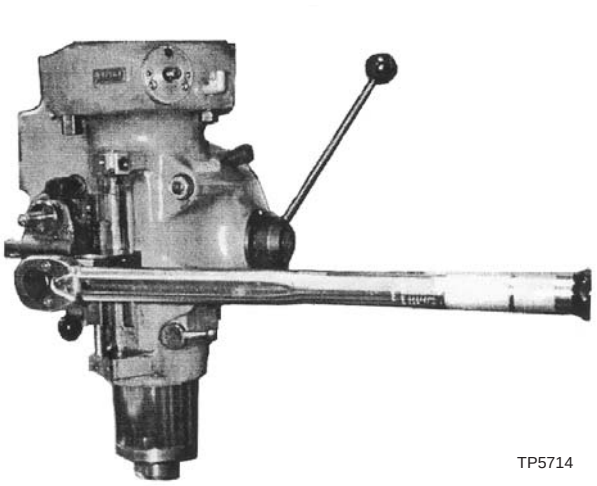


Figure 12.6 - Torque of Ballnut Bracket on J-Head Housing

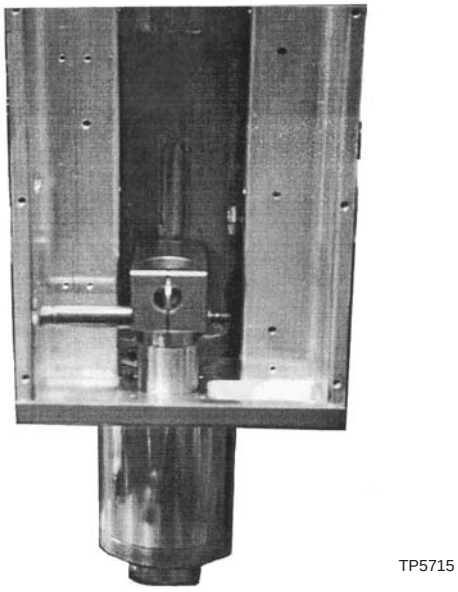


Figure 12.7 - Ballnut Bracket and Third Axis Lower Housing

11. Carefully roll the quill down and place the installation tool into the bearing bore; this is a 2-part operation. The bottom assembly has to be positioned under the tool while rolling the quill down to achieve your goal.
12. Keep the quill in the lower position using the lock lever.
13. Position an indicator on the front face of the bottom plate of the lower assembly.
14. Move the X axis plus and minus and rotate the lower assembly until the plate is parallel with the table. (or no movement on the indicator is detected).
15. Leave the indicator on one end of the plate at zero.

16. Tighten the screw with a hex wrench on the head of the screw while holding the nut with a combination wrench. Watch for any movement on the indicator detecting the lower assembly is twisting out of alignment (see Figure 12.8).
17. If this condition starts to happen, unlock the quill lever and roll the quill up to the top position. Hold the screw head secure using a hex wrench and tighten the nut with a combination wrench from the top.
18. Unlock the lever and roll the quill down to the center of the travel once again.
19. Loosen the socket head cap screw on the ball nut block and place the installation tool in from the top of the ball nut block.
20. Retighten the socket head cap screw.
21. Lubricate one 7201 bearing using the lithium type grease supplied.
22. Install the 7201 bearing with the thrust side facing down in the upper bore of the top housing.
23. Place the top housing on the top of the lower assembly (see Figure 12.9).
24. Fasten the two together using the supplied socket head cap screws (#10-32 x 1”) and hard washers, but tighten only enough so that the top housing can be moved around.
25. Roll the quill up until the installation tool is close to the bearing bore in the bottom of the top housing.
26. Move the top housing until it is approximately over the installation tool.
27. Carefully try to roll the quill up and move the top housing until the installation tool slides into the bearing bore.

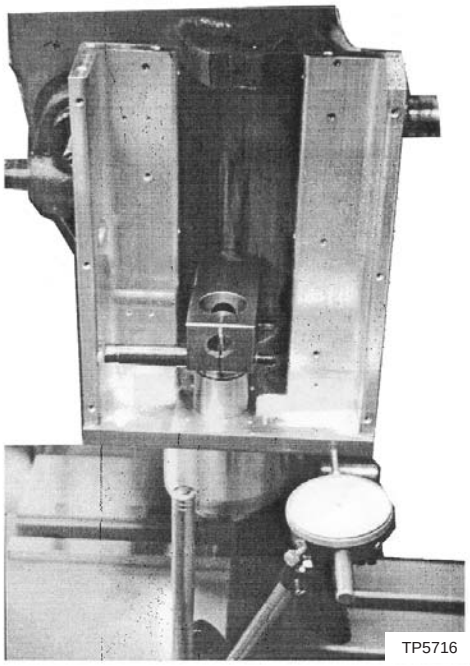


Figure 12.8 - Zeroing in the Third Axis Lower Housing

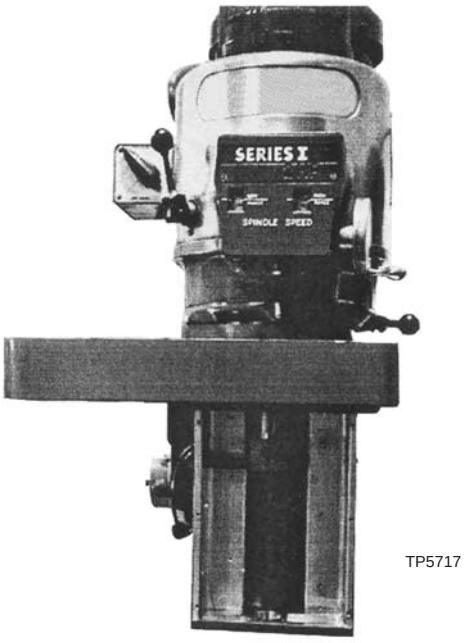


Figure 12.9 - Installation of Upper Housing

28. Place the right mount angle inside the top housing on the machined surface and attach to the front of the feed disengage lever boss, then fasten the base of the angle to the floor of the top housing (see Figure 12.10).
29. Rotate the top housing until the tapped holes line up with the holes in the base of the mount.
30. Carefully remove the mount and tighten the (6) socket head cap screws securely.
31. Place the feed disengage mount back in place and fasten it to the front of the flange using the (2) socket head cap screws and (2) hard washers supplied.
32. Fasten the base of the flange to the top housing using the (2) socket head cap screws and (2) hard washers supplied.
33. Place the supplied set screw (#10-32) into the side of the mount and firmly snug it against the shaft of the feed disengage lever holding it in the disengaged position.
34. Place the left side brace over the open cavity where the transmission feed cover was removed (see Figure 12.11).
35. The correct position is with the 45° angle in the front to the bottom and pushed up against the milled surface on the bottom of the top housing.
36. Fasten it to the head using (4) socket head cap screws (#10-24 x 1-1/4") and hard washers supplied.
37. Fasten the left brace to the top housing using the (2) socket head cap screws (5/16"-18 x 1-1/4") and washers supplied. Fasten the screws from inside the top housing into the brace.

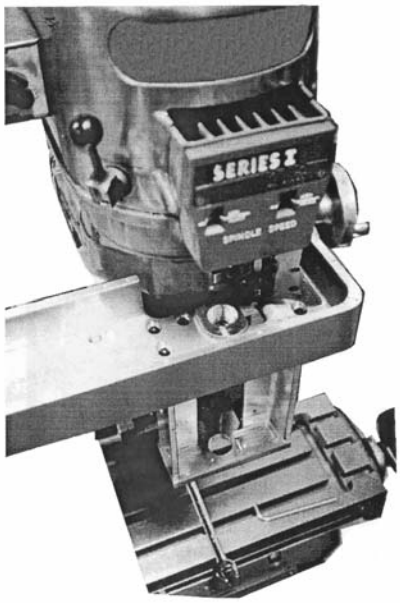


Figure 12.10 - Installation of Upper Housing

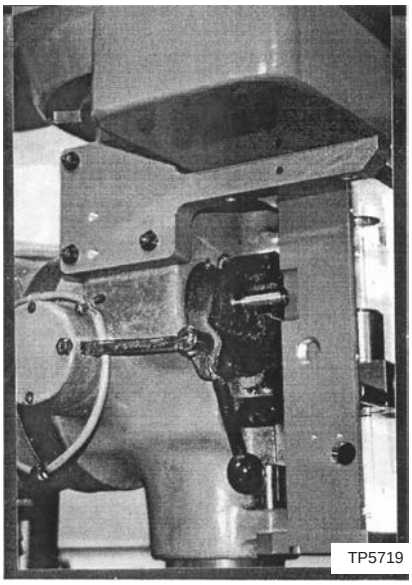


Figure 12.11 - Installation of Left Bracket Housing Support

38. Unpack the Fagor Scale and remove the small T9 screw in the shipping clip. Install the Fagor Scale through the bottom plate. Make sure the cable connection is pointed up on the reader head. The scale is fastened to the spar in the lower assembly. This is accomplished using the screws (#8-32 x 3/4") and washers (4mm) supplied on each end of the scale (see Figure 12.12).
39. Feed the cable through the top housing and push on to the reader head. Do not securely fasten the cable yet.
40. Fasten the reader head mount to the ball nut block using (2) socket head cap screws (#10-32 x ½") supplied.
41. Roll the quill down to the bottom position.
42. Slide the reader head mount forward until it bears against the backside of the reader head on the scale.
43. Move the quill until the mounting holes are in line on the Y axis, and slide the scale left to right until they are in line on the X axis.
44. At this point measure the distance between the right side of the scale and the inside wall of the angle and record this number.
45. Rotate the top of the scale until the same distance is achieved.
46. Align the scale by mounting a magnetic base with an indicator on the ball nut block and adjust the right side of the scale so it is parallel with the Z axis within .005 TIR.
47. Tighten the (2) socket head cap screws (#10-32 x 5/8") to secure the reader head bracket.
48. Fasten the reader head to the reader head bracket using the (2) socket head cap screws (#8-32 x 3/4") and washers (4mm) suppled (see Figure 12.13).
49. Remove the T20 screw and the red shipping bracket on the reader head.

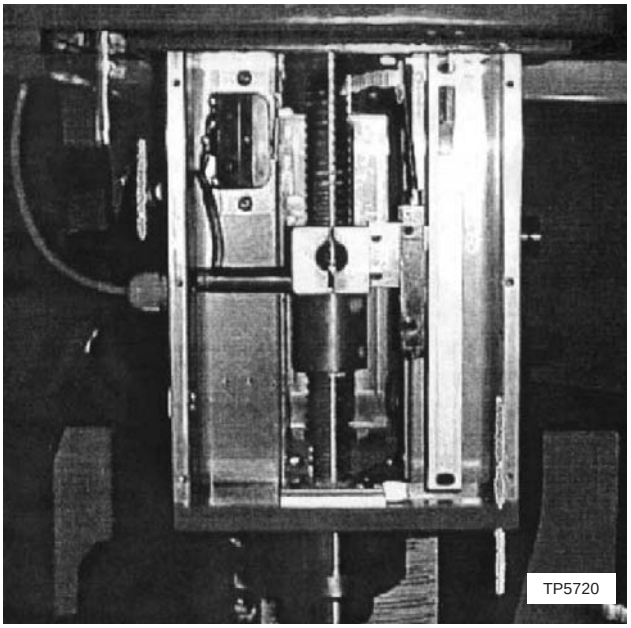


Figure 12.12 - Wiring in the Z Axis Limit Switch

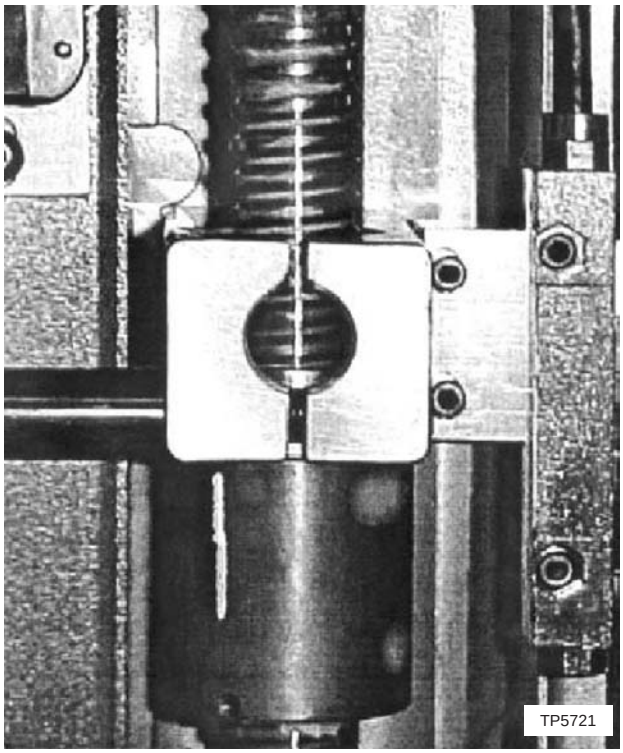


Figure 12.13 - Installation of Digital Readout Head (DRO)

50. Route the scale cable around the left side of the head making sure there is a loop at the top of the cable quill drive for travel. Install the scale cable clamps on the left side (see Figure 12.14).

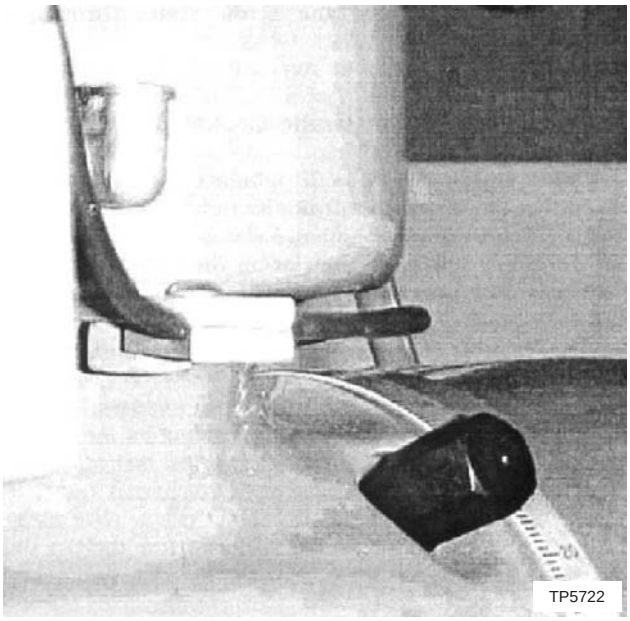


Figure 12.14 - Clamping the DRO Cable

51. Install the right chip cover from the back of the lower assembly and secure it using the remaining (3) hex head bolts (#8-32 x 3/8”).
52. Slide the black rubber pinch molding on the exposed edge of the right chip cover.
53. The quill will have to be moved up and down to permit wrench access for tightening the (3) bolts.
54. Lube the other 7201 bearings using the lithium type grease.
55. Place it in the bottom bore of the top housing with the thrust sides facing up! (Hint: If the bearing starts and gets slightly cocked, you can use the install tool in the block to help push it in the bore by simply rolling up the quill until the install tool contacts the bearing and pushes it in.)
56. Remove the installation tool from the ball nut block.
57. Place the quill in the middle of the travel.
58. Slide the ball screw assembly in from the top of the bottom plate of the lower assembly and in front of the ball nut block. Slide it through the bottom bearing hole in the lower assembly until it can be slid through the bottom of the ball nut block. Slide the ball screw assembly up until the ball nut journal engages into the bore of the ball nut. Snug the socket head cap screw (5/16”-24) to hold the screw assembly in the ball nut block.
59. Roll the quill up until the screw slides through the 7201 bearings completely.
60. Place the W01 lock washer over the top of the screw and against the top of the 7201 bearing.
61. Screw the N01 lock nut on the threads of the screw until it pre-loads the 7201 bearings.

- NOTE -

The main objective here is to tighten the nut enough to obtain little or no end play in the bearings, but not so tight that the bearings will not turn.

62. Find a tooth on the washer and slot on the nut that line up and bend the tooth in the washer into the slot on the nut.
63. Slide the 6201 bearing into the bottom of the lower assembly and on to the lower journal of the screw.
64. Re-install the bearing access plate on the bottom of the lower assembly. Fasten using the (4) button head cap screws (#4-40 x 3/8”) that were removed at disassembly.

65. Place the screw pulley (hub down) and key in place on the end of the ball screw and fasten securely.

- NOTE -

Depending on the thickness of the serial # boss, you might have to install the belt (480 5m) with the pulley at the same time (see Figure 12.15).

66. Rotate the pulley by hand until the ballnut is at the top position and place the limit switch assembly on the inside face of the left angle. Slide it so the switch trips at this position. Precise actuation can be obtained by hearing the switch trip or by using an OHM meter to detect tripping (see Figure 12.12 for limit switch placement).

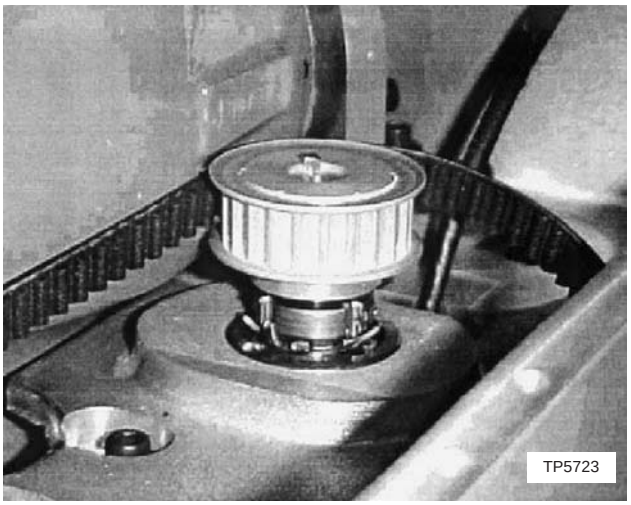


Figure 12.15 - Setting the Height of Pulley and Adjusting Belt Tension

67. Fasten securely using the (2) socket head cap screws (#4-40 x 3/8”) supplied.

68. Place the Nema adapter plate on the Servo motor and fasten using the (4) socket head cap screws (5/16”-24 x 5/8”) supplied.

69. Fasten the Nema plate and motor assembly to the motor plate using (4) socket head cap screws (1/4”-20 x 1-1/2”) and nuts. The nuts are placed in the slots in the bottom of the motor plate and the screws are placed in from the top of the Nema flange. Make sure that when the assembly is placed on the top housing the cable connector on the motor faces the back of the machine.

70. Measure the distance from the top of the top housing to the first flange on the screw pulley. Note: Record this number on a piece of paper, as it will be used for installation of the motor pulley.

71. Slide the motor pulley (hub up) over the shaft of the servo motor until the same distance is achieved from the face of the motor plate to the first flange. Secure the pulley (see Figure 12.16).

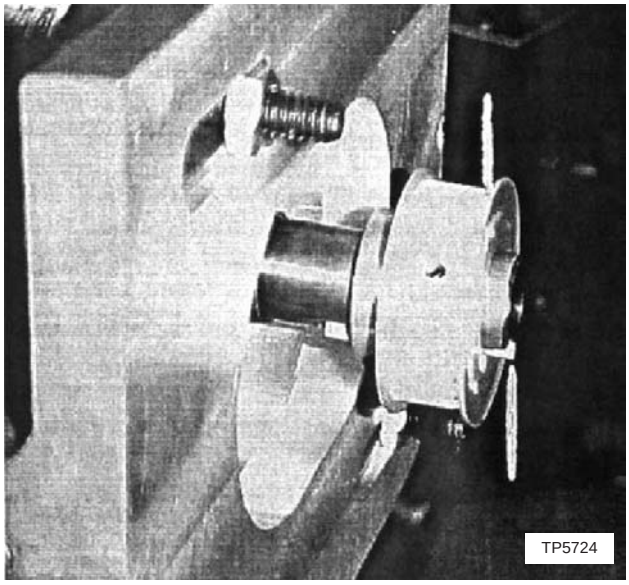


Figure 12.16 - Installation of Motor Mount Plate and Pulley

72. Holding the motor assembly in one hand, place the belt (480 5m) over the pulley with the other hand.

73. Set the assembly on top of the top housing and slide the belt over the screw pulley.

74. Position the motor plate over the mounting holes on the top housing and fasten it using the (5) socket head cap screws (#10-32 x 3/4”) supplied.

75. Screw the pan head screw (1/4”-20) against the Nema flange until the belt is preloaded with tension. Tighten the jam nut (1/4”-20) to lock the screw.

76. Remove the DRO cable from reader head and slide the cable through the top cover and fasten the top cover to the top housing using the (5) button head cap screws (#10-32 x 3/8”) supplied.
77. Install the scale cable back in the connector in the top of the reader head and this time secure it with the screws in the connector.
78. Install the strain relief in the left side of the lower assembly.
79. Slide the home switch cable through strain relief and fasten to the micro switch in the normally open position.
80. Place the bottom travel stop on the inside of the lower assembly and in line with the (2) front tapped holes. Fasten the plate to the lower assembly using the (2) socket head cap screws (#4-40 x 3/8”) supplied.

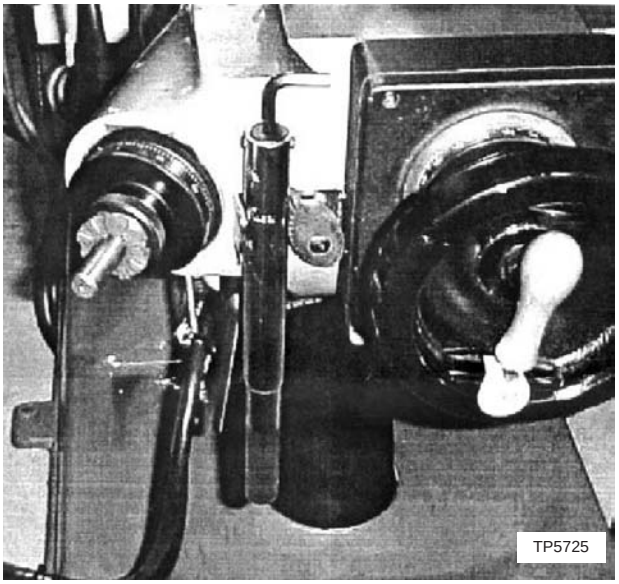


Figure 12.17 - Torque Wrench

81. Connect the motor cable to the controller.
82. Connect the home switch to the controller.
83. Connect the scale to the controller.
84. Power up controller and set software travels in + and - directions.
85. Install the E-ring (7/32”) on the right end of the socket head cap screw (5/16”-24 x 3-1/4”) in the ballnut block assembly.
86. Slowly jog the quill down the controller and apply white lithium grease on the screw above the ballnut block. Slowly jog the quill up and then down again and repeat the process until the white grease is visible on the bottom of the screw. The main idea is to fully pack the ball nut with grease. For maintenance purposes, regrease the ballscrew every 6 months or whenever it looks dry.
87. Install front cover using the (6) button head cap screws (#8-32 x 3/8”) supplied.
88. Fasten the torque wrench holder to the knee using the (2) button head cap screws (#8-32 x 3/8”) supplied.
89. Correct placement is in the front of the knee between the Graduated knee dial and Y axis bracket (see Figure 12.17).

- NOTES -

CHAPTER 13 - PARTS LISTINGS

2J-HEAD TOP HOUSING

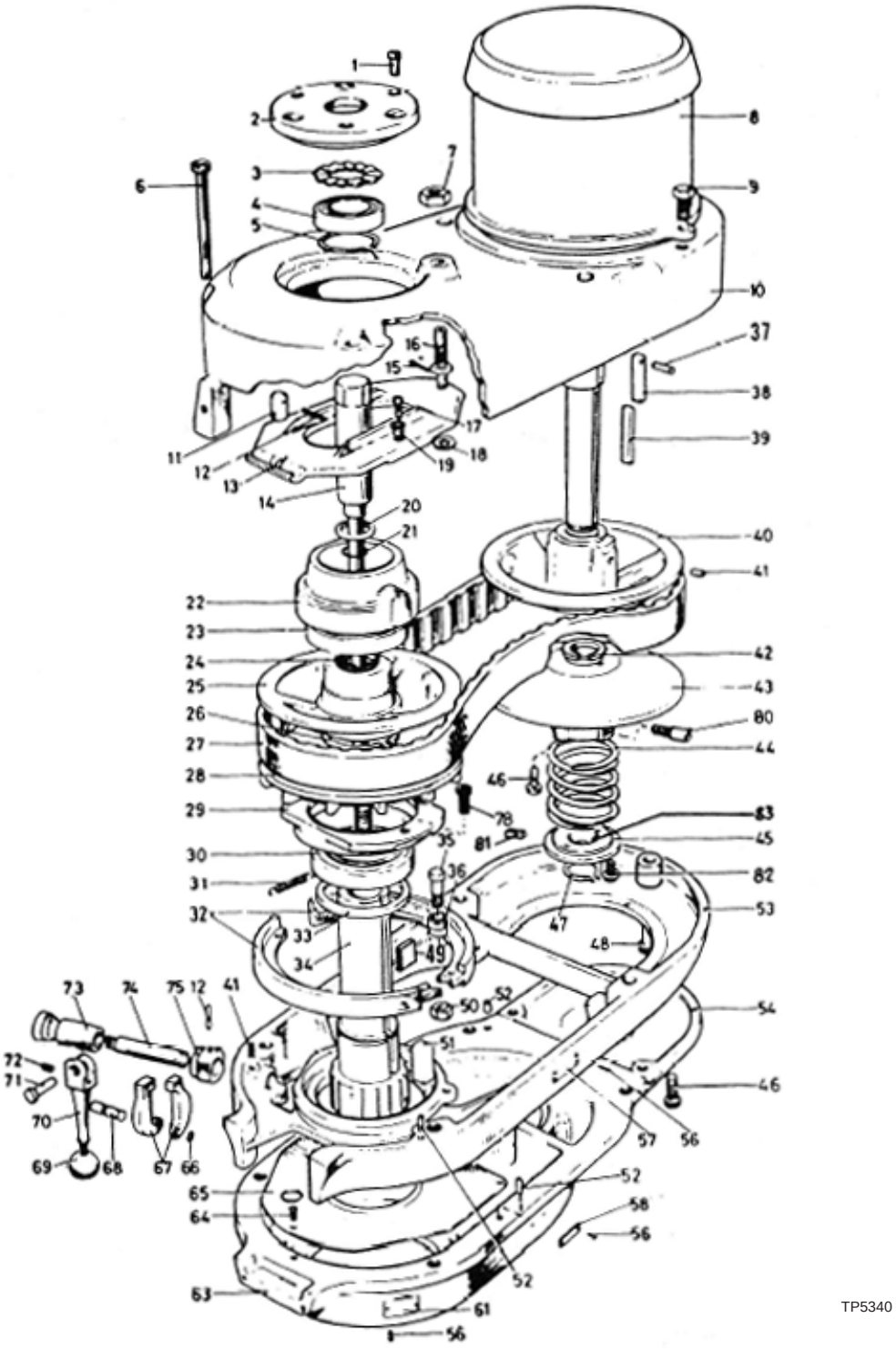


Figure 13.1 - 2J-Head Top Housing Assembly

2J-HEAD TOP HOUSING

ITEM	CODE NO	DESCRIPTION	QTY
1	11011033	Screw, Socket Hd Cap, 1/4”-20 x 3/4” Lg	3
2	12180094	Cap, Top Bearing	1
3	11181977	Washer, Wave Spring	1
4	11180252	Bearing, Ball, Fafnir #9107 NNP	1
5	11180848	Ring, Snap, #5100-137	1
6	11011069	Screw, Socket Hd Cap, 5/16”-18 x 6”	2
7	11011745	Nut, UNC Hex Jam, 3/8”-16	1
8	11550001	Motor, 2 HP, Multi-Volt, 50/60	1
9	11011148	Screw, Hex Hd Cap, 3/8”-16 x 1"	2
10*	12180051	Housing, Upper Belt	1
11	12180066	Stud, Speed Change Chain	1
12	11010535	Pin, Roll, 5/32" Dia. x 1.00" Lg	2
13	11180058	Plate, Speed Change	1
14	12184920	Assembly, Drawbar	1
15	11010606	Pin, Cotter, 3/32" Dia. x 3/4"	1
16	12180074	Stud, Speed Change Plate Pivot	1
17	11011020	Screw, Socket Hd Cap, #10-32 x 3/4”	2
18	11180095	Washer	1
19	12180089	Sleeve, Pivot	2
20	12180093	Washer, Drawbar	1
21	11180915	“O” Ring, Parker #2-14	1
22	12180056	Housing, Spindle Pulley Bearing Sliding	1
23	11170262	Bearing, Ball, Fafnir #RM9110NPP	1
24	11182124	Insert, Plastic	2
25	12183934	Varidisc, Adjustable Drive A	1
26	11180855	Ring, Retaining, #5102-156	1
27	11182120	Belt, Varispeed	1
28	12180082	Varidisc, Stationary Drive	1
29	12180043	Cap, Brake and Bearing	1
30	11170262	Bearing, Ball Fafnir #RM9110NPP	1
31	11182081	Spring, Brake	2
32	12180073	Shoes, Brake	2
33	12180078	Spacer, Spindle Pulley	1
34	12180042	Assembly, Spindle Pulley Hub	1
35	11011138	Screw, Hex Hd Cap, 1/4”-20 x 3/4"	1
36	12180071	Sleeve, Brake Shoe Pivot	1
37	11010513	Pin, Roll, .125” x .437”	1
38	12550007	Key, Drive, Fixed Varidisc	1
39	12550004	Assembly, Key, Drive, Varidisc	1
40	12550006	Varidisc, Stationary Motor	1

ITEM	CODE NO	DESCRIPTION	QTY
41	11011287	Screw, Stainless Steel, 1/4”-20 x 1/4”	2
42	11182126	Insert, Plastic Replaceable Type	2
43	12550046	Assembly, Adjustable Motor Varidisc	1
44	11182083	Spring, Varidisc Motor Shaft	1
45	11550003	Collar, Adjustable Varidisc Spring	1
46	11011022	Screw, Socket Hd Cap, #10-24 x 1.00” Lg	3
47	11150843	Ring, Snap	1
48	11011052	Screw, Socket Hd Cap, 5/16”-18 x 3/4”	1
49	11182122	Key, Plastic	1
50	11011707	Nut, Hex Jam, .250”-20	1
51	12180084	Key	1
52	12180107	Pin, Taper, #4 x 1.00"	4
53*	12180052	Base, Belt Housing	1
54	12180088	Cover, Motor Pulley	1
56	11011552	Screw, Drive, Type U, #0 x 1/4"	8
58	11182893	Nameplate, Hi-Low Range	1
61	11182894	Nameplate, Quill Feed	1
63	12180053	Housing, Gear	1
64	11011443	Screw, Round Hd Machine, #10-24 x 3/8"	3
65	11185030	Plate, Gear Housing	1
66	11180818	Ring, Snap, #5100-25	1
67	11182306	Finger, Brake Operating	2
68	12180083	Stud, Brake Finger Pivot	1
69	11192151	Knob, Bakelite, 1/4” x 20"	1
70	12190133	Handle, Brake	1
71	12190134	Pin, Brake Lock	1
72	11011260	Screw, Stainless Steel, #10-32 UNF x 1/4"	1
73	12180104	Sleeve for Brake Lock Shaft	1
74	28025521	Shaft, Brake Lock	1
75	12180069	Cam, Brake Lock	1
78	11011031	Screw, Socket Hd Cap, 1/4”-20 x 5/8"	1
80	11011016	Screw, Flat Hd Cap, #10-32 x 0.500"	1
82	11011006	Screw, Socket Hd Cap, #8-32 x 0.250"	1
83	12550008	Key	1

* Item 10 and 53 sold as assembly only

2J-HEAD BACK GEAR

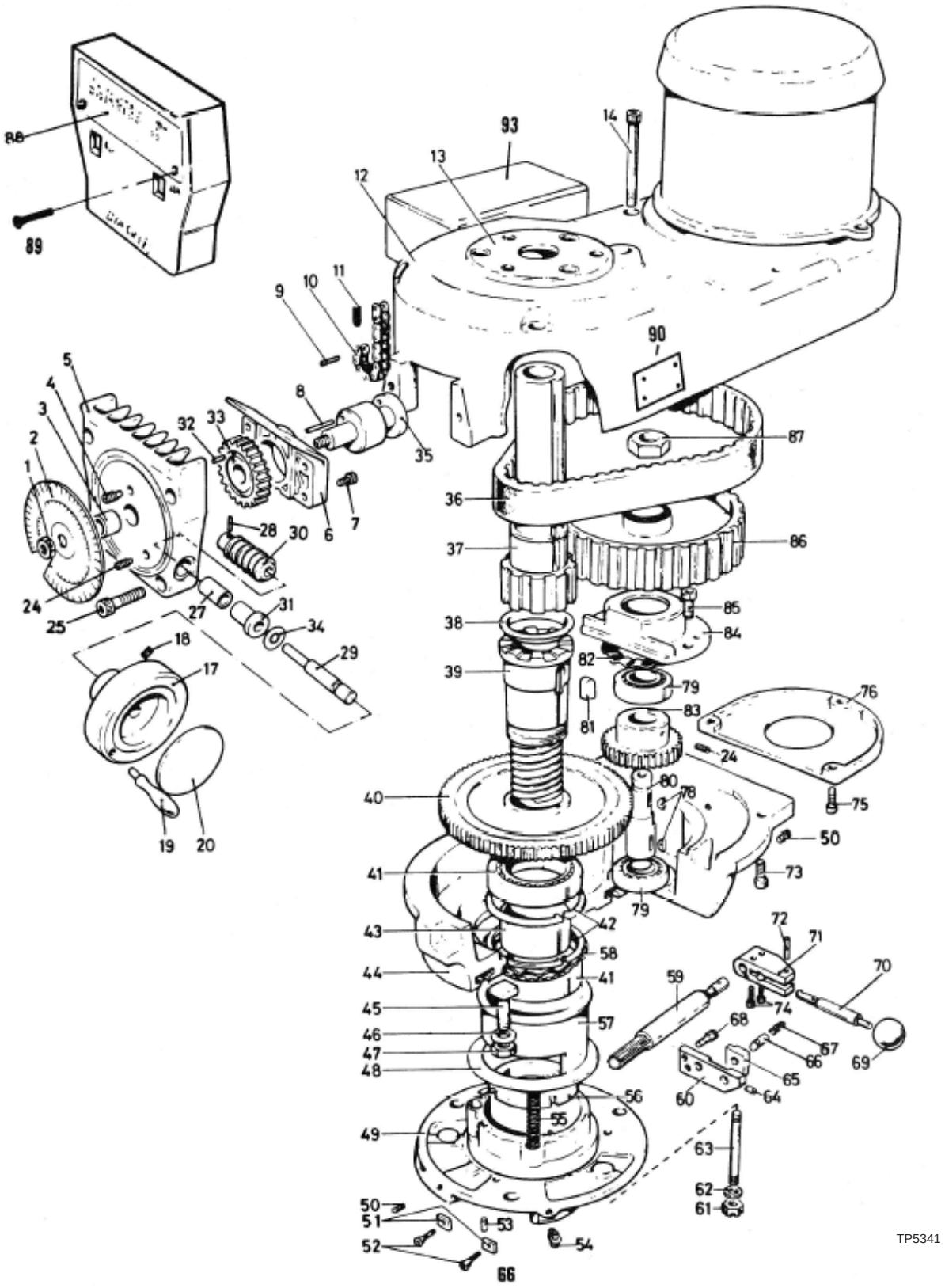


Figure 13.2 - 2J-Head Back Gear Assembly

2J-HEAD BACK GEAR

ITEM	CODE NO	DESCRIPTION	QTY
1	11011710	Nut, Hex, 5/16"	1
2	11180133	Dial, Spindle Speed	1
3	11183646	Bushing, Bronze, Boston #B810-4	1
4	11011380	Screw, Full Dog Socket Hd Set, 1/4”-20 x ½” Set	1
5	12180055	Housing, Speed Changer	1
6	12182003	Block, Plastic Bearing	1
7	11011031	Screw, Socket Hd Cap, 1/4”-20 x 5/8"	4
8	11010516	Pin, Roll, 1/8" Dia. x 5/8" Lg	1
9	11010520	Pin, Roll, 1/8" Dia. x 1.00" Lg	1
10	11183720	Chain, Speed Changer, Morse #35	1
11	12180066	Stud, Speed Change Chain	1
12	12180051	Housing, Belt	1
13	12180094	Cap, Top Bearing	1
14	11011065	Screw, Socket Hd Cap, 5/16”-18 x 4"	1
17	12182001	Hub, Speed Change	1
18	11181233	Screw, Socket Hd Set, 1/4”-UNC x 3/8"	1
19	11182178	Handle, Machine, #3302	1
20	11182892	Plate, Caution	1
24	11011287	Screw, Stainless Steel, 1/4”-20 x 1/4"	2
25	11011037	Screw, Socket Hd Cap, 1/4”-20 x 1-1/4"	4
27	11183645	Bushing, Oilite	1
28	28300619	Pin, Roll, 2.5mm x 12mm Lg	1
29	28025716	Shaft, Speed Changer	1
30	28007307	Gear, Boston Worm	1
31	11180214	Bushing, Oilite Flanged, FB	1
32	11010539	Pin, Roll, 3/16" Dia. x 3/8" Lg	1
33	12180090	Gear, Speed Change Spur	1
34	11181923	Washer, Wavy Spring	1
35	12180065	Drum, Speed Change Chain	1
36	11552106	Belt, Timing	1
37*	12180042	Hub, Spindle Pulley	1
38*	12180064	Sleeve, Timing Pulley Clutch	1
39	12180059	Hub, Splined Gear	1
40**	12180062	Gear, Spindle Bull	
41	11180254	Bearing, Ball, Fafnir #RM9308NPP	2
42	11180803	Ring, Snap, #5000-244	2

ITEM	CODE NO	DESCRIPTION	QTY
43	12180063	Spacer, Bull Gear Bearing	1
44	12180052	Housing, Gear	1
45	11181650	Bolt, Tee	3
46	11181906	Washer, Flat, 15/32" ID x 15/16" OD x 1/16"	3
47	11011750	Nut, HDN Finished Hex Jam, 7/16”-14	3
48	11181986	Washer, Ball Bearing Gear Sleeve	3
49	12180054	Bracket, Fixed Clutch Bracket	1
50	11011246	Screw, Socket Hd Set, 5/16”-18 x 5/16"	2
51	28025615	Guide	2
52	28025671	Screw, Flat Socket Hd Cap, #10-32 x 3/8"	2
53	11010511	Pin, Roll, 1/8” x 1/4" Lg	1
54	11183104	Cup, Oil, Gits #1202 Style L	1
55	11182071	Spring, Compression, 3/8" OD x 3.00" Lg	3
56	11181794	Locknut, Bearing, #N-08	1
57	12180061	Sleeve, Bearing	1
58	11181977	Washer, Wave Spring	1
59	12180067	Bull Gear Shift Pinion	1
60	12180161	Plate, Hi-Low Detent	1
61	11181732	Nut, Hex, 3/8”-16"	3
62	11151913	Lockwasher, 3/8"	3
63	12180085	Studs	3
66	12180100	Plunger, Hi-Low Detent	1
67	11182072	Spring, 3/4” x 0.032 x 9/16"	1
68	11011017	Screw, Socket Hd Cap, #10-32 x ½" Lg	2
69	11192151	Knob, Bakelite, 1/4”-20	1
70	12180099	Crank, Hi-Low Shift	1
71	12180096	Block, Hi-Low Pinion	1
72	11010516	Pin, Roll, 1/8" Dia. x 5/8" Lg	1
73	11011052	Screw, Socket Hd Cap, 5/16” x 3/4” Lg	4
74	11181007	Screw, Socket Hd Cap, #8/32 x 0.625"	2
75	11011022	Screw, Socket Hd Cap, #10-24 x 1.00"	1
76	12180088	Cover, Motor Pulley	1
78	11013079	Key, Woodruff #9	2
79	11180235	Bearing, Fafnir #203NPP-C8	2
80	12180075	Shaft, Bull Gear Pinion Counter	1
81	12180103	Key, Sq, .312” x .540”	1
82	11181975	Washer, Wave Spring	1
83**	12180077	Pinion, Bull Gear	

ITEM	CODE NO	DESCRIPTION	QTY
84	12180076	Cap, Bull Gear Pinion Bearing	1
85	11011011	Screw, Socket Hd Cap, #10-24 x 5/8" Lg	2
86	12550016	Pulley, Timing Belt	1
87	11191738	Nut, Hex Jam, 5/8-18"	1
88	11182912	Nameplate, Speed Change	1
89	11011139	Screw, Flat Hd Machine, #8-32 x 0.750"	2
90	11182897	Plate, Lubrication	1
93	11182655	Drum, Switch	1

* Items 37 and 38 sold as assembly only

** Items 40 and 83 sold as assembly only

2J-HEAD LOWER HOUSING

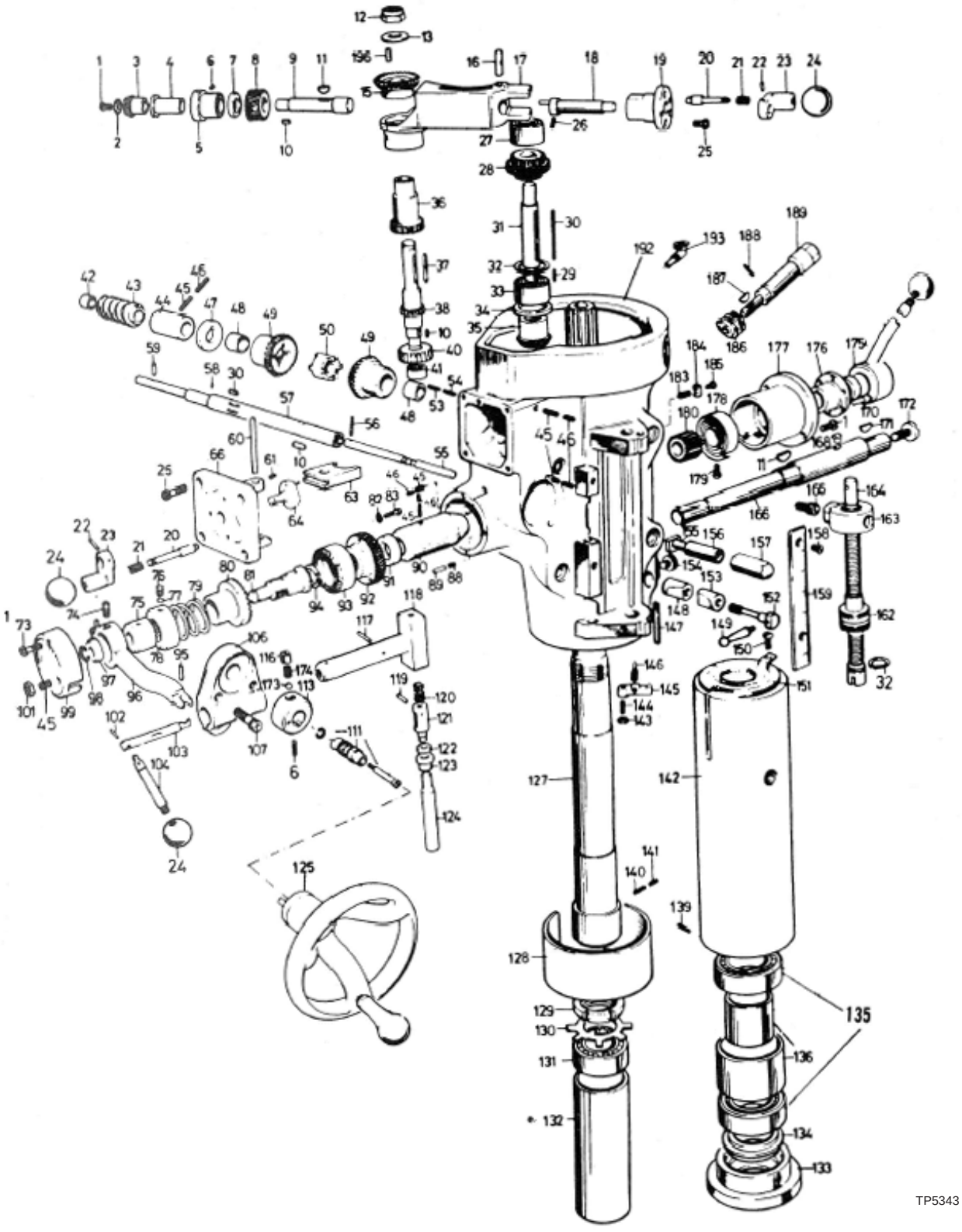


Figure 13.3 - 2J-Head Lower Housing Assembly

2J-HEAD LOWER HOUSING

ITEM	CODE NO	DESCRIPTION	QTY
1	11011445	Screw, Round Hd Cap, #10-24 x 3/8" Lg	3
2	12190163	Washer, Bevel Pinion	1
3	12190203	Gear, Feed Bevel Pinion	1
4	12190164	Sleeve, Feed Worm Gear Shaft	1
5	11192303	Bushing, Worm Cradle	1
6	11011287	Set Screw, 1/4”-20 x 5/16"	2
7	12190165	Spacer, Worm Gear	1
8	12190266	Gear, Feed Drive Worm	1
9	12190167	Shaft, Feed Drive Worm Gear	1
*	12193440	Assembly, Gear Drive Shaft	
10*	12190162	Key, Worm Shaft, 1/8" Sq. x 5/16"	3
11	11013078	Key, Woodruff #7	3
12	11191796	Locknut, Flexloc, 3/8”-24"	1
13	12190199	Washer, 3/8"	1
15	11192209	Gear, Feed Reverse Bevel	1
16	12190168	Pin, Feed Engage	1
17	12190059	Cradle, Word Gear	1
18	12190169	Throw-out, Worm Gear Cradle	1
19	12190170	Sleeve, Shift	1
20	12190138	Pin, Shift	2
21	11192052	Spring, Compression	2
22	11010517	Pin, Roll, 1/8” x 3/4"	2
23	12190064	Crank, Shift Crank	2
24	11192151	Ball, Black Plastic, 1" Dia.	4
25	11011010	Screw, Socket Hd Cap, #10-24 x ½" Lg	7
26	11011258	Setscrew, #10-24 x 3/8"	1
27	12190181	Bushing, Cluster Gear Shaft Upper	1
28	28007099	Assembly, Cluster Gear (Supplied as One Unit)	1 unit
29	12190148	Key, 1/8" Sq. x 3/4"	1
**	12193544	Assembly, Bevel Feed Pinion	
30*	12190175	Assembly, Key, 1/8" Sq. x 9/16"	2
31	28007106	Shaft, Cluster Gear Shaft	1
32**	11190836	Ring, External Retaining, #5100-62	2
33**	12190149	Bearing, Bevel Gear	1
34**	12190150	Spacer, Bevel Gear Thrust	1
35**	12190180	Pinion, Feed Reverse Bevel	1

ITEM	CODE NO	DESCRIPTION	QTY
36*	12190146	Gear, Feed Driving	1
37*	12190176	Key, Round End, 1/8" Sq. x 3/4"	1
38*	12190145	Shaft, Cluster Gear Input	1
40*	12190144	Gear, Feed Drive	1
41	1110-310	Bearing, Torrington Needle, B-66	1
42	11193637	Bushing	1
43	28007307	Gear, Worm Speed Control	1
44	12190155	Bushing, Feed Worm Shaft	1
45	11011268	Setscrew, Socket Hd, 1/4”-20 x ½" Lg	6
46	11011542	Setscrew, 5/16”-18 x 15/16" Lg	5
47	11190152	Washer, Feed Worm Shaft Thrust	1
***	12193432	Assembly, Bevel Feed	
48***	11183646	Bearing, Oilite	2
49***	12190151	Gear, Feed Reverse Bevel	2
50	12190153	Clutch, Feed Reverse	1
53	11011547	Screw, Stainless Steel, 0.312”-18 x 0.156"	1
54	11011375	Setscrew, Dog Point, 0.312-18 x 0.250"	1
55	12190157	Rod, Reverse Clutch	1
56	11010509	Pin, Roll, 3/32” x 3/4" Lg	1
57	12190198	Shaft, Feed Worm	1
58	12190200	Pin, 3/32” x 5/16" Lg	1
59	28007308	Pin, 0.110” x 7/16" Lg	1
60	12190179	Rod, Feed Shift	1
61	11011260	Setscrew, #10-32 x 1/4" Lg	1
63	11190061	Fork, Feed Gear Shift	1
64	12193446	Assembly, Cluster Gear Shift Crank	1
66	12190065	Cover, Cluster Gear	1
73	11011014	Screw, Socket Hd Cap, #10-32 x 1-1/2"	2
74	12190188	Pin, Clutch Ring	2
75	12190098	Ring, Clutch	1
76	11011265	Setscrew, 1/4”-UNC x 1/4"	1
77	12190073	Plug, Brass, 3/16" Dia. x 3/32"	1
78	12190105	Locknut, Overload Clutch	1
79	11192055	Spring, Safety Clutch	1
80	28007058	Clutch, Overload	1
81	28007054	Sleeve, Overload Clutch	1
82	11191920	Washer, Single Spring	3
83	11011431	Screw, Round Hd, #8-32 x 5/8"	3

ITEM	CODE NO	DESCRIPTION	QTY
88	11192032	Spring, Compression, 1/4" Dia. x 1-1/4"	1
89	12190096	Brass, Overload Clutch Lever Spring Plunger	1
90	12190106	Bushing, Quill Pinion Shaft	1
91	12190104	Spacer, Pinion Shaft Worm Gear	1
92	11190103	Gear, Overload Clutch Worm	1
93	28007059	Ring, Overload Clutch	1
94	11190870	Ring, External Retaining	1
95	11010717	Pin, Dowel, 3/16” x 5/8"	1
96	12193427	Assembly, Overload Clutch Trip Lever	1
97	12190097	Washer, Overload Clutch	1
98	11190822	Ring, External Retaining, #5100-37	1
99	12190068	Cover, Clutch Arm	1
101	11011740	Locknut, Chemically Blacked, 1/4” x 20 UNC	1
102	11010717	Pin, Dowel, 3/16 x 3/4"	1
103	12190094	Rod, Cam	1
104	12190095	Handle, Trip	1
106	12190067	Bracket, Feed Trip	1
107	11011035	Screw, Socket Hd Cap, 1/4”-20 x 1" Lg	2
111	12193433	Assembly, Reverse Knob	1
113	12190159	Assembly, Handwheel Clutch	1
116	12190154	Screw, Handwheel Clutch Spring	1
117	11010515	Pin, Roll, 1/8” x 9/16" Lg	1
118	12190093	Assembly, Cam Rod Sleeve	1
119	11010513	Pin, Roll, 1/8” x 7/16" Lg	1
120	11192053	Spring, Compression Spring	1
121	12190091	Plunger, Trip	1
122	12190092	Bushing, Feed Trip Plunger	1
123	12190090	Bushing, Trip Plunger	1
124	12190089	Plunger, Feed Trip	1
125	28007120	Assembly, Handwheel	1
127	12190191	Spindle	1
128	11190081	Skirt, Quill	1
129	11191790	Locknut, #06	
130	11191942	Lockwasher, W-06	1
131	11190237	Bearing, Fafnir #M206K	1
132	12190197	Sleeve, Bearing	1
133	12190196	Nosepiece	1
134	12780915	Shield, Spindle Dirt	1

ITEM	CODE NO	DESCRIPTION	QTY
135	11190238	Bearing, Spindle	1
136	12193513	Spacer, Bearing	1
139	11011265	Setscrew, 1/4”-UNC x 1/4"	1
140	12193540	Screw, Collet Alignment, 1/4-32"	1
141	11011545	Setscrew, Special Locking, 1/4”-32 x 1/8"	1
142#	12190192	Quill	1
143	28300336	Nut, Steel, #6-32 NC	1
144	28300609	Setscrew, #6-32 x 3/4"	1
145	28007042	Lever, Feed Trip	1
146	12190185	Pin, Trip Lever	1
147	12200103	Rod, Indicator	1
148	12190109	Sleeve, Quill Lock, Tapped	1
149	12200098	Lock Handle	1
150	11011595	Screw, Round Hd, #10-32 x 3/8" Lg	2
151	11192403	Strainer, Felt Oil	1
152	12190111	Bolt, Quill Lock	1
153	12190110	Sleeve, Quill Lock, Untapped	1
154	12200102	Screw, Rod Indicator Thumb	1
155	12191620	Bolt, Tee, ½"	4
156	12190135	Spacer, Lower Clamping Bolt	2
157	12191736	Nut, Hex, ½” x 1-1/2"	2
158	11011411	Screw, Round Hd, Chem. Blacked, #6-32 x 1/4"	2
159	11195306	Scale, Quill, Micrometer Inch	1
162	12190344	Assembly, Quick Nut	1
163	12190082	Stop Nut, Quill	1
164	12190083	Stop, Quill, Micro-Screw	1
165	11011090	Screw, Socket Hd Cap, 3/8”-UNF x 5/8"	1
166	28007063	Shaft, Quill Pinion	1
168	12200111	Pin, Spring	1
170	11010541	Pin, Dowel, 3/16” x 3/4" Lg	1
171	11013076	Key, Woodruff #3	1
172	12190182	Screw, Pinion Shaft Hub	1
173	11192165	Ball, Steel	1
174	11192054	Spring, Compression	1
175	12201031	Assembly, Quill Feed Handle	1
176	28009053	Hub, Quill Pinion	1
177	12190066	Cover, Spring	1
178	11192020	Spring, Clock	1

ITEM	CODE NO	DESCRIPTION	QTY
179	28007150	Pin, Outside Clock Spring	1
180	28007064	Pinion, Quill	1
183	12190085	Lever, Reverse Trip Ball	1
184	12190086	Plunger, Feed Reverse Trip	1
185	12190087	Screw, Reverse Trip Ball Lever	1
186	11192207	Gear, Worm	1
187	11013077	Key, Woodruff #5	1
188	11011370	Setscrew, Socket Hd, 1/4”-UNC x 20 x 3/8"	1
189	12190850	Shaft, Adjustable Worm	1
192#	12190051	Housing, Quill	1
193	11193111	Cup, Oil	1
196	12190162	Key, Worm Shaft, 1/8" sq. x 5/16"	1

* Item Numbers 10, 36, 37, 38, and 40 sold as assembly 12193440

** Item Numbers 32, 33, 34, and 35 sold as assembly 12193544

*** Item Numbers 48 and 49 sold as assembly 12193432

Item Numbers 142 and 192 sold as assembly 12124541

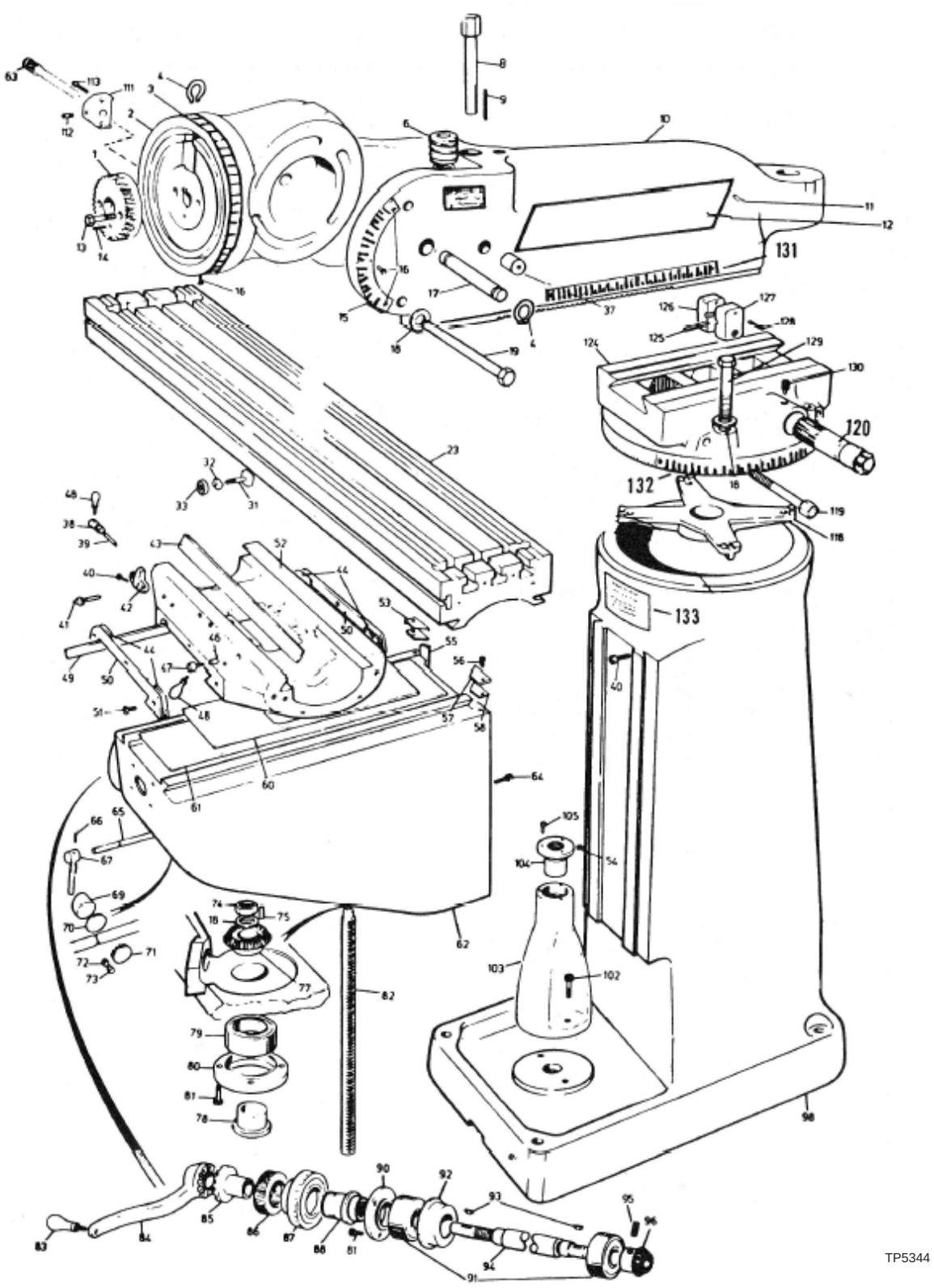


Figure 13.4 - Basic Machine Assembly

BASIC MACHINE

ITEM	CODE NO	DESCRIPTION	QTY
1	12190178	Housing, Adjustable Gear Tilting Quill	1
2	12069013	Assembly, Ram Adapter	1
3	11060603	Scale, Adapter	1
4	11060892	Ring, External Retaining	2
6	11062206	Worm, Vertical Adjusting	1
8	12060130	Shaft, Vertical Adjusting Worm	1
9	12060138	Key, Sq., 0.188” x 1.938"	1
10	12060128	Ram	1
11	11011556	Screw, Drive, Type 0, #6 x 0.375"	4
12	11060502	Nameplate, Ram	2
13	11011035	Screw, Socket Hd Cap, 1/4”-20 x 1"	2
14	11010590	Pin, Roll, 0.312 x 1.50"	1
15	11062826	Plate, Angle, Graduated	1
16	11011555	Screw, Round Hd Drive	5
17	12061028	Pin, Adapter Pivot	1
18	11200109	Washer, Chamfered and Hardened, ½” x 1/8 x 1"	2
19	11061180	Bolt, Hex Hd, Adapter Locking, 0.500”-13 x 7.25"	3
23	12060347	Table, 48" Lg	1
31	11061602	T-Bolt, Stop Piece	2
32	11062301	Piece, Table Stop	2
33	11011720	Nut, 3/8”-16 Hexagon	3
34	12060122	Washer	2
37	12060328	Bushing, Clamping	1
38	12060119	Bolt, Saddle Lock	1
39	12060125	Plunger, Saddle Lock	1
40	11770252	Screw, Low Hd	2
41	11060088	Screw, Gib Adjusting	3
42	12060300	Bracket, Table Stop	1
43	12060482	Gib, Table with Chrome	1
44	11062406	Wiper, Felt	4
46	12060118	Plug, Table Lock, Table/Saddle Lock R.H.	2
47	12060119	Bolt, Table Lock - R.H. (12060114 for L.H.)	1
48	11062179	Handle, Table Lock	2
49	12060124	Gib, Saddle/Knee	1
50	12060123	Plate, Saddle/Knee Wiper	2
51	11011580	Screw, Oval Hd, #10-32 x ½"	6

ITEM	CODE NO	DESCRIPTION	QTY
52	12060487	Saddle, with Chrome	1
53	12060093	Holder, Left Hand Column Wiper	1
55	12060146	Gib, Knee/Column	1
56	11011031	Screw, Socket Hd Cap, 0.250”-20 x 0.625"	2
57	12060094	Holder, Right Hand Column Wiper	1
58	11062405	Guard, Upper Chip, Kn 60 11060153	1
61	11060152	Guard, Lower Chip	1
62	11060493	Knee, with Chrome	1
63	12069999	Pin, Head Rotation Stop	1
64	11770252	Screw, Low HD	1
65	12060148	Shaft, Knee Lock	1
66	11010409	Pin, Taper, 1” x 1"	1
67	12061230	Hub, Lock Shaft	1
69	12060089	Plunger, Knee Lock	1
70	12150131	Washer, Table Locking	1
71	11010786	Plug, Knee Binder (Plastic)	1
72	11011375	Setscrew, Dog Pt., 5/16”-18 x 5/16"	1
73	11011270	Setscrew, 5/16”-18 x 5/16"	1
74	11011755	Nut, Jam, ½”-20"	1
75	12060071	Key, 3/16” x 3/16” x 7/8"	1
77	11062204	Gear, Bevel	1
79	11060205	Bearing, Fafnir #W306PP3	1
80	12060070	Ring, Bearing Retaining	1
81	11011031	Screw, Socket Hd Cap, 1/4”-20 x 5/8"	6
82	12060069	Inch, Elevating Screw	1
83	12060060	Handle	1
84	11060080	Crank, Elevating	1
85	12060079	Clutch, Gearshaft	1
86	12060078	Locknut, Dial	1
87	12060213	Dial, 100 Graduation	1
88	12060077	Holder, Dial	1
90	12060210	Ring, Bearing Retaining	1
91	11060204	Bearing, Fafnir H204KTT	2
92	11011030	Screw, Socket Hd Cap, 1/4”-20 x ½"	3
93	11013078	Key, Woodruff #7	2
94	12060147	Shaft, Elevating, Z Axis	1
95	11011220	Setscrew, 1/4”-20 x 1/4" Lg	2
96	11062205	Gear, Bevel Pinion	1

ITEM	CODE NO	DESCRIPTION	QTY
98	12060209	Column	1
102	11011074	Screw, Socket Hd Cap, 3/8”-16 x 1"	2
103	12060207	Pedestal	1
104	12060051	Nut, Elevating Screw	1
105	11011195	Screw, Socket Hd Cap, 1/4”-20 x 1"	3
111	12650180	Block, Stop (Head Rotation)	1
112	11152094	Plunger, Spring	1
113	11011017	Screw, Socket Hd Cap, #10-32 x 0.500"	2
118	12060144	Spider	1
119	11060112	Stud, Ram Lock	2
120	12060255	Pinion, Ram	1
124	12060208	Turret	1
125	12060137	Bar, Ram Clamp	2
126	12060141	Clamp, Ram, Blank	2
127	12060113	Clamp, Ram, Tapped	2
128	11010619	Pin, Cotter	2
129	11061178	Bolt, Hex, ½”-13 x 5"	4
130	12060140	Screw, Ram Pinion	1
131	11060602	Scale, Ram	1
	11980426	Drive, Screw	2
132	11060601	Turret, Scale	1
	11989426	Screw, Drive	2
133	11010200	Plate, Warning	1
	11980426	Screw, Drive	4

LEFT END OF X AXIS BALLSCREW

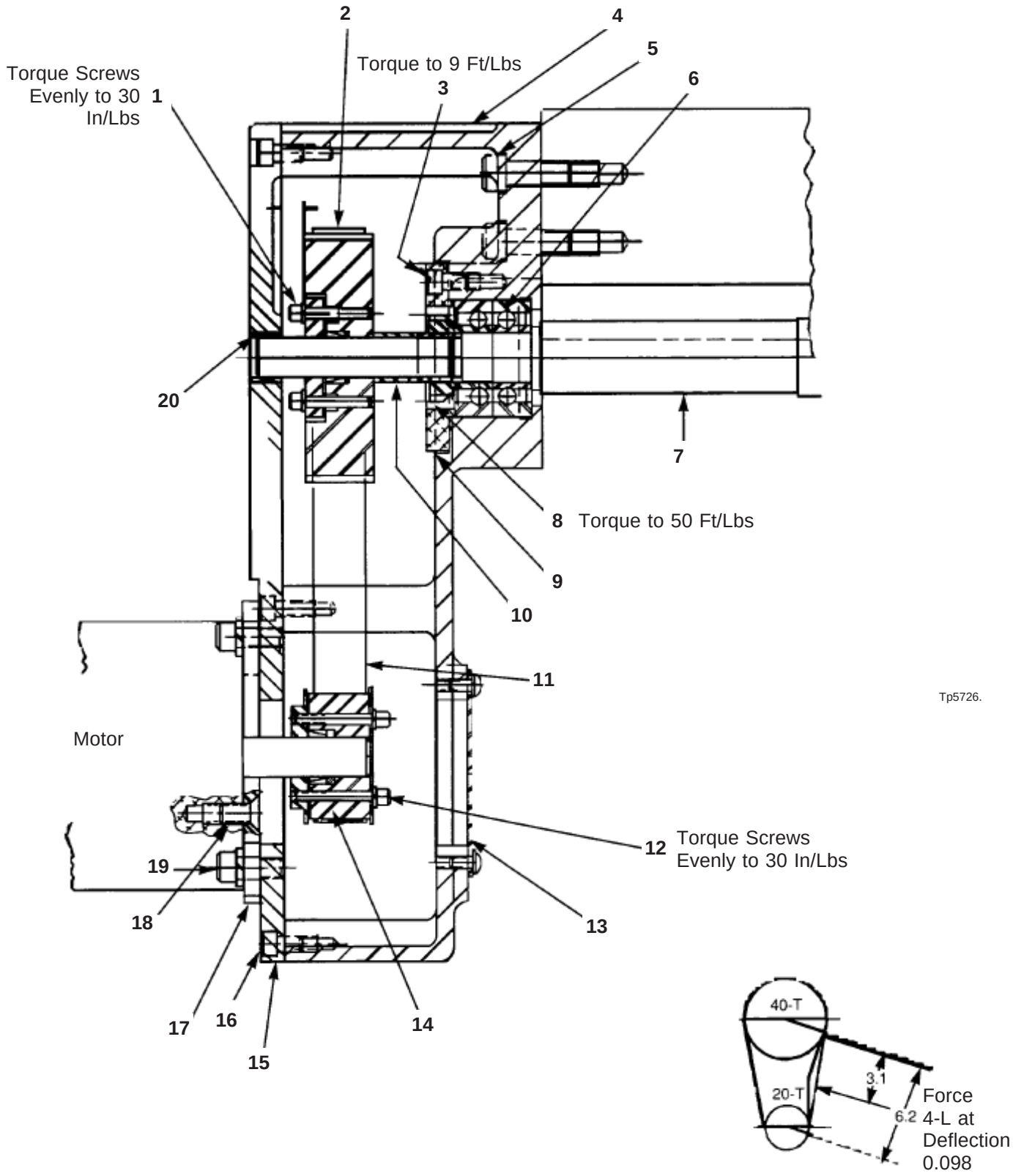


Figure 13.5 - Left End of X Axis Ballscrew

LEFT END OF X AXIS BALLSCREW

ITEM	CODE NO	DESCRIPTION	QTY
1	11010210	Screw, Socket Hd Cap, #8-32 x 1.000"	4
	61705552	Washer, Plastic Nylite, 4 mm	4
2	24649915	Pulley Assembly (40-T)	1
3	11011030	Screw, Socket Hd Cap, 1/4”-20 x 0.500"	3
4	12749003	Bracket	1
5	11011075	Screw, Socket Hd Cap, 3/8-16 x 1.250"	4
6	11060203	Bearing, Fafnir RM 204-KT4	1
7	12746209	Ballscrew, X Axis	1
	11011075	Screw, Socket Hd Cap, 3/8”-16 x 1.250"	2
8	11151779	Locknut	1
9	12746126	Retainer, Bearing	1
10	12746109	Spacer, Pulley	1
11	21577911	Belt, HTD 560-8M-20	1
12	11980227	Screw, Socket Hd Cap, #8-32 x 1.250"	4
	11191920	Lockwasher, #8	4
13	12780491	Cover	2
	11665162	Screw, Button Hd Cap, #10-32 x 0.375"	1
14	64649912	Assembly, Pulley (20-T)	1
15	12746116	Cover, Bracket	1
	11010543	Pin, Roll, 3/16” x 1"	2
16	11011031	Screw, Socket Hd Cap, 1/4”-20 x 0.625"	6
17	12746122	Adapter, Motor Counting	1
18	11010173	Screw, Flat Hd Cap, 5/16”-24 x 0.625"	4
19	11665570	Screw, Socket Hd Cap, 5/16”-18 x 0.750"	4
	11421984	Washer	4
20	11746111	Bearing, Needle, Torrington M-1081	1

RIGHT END OF X AXIS BALLSCREW

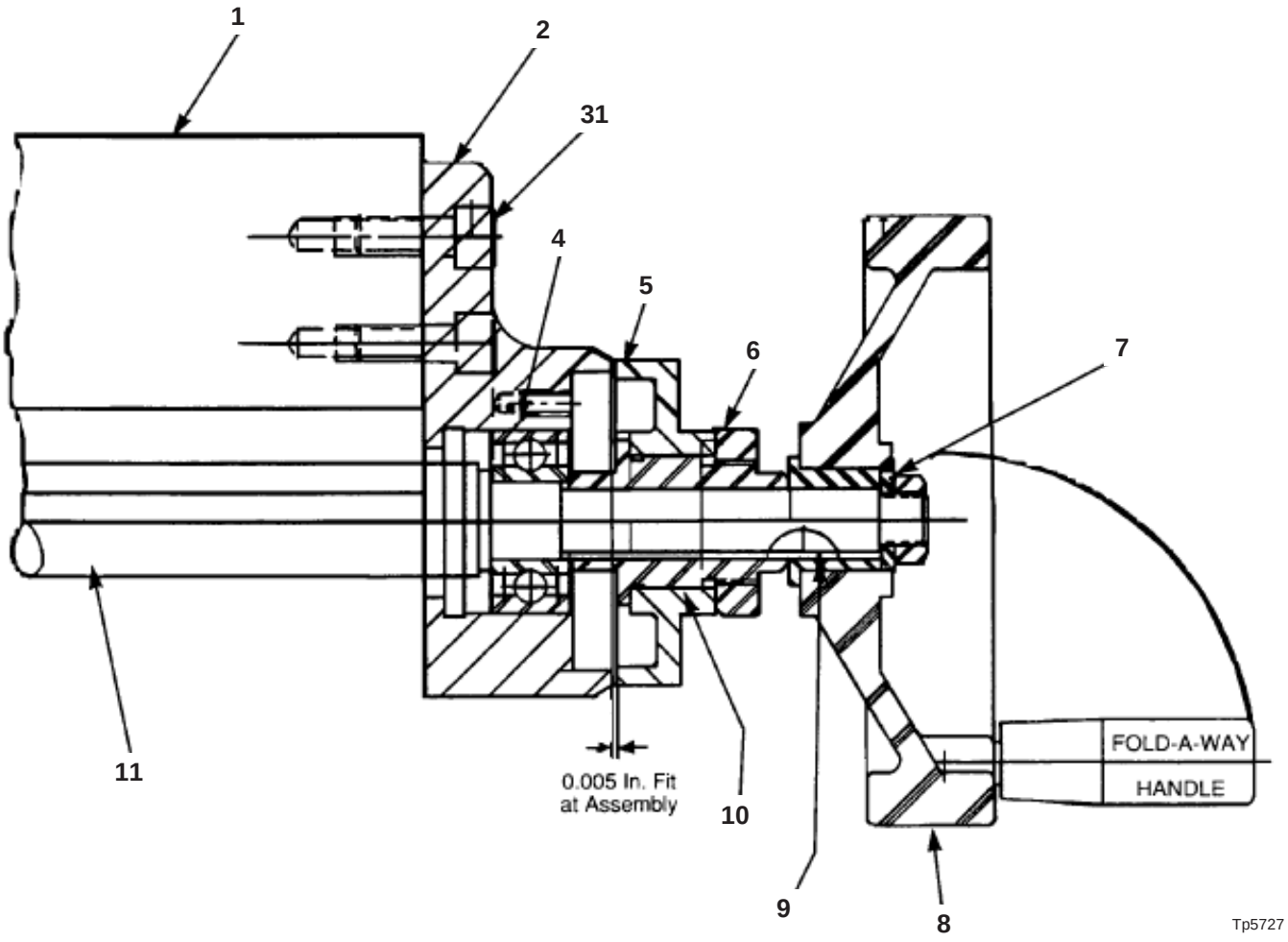


Figure 13.6 - Right End of X Axis Ballscrew

ITEM	CODE NO	DESCRIPTION	QTY
1	12060347	Table, 48"	1
2	1260115	Bracket	1
3	11011074	Screw, Socket Hd Cap, 3/8”-16 x 1.000"	4
4	11060204	Bearing, Fafnir H 204K	1
5	12060214	Dial	1
6	12060078	Locknut	1
7	11011755	Nut, Jam, ½”-20 NF	1
	12150164	Washer, Flat	1
8	12746140	Handwheel	1
9	11013078	Key, Woodruff	1
10	12060084	Holder, Dial	1
11	12746209	Ballscrew, X Axis	1
	11011075	Screw, Socket Hd Cap, 3/8”-16 x 1.250"	2

BALLSCREW WITH NUT BLOCK

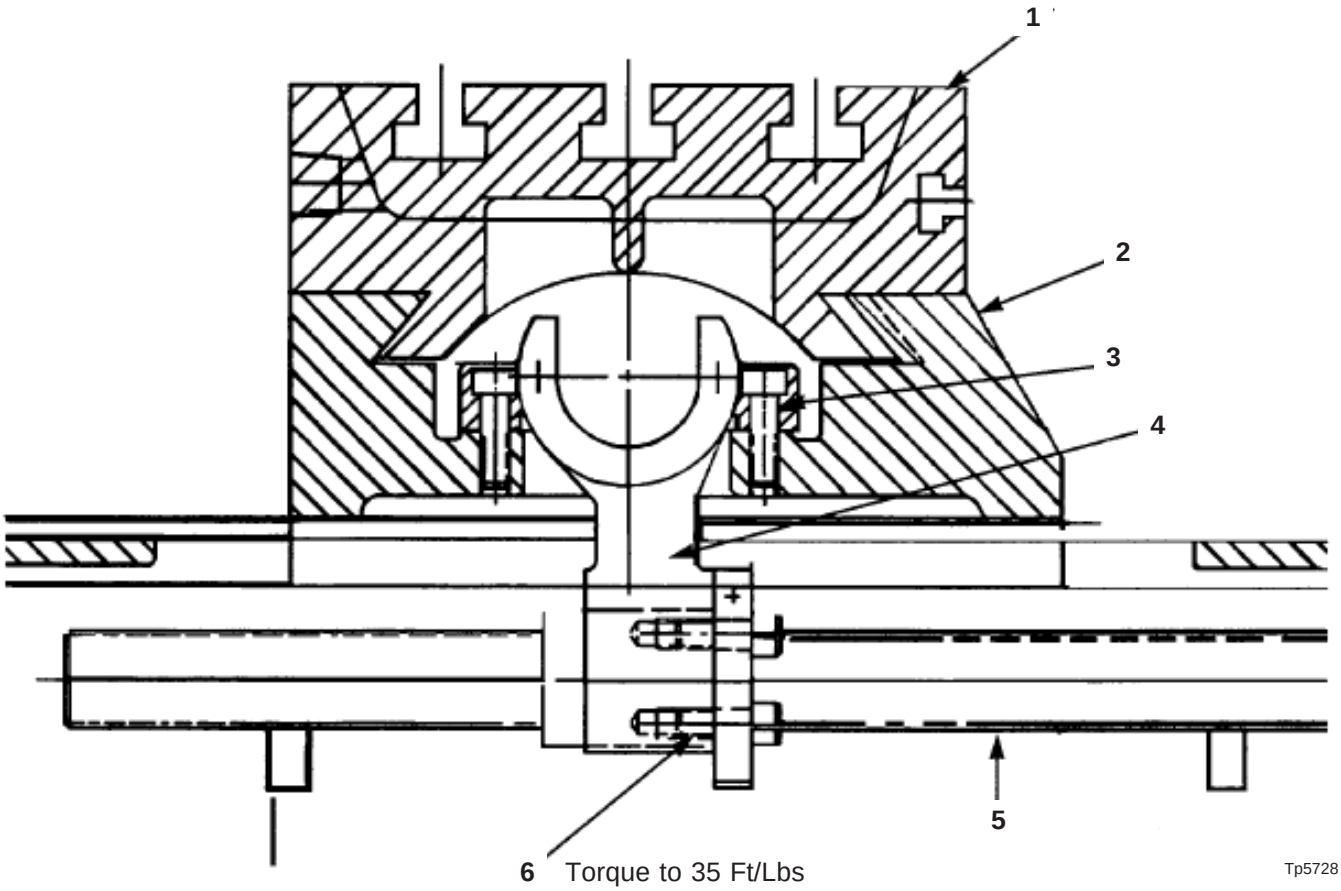


Figure 13.7 - Ballscrew with Nutblock

ITEM	CODE NO	DESCRIPTION	QTY
1	12060347	Table, 48"	1
2	12060487	Saddle	1
3	11011075	Screw, Socket Hd Cap, 3/8”-16 x 1.250"	4
4	12749023	Nutblock	1
5	11746208	Ballscrew	1
6	11011074	Screw, Socket Hd Cap, 3/8”-16 x 1.000"	3

Y AXIS DRIVE WITH NUTBLOCK

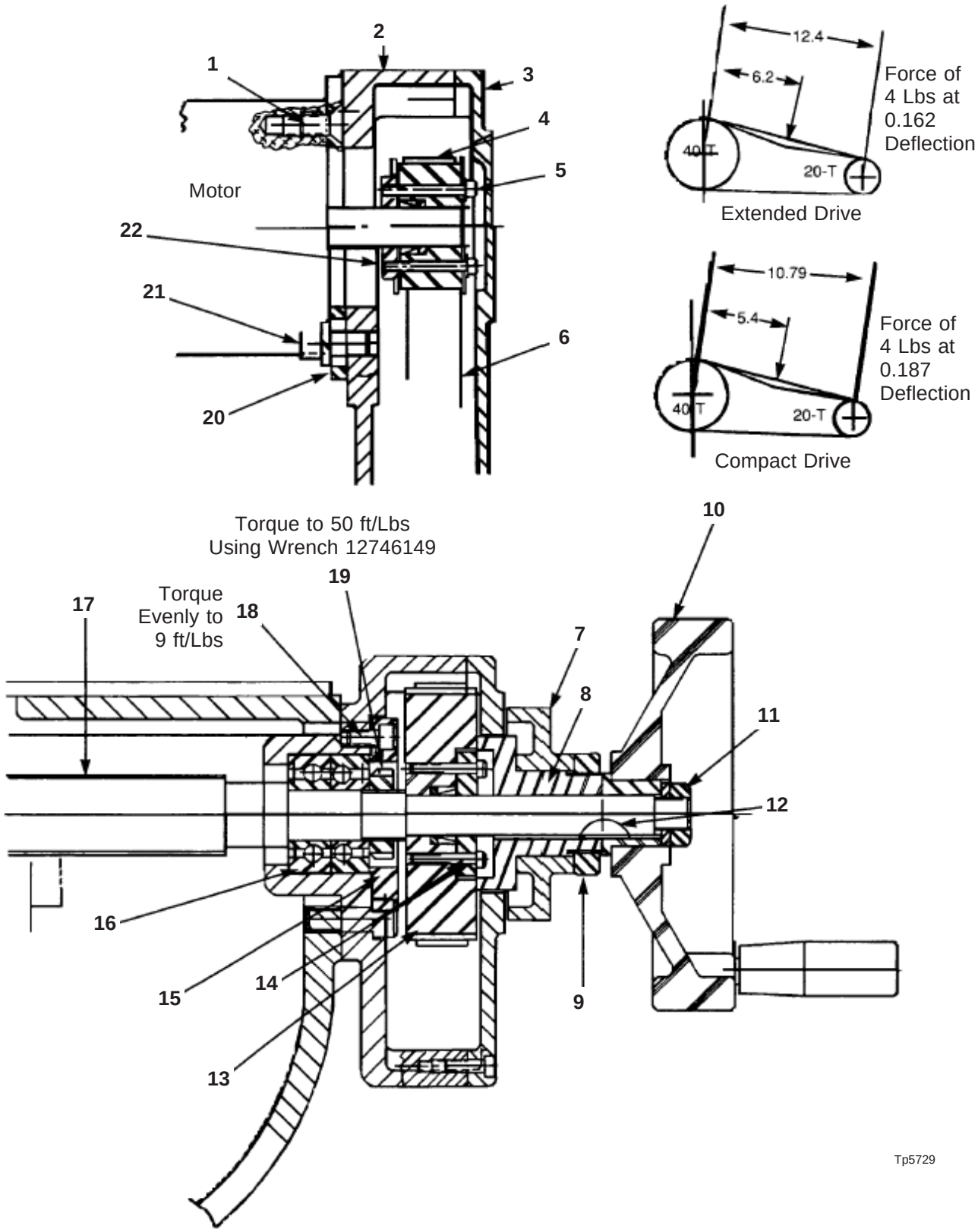


Figure 13.8 - Y Axis Drive with Nutblock

Y AXIS DRIVE WITH NUTBLOCK

ITEM	CODE NO	DESCRIPTION	QTY
1	1101073	Screw, Flat Hd Cap, 5/16”-24 x 0.620"	4
2	12746205	Housing (Compact Drive)	1
	12746117	Housing (Extended Drive)	1
3	12746214	Cover (Compact Drive)	1
	12746118	Cover (Extended Drive)	1
4	64649912	Assembly, Assembly (20-T)	1
5	11980227	Screw, Socket Hd Cap, #8-32 x 1.250"	4
	11191920	Lockwasher, #8	4
6	21577910	Belt, (Extended Drive) HTD 880-8M-20	1
	11601076	Belt, (Compact Drive) HTD 800-8M-20	1
7	12060214	Dial	1
8	12746143	Holder, Dial	1
9	12060078	Locknut	1
10	12746140	Handwheel	1
11	11011755	Nut, Jam, ½”-20	1
12	11011078	Washer, Flat	1
13	11665570	Screw, Socket Hd Cap, 5/16”-18 x 0.750"	4
	11421984	Washer	4
14	11011011	Screw, Socket Hd Cap, #10-24 x 0.625"	6
15	24649915	Assembly, Pulley (40-T)	1
16	11010210	Screw, Socket Hd Cap, #8-32 x 1.000"	4
	61705552	Washer, Plastic Nyltie, 4 mm	4
17	12746126	Bearing Retainer	1
18	11060203	Bearing	1
19	11746208	Ball Screw	1
20	11011030	Screw, Socket Hd Cap, 1/4”-20 x 0.500"	4
21	11151779	Locknut	1
22	12746122	Adapter, Motor Mounting	1
	11010543	Pin, Roll, 3/16” x 1.000"	2

Z AXIS SCALE AND MOUNTING

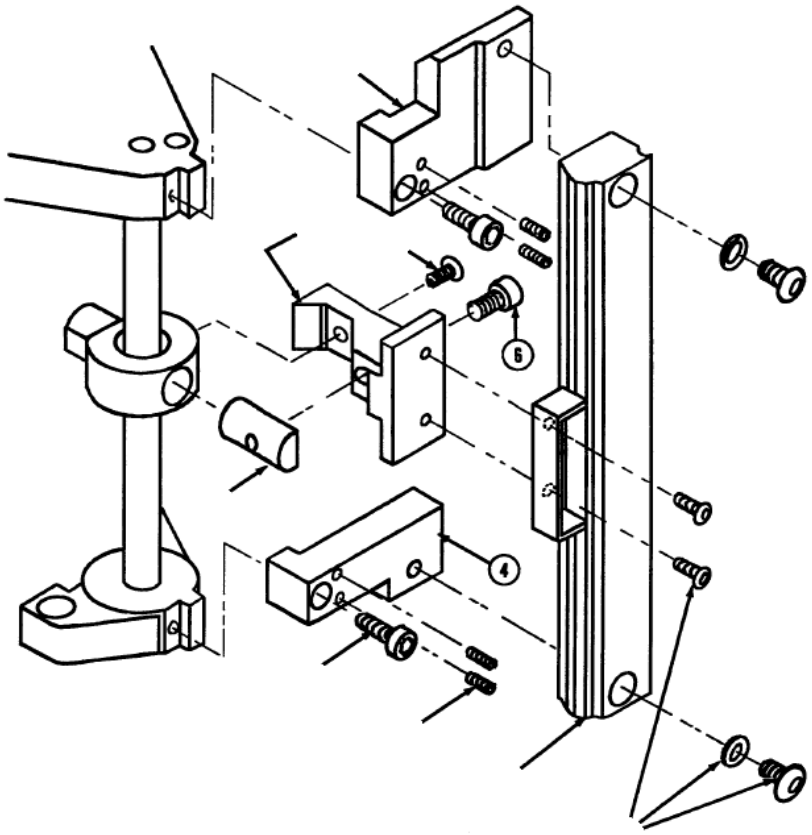
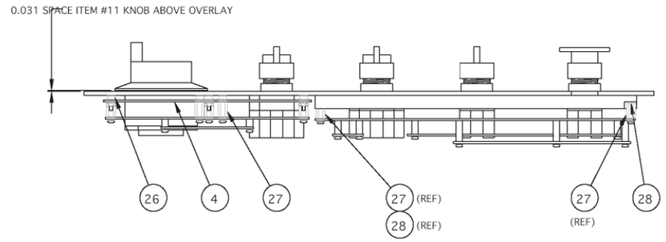


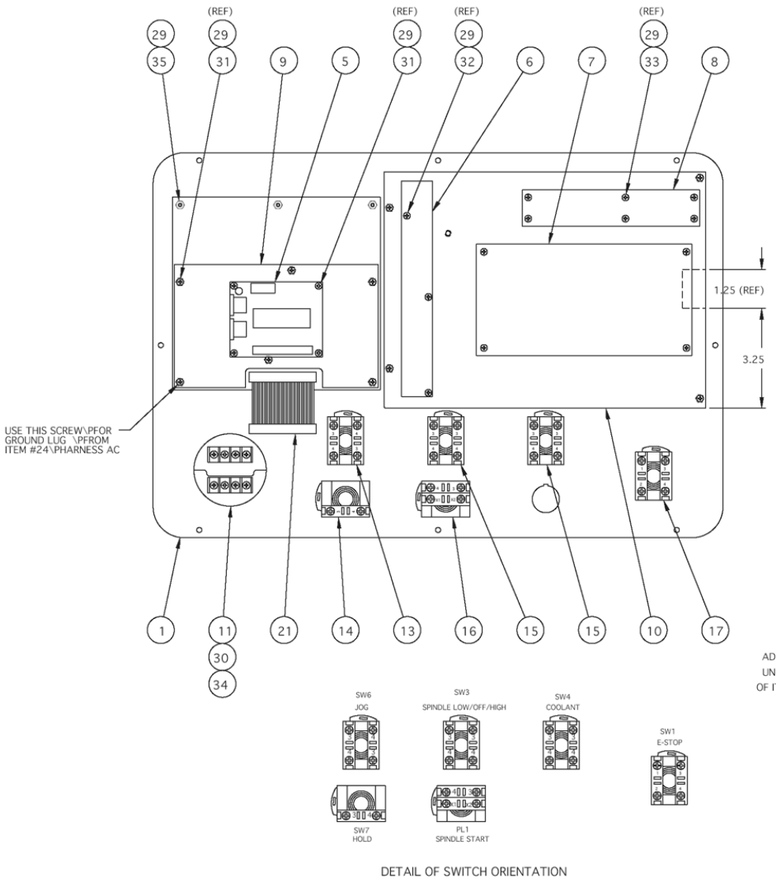
Figure 13.9 - Z Axis Scale Assembly

ITEM	CODE NO	DESCRIPTION	QTY
1	11813104	Scale, Z Axis (.0005" Resolution)	1
	11819050	Scale, Z Axis (.00025" Resolution)	1
2	385026-105	Screw, Socket Hd Cap, #6-32 x 0.500"	4
3	385026-104	Screw, Socket Hd Cap, #10-32 x 0.750"	2
4	385026-101	Bracket, Lower	1
5	385011-153	Pin	1
6	385001-372	Screw, Socket Hd Cap, 1/4”-20 x 1.000"	1
7	385026-103	Screw, Button Hd Cap, #10-32 x 0.625"	1
8	385026-100	Bracket, Reading Head	1
9	385026-102	Bracket, Upper	1
10	383106-351	Hardware Kit (Supplied with Scale)	AR

LCD PANEL ASSEMBLY



WIRING CHART		
CABLE / HARNESS / COMPONENT	FROM:	TO:
11597887 DATA CABLE	11597865 PCB ASSY P1	11597867 PCB ASSY J1
11597855 DISPLAY LCD	UPPER HARNESS	11597888 PCB ASSY CN1A
11597855 DISPLAY LCD	LOWER HARNESS	11597888 PCB ASSY CN1B
11591096 CABLE INVERTER POWER	11597888 PCB ASSY CN1	11591092 PCB ASSY CNA1 & CNB1
11591094 CABLE VIDEO CONTROLLER	11591092 PCB ASSY CN1	11597855 DISPLAY LCD CN1
11591095 CABLE VIDEO/DISPLAY CNTRL	11591093 PCB ASSY CNC1	11591092 PCB ASSY CNC1
11597875 CABLE ASSY KEYBOARD	11597867 PCB ASSY To PC CONN	MOUNT TO 11597854 PENDANT BOX
11597877 CABLE ASSY VIDEO LCD	11591092 PCB ASSY P1	MOUNT TO 11597854 PENDANT BOX
11597885 HARNESS ASSY AC	SEE 11597885 ASSY DWG	MOUNT TO 11597854 PENDANT BOX
11597886 HARNESS ASSY DC	SEE 11597886 ASSY DWG	MOUNT TO 11597854 PENDANT BOX



QTY	ITEM	PART NO.	DESCRIPTION	U/M
1.13	36	8694K87	FOAM STRIP 3/4 x 1/2 PSA BACK (McMASTER-CARR OR EQUIV)	IN
3	35	31506533	NUT HEX #4-40	EA
4	34	11598130	P. H. M. S. M3 x 6mm LONG PHILLIPS	EA
6	33	31506402	P. H. M. S. #4-40 x .50 LONG PHILLIPS	EA
7	32	31506401	P. H. M. S. #4-40 x .38 LONG PHILLIPS	EA
14	31	31506399	P. H. M. S. #4-40 x .25 LONG PHILLIPS	EA
4	30	21712100	WASHER FLAT M3	EA
30	29	11980172	WASHER SPLIT LOCK #4	EA
4	28	11010242	WASHER FLAT #4	EA
10	27	11014010	STANDOFF #4-40 x .25 OD x .50 LONG	EA
9	26	11014011	SPACER .115 ID x .25 OD x .156 LONG	EA
1	25	11597886	HARNESS ASSY DC PENDANT	EA
1	24	11597885	HARNESS ASSY AC PENDANT	EA
1	23	11597877	CABLE ASSY INT VIDEO LCD	EA
1	22	11597875	CABLE ASSY INT KEYBOARD SERIAL	EA
1	21	11597887	CABLE KEYBOARD DATA	EA
1	20	11591096	CABLE INVERTER POWER	EA
1	19	11591095	CABLE VIDEO CONTROL/DISPLAY CNTRLLR	EA
1	18	11591094	CABLE VIDEO CONTROLLER/LCD	EA
1	17	11597880	SWITCH BUTTON E-STOP NC	EA
1	16	11597884	SWITCH PUSH BUTTON ILLUM. GREEN	EA
2	15	11597882	SWITCH 3 POSITION	EA
1	14	11597883	SWITCH PUSH BUTTON NON- ILLUM. RED	EA
1	13	11597881	SWITCH 3 POSITION MOMENTARY	EA
1	12	11597648	NAMEPLATE E-STOP	EA
1	11	11598677	PULSE GENERATOR MANUAL	EA
1	10	11597899	BRACKET INVERTER/CONTROLLER MOUNT	EA
1	9	11597889	BRACKET KEYBOARD DECODER MOUNT	EA
1	8	11591093	PCB ASSEMBLY DISPLAY CONTROL SWITCH	EA
1	7	11591092	PCB ASSEMBLY VIDEO CONTROLLER	EA
1	6	11597888	PCB ASSEMBLY INVERTER	EA
1	5	11597867	PCB ASSEMBLY KEYBOARD DECODER	EA
1	4	11597865	PCB ASSEMBLY KEYBOARD	EA
1	3	11597855	DISPLAY LCD 10.4"	EA
1	2	11591091	OVERLAY	EA
1	1	11597869	FRONT PANEL	EA

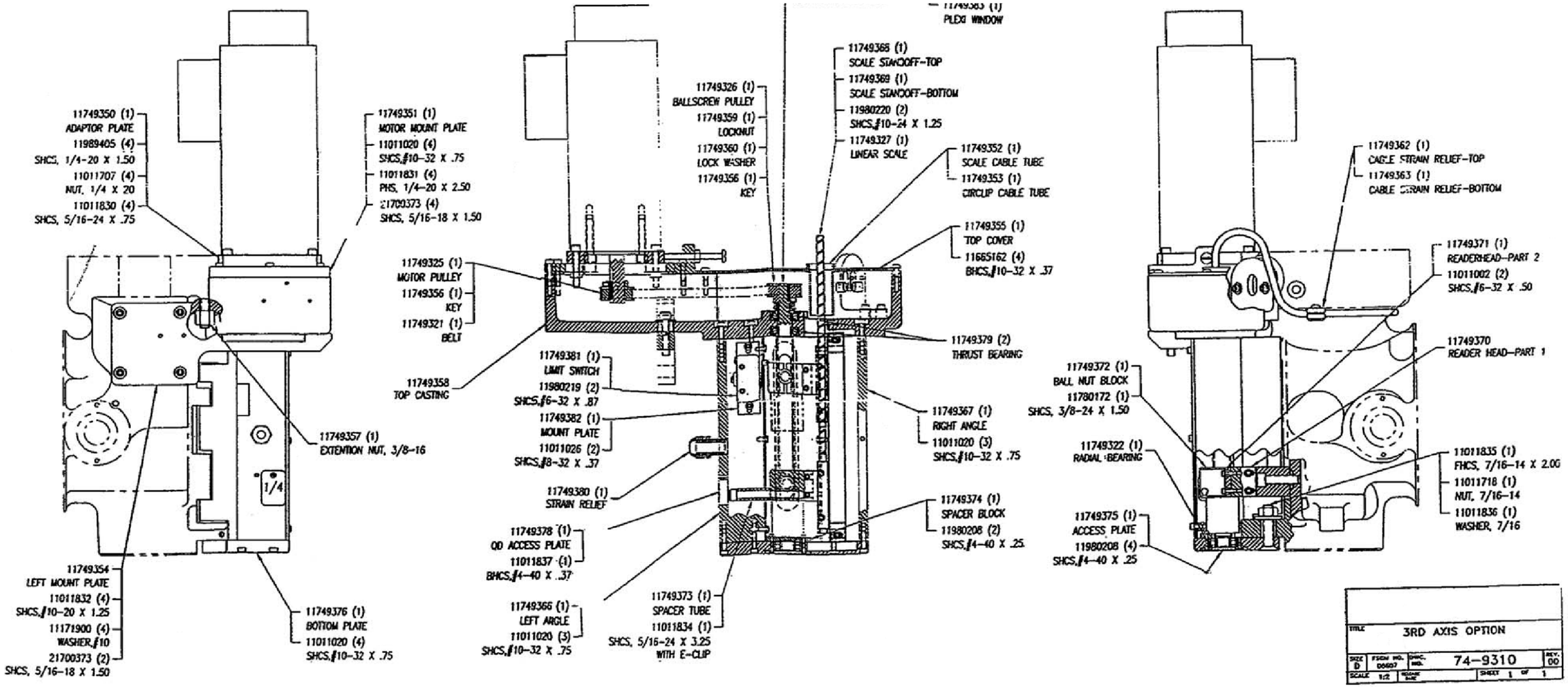
ASSEMBLY FRONT PANEL
FLAT PANEL DISPLAY

DWG. NO. 59-7890 REV. 03

1 = 2 | 1/01/01 | 1 = 1

14-41

Z AXIS MOTOR ASSEMBLY



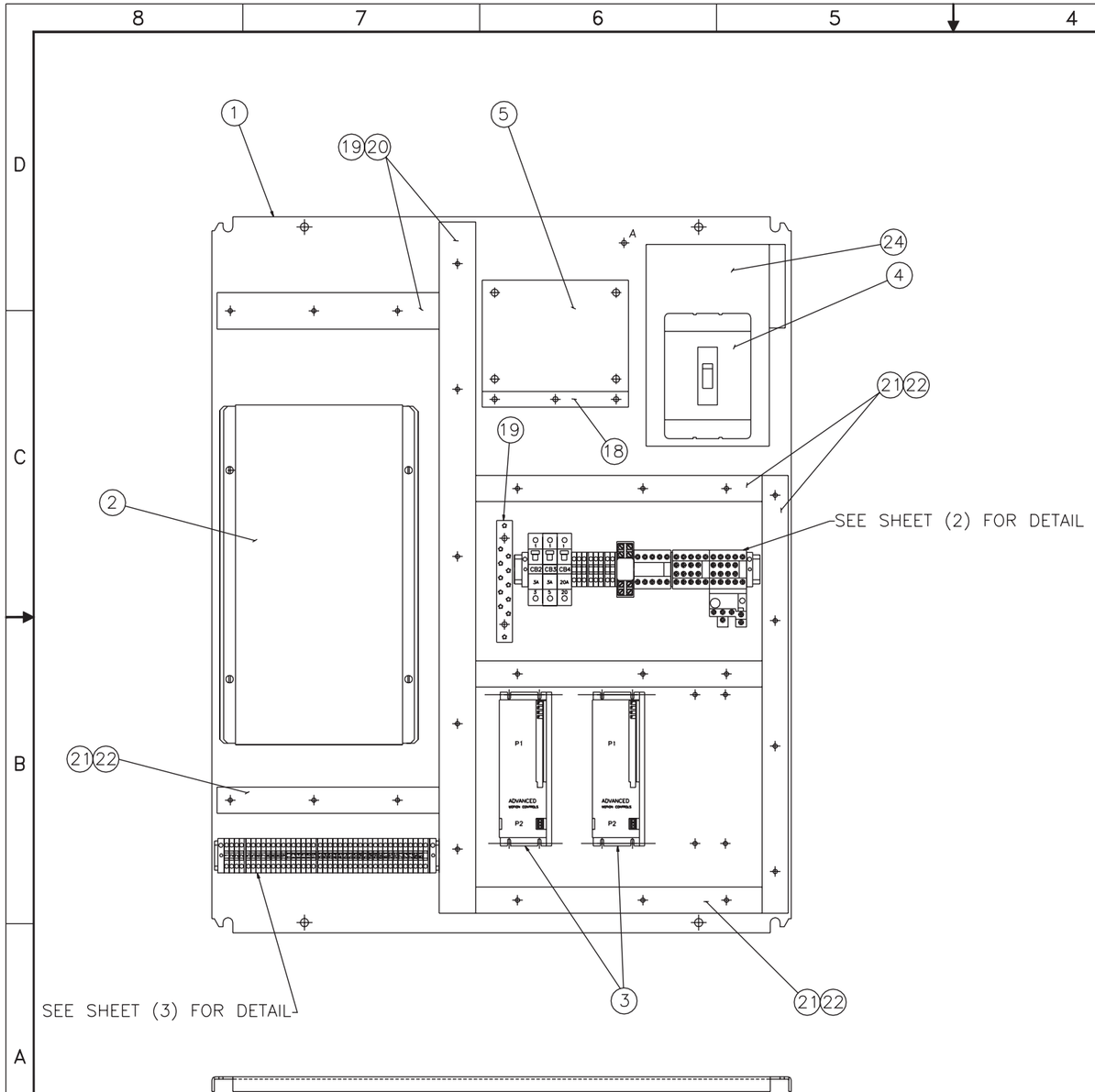
Z AXIS MOTOR ASSEMBLY

ITEM	CODE NO	DESCRIPTION	QTY
1	11598888	Assembly, Encoder and Motor*	1
2	31937757	Plate, Motor Cable Cover	1
3	31504221	Connector, Str. .500", .125”-.250”	1
4	31500331	Connector, Rcpt Box Mtg 10P	1
5	31501245	Connector, Rcpt Box Mtg	1
6	31938894	Screw Flat Head Modified	4
7	31506401	Screw, Phillips Hd, #4-40 x 3/8”	8
8	31506556	Washer, Flat #4	8
9	31506588	Washer, Lock Split #4	8
10	31541747	Tubing, Ht Shrink 1/16" ID	.5 ft.
11	31541549	Tubing, Ht Shrink, 3/32" ID	.33 ft.
12	31938302	Gasket, Top, Neoprene, 1/16" Thick	1
13	31505104	Gasket, Plain, 10-40450-18	2
14	31505179	Wire, 16 AWG, Green/Yellow	1 ft.
15	31500531	Terminal, Ring, PIDG, 22/16 #10	1
16	31506581	Washer, Lock Type A #8	1
17	31542725	Label	1
18	31500583	Tie, Cable, 4"	6
	*11598888	Assembly, Encoder and Motor:	
	31542636	Motor	
	31542716	Encoder	

EQUIPMENT PANEL ASSEMBLY

ITEM	CODE NO	DESCRIPTION	QTY
1	31542636	Motor, DC Servo, MT30H4-44	1
2	31501245	Connector, Rcpt, Box Mtg, 5P	1
3	31505104	Gasket	1
4	31944166	Plate, Cover, Motor Box	1
5	31505179	Wire, 16 AWG, Green/Yellow	1 ft
6	31500531	Terminal, Ring PIDG, 22/16 #10	1
7	31506556	Washer, Flt #4	4
8	31506588	Washer, Lk, Split #4	4
9	31506401	Screw, Phillip Hd, #4-40 x 3/8” lg	4
10	31541549	Tubing, Heat Shrink, 3/32” ID	34 ft
11	31542725	Label	1
12	31500583	Tie, Cable, 4”	3
13	31506581	Washer, Lock, Int Tooth #10	1
14	11014001	Screw, Stainless Steel, M10 x 1.0 x 10mm, Cup Pt	1
15	11665280	Loctite, #222	0

EQUIPMENT PANEL ASSEMBLY (1 of 3)



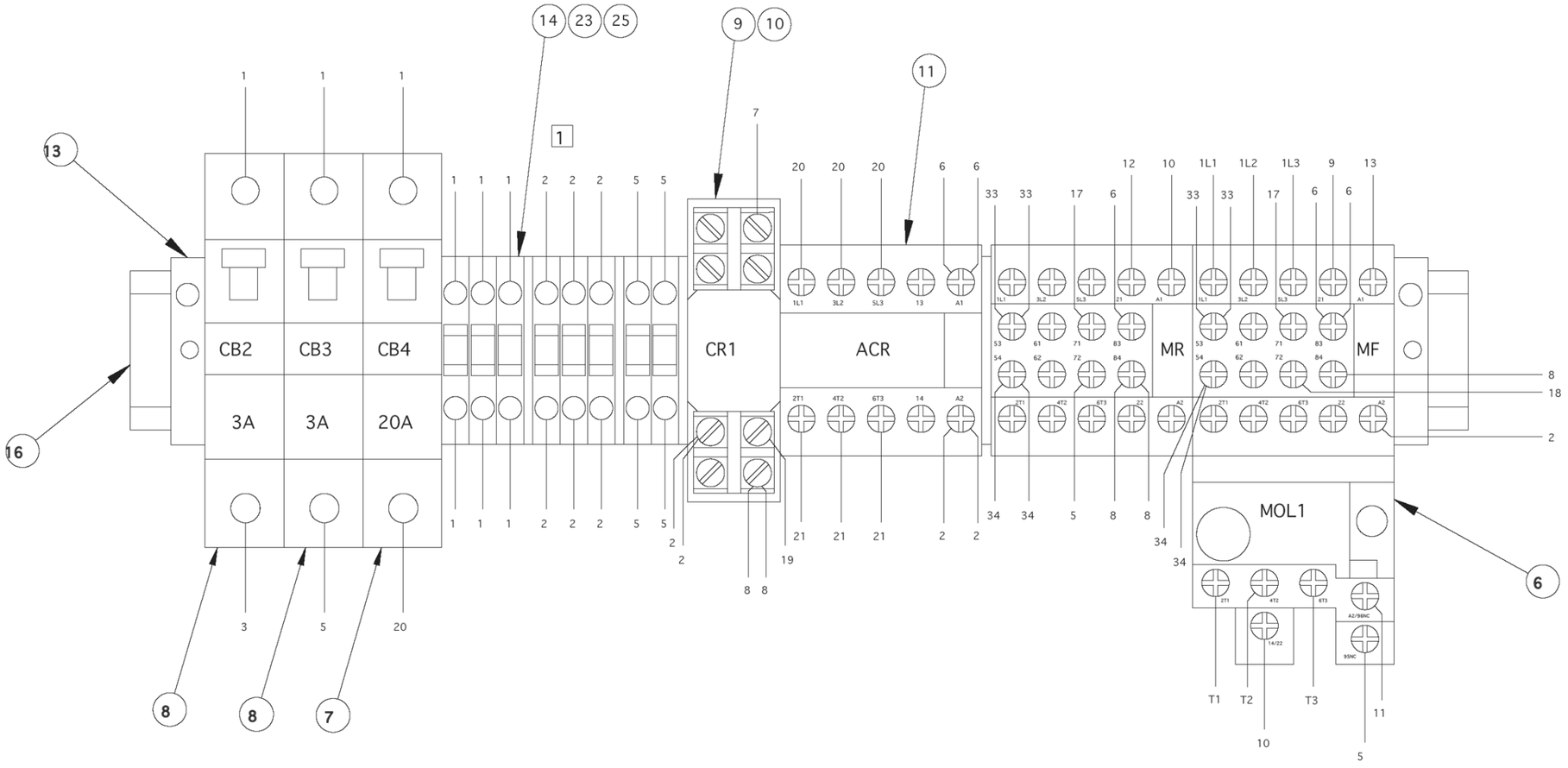
ITEM	PART #	DESCRIPTION	QTY	U/M
24	11598897	KIT, FLANGE HANDLE/OPERATING MECH	1	EA
23	31508860	TERMINAL BLOCK PARTITION	6	EA
22	31541773	COVER, WIREWAY, 1" WIDE	1	EA
21	11598868	WIREWAY, 1" WIDE X 3" HIGH	1	EA
20	11597386	COVER, WIREWAY, 1.5" WIDE	1	EA
19	11598867	WIREWAY, 1.5" WIDE X 3" HIGH	1	EA
18	11598895	BAR, TRANSFORMER SUPPORT	1	EA
17	11598935	GROUND BAR KIT, BRASS	1	EA
16	11598411	DIN RAIL, 11.75" LONG, 35mm	1	EA
15	11598866	HARNESS, INTERNAL	1	EA
14	31508130	TERMINAL BLOCK, M4/6, 10-22 AWG	48	EA
13	31508131	END CLAMP, DIN RAIL	4	EA
12	11598409	DIN RAIL, 10.75" LONG, 35mm	1	EA
11	11598797	CONTACTOR ASSY, SERVO AMP POWER	1	EA
10	11598883	SOCKET, RELAY	1	EA
9	11598882	RELAY, 2 POLE	1	EA
8	11598898	CIRCUIT BREAKER, 3 AMP, 1 POLE	1	EA
7	11598894	CIRCUIT BREAKER, 20 AMP, 1 POLE	1	EA
6	11598891	CONTACTOR/OVERLOAD ASSY, MOTOR REV	1	EA
5	11598487	TRANSFORMER	1	EA
4	11598893	CIRCUIT BREAKER, MAIN	1	EA
3	11598892	DRIVE, MOTOR	2	EA
2	11598899	LOGIC CONTROL UNIT	1	EA
1	11598856	ENCLOSURE, WITH PANEL	1	REF

TITLE: EQUIPMENT PANEL ASSY EZ-TRAK

DWG. NO. 59-8896 REV. 02

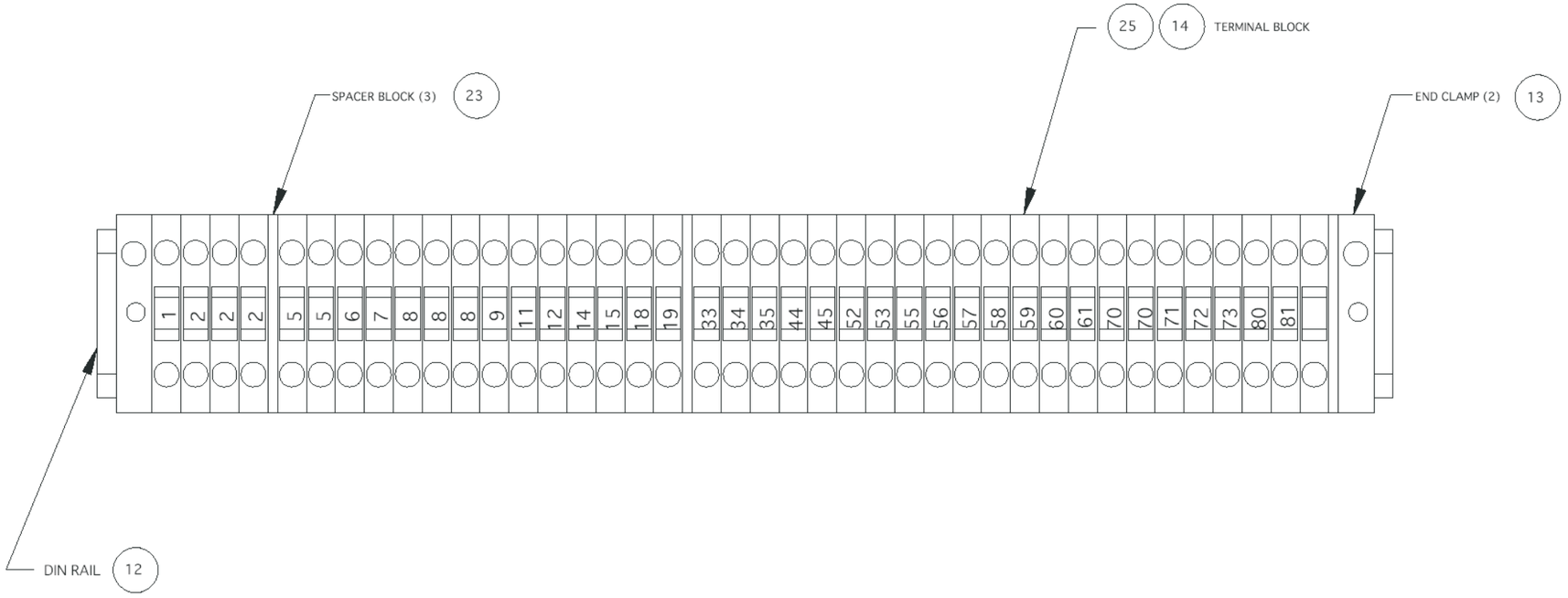
SHEET 1 OF 3

EQUIPMENT PANEL ASSEMBLY (2 of 3)



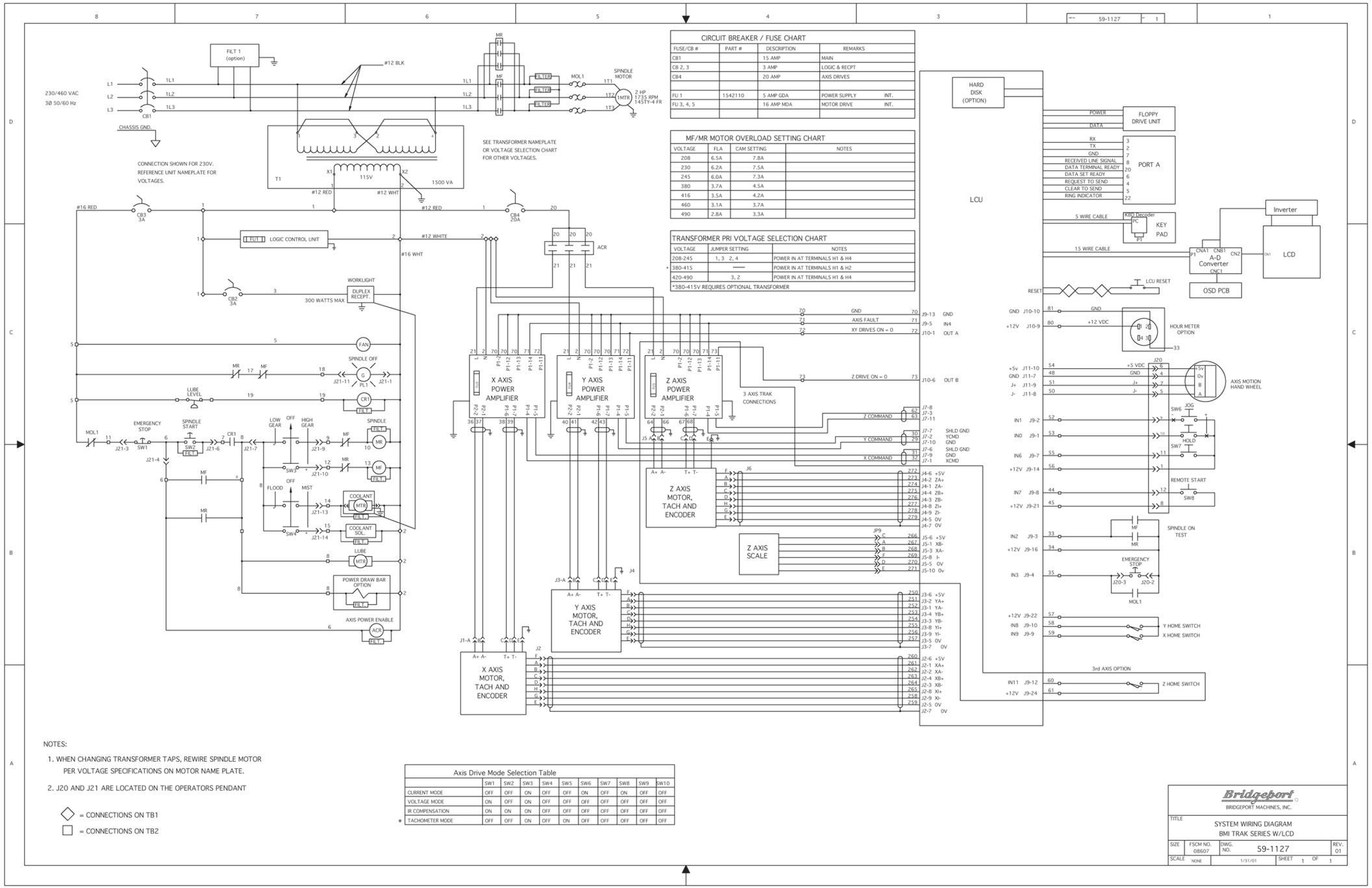
TITLE	TB1 WIRE ROUTING				
SIZE	FSCM NO. 08607	DWG. NO. 59-8896			REV. 02
SCALE NONE	RELEASE DATE 2/28/00	SHEET 2 OF 3			

EQUIPMENT PANEL ASSEMBLY (3 of 3)



TITLE: TB2 WIRE ROUTING			
SIZE	FSCM NO. 08607	DWG. NO. 59-8896	REV. 02
SCALE	RELEASE DATE 2/28/00	SHEET 3 OF 3	

MACHINE ELECTRICAL SYSTEM SCHEMATIC



- NOTES -

- NOTES -

APPENDIX A - STATIC SENSITIVE EQUIPMENT

STATIC SENSITIVE MATERIALS

- NOTE -

Static electricity has the potential to cause damage to delicate electronic components. This chapter contains necessary information and guidelines to be followed when handling these electric components or assemblies.

Static damage of components by operating personnel is becoming a significant problem plaguing the electronics industry. Technological advances in IC manufacture make possible devices with greater circuit densities, higher unit performance and quite often, higher static susceptibility. Fortunately, the problems associated with static charges in the electronics environment can be controlled.

The following are some general guidelines to follow during assembly or handling of static sensitive devices or assemblies.

GENERAL GUIDELINES

- NOTE -

Since August, 1981, all printed circuit boards, or assemblies containing static sensitive devices have been identified by this label:

Tp5749

Figure A.1 - Electrostatic Sensitive Device Label

- All assembly operations involving static sensitive devices must be performed at a specially grounded work station.
- The technician must be grounded by use of the wrist strap when working at this station.
- All electrical assembly equipment, such as soldering iron, should be grounded.
- Avoid handling static sensitive devices except when absolutely necessary.
- Under no circumstances should the static sensitive devices or assemblies containing static sensitive devices be allowed to come in direct contact with plastics (polyethylene bags, styrofoam, styrene boxes, plexiglass).

- CAUTION -

It is necessary for all field personnel to follow proper static prevention procedures when servicing any equipment containing static sensitive assemblies.

To remove or replace a printed circuit board containing static sensitive devices from the card rack, follow this recommended procedure:

EQUIPMENT REQUIRED

- Portable static-free work station kit containing floormat, grounding wire and wrist strap.
- Protective connector shunt for printed circuit board, 3M Co. 5020.
- Protective shipping/handling bag Part No. 3M Co. 2004.

PROCEDURE

1. Place a floor mat in front of the cabinet and connect ground wire to an appropriate earth ground. Check to make sure wrist strap is secure.
2. Stand on the mat and place a wrist strap on your wrist.
3. Carefully remove the printed circuit board from the unit.
4. Place the PC board in a protective shipping/handling bag.

VENDOR INFORMATION FOR STATIC PROTECTION EQUIPMENT

Work station kits MUST contain the following equipment in order to provide proper static protection:

- 3M portable field service kit - 8005 (Recommended for light duty)
- 3M Velostat floor mat - 1864
- 3M static control Wrist strap - 2064 (Recommended for heavy use)
- Velostat PC board edge protector - 5200
- Velostat shipping/handling PC board protective bag - 204

All equipment is available from:

3M Static Control System
223-2 Southwest 3M Center
St. Paul, MN 55101
(612) 733-9420

- NOTES -

- NOTES -

APPENDIX B - INSTALLATION AND USE OF SAFEGUARDS

Both American National Standard B11.8 and O.S.H.A. Section 1910.212 assign responsibility for point of operation safeguarding of milling machines to the employer/user. Therefore, to prevent serious injury resulting from the rotating cutter, flying chips, or splashing coolant, point of operation safeguarding should be used on milling machines to the greatest extent practicable.

This chapter provides basic information for the installation and use of the general purpose safeguard. It also contains the names of several manufacturers of other types of point of operation safeguarding for vertical milling machines.

Remember, point of operation safeguarding is your responsibility as the employer/user. You are in the best position to evaluate your safeguarding needs and ensure that the proper safeguards are installed and used.

- CAUTION -

A safety shield is supplied for protection from chips and coolant with every machine we ship.

The chip and coolant shields have been designed and are custom manufactured with the highest clear impact material commercially available: polycarbonate (G.E. Lexan). It has an impact strength 5 to 10 times greater than acrylic (plexiglass) or butyrate (UVEX) materials, thereby offering the greatest protection for our customers. Some of the new "easy to dispose of" coolants and/or cutting oils contain chemicals harmful to polycarbonate. These chemicals are: Mono-ethanolamine, Di-ethanolamine, Tri-ethanolamine and the combination thereof. These chemicals may significantly reduce the impact strength of the shield within days, and could destroy the entire shield in weeks.

Use of use of coolants and/or cutting oils containing these chemicals will void the warranty on your safety shield, and could cause injury to your workers.

- WARNING -

A safeguard DOES NOT take the place of any other safety practice or safety equipment.

YOU MUST ALWAYS wear safety glasses and safety shoes.

YOU MUST ALWAYS stop the spindle of the machine completely before changing or adjusting the workpiece, fixture, or tool.

YOU MUST NEVER wear gloves, long sleeves, long hair, rings, watches, neckties, jewelry or other loose items.

GENERAL PURPOSE SAFEGUARDS

There is no single safeguard which can match the versatility of the Series I machine. As a result, you will find that the general purpose safeguard, like all safeguards, will be suitable for some operations, but not for others. Carefully analyze the operation to be performed before deciding whether this safeguard is suitable. Adjust the safeguard to suit your special requirements. If you find that it is not suitable for a particular application, you should use an alternate form of protection.

INSTALLATION FOR MACHINES WITH R-8 SPINDLE TAPER

If your Series I standard milling machine was manufactured on or after January 1, 1983, the manufacturer has drilled and tapped two holes in the nose cap of the spindle to be used for mounting the guard (the two untapped holes serve to remove the nose cap with a spanner wrench).

1. Place mounting ring “B” underneath top of guard “D”.
2. Place two socket head cap screws “A” through the holes in ring, and hand-start them into the threaded holes in the nose cap until hand tight.
3. Align guard to be square with table of machine (unless angular mounting is desired).
4. Tighten screws with a 3/16” Allen wrench.

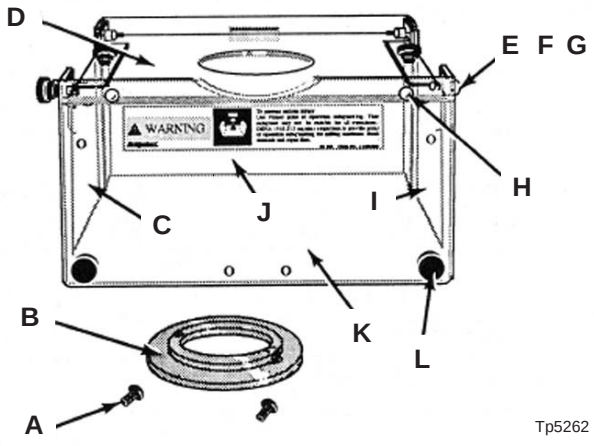


Figure B.1 - Milling Machine with R-8 Spindle Taper

Retrofits

If your Series I standard machine was manufactured prior to January 1, 1983, you must retrofit as follows:

1. Manually tap the existing spanner wrench holes with a .250”-20 bottoming tap.

- CAUTION -

There is no need to drill new holes, nor deepen the existing holes. Attempts at either practice may result in spindle damage.

2. Proceed to mount the guard as indicated above.

MACHINES WITH ERICKSON #30 QUICK CHANGE OR UNIVERSAL #200 QUICK CHANGE SPINDLES

If your milling machine attachment was manufactured after January 1, 1985 and has either an Erickson #30 or a Universal #200 quick change spindle, the manufacturer has drilled and tapped four #8-32 holes in the nose cap of the spindle for mounting the guard.

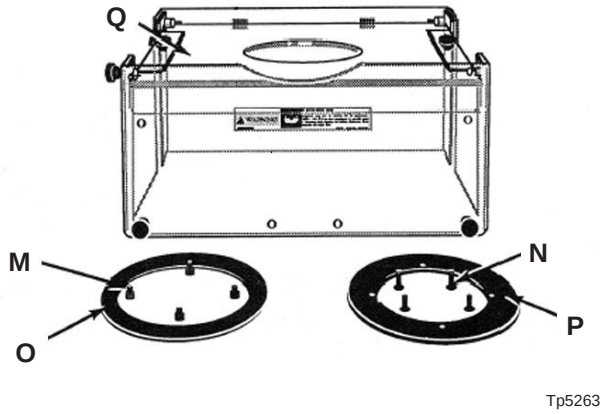


Figure B.2 - Milling Machine with Erickson #30 Quick Change Spindle

ERICKSON SPINDLE

If the nose cap mounting ring has not been installed, the following procedure will apply:

1. Remove the spindle locknut. This is done by removing the long button head black finish screw, which is normally left of the cadmium-finished button head screw on the locknut of the spindle. This will allow you to unscrew the locknut by turning it counter-clockwise.
2. Place the nose cap mounting ring “O” up against the quill nose cap and install the four button head cap screws “M”.

- NOTE -

The counterbored side of the nose cap mounting ring fits against the nose cap.

3. Lower the quill. Place the clamping ring “P” underneath the top of the guard “Q” and position the guard under the spindle.
4. Install the four socket head cap screws “N” through the nose cap mounting ring and thread them into the clamping ring.
5. Align the front of the guard parallel to the front of the table. Tighten the screws clamping the guard in position.
6. Reinstall the quick change locknut. Refer to assembly instructions.

If the nose cap mounting ring has been installed, omit steps 1, 2, and 6.

UNIVERSAL #200 QUICK CHANGE SPINDLES

The quick change locknut is not to be removed. To install the spindle safeguard, follow the preceding steps listed above: 2, 3, 4 and 5.

R-8 Shield Assembly (Code No. 11191200)

ITEM	CODE	DESCRIPTION	QTY
A	11011031	Screw, Socket Hd Cap, .250”-20 x .625”	2
B	12191201	Ring, Guard	1
C	11191204	Shield, Left Side	1
D	11191206	Shield Assy, Top	1
E	11665810	Screw, Button Hd Cap, #10-32x.750”	3
F	11010065	Washer, Plastic, #10-32	8
G	11010055	Nut, Stop, Plastic, #10-32	3
H	11010063	Screw, Drive, Type U, #12 x .625”	2
I	11191205	Shield, Right Side	1
J	11191203	Assembly, Rear Shield	1
K	11121202	Assembly, Front Shield	1
L	11010056	Screw, Hand, #10-32 x .750”	4

Quick Change Shield Assembly (Code No. 11190341)

ITEM	CODE	DESCRIPTION	QTY
A	11011031	Screw, Socket Hd Cap, .250”-20 x .625”	2
C	11191204	Shield, Left Side	1
E	11665810	Screw, Button Hd Cap, #10-32x.750”	3
F	11010065	Washer, Plastic, #10-32	8
G	11010055	Nut, Stop, Plastic, #10-32	3
H	11010063	Screw, Drive, Type U, #12 x .625”	2
I	11191205	Shield, Right Side	1
J	11191203	Assembly, Rear Shield	1
K	11121202	Assembly, Front Shield	1
L	11010056	Screw, Hand, #10-32 x .750”	4
M	11651199	Screw, Button Hd Cap, #10-32 x .500”	4
N	11980224	Screw, Socket Hd Cap, #8-32 x .625”	4
O	12190330	Ring, Guard	1
P	12190331	Ring, Guard	1
Q	11191207	Shield Assy, Top	1

- NOTES -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