OPERATING MANUAL

FOR THE

R2E3 SERIES I CNC

MILLING, DRILLING & BORING MACHINE

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Bridgeport® TEXTRON

Bridgeport Machines Division of Textron Inc.

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SAFETY INFORMATION

To prevent serious bodily injury, you should observe the following basic safety precautions when installing, operating or servicing your Bridgeport milling machine.

1. Follow all instructions in the machine manual.
2. Wear approved industrial safety glasses and safety shoes.
3. **Do not** wear gloves, long sleeves, long hair, rings, watches, jewelry or other loose items that could become caught in moving parts.
4. Keep all parts of your body away from moving parts (belts, cutters, gears, etc.)
5. Use proper point of operation safeguarding.

These 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 B11.8-1974).

This publication is available from: The American National Standards Institute
1430 Broadway
New York, New York 10018

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 B11.8-1974, 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

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

This manual provides the operator with information and examples necessary to operate the Bridgeport R2E3 Series I CNC Milling Machine. The R2E3 is totally dedicated to Computer Numeric Control (CNC), using BOSS 8 I (Bridgeport Operating System Software, Series I).

This manual is divided into the following major sections:

- Operator Controls, and Indicators
- System Start Up/Shutdown
- System Operating Modes
  - SET UP
  - RUN
  - MDI
  - MDI STORE
- Editing Capabilities
- Optional Equipment
- Tool Holders
- Appendix
  - System Status/Error Messages
  - System Specifications

- Glossary

1.2 REFERENCE MANUALS

Two other manuals exist for this product.

1. R2E3 Installation and Maintenance Manual (11040529)
2. R2E3 Programming Manual (11040532)

1.3 GENERAL DESCRIPTION

The Bridgeport R2E3 Series I CNC is a Vertical Milling Machine operated via a Front Panel with an LCD (liquid crystal display). It provides 3 axis linear and 2 axis switchable plane circular interpolation. The design makes extensive use of VLSI (very large scale integration).

A communication protocol embedded in BOSS 8 I is used in conjunction with the remote serial interface port, which will be known as Port B. The protocol, EIA RS-491, includes means for checking transmitted data for errors using the following ASCII codes: <DC1> Start Read, <DC2> Device on, <DC3> Stop Read, <EOT> End Transmission.

1.4 ARCHITECTURE

The system contains three sections, see Figure 1-1, all working together as one. The individual sections are:

1. Milling Machine (mechanical)
2. Control and Power (electrical)
3. Interface (electromechanical)

Each section is specialized and interacts with the other two to make the system function as a whole. The milling machine contains all mechanical aspects of the machine and the controller contains all electronic aspects of the machine. The electromechanical interface provides the link between the milling machine and the control.

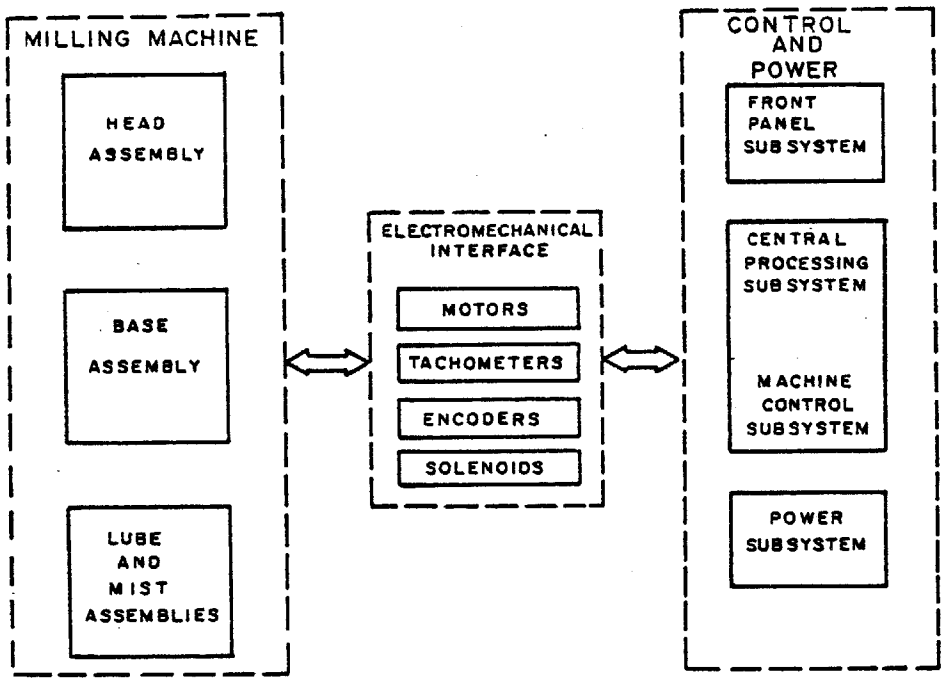


Figure 1-1: The R2E3 System - Functional Blocks

1.4.1 Milling Machine

This section contains (see Figure 1-2):

1. Head Assembly - Contains the mechanical components of the quill (Z axis), the pneumatics and their support structure. The Z axis drive motor and spindle motor are mounted to this support structure.

2. Base Assembly - Contains the saddle (Y axis), table (X axis), knee, and their support structure. The X axis and Y axis drive motors are mounted to this structure.

3. Lube and Mist Assemblies - Contains the air regulator and filter, the lubrication pump and the optional mist assembly. These components are the starting points for the distribution of pressurized air, mist coolant and way lubricant.

1.4.2 Control And Power

This section consists of (see Figure 1-2):

1. Front Panel - Most operator control is through the Front Panel, in any one of four modes following system start up. These modes are; Set Up, Run, MDI (Manual Data Input), and MDI Store. Editing is possible via the Front Panel, however it is intended for use in the Set Up mode allowing modification to existing part programs.

2. Control - All operator and electronic input plus machine feedback is analyzed by this subsystem.

3. Power - Incoming electrical power is conditioned and distributed to the controller and electromechanical parts by this subsystem.

4. Controllers - These convert electrical signals into voltage and current to the DC motors.

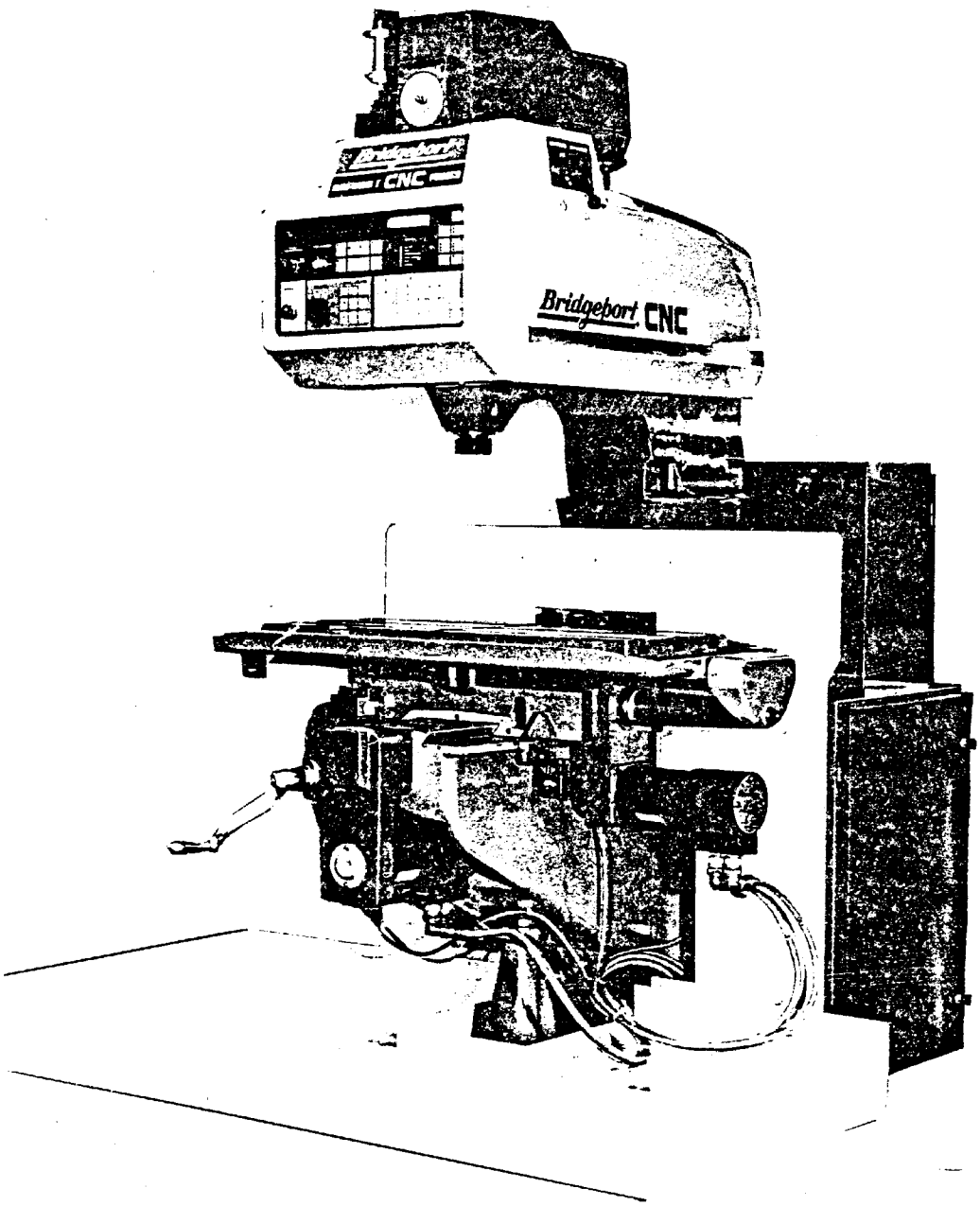


Figure 1-2: R2E3 Series I CNC

1.4.3 ElectroMechanical Interface

This section contains three parts, see Figure 1-2. These parts convert electrical signals into mechanical motion.

1. DC Motors - These take drive current from the control and convert them into axis movements.

2. Encoders and Tachometers - These convert axis movements from the motor into electrical signals which the system can decode.

3. Solenoids - These convert electrical signals to pneumatic and hydraulic power.

1.5 MODES OF OPERATION

1.5.1 Set Up Mode

Set Up prepares the machine for part making. This includes establishing machine reference points, tool characteristics, initial axis positions, and the loading of part programs.

1.5.2 Run Mode

Runs a complete part program previously loaded into memory, either in Automatic or Block-by-Block mode. Run mode will also work with DNC LINK.

1.5.3 MDI Mode (Manual Data Input)

In this mode the operator can input and execute a single program block.

1.5.4 MDI Store Mode

The MDI Store mode allows the operator to input and execute a part program on a block-by-block basis, and store each block at the end of the part program text buffer.

CHAPTER 2

OPERATOR'S CONTROLS AND INDICATORS

This chapter describes the keys, knobs and switches associated with operator controls on the milling machine. Descriptions include the location and purpose of each control.

2.1 OPERATOR CONTROLS

There are four groups of operator controls.

1. Front Panel Control
2. Power & Control/Axis Drive
3. Tape Reader Adapter/Remote Serial Interface
4. Lube and Pneumatic Control

2.1.1 Front Panel Control

The control keys and operating switches are color coded on the Front Panel in the following groups:

1. Machine Controls
2. EMERGENCY STOP
3. SET UP
4. RUN
5. Manual Data Input (MDI) and MDI STORE
6. Display Screen
7. Status LEDs

The groups mentioned above are shown in Figure 2-1.

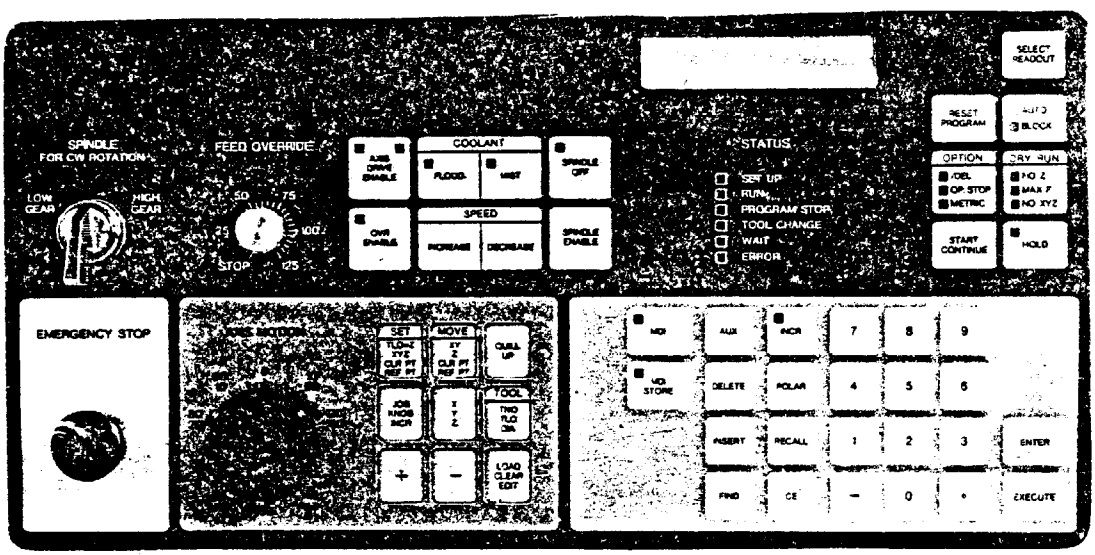


Figure 2-1: Operator's Front Panel

NOTE

All 48 keys on the Operator's Front Panel are pressure sensitive. You must apply slight, but firm, pressure for activation.

2.2 FRONT PANEL

This is the color coded panel containing 48 pressure sensitive keys, 24 LED indicators, 4 manual switches and a 40 character alphanumeric LCD screen. The panel is located on the front of the head assembly.

2.2.1 Machine Controls

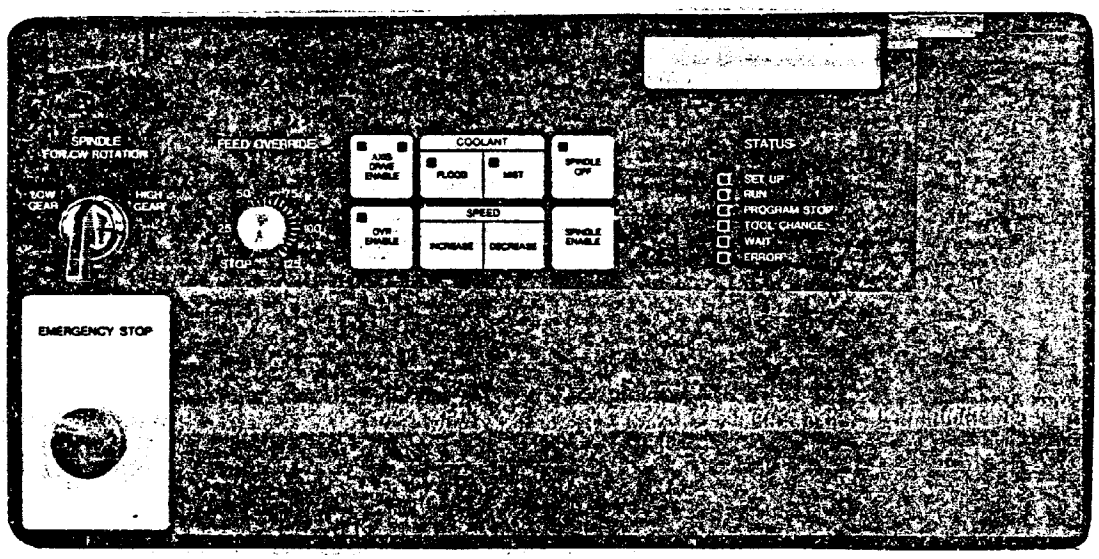


Figure 2-2: Machine Controls

1. SPINDLE OFF:
The green LED will be on when spindle is OFF; this is the safe condition. When the spindle is running, pressing SPINDLE OFF will stop the spindle.

2. SPINDLE ENABLE:
Simultaneously pressing the SPINDLE ENABLE key and moving SPINDLE FOR CW ROTATION lever to either HIGH GEAR or LOW GEAR will turn the spindle ON (SPINDLE OFF LED will be off).

3. SPINDLE FOR CW ROTATION:
This is a selector switch with two gear positions: HIGH and LOW. The switch is used to select the direction of spindle rotation (CW or CCW) in conjunction with the speed range lever (located on the right side of the head assembly, see Figure 2-3.

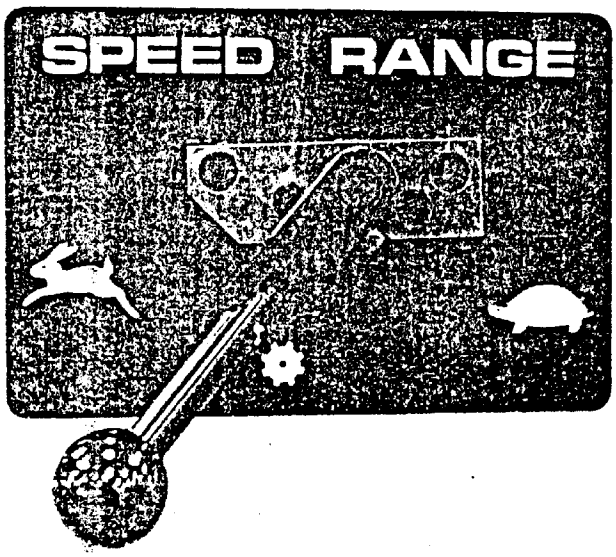


Figure 2-3: Speed Range Control

With the GEAR LO/SPEED LO or GEAR HI/SPEED HI, the spindle will rotate in the clockwise direction; other combinations, GEAR HI/SPEED LO, or its complement, will cause counterclockwise rotation.

4. SPEED INCREASE/DECREASE Key:
This allows increases or decreases to the spindle speed only while the key is pressed. It will not operate unless the spindle motor has been turned on. Releasing the key stops further action in the direction selected, and speed remains at the level reached when the button was released. Spindle speed is indicated by the speed dial located at the center of the head assembly, see

Figure 2-4.

NOTE

The S value in a part program is displayed for information only and has no effect on the actual spindle speed.

5. AXIS DRIVE ENABLE:
This key enables power to the axis drives. When pressed after power up, any error messages displayed at this time will reflect the condition of the battery backed up memory and the internal communications or axis drive system. The red LED in this key when lit will show a successful test but no power to the axis drives. The green LED shows power to the axis drives.

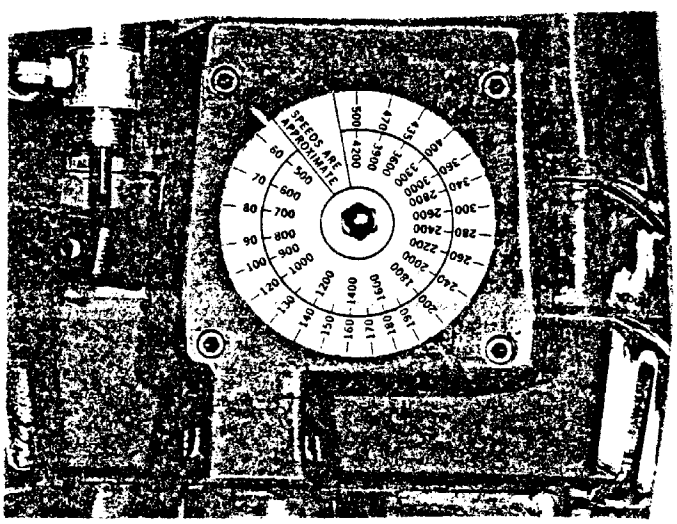


Figure 2-4: Speed Dial R2E3

Feed Override Knob

1. FEED OVERRIDE:
This knob allows the operator to modify the feedrate entered via the part program by a factor of 10% to 125%. Below 10%, the system goes into a feed hold condition, even if OVERRIDE is not enabled.

2. OVR ENABLE:
Pressing this key will enable the FEED OVERRIDE control at the immediate left.

NOTE

In the Set Up, Block Run and MDI modes, the FEED OVERRIDE control affects the rapid traverse rate as well as the feedrate. In Auto Run it only affects the feedrate.

COOLANT

The FLOOD and MIST keys operate the optional coolant devices available for the machine. When in use (LED on) the coolant operations are active with the spindle.

EMERGENCY STOP

This is a red mushroom button. When pressed, it stops the spindle motor and axes drives. Program execution is terminated and the system is set in the System Start Up mode.

When EMERGENCY STOP is pressed the part program and TLOs are not destroyed, but axis position is lost. To recover from EMERGENCY STOP, first pull out the button, then execute the AXIS DRIVE ENABLE sequence which returns each axis to the Home position.

NOTE

This button should be used only when safety is threatened. In normal use, the HOLD button should be used to interrupt axis motion.

2.2.2 SET UP

Set Up is intended for use in the initial preparation of the milling machine, before operation of the part program. This includes the loading of tool length offset values, tool diameters, axis Reference Points and the Clearance Point. Set Up is also used when employing the full edit capability, loading paper tape or EZ-LINK part programs and clearing part program data from the text buffer. The Set Up keys are located in the dark green section of the Front Panel. Several of these light green keys are multifunction and must be pressed more than once to activate the desired function.

SET key

The SET key is a multifunction key which allows the operator to

establish Tool Length Offset (TLO) values, establish a part program reference system (XYZ), a Clearance Point (CLR PT), and Machine Reference Points (REF PT) for X and Y. Scrolling through the menu by repeated operation of the key will display the various selections.

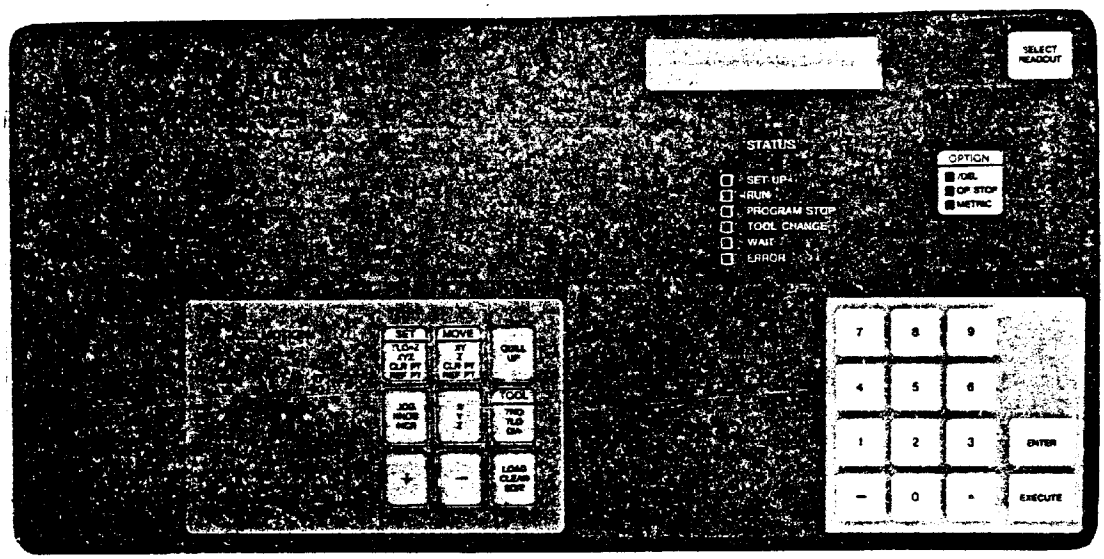


Figure 2-5: Set Up Mode Controls

MOVE Key

MOVE is a multifunction key which enables the operator to move to any keyed in X, Y and Z coordinate value, Clearance Point, or Reference Point. Repeated operation of the key will cause each new display to appear.

QUILL UP

Pressing this key will enable Z axis motion to the Home position. EXECUTE will initiate the Z motion. The display will show:

```
-----------------------------------------
|Q U I L L   U P       E X E C          |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|                    M Z       1 . 5 0 0 0|
-----------------------------------------
```

NOTE

During QUILL UP, the Z display will show the distance from the Z mechanical reference point (machine zero), not the Z axis part program coordinate value.

JOG/KNOB/INCR Key

The JOG key together with the associated key functions (XYZ, "+", "-" and AXIS MOTION knob), allows the operator to move each axis to any desired location in increments as small as .0001 inch/jog.

TOOL Key

Repeated pressing of the TOOL key will scroll through each of the 24 tools currently in the tool buffer. The ENTER key will scroll the screen display through T, TLO and DIA inputs for each tool.

LOAD/CLEAR/EDIT Key

This multifunction key will enable loading part program text, clearing system data from various buffers, and editing or entering part program text. Each time the key is pressed the screen display advances through LOAD, CLEAR or EDIT.

2.2.3 RUN

Run assumes that a part program exists in the text buffer. If no program exists, it will be necessary to load one. Part programs can be entered from remote computer terminals, DNC LINK, or through the EZ-CAM via serial Port B or Port A using the Editor. A paper tape reader may be used via the port marked C.

During part program Run, the LCD screen will display the current program block information. The axis position data will be in part program coordinates. Run LED in the status column under the LCD screen will be on.

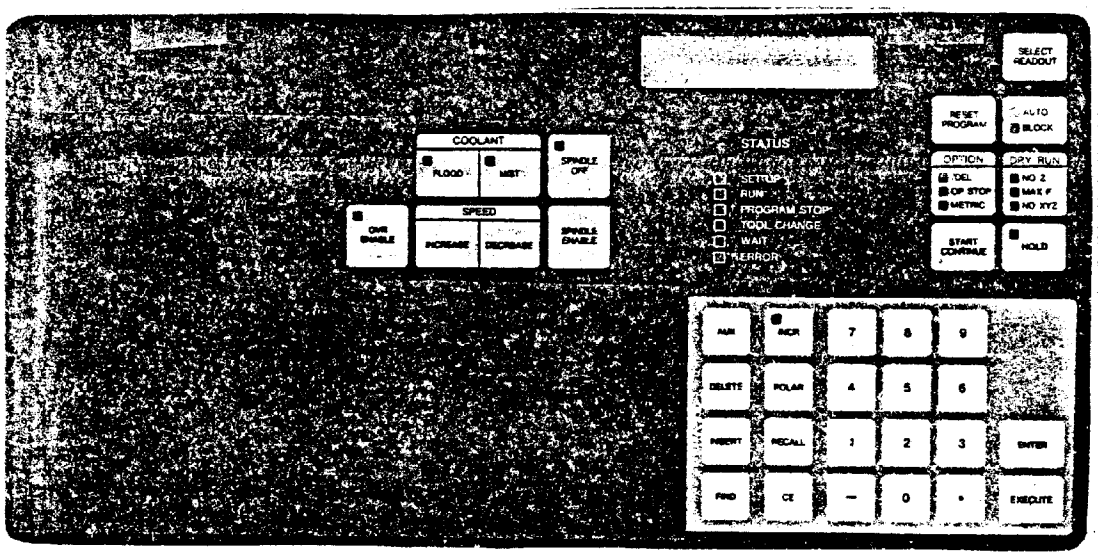


Figure 2-6: Run Mode Keys

SELECT READOUT Key

During part program execution and when part program coordinates are being displayed the SELECT READOUT will cause the axis positions displayed on the screen to toggle between the X and Y axes or the Z axis.

RESET PROGRAM Key

This will return the part program to the beginning of the text, initialize run registers and display the first 20 characters in the first data block.

AUTO/BLOCK Key

Pressing the AUTO/BLOCK key will enable the system to run in either AUTO, automatic execution of a part program or BLOCK, block-by-block execution of a part program.

2.2.4 Special Operations

OPTION Key

OPTION is a multifunction key which allows the operator to choose options such as /DEL, OP.STOP, METRIC, BOSS 8 I/BOSS 4-7, and BAUD.

START/CONTINUE Key

START begins operation of the part program (after enabling by the AUTO/BLOCK key) either at the top of the text, or at a specified sequence number. CONTINUE resumes execution after an interruption such as PROGRAM STOP or system HOLD.

NOTE

It is not necessary to press this key twice to use continue.

HOLD

This key stops part program execution and interrupts axis motion without loss of the program position. All axes will decelerate to a smooth stop.

NOTE

In RAPID TRAVERSE (G0), motion may continue up to 0.2 inches after HOLD is pressed. The unused portion of the active registers are not lost. To continue, press START/CONTINUE.

PPRINT

There is no key labeled PPRINT, but the term is included to represent the effect of a program stop command embedded in the part program (M00, M01, M06). When this command is reached, the display will exhibit a comment statement from the program between quotation marks (' '). Comments beyond 40 characters will only display the first 40 characters. An example of a possible comment is shown below:

```
-----------------------------------------
|  I N S E R T   T O O L   1 =          |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|    . 5 0 0   D I A     E N D   M I L L|
-----------------------------------------
```

NOTE

When using a teletype 43 or another device which does not have the straight quote, | , the slanted quote, , must be used.

2.2.5 MDI - Manual Data Input

MDI enables the operator to enter additional part program blocks from the Front Panel Keypad, see Figure 2-7. When entering additional blocks the input format is determined by the G preparatory function code. The LCD screen will provide dialogue information (menu) requests, as determined by the G code, in an interactive exchange with the operator. MDI results in no addition to the text buffer. For details see Chapter 7.

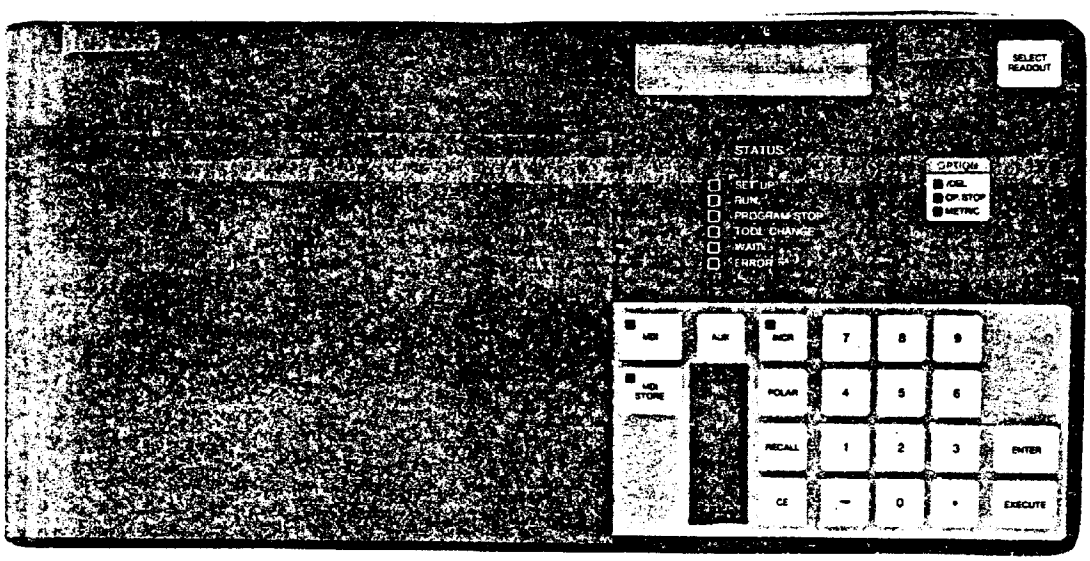


Figure 2-7: MDI Mode - Application Keys

MDI STORE Key

This key enables the operator to build a part program , execute blocks and store them at the end of the program text. When MDI STORE is pressed, the screen will exhibit DEF in the top display. After a part program number is entered, the operator is given the opportunity to enter tool parameters for the program. Data entry is performed in the same manner as in the MDI mode, however, EXECUTE will now store the data in the text buffer.

Quick Edit Keys

FIND - To search for N, T or (part program number)
INSERT - To enable the entry of new text
DELETE - To delete a part program block
RECALL - To backup the edit pointer by one block
AUX - To enable MDI entry of S, T or M codes

For details see Section 5.2.

INCR

Use of this key in MDI, MDI STORE, or INSERT allows the operator to specify the incremental dimensioning system for future axis moves. When the LED in the INCR key is off, pressing INCR will cause a G91 to be inserted in the part program and the LED will go on. The INCR key will also work independently of the MDI mode without modifying the part program buffer. The LED will reflect the status of the machine.

NOTE

When not in MDI, MDI STORE, or INSERT the INCR key will change the current operation of the system without any addition to the part program.

POLAR

POLAR input enables replacement of X, Y input with R, A, I, J, where R is the polar radius, A is angular distance from the +X axis, and I & J are the pole centers. The POLAR function is available in MDI, MDI Store, or Insert mode only.

"0 - 9", "." (Decimal)

Numerals as needed for data input.

"-" (Minus Sign)

Minus sign is required for entering negative data, absence of this sign assumes a positive value. It is not used for a JOG negative move.

2.2.6 Status Indicators (LED)

The current status, or mode condition, of the machine control is provided by 24 indicator lamps.

2.3 POWER & CONTROL/AXIS DRIVE

The Power Equipment Enclosure is mounted on the rear of the machine, and contains the single electrical power connection to the fusible disconnect switch. All incoming power enters at the Main Disconnect switch located on the upper right corner when facing the Power Equipment Enclosure. The maximum allowable line voltage is 600 volts AC. The option of selecting 5 incoming line voltages is available in kit form through Bridgeport as follows:

208 VAC	50/60 Hz
230 VAC	50/60 Hz
380 VAC	50/60 Hz
420 VAC	50/60 Hz
460 VAC	50/60 Hz

2.3.1 Spindle Motor Protection

The spindle motor is a 3 phase 2 HP AC motor. It operates on 220, 230 or 440 VAC. Three heaters protect the spindle motors against excessive currents. If the current drawn by the load becomes excessive, these overload heaters will shut down, stopping current to the spindle. These heaters must be reset before the spindle motor can be restarted.

WARNING

RESETTING THE HEATERS REQUIRES A QUALIFIED MAINTENANCE TECHNICIAN, LEVEL II. OPERATORS SHOULD NOT ATTEMPT THIS JOB. SERIOUS PERSONAL INJURY COULD RESULT FROM FAILURE TO HEED THIS WARNING.

2.3.2 Auxiliary Power Outlets

Five power receptacles are provided on the Power Equipment Enclosure. They are found directly above the communication ports located on the right side of the cabinet, the operator facing the cabinet, see Figure 2-8. * Correct as follows:

- Dual receptacles are powered with 115/1/60 each fused at 4A. It is interlocked with the spindle motor so that power to the receptacle is on when the spindle is on, and off when spindle is off. This is used to drive the flood coolant pump when this accessory has been purchased for the machine.

- Dual receptacles are powered with 115/1/60 and fused for a standard machine light, a Tape Reader or EZ-FILE. When the Main Disconnect switch is on, these receptacles will be on and are NOT affected when the EMERGENCY STOP button is pushed.

- Another receptacle is available for the spray coolant option when this accessory is purchased for the machine. It is also fused at 115/1/60.

2.4 PORT A/PORT B INTERFACE SUBSYSTEM

The Communications Panel, see Figure 2-8, is located on the left side of the Power Control Panel (operator facing the machine). This panel is configured to accept three types of communication interfaces:

PORT A provides the interface for communications terminal (CRT or TTY) for part program editing. Both 20 ma current loop and RS-232 are provided on this port, see Appendix C for pin-outs.

PORT B is provided for remote loading and down loading of part programs. There are two communication protocols provided for this remote interface, RS-491 level 2 (EIA standard for numerical control) and Bridgeport's EZ-LINK protocol. The EZ-LINK protocol is supported by both EZ-CAM and EZ-FILE systems, see Optional Equipment. RS-232 and RS-422 are both available on Port B, see Appendix C for pin-outs.

PORT C is provided for the Remex paper tape reader.

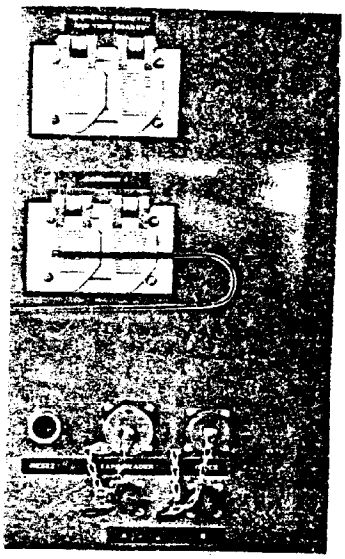


Figure 2-8: Tape Reader Input Port & the Serial Interfaces

2.5 RESET SWITCH

Pressing the RESET switch will cause the R2E3 to go into system start up. Refer to Section 3.6.2.

2.6 LUBE & PNEUMATIC CONTROL SUBSYSTEM

The lubrication and pneumatic controls, are located together in an enclosure on the left side of the column (operator facing machine), see Figure 2-9. The operator is limited to checking, filling oil reservoir levels, air pressure checks and adjustments.

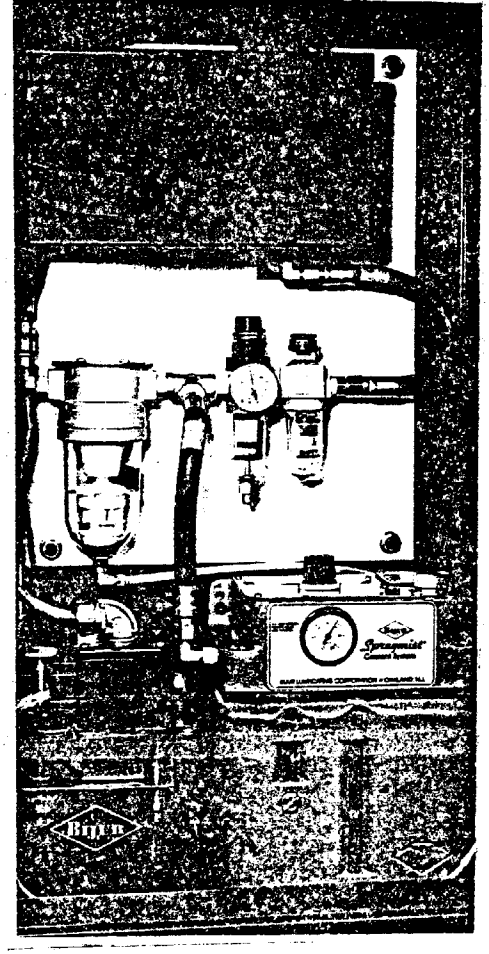


Figure 2-9: Lube & Pneumatic Controls

2.6.1 Lube Assembly

The automatic lubricating system distributes oil to all sliding mechanical surfaces in the machine. The primary component of this system is the Bijur tank. The operator should periodically inspect the level of oil (Sunoco Waylube #1180 or equivalent) and refill if the level is low.

An interlock is built into the lubricator which will prevent the SPINDLE ENABLE from working if the oil level is too low.

NOTE

Low oil level will not stop a job in progress but will prevent the spindle from being started for the next job.

2.6.2 Pneumatic Assembly

Supply pressure of the pneumatic system is 100 psi. Normal pressure on the indicator should be maintained at 80 psi, see Figure 2-9. The inlet side of the pressure regulator contains an air filter; the pressure indicator is between the two glass reservoirs followed by the air lubricator. The oil level in this glass should be checked daily and kept between the indicated marks.

NOTE

The knurled screw over the air filter will adjust the air pressure to the desired level.

CHAPTER 3

SYSTEM START UP/SHUTDOWN

3.1 START UP

The following procedure is necessary to start up the R2E3 System. After successful completion of the system start up, one of the four modes of operation may be entered to begin machine operation.

3.1.1 Prestart Considerations

Before attempting to start the machine, make a careful check of the following conditions.

1. Level of lubricating oil - refill if low.
2. Position of X, Y, & Z axes with respect to fixtures or other parts left on the table.
3. Air pressure level - adjust to nominal 80 psi.

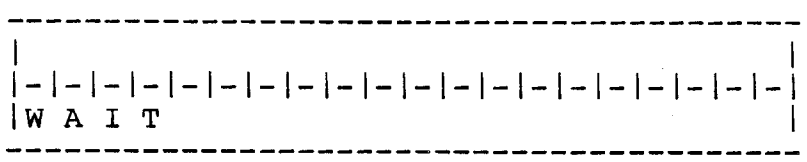
3.1.2 System Start Up Procedure

Power On

To power up the system move the MAIN DISCONNECT switch to the ON position. This switch is located on the upper right corner of the Power Equipment Enclosure.

Initial Condition

There will be a system self diagnostic test, as the following message is displayed:

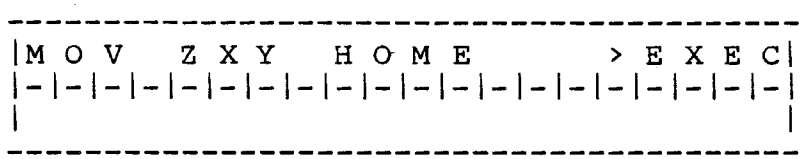


During this period all LEDs are illuminated as part of an extensive internal diagnostic check. When the system successfully passes the test, the message ENABLE AXIS DRIVES will be displayed and the red LED in AXIS DRIVE ENABLE will go on.

NOTE

There may be an error message in the upper left hand corner of the LCD. This will alert the operator of any problem in the system.

When AXIS DRIVE ENABLE is pressed, the LCD screen will exhibit the following:

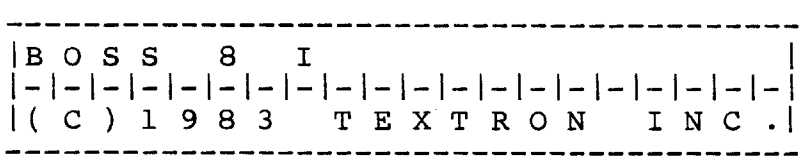


EXECUTE will initiate a machine homing sequence:

1. Quill moves up to Home position.
2. The X and Y axes will move to the Home positions in sequence.

The AXIS DRIVE ENABLE green LED will indicate power has been applied to the axis drives. The LED in SET UP will show the machine is in the Set Up mode.

At the conclusion of this sequence, the display will show:



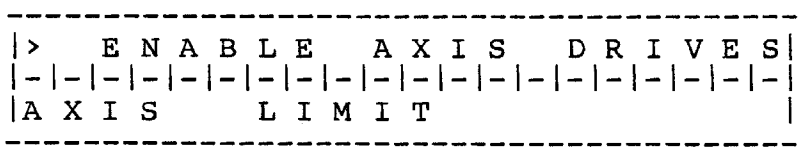
If the system detects a dead battery, BAT will be displayed on the bottom left of the LCD. If other system faults are detected they will be displayed as error codes on the lower portion of the LCD and will only be displayed after the system has been homed.

NOTE

If a CRC prom error is found during the selftests, the system will display the error message,CRC and will not continue with the power up sequence.

Axis Limit Check

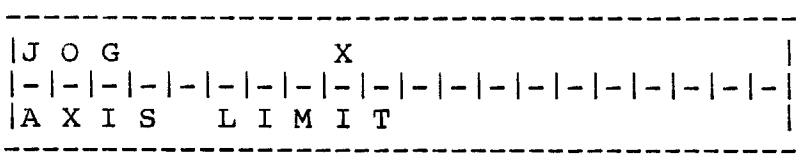
If an axis limit has been exceeded or EMERGENCY STOP is active, the red LED will go on in the AXIS DRIVE ENABLE. When the AXIS DRIVE ENABLE is pressed the internal logic will check the status of axis limit switches, located in the X and Y axes, and the quill (Z), and the screen will show:



The red AXIS DRIVE ENABLE LED indicates that power to the axis drive has been disabled. Pressing the AXIS DRIVE ENABLE key will automatically set the system in the Jog submode. The following will appear:

NOTE

The operator must determine which axis is on a limit.



The JOG "+" or "-" keys can then be used to move away from the limit switch. When the slide has been positioned within the normal travel range the display will show:

```
-----------------------------------------
|> E N A B L E   A X I S   D R I V E S  |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|                                       |
-----------------------------------------
```

CAUTION

To guard against damage to the machine tool,select the correct jog direction. Software travel limits are not active until after the next homing operation.

This display is forced on the operator because the system has lost the relationship between part program coordinates and the machine coordinate Home position. This operation will now validate all previously stored coordinates.

3.2 CONDITIONS FOLLOWING START UP

3.2.1 Default Condition

Immediately following successful start up, the active tool will be T1. When the quill goes "Home", Z will be set equal to the T1 TLO. The system will then go into the Set Up mode and the SET UP LED indicator will come on. The start up (default) condition of the system is:

1. BOSS 8 I - Operation Mode
2. G0 - Rapid Traverse
3. G17 - X, Y Plane Circular Interpolation
4. G30 - Mirror Image - OFF
5. G40 - Diameter Compensation - OFF
6. G44 - Constant Surface Feed Control - OFF
7. G70 - Inch Data Input
8. G72 - Transformation - OFF

9. G75 - Multiquadrant Input

10. G90 - Absolute Programming

11. DNC - OFF

3.2.2 Self Test Diagnostic Description

During execution of programs, the following checks are made for error conditions:

- o Part program data input
- o Cutter Compensation calculations
- o Illegal interpolation command
- o Communications fault check
- o System fault check
- o Front Panel fault check
- o Auxiliary function controller fault check
- o Axis drive fault check
- o Tool table or part program memory fault check
- o Axis overtravel

These checks are not apparent to the operator unless an error code is displayed on the LCD during the wait message.

3.2.3 Self Test Error Messages

Errors which are found by software checking are displayed on the screen as a 4 character Hex code. A listing of the error messages and a detailed explanation of the relationship of the Hex code to the specific error messages is discussed in Appendix A.

3.3 NORMAL SHUTDOWN PROCEDURES

To shutdown overnight, or for an extended period of time, use the following procedure:

- o Select Block mode or wait for a tool change block.
- o Turn spindle OFF.
- o Switch machine Main Disconnect to OFF.

3.4 EMERGENCY STOP

This should be used only when safety is threatened. When activated, it deenergizes the spindle motor and the axes drives. Program execution is terminated and the system reverts to system start up when power is restored to spindle and axes drives.

NOTE

The part program and TLO/DIA data are not lost, but axis position is lost. It will be necessary to reestablish axis positions after an EMERGENCY STOP, see section 4.2.

3.5 POWER FAILURE

Loss of power to the machine for more than 1/60 of a second (1 cycle) will cause system shutdown. Return of power will require system start up procedures as with EMERGENCY STOP.

3.6 RESET

There are two different operations involved with the following:

RESET PROGRAM key
RESET Pushbutton switch

3.6.1 RESET PROGRAM Key

This key causes many internal operations to be performed:

1. Initialize the program registers.

2. Places the line pointer at the top of the text.

3. Displays first 20 characters of first line in the text.

4. Displays current operational mode:

   Either BOSS 4-7
   Or BOSS 8 I
   and DNC LINK ON or OFF

   Pressing RESET PROGRAM during execution of part program blocks will have no effect.

3.6.2 RESET Pushbutton Switch

Pressing this pushbutton places the R2E3 in a startup condition. The startup procedure should be followed. Refer to Section 3.1.2.

CHAPTER 4

OPERATION IN SET UP MODE

4.1 SYSTEMS OPERATION

The Set Up mode is the default condition following system start up after the self check diagnostic tests have been completed. The Set Up LED in the STATUS column will be on. Use this mode to prepare the milling machine for execution of a part program. The Set Up keys are located in the dark green area of the Front Panel, see Figure 4-1. The following operations are available:

1. Establishment of machine/part program coordinate system
2. Axis jog
3. Entering tool data
4. Loading part programs
5. Clearing tool/text registers
6. Editing functions

Before entering the Run mode of operation there should be a part program ready to run in the text buffer. If no program exists, it will be necessary to either load or create a program.

The instructions and explanations required for the preparation and operation of the system are addressed in the following sections.

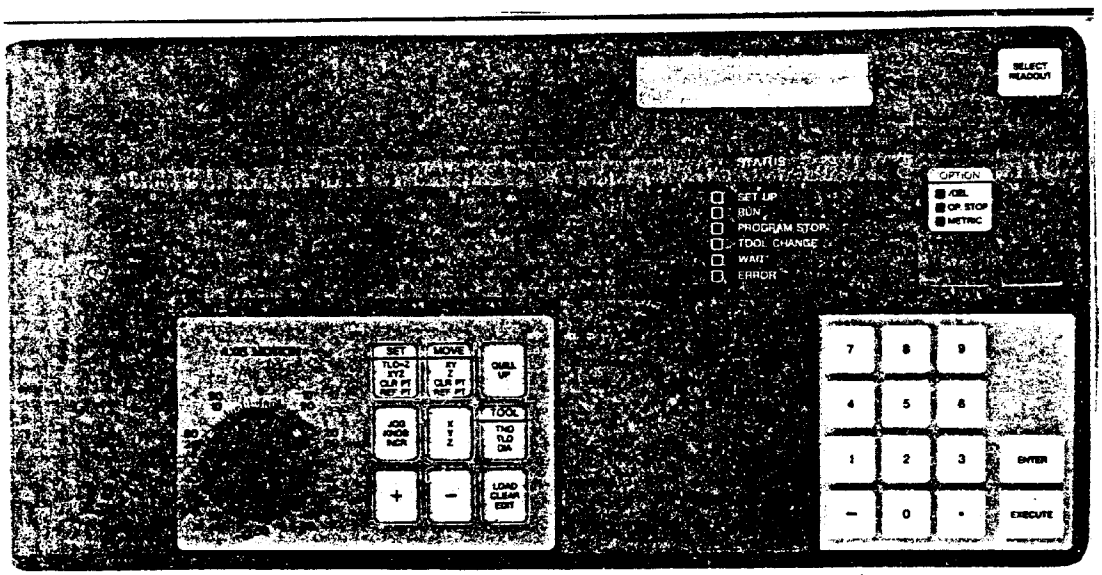
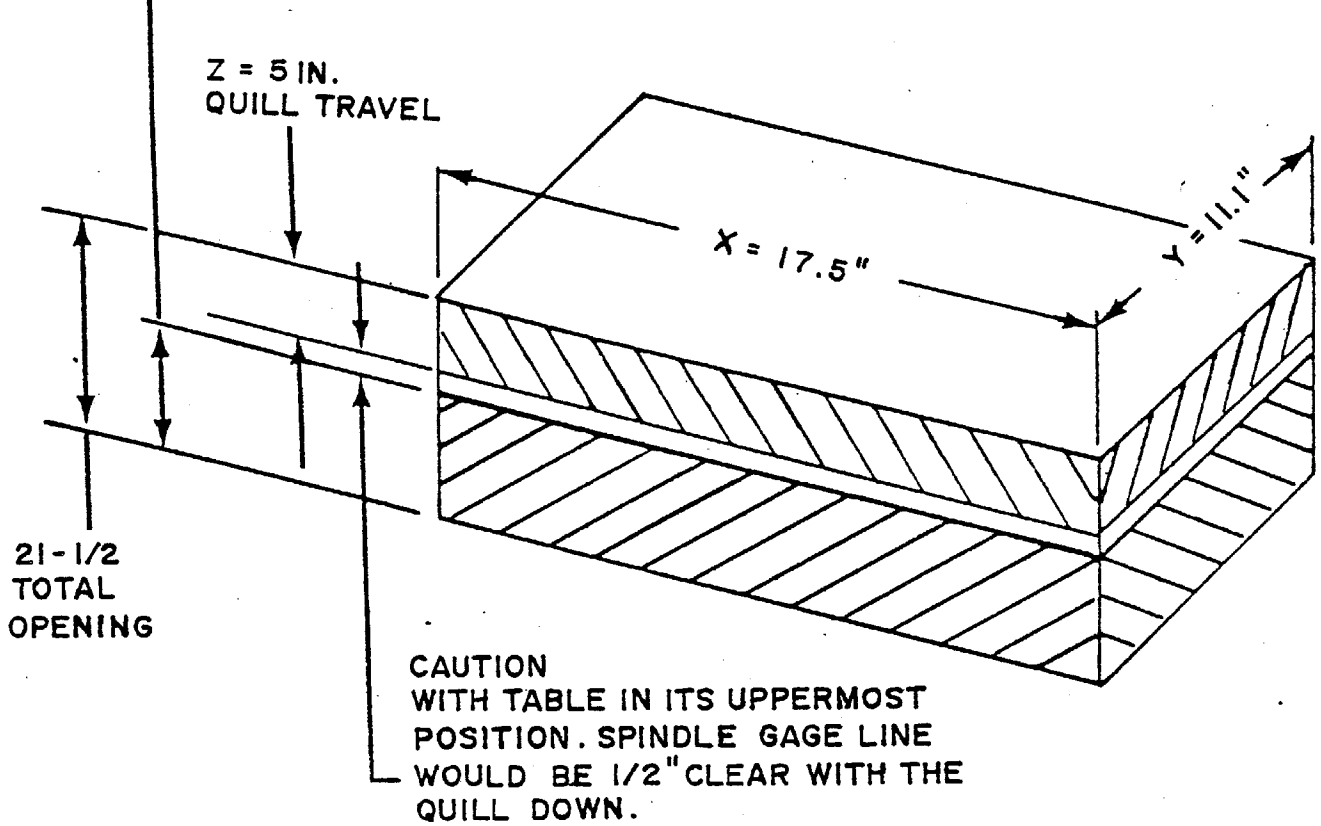


Figure 4-1: Set Up Mode Keys

4.2 MACHINE COORDINATE SYSTEM

The R2E3 control contains an internal, absolute reference system (machine coordinates) that continually tracks each axis position with respect to the Home position of the machine axes, see Figure 4-2. The operator may establish a Reference Point, based on the part to be machined, which is expressed in these absolute coordinates.

For convenience in programming, a part program zero point can also be designated where all X and Y axes moves will provide convenience for the programmer or operator. This is a separate and independent coordinate system which can be set manually by the operator through the SET XYZ function, see Section 4.5.2.



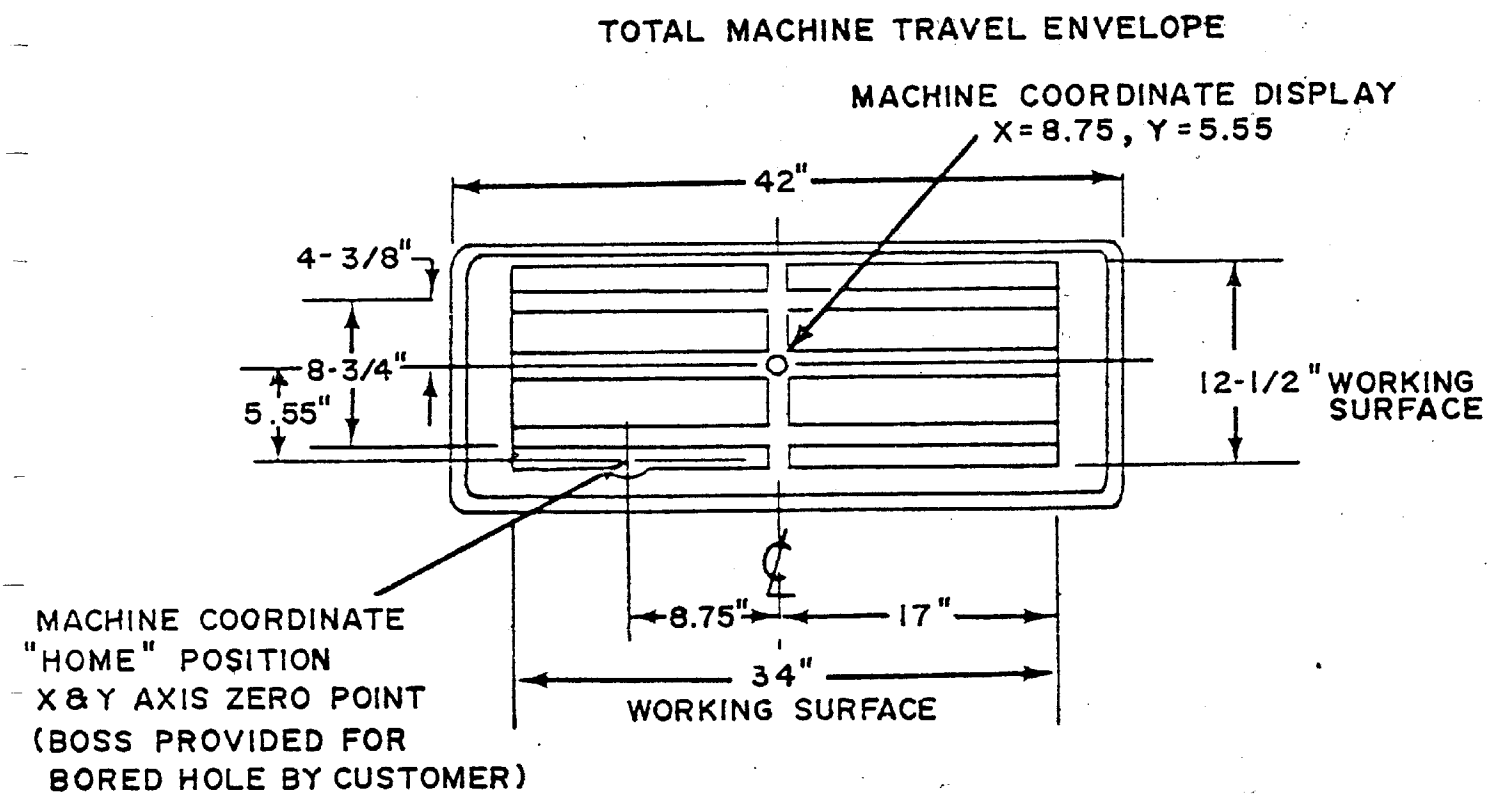


Figure 4-2: Machine Coordinate System

The Clearance Point, can be used during the tool change operation. This is an arbitrary point, established by the operator, which will allow adequate clearance during the tool change.

The X and Y Reference Point and the Clearance Point are expressed in the machine absolute coordinate system. The part program zero point will be expressed in its own independent coordinates. The use of the two reference systems has two useful advantages.

1. It allows the part program to be written in convenient coordinates of the programmers choice, regardless of the part being produced.

2. It provides a way to regain the part program zero if the workpiece is moved from its position in the fixture.

During part program execution, the X, Y, or Z coordinates displayed on the LCD will be in the part program coordinates. The machine coordinate values are shown only when SET REF PT, SET CLR PT and QUILL UP (and the corresponding designations in MOVE) are keyed in.

4.3 AXIS JOG

Pressing the JOG/KNOB/INCR key the first time will cause the following display:

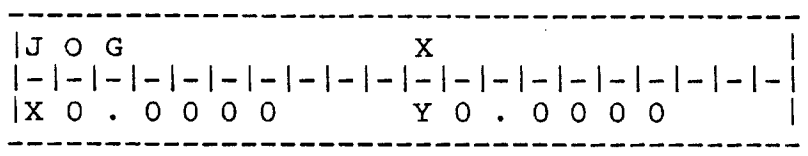
```
-----------------------------------------
|J O G                X                 |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|X 9 . 0 0 0        Y 5 . 0 0 0         |
-----------------------------------------
```

Pressing the "+" or "-" key will initiate continuous motion of the selected axis in the designated direction. The default condition for JOG is JOG, X axis, continuous motion. This will be the power up state, following system start up.

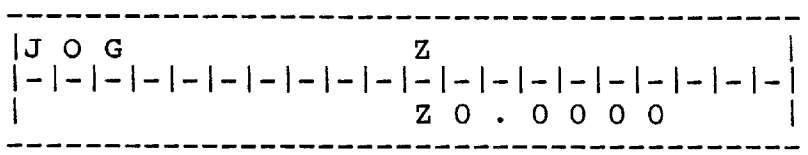
To select the JOG axis desired, press the X/Y/Z key; after each use the upper screen will read JOG X, Y or Z. When the SELECT READOUT key is pressed, it will alternately exhibit the X and Y, or the Z coordinate value(s) in the lower half of the screen.

Examples of the LCD screen displays are shown below:

With X axis selection

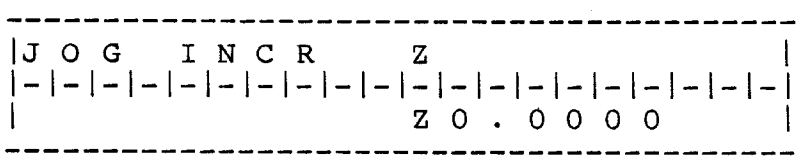


With Z axis selection



To use the AXIS MOTION knob, motion independent of the "+" or "-" keys, press the JOG/KNOB/INCR key again and the screen will display JOG KNOB. The XYZ key will bring the desired axis to the screen. Axis motion will then be controlled by the knob. Full rotation of the knob will cause approximately 0.1 inch of motion in the axis and direction chosen. Positive approximate motion; X axis left, Y axis out, or Z axis up, is initiated by a clockwise rotation; complimentary motion is by the counterclockwise direction. There are 50 detent positions included in one full rotation of the knob; each detent position will provide approximately .002 inches of motion in the axis chosen.

If still greater precision of motion is required to position the axis, the third function, INCR, is pressed. This will enable the "+" or "-" keys again, making each key activation initiate 0.0001 inch of incremental motion in the desired direction. The key indicating desired direction must be pressed for each jog.



4.4 ENTERING TOOL DATA

Specific tool lengths and diameters must be entered for the tools selected to machine a part. The following information is needed for tool data.

1. Tool Length Offset (TLO) values - maximum entry is 6.5536 in. (166.46mm)

2. Tool Diameter (DIA) values - maximum entry is +/-3.2768 in. (8323mm)

The data stored in the R2E3 tool buffers is nonvolatile, it will be retained in memory (approx 1 year) with the power off. New tool data may be entered through statements preceeding program execution via part program. Old tool data may be updated in Set Up mode by manually overwriting the old entries.

NOTE

The control memory will retain the last value entered manually, but can not be over written by different values embedded in the part program when it is executed.

4.4.1 Manual Knee Adjustment

It is necessary to have adequate clearance between the tool and the workpiece for tool changes. Minimum clearance for a tool change requires in excess of 2 11/16 inches, the length of the portion of the tool holder which inserts into the spindle. The height of the knee should be adjusted using the longest programmed tool.

1. Place the longest tool in the machine and clamp the work piece to the table.

2. Return quill to the Home position, then set the Z axis to an arbitrary but convenient distance, for example; 0.5 inches.

3. Crank knee upward until tip of the tool just touches, not penetrates the work piece. If the height of the work piece above the table plus the preset 0.5 inches equals at least 2 3/4 inches, the knee height will provide adequate clearance for tool changes. Such tool change position perhaps the CLEAR POINT would be located off the work piece and fixture to obtain that clearance.

4.4.2 TLO Input

TLOs are entered through TLO = Z on the SET key, TOOL key or through part programs.

SET Key

Use the SET key when TLO value for the tool has not been premeasured and it is necessary to use the machine coordinate system to determine the offset.

When the SET key is pressed once, the screen will display TLO = Z in the upper left of the screen with the current value for the tool number shown in the lower right.

```
-----------------------------------------
|S E T   T L O = Z     E X E C          |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|T   0 1             M Z   0 1 . 0 0 0 0|
-----------------------------------------
```

To bring another tool number to the screen, you must use the TOOL key. Each time TOOL is pressed, screen will scroll through each of the 24 numbers.

Insert the longest tool into the machine and clamp the work piece to the table in the desired location. Using the incremental Jog, move the quill (Z axis) so that the tip of the tool just touches the "Z" zero usually the top of the work piece.

Insert the next tool in the machine and key in the correct tool number. With incremental jog, move the Z axis until the top just touches the top of the workpiece, or "Z" zero point, and press EXECUTE. Continue until all TLO values have been determined for each tool programmed.

To display a specific tool number from the 24 carried in the tool buffer, use the TOOL key and either of two techniques to select the desired number:

1. Enter the tool number desired, then press ENTER. Return to SET TLO = Z to finish entering the offset value for that tool.

2. Continued activation of TOOL will cause the display to scroll through each tool number. EXECUTE will load that number into the active buffer. Return to SET TLO = Z and the selected tool will appear in the display.

NOTE

The Z display exhibits the distance from the Z mechanical Reference Point (Home), not part program coordinates.

TOOL Key

The TOOL key can be used when tool lengths have been premeasured, see Figure 4-3. This will allow you to enter TLO values, as well as tool diameters directly into the tool buffer by keying in the values using the Keypad.

Pressing TOOL will scroll through the tool data table, from tool number 1 through 24. ENTER loads the contents of the input field (prompt in upper screen) into the lower screen display and EXECUTE loads the contents into the tool table and brings up the next tool number.

To load the tool buffer, press the TOOL key once to bring the display TOOL T to the screen. The tool number is keyed in, followed by ENTER, which brings the message TOOL TLO for the keyed in tool number.

```
|T O O L              T                |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|T 0 1 /   1 . 2 5 0 0 / -   0 . 5 0 0 0|
```

The same procedure will also allow the tool diameter (TOOL DIA) to be entered. Pressing EXECUTE will introduce these values to the data buffer and return the screen display to TOOL T so that different tool numbers and their values can be entered. Pressing ENTER without keying in numeric data will generate a null, no change will take place and the screen display will advance to the next field.

Entering a T value will set the input tool number as the current, active tool and the screen will display the TLO/DIA values for that tool. CE, CLEAR ENTRY key, pressed once, will delete the last numeric character entered. Pressed twice it will delete the entire input field.

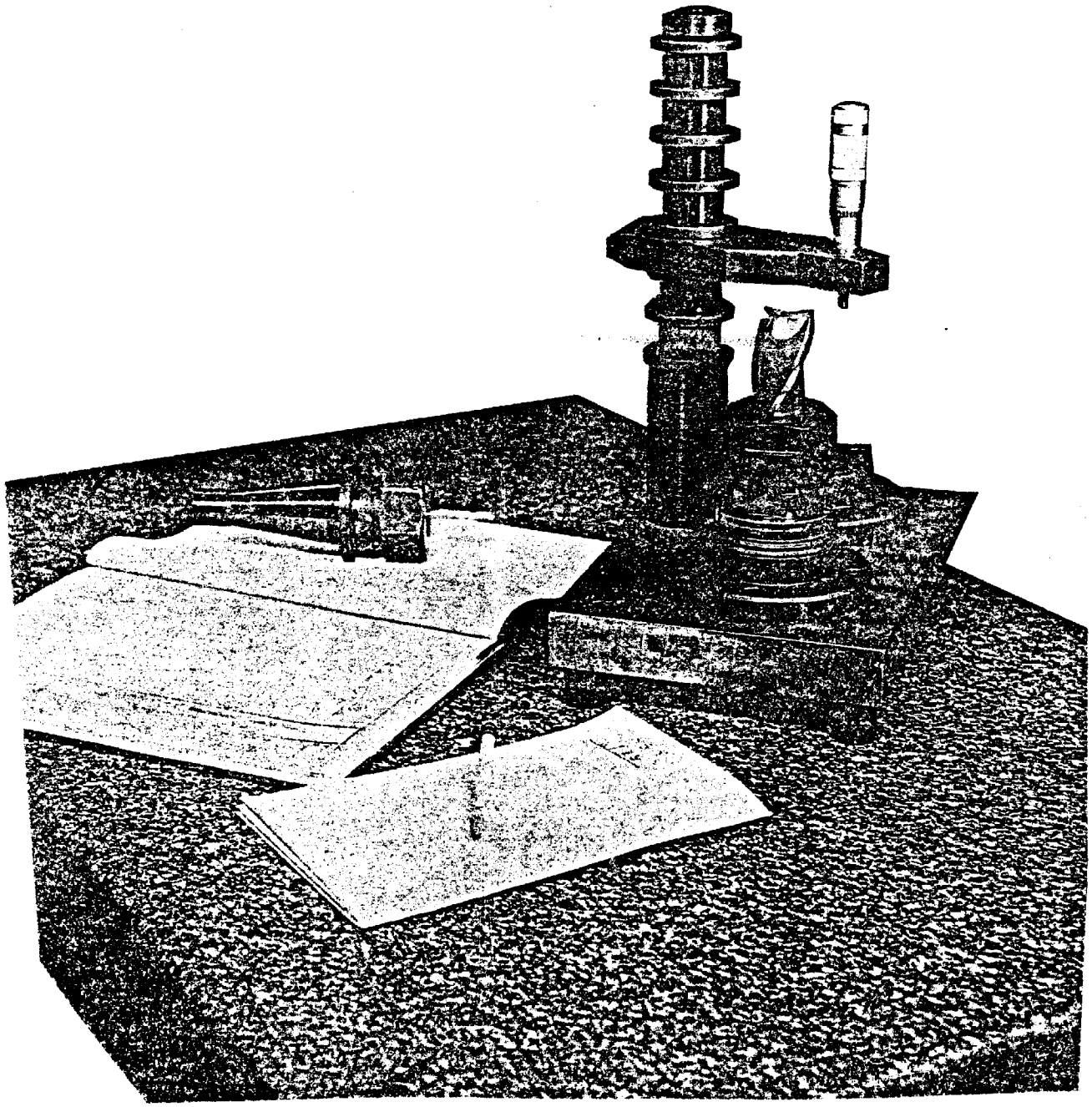


Figure 4-3: Preset TLO Measurement

Programming

New TLO values can be entered by defining their values in the the part program. When TLOs are entered this way, the values are not moved into the tool tables until the block in which the TLO data is defined is executed. Note that if a TLO, other than zero, already exists for a particular tool it will not be overwritten by TLOs contained in the part program.

4.4.3 Tool Diameters

Tool diameters are entered two ways, with the TOOL key or through the part program. This is the same as described for TOOL TLO.

When the tool diameter(s) are not the same as those called for by the part program, Cutter Diameter Compensation must be used.

4.4.4 Cutter Diameter Compensation

Differences in tool diameter are due to wear during use and to losses during regrinding. When a tool diameter is less than the one called for in the part program, the operator must compensate for that difference. Provision to automatically calculate a new tool pathway, based on those differences, is embedded in the BOSS 8 I firmware.

1. Calculation of compensation value

   The compensation value to be entered is the difference of the programmed diameter and the actual diameter.

   Example:

   Programmed Cutter = .500" Dia. End Mill
   Actual Cutter = .485" Dia. End Mill

   .485" Actual
   -.500" Programmed

   -.015" Dia.

   Compensation entered is: -.015"

   If the actual cutter is smaller than that programmed, the input value is always negative. If a larger cutter than that programmed was used, the compensation value will always be positive.

2. Entry in Set Up mode

   - o Enter Set Up mode and press the TOOL key, conformation is on the LCD screen.
   - o Continue to press the TOOL key until the tool number desired appears on the screen, upper line.
   - o Press ENTER to scroll through TLO and DIA.
   - o Key in compensation value from numbers in the yellow section on the Keypad.
   - o Press EXECUTE to insert value into the tool buffer.

3. Entry in part program

   Cutter Diameter Compensation values may be programmed at the beginning of the program text, or embedded in the program using the Tn/d command. These values will be activated when cutter compensation is turned on by a G41 or G42 function.

   Example:

```
T1//.5   - Tool #1  .5"   Compensation
T2//.25  - Tool #2  .25"  Compensation
T3//.187 - Tool #3  .187" Compensation
```

Note that if a cutter diameter already exists for a particular tool, it will be overwritten by cutter diameters contained in the part program.

The BOSS 8 I Control for Cutter Diameter Compensation computes new points for the tool, ahead of the currently programmed tool motion. Such points generate new blocks of data internally within the control. This data is dependent upon the stored program text containing the preparatory functions and the use of stored values of compensation.

4.5 SETTING REFERENCE POINTS

Reference coordinates are tracked by two separate registers, depending on the reference system chosen. Table 4-1 summarizes the Reference Points and their applicable tracking registers.

REFERENCE POINT	TRACKING REGISTER	AXES INVOLVED
1. Machine	Machine Coord	Z Home, XY to Home
2. Reference	Machine Coord	Z Home, XY to Position
3. Part Program	Part Program	XYZ
4. Clearance	Machine Coord	Z Home, XY to Position

Table 4-1: Reference Points and Tracking Registers

NOTE

When setting the various reference points before running a part program, it is important to begin with the machine Home operation then follow the order shown in Table 4-1. This is only necessary if the operator desires to set a new reference point.

4.5.1 Reference Point

The Reference Point will provide absolute coordinate values relative to the machine coordinate zero points (Home site for each axis). Use JOG to move the axes to a convenient location; a bore, dowel pin or other location edge. EXECUTE will load the values from the absolute coordinate registers to the machine Reference Point register.

Reference Point will allow a return to an important location on the fixture or the work piece to determine whether it has moved from its originally clamped position.

```
-----------------------------------------
|S E T   R E F P T   X                  |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|X 9 . 5             Y 6 . 0            |
-----------------------------------------
```

SET REF PT allows you to define a convenient point in the machine coordinate system from which indicator devices can be used to pick up the part program coordinate system. The use of the REF PT setting is optional. If this feature is used the CLR PT and part program zero are set to the machine coordinate zero (X,Y axis home). The following sequence should be used with REF PT.

1. Reference Point
2. Part Program Zero Point
3. Clearance Point

NOTE

Important

Failure to set the machine Reference Point first will result in loss of the XY offset values (Part Program Zero) and the Clearance Point values.

4.5.2 Part Program Zero (SET XYZ)

Use JOG to place the X, Y and Z axes at the part program zero point. (The Z axis will be determined relative to the longest tool and, usually, the lowest depth for that tool, the most negative Z axis position.) When axes are in position, key in SET XYZ with the SET key.

```
|S E T   X Y Z       X                  |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|X 1 . 5 0 0 0       Y 4 . 0 0 0 0      |
```

The operator has the choice of assigning any coordinate value to each axis by keying in the numbers as the appropriate axis prompt appears on the upper portion of the screen. During execution of the program, the axis coordinates which appear in the screen will reflect the coordinates from part programming zero.

NOTE

QUILL UP or M6 cancels the SET Z and automatically loads the TLO from the tool table.

4.5.3 Clearance Point

Use QUILL UP to move the Z axis to the Home position. Then jog the X and Y axes to any convenient point away from the work piece where other operations can take place eg. program stop or tool change. Enter SET CLR PT and press EXECUTE to load the X and Y coordinates as the CLR PT coordinates.

```
|S E T   C L R P T     E X E C          |
|M X 1 . 7 5 0 0       Y 3 . 2 5 0 0    |
```

4.6 MOVE OPERATION

When MOVE is pressed, the screen will read MOVE XY and the coordinate value of X is keyed in; ENTER will load the contents of the X value into a buffer and advance the entry field to the Y axis. When Y is entered, EXECUTE will initiate axis motion in the XY plane. MOVE Z will do the same in the Z axis, EXECUTE will initiate motion.

```
|M O V   X Y       X                    |
|X 1 . 7 5 0 0     Y 0 . 3 7 5 0 0      |
```

```
|M O V   Z           Z                  |
|                    Z 0 . 7 5 0 0      |
```

When MOVE CLR PT is pressed, the upper screen will display the coordinates of the previously established Clearance Point; the current position is shown in the lower screen. EXECUTE will initiate motion and move the quill to the Home position and the axes to the CLR PT.

```
|C X 4 . 3 7 5 0   Y 2 . 0 0 0 0       |
|M X 1 . 7 5 0 0   Y 0 . 2 5 0 0       |
```

When MOVE REF PT is pressed, the absolute coordinates of the current position are displayed on the lower part of the screen. The previously stored coordinates for Reference Point will appear in the upper screen. EXECUTE will move the axes to the REF PT.

A Z axis move up (+Z) will occur before the X, and Y axes move.

```
-----------------------------------------
|R X 4 . 3 7 5 0   Y 2 . 0 0 0 0       |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|M X 1 . 7 5 0 0   Y 0 . 2 5 0 0       |
-----------------------------------------
```

4.7 LOADING PART PROGRAMS

Part programs can be loaded by any one of the following:

1. Teletypewriter
2. Paper tape
3. EZ-FILE
4. Remote computer console
5. EZ-CAM

4.7.1 Baud Rate

It is first necessary to set the transmit/receive baud rate within the control to match the peripheral equipment. Scroll the OPTION key to display the baud selection. In this selection, the screen will show:

```
-----------------------------------------
|O P T   B A U D     [ A ]              |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|[ A ] 3 0 0     [ B ] 9 6 0 0          |
-----------------------------------------
```

The initial values displayed will be the current setting. Keying in another baud rate, followed by ENTER, will store the new rate for Port A and enable the baud rate for Port B to be entered. EXECUTE will initiate action with this newly entered rate. The baud rates available in this system are 110, 300, 600, 1200, 2400, 4800 and 9600.

NOTE

If any other baud rates are attempted, the system will maintain the existing rate.

4.7.2 Input From Peripheral Equipment

After setting baud rates loading from peripheral devices will be through the LOAD/CLEAR/EDIT key, the screen display, and the plug connectors located on the left side of the Power Equipment Enclosure.

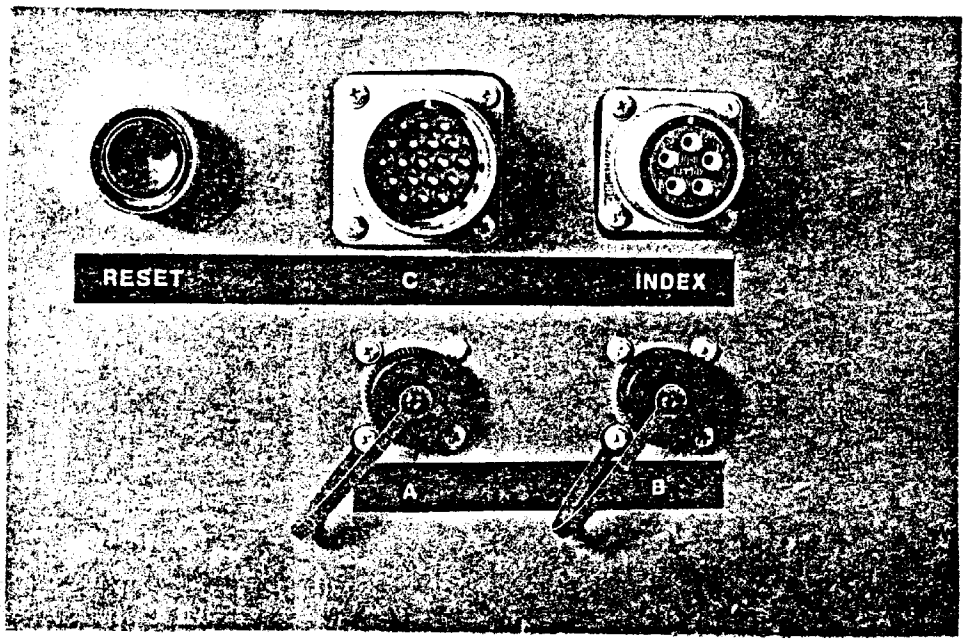


Figure 4-4: Plug Connectors for Communications

PORT C shown in Figure 4-4, accepts the paper tape reader/loader option. This is done through the LOAD/CLEAR/EDIT key which will display the following message after pressing LOAD:

```
-----------------------------------------
|L O A D                                |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|0 P T R   1 D N C   2 R E M            |
-----------------------------------------
```

The lower screen provides the option of loading part program text through a paper tape reader, DNC LINK, or a remote communication device (REM). When "0", "1" or "2" is keyed in, EXECUTE will enable the chosen device. EXECUTE will enter the LOAD submode and a "*" prompt will appear at the extreme lower left portion of the screen.

```
|L O A D   P T R                          |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|*                                        |
```

If LOAD REM is selected, the screen will display:

```
|L O A D   R E M     :                   |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|O F R O M   R E M   1 T O   R E M        |
```

LOAD FROM REM loads a part program (per RS-491-II protocol) into the R2E3 text memory from Port B. LOAD TO REM reads the program currently stored in the R2E3 text memory out to the remote storage device.

LOAD FROM REM with program number loads the specified program into R2E3 text memory from the EZ-FILE, EZ-CAM or any Host computer that supports the EZ-LINK protocol. At the end of LOAD, the LCD display will show the following:

```
|L O A D E D :         C H A R   8 2 5  |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|N 1 G 0 0 G 9 0 X 4 . Y 4 . T 1 M 0 6  |
```

1. The upper screen will show the total number of characters present. The system is capable of storing up to 12000 characters in the text buffers.

2. The lower screen will exhibit the first block of data in the loaded program; up to 20 characters.

To abort LOAD in progress, press the LOAD/CLEAR/EDIT key. This will set the system to CLEAR and terminate the LOAD program.

NOTE

All new data is loaded at the end of previously stored data.

The DNC LINK is designated primarily to allow the R2E3 to execute part programs longer than 100 feet in length, the maximum storage space in the text memory. The program is run with the remote device (EZ-CAM or EZ-FILE) acting as the excess storage space. DNC OFF is the default condition.

Part programs can also be loaded from a teletypewriter through the Editor. This uses the Port A receptacle at the lower left, Figure 4-4, while the LOAD/CLEAR/EDIT key is pressed 3 times to bring the following screen display:

```
|E D I T                                  |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|*                                        |
```

The system is now in the EDIT mode, refer to Chapter 5 for instruction in editing.

4.8 CLEARING DATA

To clear out various data or text in memory the LOAD/CLEAR/EDIT key is pressed 2 times followed by EXECUTE. The screen will diplay:

```
|C L E A R                                |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|0 R U N     1 P R G M     2 T O O L      |
```

When "0", "1", or "2" is entered, EXECUTE will bring about the following action.

0 CLEAR RUN clears out the part program run buffer and any data entered in the system run registers. It also aborts DNC link.

1 CLEAR PRGM clears out the part program text area. The following will be displayed:

```
|C L E A R                                |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|0 A L L   1 M A C           < P R G M >|
```

- o CLEAR PRGM ALL ("0") clears out the entire part program text area.
- o CLEAR MAC ("1") clears out the macro library (all part program text up to the first designated program number).
- o PRGM NUM - When a number of up to 5 digits (other than the single digits 1 or 0) is entered after the prompt in the upper screen, the figure is interpreted as a part

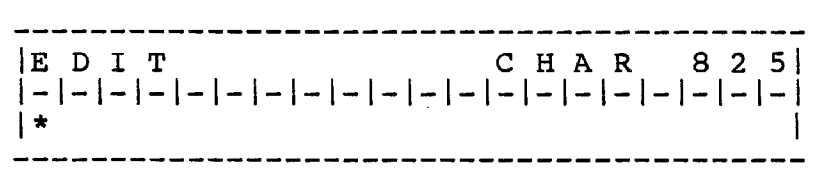
program number. The R2E3 will search for this number, and if found, will delete that program from memory.

2 CLEAR TOOL clears out the tool data table.

4.9 EDITING

Editing is possible while in Set Up mode and is used to insert, modify or delete blocks of part programs in the run buffer. This is entered by pressing the LOAD/CLEAR/EDIT key three times.

Using the EDIT key, a local console with an alphanumeric keyboard is used to modify, locate or insert part program text. It is entered by pressing EXECUTE. The display will exhibit a "*" indicating EDIT is active.



The screen will also display the number of characters in the part program text area.

NOTES

1. If EDIT was entered it can be exited by pressing the LOAD/CLEAR/EDIT key again. (This is a useful feature when EDIT has been entered inadvertently.)

2. At the end of EDIT, the "*" prompt character will disappear indicating EDIT is no longer active.

A more detailed explaination of EDIT is presented in Chapter 5.

CHAPTER 5

EDITING

5.1 PROGRAM EDITING METHODS

Editing functions on the R2E3 are performed two ways:

1. In the Front Panel Edit (Quick Edit) mode using the keypad functions provided within the system.

2. In the full edit capability while in the Set Up mode using a local keyboard.

5.2 QUICK EDIT

Front Panel Edit keys are found in the yellow portion of the keypad, see Figure 5-1. The edit feature is active in the Set Up, and Run modes and is provided to enable quick modification or additions to existing part programs. Changes can be accomplished on a block-by-block basis. Quick Edit is not intended for extensive editing or for entering entire part programs for execution.

Changes to specific blocks in existing part programs are made by deleting the entire block then reentering the block with the appropriate changes made. The following list of keys and their assigned functions will describe the use of the "quick edit" feature.

CAUTION

Canned cycles can not be deleted or inserted into, when in the Edit mode. Doing so may cause machine corruption.

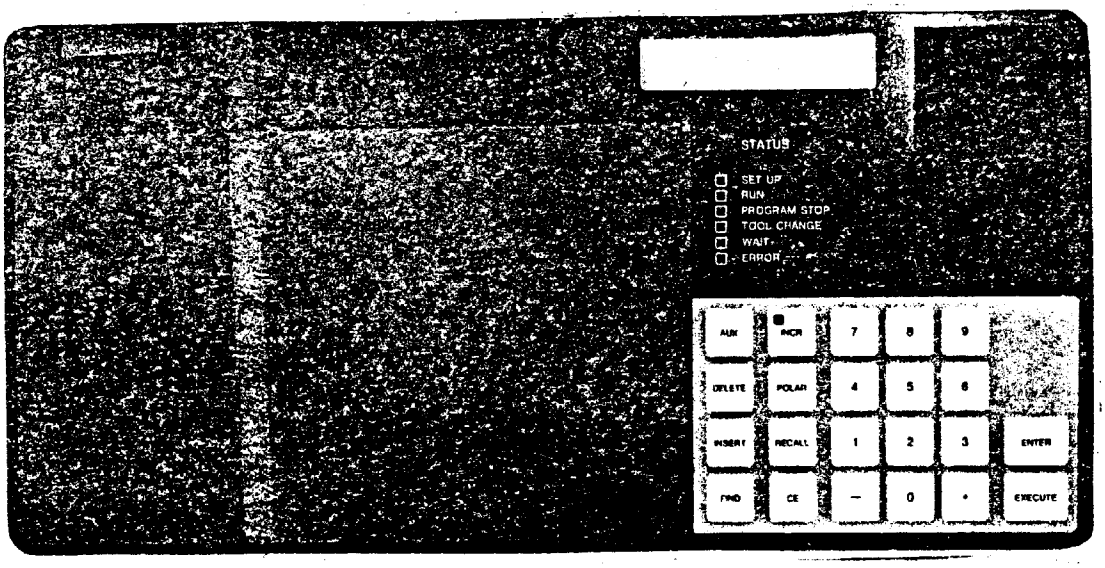


Figure 5-1: Quick Edit Controls Front Panel

5.2.1 FIND

This enables searching for a particular part program block sequence number, tool number, or part program number. Each time the FIND key is pressed, the screen messages will advance through N, T and part number. Entering an appropriate value and pressing EXECUTE will search the part program for the desired value. The search will begin at the current program line, continue to the end of the text and move on to the top of the program. If no match is found, NF will be displayed. If the block is found, the display will read the first 40 characters of the block.

Example:

```
-----------------------------------------
|F I N D            N                   |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|                                       |
-----------------------------------------
```

Key in 100 and EXECUTE the screen will display:

```
-----------------------------------------
|N 1 0 0 G 0 G 9 0 X 1   0 Y 2 . 0 Z . |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|5 0 0 S 2 4 0 0 T 3 M 6                |
-----------------------------------------
```

Using the FIND key then the EXECUTE key without an argument will scroll up the next line.

Using FIND in the Run mode will cause definition blocks to be executed.

NOTE

In Run mode the program search starts at the current line and continues to the end of the program. The search does not wrap around in Run mode.

5.2.2 INSERT

When the INSERT key is pressed the current line is displayed. INSERT enables the insertion of a part program text in front of the current line when the EXECUTE key is pressed. The MDI entry is used to create the new text using the available G codes in the MDI mode. When EXECUTE is activated to enter the line, the Insert mode is ended.

NOTE

After AUTO RUN the display may be showing the last line of the program but the line pointer has been set to the top of the program. An insertion at this time would add to the beginning of the file. To avoid this always search to the block after the proposed insertion by using the FIND key, then INSERT. INSERT will not be active when running a canned cycle.

5.2.3 DELETE

Use of the DELETE key erases the current line. When the DELETE key is pressed the current line is displayed on the screen. When the EXECUTE key is pressed, the first 40 characters of the next part program block will be displayed.

NOTE

DELETE will not be active when running a canned cycle.

5.2.4 RECALL

This backs up the part program pointer one line and displays the first 40 characters of the new line.

5.2.5 AUX

The AUX key will permit the operator to enter M, S, and T Codes in MDI, MDI Store or Insert. These codes do not appear as a routine function in the menu presentation provided in these modes.

5.2.6 INCR

Use of this key allows the operator to specify an incremental distance for an axis move rather than in absolute coordinates. When in INSERT, MDI or MDI STORE it will enter either a G90 or a G91.

5.2.7 POLAR

POLAR input enables replacement of X, Y input with R, A, I, J where R is the polar radius, A is angular distance from the positive (+) X axis, and I & J are the pole centers. POLAR is active in MDI, MDI STORE and INSERT modes. Pressing the POLAR key a second time will revert the entry to the rectangular coordinate system.

5.2.8 "0 - 9", "." (Decimal)

Numerals as needed for data input.

5.2.9 "-" (Minus Sign)

Minus sign is required for entering negative data; absence of sign assumes a positive value.

5.3 FULL EDIT METHOD

5.3.1 Description

The Editor enables the operator to input, change or delete the part program via a local console such as a teleprinter or CRT. The Editor has two modes of operation, Command mode and Text mode.

1. Command mode is used to control the operation of the Editor. In Command mode the operator may list, alter or manipulate the part program. The operator may place the line pointer at a specific line for these purposes when in Command mode.

2. Text mode is used to input new program text blocks.

The Editor is entered by pressing the LOAD/CLEAR/EDIT button on the Front Panel, and selecting EDIT. If the spindle is on when EDIT is entered, it will be turned off. If a terminal is not attached to the local port of the R2E3, the Editor may be exited by pressing only the LOAD/CLEAR/EDIT key.

Access to the text Editor is through serial Port A (active 20ma current loop or RS-232C compatible).

5.3.2 Editor Commands

Most commands consist of one character. Some commands are followed by a list of arguments. Command characters preceded by a "^", such as "^R", are control characters. They are formed by holding down the "CTRL" key and pressing the desired character at the same time.

Command mode:

A Append string: Appends the character string following A to the end of the current line and

prints the entire line at the terminal.
Syntax: A string to append

B Bottom: Sets the line pointer to the bottom (end) of the text buffer.
Syntax: B

C Change: Replaces the old string specified with the new string specified in the current line only. Any delimiter may be used.
Syntax: C\old string\new string

D Delete: Delete the specified number of lines starting with the current line and print the new current line. The argument, n, must be in the range of 0-999. If 0, or a null argument, is given, the current line will be deleted.
Syntax: Dn or D

F Find text: Find the specified string. The search begins with the next line and is in the forward direction only. If the string is not found <NF> will be printed at the terminal. The space between the 'F' and the string is not optional.
Syntax: F string

I Insert: Insert new program text. This command puts the editor in the Text mode. Text is inserted in front of the current line. If there is not enough room in the text buffer for the line being inserted the message <NR> is printed. When less than enough space for 132 characters is left in the buffer the message <AF> is printed. To return to Command mode after inserting text, a null line must be entered <CR>.

If a string is included after the letter "I" the command will be interpreted as a single line insert and the string will be inserted as a new text line without changing the mode. A space between the "I" and the string is an optional delimiter. This mode is used to enter new data from an external TTY connected to Port A.
Syntax: I or Istring or I string

KI Kill: Delete the entire text buffer.
Syntax: KI

L	List:	Lists the entire text buffer at the terminal. Listings may be suspended, resumed and aborted through the use of CONTROL Q, CONTROL S and CONTROL O. Syntax: L
N	Next:	Moves the line pointer forward or backwards an integral number of lines. "n" must be in the range of -999 to 999. Syntax: Nn or N-n or N
^O	Abort:	This will cause the print or list in progress to be aborted. Syntax: Press the letter "O" while holding the CTRL key down.
P	Print:	Print the current line or print n lines beginning with the current line. The argument must be in the range of 0 to 999. Syntax: P or Pn
^P	Punch tape:	This command will cause the contents of the part program buffer to be transmitted to the local device in the format: 24 inches of leader (NUL), rewind stop code, the part program text, E, 24 inches of trailing NULs. Syntax: Press the letter P while holding the CTRL key down.
^S	Stop print:	This will cause the print or list in progress to be temporarily suspended. Syntax: Press the letter "S" while holding the CTRL key down.
M	Mass modify:	Replace all incidents of the old string, starting with the current line, with the new string, until the end of text is reached. Any delimter may be used. Syntax: M\old string\new string
R	Replace:	Replace line with new text. This command deletes the current line and replaces it with the specified text. Syntax: R text
^R		Repeat the line just typed.
^Q	Resume:	This will cause a suspended print or list to be resumed. Syntax: Press the letter "Q" while holding the CTRL key down.

T Top:	Moves the line pointer to the top (start) of the buffer. Syntax: T
^U	Delete line being typed. If <CR> has not been typed this will delete the line being typed. Syntax: Press the letter "U" while holding down the CTRL key.
^Z	Exit the Editor. This will return the R2E3 to Set Up mode and print the EXIT message. Syntax: Press the letter "Z" while holding down the CTRL key.
<CR> Carriage return:	Prints the next line in the buffer and makes it the current line, when not preceded by a command character. Otherwise <CR> serves as the terminator for command lines.

Text Mode:

<Rubout>, <DEL>	The last character typed is deleted.
^U	The line just typed is deleted.
<CR>	Returns the Editor to Command mode if not preceded by any other character. Otherwise the text preceding the carriage return is inserted in the part program text.
^R	Repeat the line just typed.

CHAPTER 6

OPERATION IN RUN MODE

6.1 OVERVIEW

The Run mode is entered when a part progarm is in memory, ready for operation. If no program exists, one must be entered by any one of the following methods:

1. A paper tape reader
2. MDI STORE entered blocks
3. EZ-FILE
4. A local keyboard using the full edit capability
5. The EZ-CAM

The R2E3 operates in either Automatic (continuous operation of the part program), or in Block (Block-By-Block operation). In Block, the operations are resumed after each block by pressing START/CONTINUE.

6.2 NORMAL OPERATION

Pressing the AUTO/BLOCK key will alternate between the Automatic and Block-By-Block modes. If AUTO is in effect and BLOCK is activated, the control will finish the current block, go on to the next one and then stop. In Block, the program will be halted and axis movement interrupted at the end of every block that has axis motion. Non-motion blocks such as; G91, G90, G71, G70, G41 (Dwell), G96, G97XY, etc., on lines by themselves will change LED status and update axis registers but the program will not halt at the end of Non-motion blocks.

For example:

In Block Mode N50 G0X3.Y2. Machine stops execution at the end of the Rapid move. N55 G91 Machine will change mode to incremental and execute next block. N60 G1X2.Y2.F10. Machine stops execution at the end of the feed move.

NOTE

A loop call or a macro call is considered an executable block. A macro subroutine definition is nonexecutable.

6.2.1 Pre-Start

Check the oil level and lift the plunger two or three times on the automatic lubricator before starting the machine to ensure an adequate supply of lubricant to each way. Press the AUTO/BLOCK key to enable the Run mode.

Note the readings on the X and Y absolute registers. Make any necessary moves to place the tool in the correct position relative to the work piece by using the JOG/INCR controls. SELECT READOUT allows you to alternate between the X, Y or Z axis.

Turn on the spindle.

6.2.2 Starting The Spindle

Refer to Section 2.2, under Spindle Controls.

The steps required to initiate spindle motion are summarized below.

1. Select the speed range, HI or LO, with the lever found on right side of the ram head.
2. Press SPINDLE ENABLE while simultaneously moving the SPINDLE FOR CW ROTATION lever (on the Front Panel Control) to the HI or LO position. The spindle will turn on.

NOTE

If SPEED HI and SPINDLE HI, or SPEED LO/SPINDLE LO is chosen, the spindle will turn in clockwise rotation. If SPEED LO/SPINDLE HI, or its complement is chosen, the spindle will turn counterclockwise.

3. Turn the spindle off by pressing the SPINDLE OFF key (green LED will come on).

6.2.3 Program Run

The first time through the part program in AUTO or BLOCK the RESET PROGRAM must be used to initialize the various control registers. This sets the part program in the text memory to sequence number 0. The program will then advance to the first executable sequence number and proceed.

If an M0, M1 or M6 code is programmed in the middle of a part program, the operation will be interrupted. To resume, press START/CONTINUE. The first block of a part program could be:

N1G0G90X0Y0T1M6

This block of code will initialize the various programming registers. The M6, tool change, will cause the program to stop the quill move to the Home position, and move the XY slides to the coordinate stated. The LED in TOOL CHANGE will be on. START/CONTINUE will restart action.

NOTE

If the operator forgets to turn on the spindle, rapid traverse (G0) moves will be executed. Operation will be interrupted at the first FEED block, and the ENABLE SPINDLE message will be displayed. To resume operation, turn the spindle on, press START/CONTINUE.

At the end of a run, a program M2 command resets the program block pointer to the first programmed block. Press START/CONTINUE to start execution.

The program can be interrupted at any time by pressing the HOLD button. The program then can be resumed without error by pressing START/CONTINUE. During execution of the part program,

SELECT READOUT will cause the current axis positions (displayed on the screen) to toggle between either X and Y, or Z.

NOTE

When the HOLD key is in use, the FIND, DELETE, INSERT, and RECALL keys will be inaccessible. To discontinue the HOLD condition press the START/CONTINUE key.

6.2.4 AUTO/BLOCK Operation

Pressing the AUTO/BLOCK key will run a part program in either AUTO, automatic execution of the part program or BLOCK, block-by-block execution of part program. The default AUTO screen is:

```
-----------------------------------------
|N 1 0 0 0 T 0 0 0    S 2 4 0 0 F 2 0 0|
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|X 1 . 7 5 0 0     Y 0 . 7 5 0 0        |
-----------------------------------------
```

N designates the sequence number of the current block being executed, T equals the Tool Number. The S and F alphanumerics represent the spindle speed and feedrate respectively, and X and Y the current positional coordinates of the X and Y axes with respect to part program zero.

Pressing START/CONTINUE will start program execution. Enabling the Run mode with the AUTO/BLOCK key will not change the position of the part program block line pointer.

6.3 SPECIAL OPERATIONS

6.3.1 The OPTION Key

```
-----------------------------------------
|O P T                  / D E L         |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|                                       |
-----------------------------------------
```

Pressing the OPTION key will cause the /DEL message to appear in the top right portion of the screen and EXECUTE causes the option and the LED associated with that option to come on. If EXECUTE is pressed a second time, the LED and the option will go off.

- /DEL - Activation of this function will cause the executive software (BOSS 8 I) to ignore any instruction contained in a programmed block preceeded by a slash (/).

- OP.STOP - Enabling this function allows a programmed optional stop (M1) to occur.

- METRIC - This option will run all input dimensions in the metric system during the operation of the part program.

In addition to the options listed on the key, 2 additional options will be displayed on the LCD screen but with no associated LED indicator. The first of these options provide the operator with the means to set baud rates. See section 4.7.1.

The second unlisted option is to provide compatability with part programs written for previous Bridgeport CNC machines; BOSS 4 through BOSS 7 systems. Initially, the following screen will appear:

```
-----------------------------------------
|O P T                          B O S S 8  I|
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|                                         |
-----------------------------------------
```

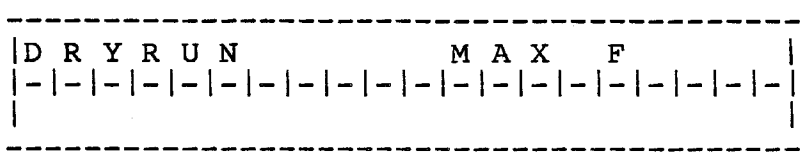
Once this option is reached, repeated activation of EXECUTE causes the screen message to toggle between BOSS 8 I and BOSS 4-7; EXECUTE enables the option currently on the screen. BOSS 8 I is the default condition following startup or reset.

NOTE

The OPTION key will be inactive during an MDI HOLD.

6.3.2 DRY RUN Key

The DRY RUN key enables a newly entered part program to be executed without tooling or workpiece to establish the program validity. Each time the key is pressed, the screen will advance from NO Z, MAX F, NO XYZ and a fourth unlabeled function on the key, BRKPT (Breakpoint). Any combination of these functions may be used.



As with the OPTION key, each listed choice can be enabled as it appears on the screen through EXECUTE.

NOTE

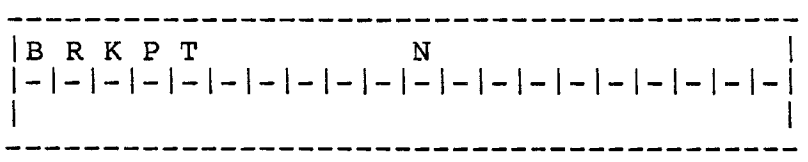
The DRY RUN keys will be inactive during an MDI HOLD.

- NO Z - Part programs can be "proven" with no Z axis movement, except for a tool change where the spindle will move up to "Home" position and establish a new NO Z plane of operation.The Z-axis can be brought down to a more convenient NO Z plane in SETUP without turning off the NO Z operation. In AUTO, the option must be terminated for the Z-axis to move from the home position.

- MAX F - Complete operation of the part program can be undertaken with maximum feedrate to examine program accuracy.

- NO XYZ - Dry runs without any axis movement are possible.

To use BRKPT, press the EXECUTE key. This will show a number prompt, then enter a sequence (N) number followed by EXECUTE. The program will stop before the designated sequence number is executed. The following screen will be displayed:



The BRKPT feature is used to allow the operator to stop at a convenient point in the program with the spindle on. When the BRKPT is reached, the display will read the first 40 characters on the block and the PROGRAM STOP LED will be on. The breakpoint register will then be cleared. The START/CONTINUE key will resume program execution at the breakpoint.

6.4 SPECIAL CONDITIONS

6.4.1 Travel Limit Switch

If a motion takes place which causes a travel limit switch to be reached, program operation will stop and the system will be cleared except for the content of the X, Y, Z absolute registers, the tool length offset registers, and the part program storage. Power to the drives will be disabled.

NOTE

The axes could have "lost" up to .1 inch with reference to the absolute register since the stop was abrupt and without deceleration.

To resume operation:

1. Press AXIS DRIVE ENABLE to restore power to the motors. Then use the various JOG options to move off the limit switch.
2. Home the machine. Correct the problem.
3. Using the FIND key search for a convenient restart point, preferably a tool change position.

6.4.2 EMERGENCY STOP

If the EMERGENCY STOP button is pushed, or power fails during part program execution, or the operator inadvertently switches the spindle off while a feed move is taking place, then the system will stop and be cleared. To resume, repeat steps 2 & 3.

6.4.3 Spindle Feed Hold

If a programmed feed block is transferred from buffer to active registers and the spindle has not been turned on, the system will go into a "Hold" condition, and the ENABLE SPINDLE message will come up. To resume operation, turn the spindle on and press the START/CONTINUE key.

NOTE

If the START/CONTINUE key is pressed before turning the spindle on, the HOLD LED will go out. To continue, turn spindle on, then press START/CONTINUE.

6.4.4 Feed Override

Feedrates may be overridden from 10% to 125% with the FEED OVERRIDE knob. Below 10% the system will be in a feed HOLD condition. Rapid traverse rates are not modified by the FEED OVERRIDE knob in the Run mode.

6.4.5 Hold

Program execution may be interrupted by depressing the HOLD button. The axis will be brought to a controlled stop. When in a HOLD condition the following keys will be ignored:

ALL YELLOW KEYS except; FIND, INSERT, RECALL, DELETE OPTION DRY RUN HOLD ALL SETUP KEYS AXIS DRIVE ENABLE RESET PROGRAM EM STOP

Following keys will perform their current functions:

OVERRIDE ENABLE COOLANT SPINDLE SPEED SPINDLE OFF/OFF SELECT READ OUT AUTO/BLOCK START/CONTINUE

6.4.6 Screen Error Messages

Errors detected by the system are displayed on the screen as a HEX code. The HEX code is listed in Appendix A.

CHAPTER 7

OPERATION IN MDI/MDI STORE MODE

7.1 OVERVIEW

MDI and MDI STORE enable the operator to create new blocks of part program data through a menu format embedded in the BOSS 8 I firmware. These modes may on some occasions create entire part programs, but will also add to or complete a program already loaded in the machine. MDI created blocks are executed without storage of the text; MDI STORE will execute and store each block at the end of the existing program text.

Absolute or Incremental data may be entered in rectangular or polar coordinates using the inch or metric dimension systems. Refer to Section 4.4, for TLO information.

7.2 MDI MODE

Part program blocks are built up by supplying the information required from the "menu" format. This format is derived from a limited array of G codes which demand certain objective data to complete. An opportunity to review what has been entered or to change an entry is offered through the operator/computer interchange. When the block is complete, the information in it can be executed by the milling machine. A complete list of the G codes available in this "menu" format is shown in Table 7-1.

When MDI is entered, the initial screen display is:

```
-----------------------------------------
|0 0   R P D          G                  |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|      E N T E R   C Y C L E             |
-----------------------------------------
```

The first two numbers on the top line of the LCD show the current sequence number, automatically updated after completion of each line entry. The next space on the top line identifies the current G code (default G code is G0, rapid traverse). The last part of the top line is the input parameter prompt and data input area. The lower line gives an abbreviated summary (mnemonic) of the meaning of the data entered on the top line.

Pressing ENTER will load the contents of the data entered (via the keypad) into the text buffer and advances the prompt character to the next input parameter. If no entry is made and ENTER is pressed, no entry will be made for that parameter (null entry).

When the end of the parameter list for that G code block has been reached, pressing ENTER will cause a Review mode to begin. In this, the operator can review and change through CE key any data entered. The CE key will delete the incorrect value and the new value can be entered. The system must be in the REVIEW mode before execution can occur. REVIEW mode is entered automatically after all cycle parameters have been entered. It is suggested that all MDI, MDI STORE, and INSERT data be reviewed for keystroke error before execution.

EXECUTE will load the input lines from the text buffer into the system and execute the block.

NOTE

EXECUTE can not be activated until all parameters have been entered.

The following is a typical display for MDI.

```
-----------------------------------------
|0 3   O F R A M E   X 1 . 5            |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|      E N T E R     C N T R   P T      |
-----------------------------------------
```

The screen shows the part program pointer on line number 3, using a G170 (OUTSIDE FRAME) and entering an X center point value.

7.2.1 CANNED CYCLE OPERATING NOTES

The following notes have been extracted from the Programming Manual (11040532). They are repeated here for your convenience. These notes must be used in conjunction with G codes for canned milling cycles:

1. The following mill cycles are cutter diameter compensated using the cutter diameter for the tool currently being used.

2. The mill cycles include an approach and departure tangential to the part work surface, a Z-axis step capability for deep cuts and roughing and finishing cuts.

3. Length, width, fillet radius, step depth, step over, clearance, finish allowance are all unsigned values.

4. Not applicable in MDI.

5. Not applicable in MDI.

6. All parameters except step depth, finish feed and plunge feed must be entered even if they are zero (0). If finish feed is omitted, it will default to the mill feedrate. If plunge feed is omitted, it will default to 50% of the mill feedrate.

7. The Z start point must be at a clearance point above the work surface. Z cannot be at machine zero (0). It must be a minimum of .050" below Z home position.

8. The dimension to the X, Y center point and the Z clearance plane may be incremental or absolute. All other dimensions are incremental as noted.

9. Not applicable in MDI.

10. Milling cycles end execution at the center of the shape (Y+Y center point defined in cycle) with the Z-axis at the Z clearance plane.

11. A G179 cycle will put the system in absolute programming mode after execution. If the Incremental Programming mode (G91) was programmed prior to a G179, pressing the INCR button is necessary to remain in the incremental mode.

NOTE

MDI entries are limited to the following list of G codes.

Table 7-1: MDI & MDI Store Mode

G CODE DATA REQUIREMENTS

G CODE	AXIS DATA REQUIRED	MNEMONIC ON SCREEN	END FUNCTION
G0		RAPID	Rapid traverse positioning move
	X	END PT	End point
	Y	END PT	End Point
	Z	END PT	End point
	Polar		
	A	END ANGL	End angle
	Z	END PT	End point
G1		LIN	Linear interpolation, feed
	X	END PT	End point
	Y	END PT	End point
	Z	END PT	End point
	F	FEED	Feedrate
	Polar		
	A	END ANGL	End angle
	Z	END PT	End point
	F	FEED	Feedrate
G2		CW	Clockwise
G3		CCW	Counterclockwise
	X	END PT	End point
	Y	END PT	End point
	I	CNTR PT	Center point
	J	CNTR PT	Center point
	F	FEED	Feedrate
	Polar		
	A	END ANGL	End angle
	F	FEED	Feedrate

G170		OFRAME	Outside frame mill
G171		IFRAME	Inside frame mill
	X	CNTR PT	Center point
	Y	CNTR PT	Center point
	Z	START PT	Start point
	X	DIM	Dimension
	Y	DIM	Dimension
	R	FILLET	Fillet radius
	Z	DIM	Dimension
	Z	STEP	Step
	P	CLR DIM	Clearance Dimension
	F	FEED1	Feedrate 1
	P	FIN DIM	Finish Dimension
	F	FEED2	Feedrate 2
G172		POCKET	Pocket mill
	X	CNTR PT	Center point
	Y	CNTR PT	Center point
	Z	START PT	Start point
	X	DIM	Dimension
	Y	DIM	Dimension
	R	FILLET	Fillet radius
	Z	DIM	Dimension
	Z	STEP	Step
	P	STEPOVER	Stepover
	P	CLR DIM	Clearance Dimension
	F	FEED1	Feedrate 1
	P	FIN DIM	Finish Dimension
	F	FEED2	Feedrate 2
G173		OFACE	Outside face mill
G174		IFACE	Inside face mill
	X	CNTR PT	Center point
	Y	CNTR PT	Center point
	Z	START PT	Start point
	X	DIM	Dimension
	Y	DIM	Dimension
	Z	DIM	Dimension
	Z	STEP	Step
	P	OVERLAP	Overlap
	P	CLR DIM	Clearance Dimension
	F	FEED	Feedrate

NOTE

The sum of the Clearance Dimension and the Final Dimension must be less than half of the X or Y dimension whichever is the smaller.

G175		OCIRC	Outside circle
G176		ICIRC	Inside circle
	X	CNTR PT	Center point
	Y	CNTR PT	Center point
	Z	START PT	Start point
	R	CIRC RAD	Circle radius
	Z	DIM	Dimension
	Z	STEP	Step
	P	CLR DIM	CLearance Dimension
	F	FEED1	Feedrate 1
	P	FIN DIM	Finish Dimension
	F	FEED2	Feedrate 2
G179		SLOT	Slot mill
	X	CNTR PT	Center point
	Y	CNTR PT	Center point
	Z	START PT	Start point
	P	LG	Length
	P	DIA	Diameter
	P	ROT FR XAX	Rotation from X axis
	Z	DIM	Dimension
	Z	STEP	Step
	F	FEED	Feedrate
G81		DRILL	Drilling cycle
G82		SPOT	Spotfacing cycle
G84		TAP	Tapping cycle
G85		BORE1	Boring cycle
G89		BORE2	Boring cycle
	X	END PT	End point
	Y	END PT	End point
	Z	DIM	Dimension
	Polar		
	A	END ANGL	End angle
	Z	DIM	Dimension

NOTE

The sum of the Clearance Dimension and the Final Dimension must be less than the circle radius.

G83		PECK	Deep hole drilling cycle
G87		CHIPBK	Chip breaking cycle
	X	END PT	End point
	Y	END PT	End point
	Z	DIM	Dimension
	Z	1ST PECK	First peck
	Z	PECK	Peck
	Polar		
	A	END ANGL	End angle
	Z	DIM	Dimension
	Z	1ST PECK	First peck
	Z	PECK	Peck
G181		DRIL	Drilling cycle
G182		SPOT	Spotfacing cycle
G184		TAP	Tapping cycle
G185		BORE1	Boring cycle
G189		BORE2	Boring cycle
	X	START PT	Start point
	Y	START PT	Start point
	Z START PT	Start point	
	X	DIM	Dimension
	Y	DIM	Dimension
	Z	DIM	Dimension
	P	# HOLES	Number of holes
	F	FEED	Feedrate
	Polar		
	A	START ANGL	Start angle
	Z	START PT	Start point
	A	DIM	Dimension
	Z	DIM	Dimension
	P	# HOLES	Number of holes
	F	FEED	Feedrate

G183		PECK	Deep hole drilling cycle
G187		CHIPBK	Chip breaking cycle
	X	START PT	Start point
	Y	START PT	Start point
	Z	START PT	Start point
	X	DIM	Dimension
	Y	DIM	Dimension
	Z	DIM	Dimension
	Z	1ST PECK	First peck
	Z	PECK	Peck
	P	# HOLES	Number of holes
	F	FEED	Feedrate
	Polar		
	A	START ANGL	Start angle
	Z	START PT	Start point
	A	DIM	Dimension
	Z	DIM	Dimension
	Z	1ST PECK	First peck
	Z	PECK	Peck
	P	# HOLES	Number of holes
	F	FEED	Feedrate
G191		DRILL	Drilling cycle
G192		SPOT	Spotfacing cycle
G194		TAP	Tapping cycle
G195		BORE1	Boring cycle
G199		BORE2	Boring cycle
	X	START PT	Start point
	Y	START PT	Start point
	Z	START PT	Start point
	X	DIM	Dimension
	Y	DIM	Dimension
	Z	DIM	Dimension
	P	# HOLES X	Number of holes on X axis
	P	# HOLES Y	Number of holes on Y axis
	F	FEED	Feedrate

G193	PECK	Deep hold drilling cycle
G197	CHIPBK	Chip breaking cycle
X	START PT	Start point
Y	START PT	Start point
Z	START PT	Start point
X	DIM	Dimension
Y	DIM	Dimension
Z	DIM	Dimension
Z	1ST PECK	First peck
Z	PECK	Peck
P	# HOLES X	Number of holes on X axis
P	# HOLES Y	Number of holes on Y axis
F	FEED	Feedrate

7.3 MDI STORE

In MDI STORE, the program blocks are entered with the same "menu" format and executed as with MDI. The completed blocks are stored at the end of the text buffer.

When MDI STORE is pressed the screen will show:

```
-----------------------------------------
|O 0   D E F          :                 |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|E X E C              P R G M   #       |
-----------------------------------------
```

After the part program number is entered, the operator may enter tool parameters for the program. The following screen is displayed:

```
-----------------------------------------
|O 0   D E F          T                 |
|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|-|
|E N T                T O O L           |
-----------------------------------------
```

When the tool number has been entered, the operator will be prompted for the TLO, DIA, and the spindle speed. EXECUTE will cause the tool data to be stored in the part program buffer after the part program.

CHAPTER 8

OPTIONAL EQUIPMENT

8.1 OPTIONAL EQUIPMENT

The following is a list of optional equipment available for the R2E3 Series I CNC system:

1. Paper Tape Reader, enclosure and data cable
2. EZ-FILE~ - Floppy Disk Storage
3. #30 Quick Change Tool Kit
4. I-4 Indexer
5. Coolant System - Mist and/or Flood
6. EZ-CAM~

8.2 PAPER TAPE READER

The paper tape reader is a device for loading part programs and is a portable unit that can be transported from one machine to another, if desired. The R2E3 Series I CNC is equipped with an MS type connector for the paper tape reader cable.

8.3 EZ-FILE~ MASS STORAGE DEVICE

The Bridgeport EZ-FILE~ is a floppy disk base device providing easy and fast part program storage. The storage medium is a 5 1/4 floppy diskette with a atorage capacity of 400K bytes (3200 feet of tape) and up to 77 part programs. These floppy diskettes are also compatible with Bridgeport's interactive graphics part programming system EZ-CAM~.

Communications and control of the EZ-FILE~ is primarily through the R2E3 system. All part programs can be saved and retreaved via their individual 5 digit numeric name. A special communications link is also provided for the execution of part programs that are too long to reside in the Control's memory.

8.4 #30 QUICK CHANGE TOOL KIT

This option contains a Bridgeport #30 Quick Change basic tooling package composed of collets and corresponding tool holders, a locking fixture for assembly of cutters in the holders, and appropriate wrenches. The kit contains:

1. End Mill holders
2. Shell Mill adapter
3. Tenthset boring head with adapter
4. Boring Cutter (carbide tipped)
5. Drill and End Mill chucks
6. Standard Collets
7. 300 Series Collets
8. Drill and End Mill extension chuck

8.5 I-4 INDEXER

This option permits miscellaneous function M51 (Index Table) to be programmed in conjunction with the use of a suitable Indexing Table which inhibits data transfer and prevents machine movement while the indexing operation is taking place (Erickson 450 or 600 Indexer with oil tight limit switches LS-1 and LS-2).

Plug receptacle for the Index Table option is the top right space on the Tape Reader/Remote Serial Interface panel (next to the 15 pin paper tape plug).

8.5.1 Physical Description

The package resembles the pneumatic brake manifold and incorporates the same cover, mounting plate dimensions, mounting bracket, and hardware. The mounting plate uses a single solenoid valve. Main air is supplied to the index control by a "tee" located in the main air line. A 7.5" hose is available to continue the main air to the brake manifold.

8.6 COOLANT SYSTEM - MIST AND/OR FLOOD

With the Auxiliary Control Group option, the coolant will be turned ON/OFF with the spindle. Separate coolant switches are provided.

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

8.7 EZ-CAM~

The EZ-CAM~ (Computer Aided Manufacturing) is a desk top computer with interactive graphics and part programming capability. This option permits the operator to accomplish the following:

1. Reproduce a part graphically on the CRT from an engineering drawing.

2. Program the part through an interactive menu format.

3. Display the shape and tool path to "prove" the program before committing it to production.

4. Load the generated programs, through EZ-LINK~, Paper Tape, or EZ-FILE~ directly into the CNC milling machines.

CHAPTER 9

TOOLS AND TOOL HOLDERS

9.1 TOOL HOLDERS

9.1.1 General Description

All cutting tools are adapted to the machine spindle with tool holders that have common features as shown in Figure 9-1.

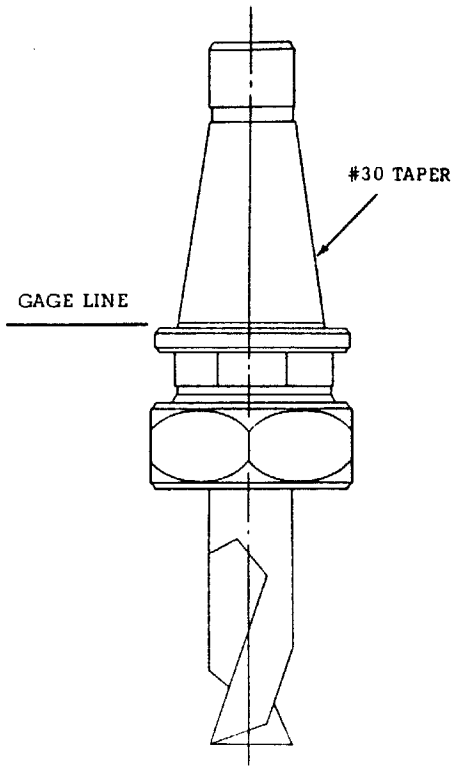


Figure 9-1: Tool and Tool Holder

9.2 TOOL SETTING

When a cutting tool is placed into its tool holder, the cutting edge or tip is located at an imprecise distance from the gage line of the tool holder. Subsequently programmed Z axis motions with that tool are equally inaccurate. Two versatile methods for controlling Z axis depth are available with the R2E3 Series I, both of which are simple and accurate. The following section on Tool Length Offset explains those two methods. Two approaches concerning the tool holder are explained below.

1. Setting tools at random: If a series of cutting tools are selected for a job, the tools can be assembled in their holders according to length. It is recommended that after assembling the tools in holders, they are lined up on a table and checked carefully to make certain they are arranged according to length. This will help the operator calculate tool length offsets, adjust the knee properly, and minimize quill travel and cycle time.

2. Preset tools: The F115 form should be completed using all of the columns available. The information for this calculation on tool holders is in the Tooling Manual (M122) and in catalog data for the cutting tool itself.

It is possible that under certain conditions a greater degree of precision is required in the presetting of tools for the following reasons.

1. When the depth of the cut must be a certain minimum.

2. When the possibility of interference between a portion of the tool holder and the workpiece or the tool holder and its clamp is evident.

3. When the need to standardize tool and tool holder length combinations is required.

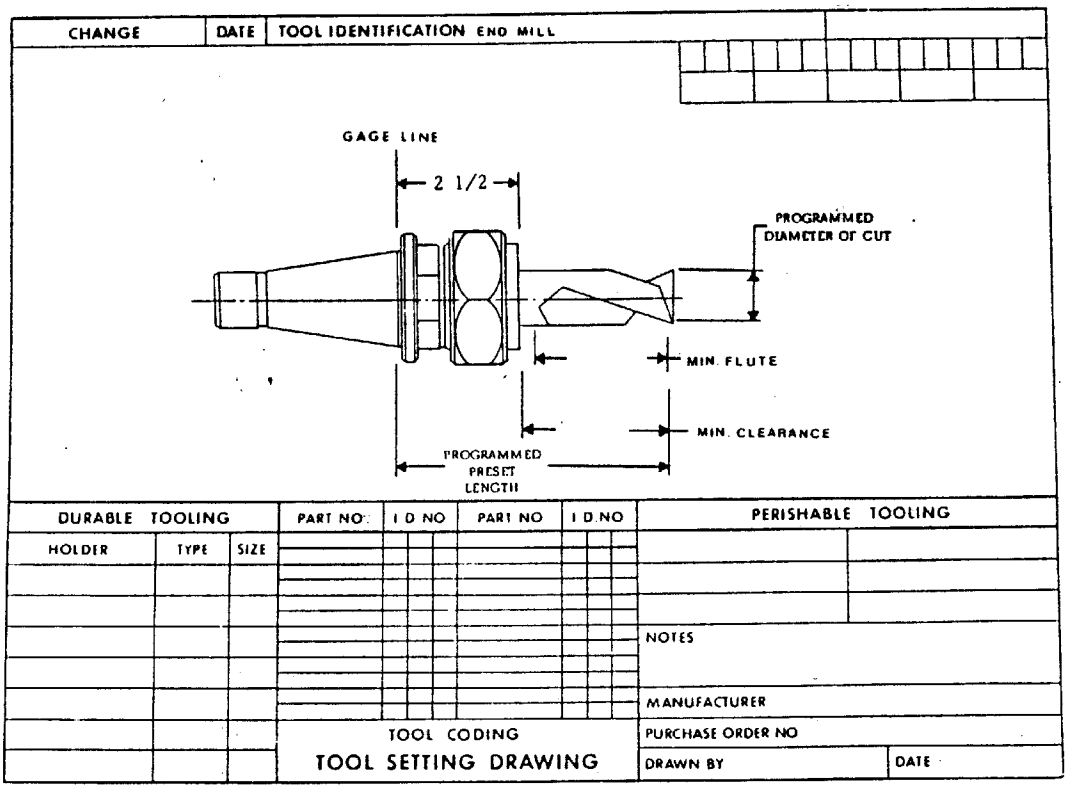


Figure 9-2: Tool Setting Drawing

APPENDIX A

SYSTEM STATUS/ERROR MESSAGES

A.1 SYSTEM ERROR MESSAGES

System error messages (ERROR LED in status column ON) will be displayed on the screen as a 4 character number written in the hexadecimal notation. The top line of the screen exhibits a data block number, spindle speed and feedrate information. The block shown or the block following will contain the error.

The second line shows the message "ERROR" followed by a 4 character Hex number. This number, from left to right, corresponds to 4 possible error/status sets, labeled 1 through 4, each containing 4 possible error messages (see Table A-1). Consult the list of error combinations (Table A-2) to determine the error(s) which apply.

Table A-2 shows the conversion of the Hex notation to the corresponding 4 bit binary nibble. Each bit, from right to left, denotes increasing powers of the base 2 (binary system), the numbers 1, 2, 4, and 8 represent the decimal equivalent of each of those bits. Each appearance of "1" under any of these decimal values corresponds to the appropriate messages listed within the set, see Table A-1.

Example:

```
|N 0 9 T 0 3          S 4 0 0   F 3 0 . 0|
|E R R O R :   C 0 4 2                    |
```

C	0	4	2
Set 1	Set 2	Set 3	Set 4

(See Table A-1)

Table A-1: Error Message Sets

SET NO.	BIT VALUE	ERROR MESSAGE	ACTION
1	1	Front Panel not sending valid key values	B
	2	Internal Communications Error	C,B
	4	Drive fault	C,B
	8	Electronics faults	C
2	1	ROM failure	B
	2	RAM failure	A,B(1)
	4	Tool Table Check sum error	A(1),B
	8	Part Program Checksum error	A(1),B
3	1	Commanded move would exceed machine limits	A
	2	EAF SOFT (communications) error	C
	4	Communications error	A
	8	System fatal error	C
4	1	Programming error found by Parser	A
	2	Cutter Compensation error #1 - no intersection found	A
	4	Cutter Compensation error #2 conflict deciding which intersection applies	A
	8	Spindle not enabled for a non G0 move	A

* A = Operator/Programmer repairable
B = Maintenance/Field Rep. repairable
C = Activate reset, if same message persists, go to B
(1) May be caused by a dead battery on power up

Table A-2: Error Combinations - Hex To Binary

HEX NO. SYMBOL	EQUIVALENT 4-BIT BINARY CODE CORRESPONDING DECIMAL VALUE 8	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
B	1	0	1	1
C	1	1	0	0
D	1	1	0	1
E	1	1	1	0
F	1	1	1	1

The first number, Hex C, refers to Set 1 (Table A-1). In Table A-2, C represents the combination of error messages listed under decimal 4 and 8. From Table A-1, Section 1, you may read the errors referred to as: Drive Fault - check FMDC LEDs (4), and Electronics Fault (8). The next number, 0, signifies no errors in Set 2. Hex 4 translates to the message, under 4 in Set 3: Communications Error; while Hex 2 (last number) represents: Cutter Compensation Error #1 - No Intersection Found (under decimal 2).

It may be useful to present the translation of the message by another approach:

1. From the 4 character error word, determine which set (or sets) is referenced in Table A-1. From left to right, the first number targets Set 1 in the table, the second number Set 2, and so forth.

2. Look in Table A-2 to determine which of the Set(s) of 4 possible messages are referenced. This table is used for all 4 characters in the error number.

   Each of the 4 vertical columns (to the right of the Hex character) will contain a "0" or a "1", and are headed by the numbers 1, 2, 4, and 8. Only the columns with a "1" are recognized.

3. The referenced column in Table A-2 (1, 2, 4 or 8) refers to the same number in the applicable set in Table A-1. Read the message(s) opposite the appropriate number(s) as the those applying to that Hex character in the error message.

4. Go to the next Hex character, if other than zero, and follow the same procedure.

Errors may be cleared using the following methods:

1. Press the RESET PROGRAM key. This should clear most errors.

2. Press AXIS DRIVE ENABLE and home the machine.

If it is a Tool Table or Part Program Check Sum error, it will be necessary to clear the table or the program and reenter the data.

APPENDIX B

SYSTEM SPECIFICATIONS

B.1 OVERVIEW

The R2E3 machine design is dedicated to Numerical Control. The following four sections list the systems mechanical and electrical specifications and features.

B.2 STANDARD FEATURES OF THE BRIDGEPORT R2E3 SERIES I MACHINE

1. Vertical heavy duty spindle with extra precision bearings in 3 3/8" diameter quill.
2. Uses #30 Quick Change Tooling.
3. A 2 HP continuous duty fan cooled AC induction motor with interlocked spindle brake.
4. Spindle speeds, 60-4200 RPM with interlocked power speed changer.
5. Head design based upon the proven 2J model.
6. Heavy head support with special rigid ram.
7. Large diameter turret support from standard column.
8. Dovetail ways throughout.
9. Chrome plated ways at table to saddle, and saddle to knee juncture.
10. Ballscrews 1 1/4" diameter in X and Y axes totally enclosed.

11. Stationary X ballscrews to enable the drive mounting on the saddle.

12. Z ballscrews, 2 1/2" diameter, a ball quill design.

13. Ballscrews supported by steep angular contact thrust bearings.

14. Extended deep saddle to promote the accuracy and repeatability of table position.

15. Dual special locks on the side of the knee to bind the knee to the rigid column.

16. Table with larger mounting surface in XY directions, than XY travel, and surrounding coolant trough.

17. Axis drive motors mounted entirely clear of the operator's working area.

18. Closed loop DC servo drives with encoder feedback.

19. Travel limit switches with lamp indicator and override.

20. Chip and coolant shield surrounding the table working surface on 3 sides.

21. Splash back, chip, and coolant collector pan.

B.3 CONTROL FEATURES

1. 3 axis Simultaneous continuous path contouring.

2. 2 axis Circular Interpolation in switchable planes.

3. Minimum .0001 inch (0.001 mm) input resolution; .0001 inch (0.0025 mm) output resolution.

4. EIA RS-358 (ASCII) type format, EIA RS-274D compatible.

5. Absolute/incremental input in rectangular or polar coordinates.

6. Programmable absolute zero with software limit check.

7. Numeric keyboard, conversational format in Manual Data Input mode.

8. 40 character alpha numeric display, 24 status LED indicators.

9. Plus or minus decimal point programming with leading and trailing zero suppression.

10. Manual feedrate override 10%-125% infinity variable with enable control.

11. Constant vector velocity in any combination of axis motion.

12. Deceleration override.

13. Rapid Traverse X, Y, 250 IPM (6350 mm/min), Z axis, 200 IPM (5080 mm/min).

14. Canned Z axis cycles (8), including 2 deep hole drilling routines.

15. Transformation of data by programmable mirror image, rotation, or scaling.

16. Feed hold and continue without loss of position.

17. Canned mill routines (8) including Face, Circle, Cavity, Thread Mill.

18. Full jog control of any axis in any direction with variable traverse rate.

19. Jog handwheel.

20. Part Program storage capacity: 12,000 characters, 100 ft paper tape.

21. Edit via external data terminal with 22 command characters.

22. Block Edit via Front Panel controls.

23. Multiple part program storage, 6 digit identification.

24. Macro subroutines of up to 40 macros.

25. Repetitive programming including looping and conditional jumps.

26. Arithmetic expression evaluation, +, -, *, /, SQRT, SIN, COS, TAN, ATAN.

27. 24 maximum tool offsets and 24 diameter compensation values.

28. Tape input of all tool offset values.

29. Non volatile storage for tool offset and compensation data.

30. Bi-directional search for program number, sequence number, tool number.

31. Display of part program comments.

32. Automatic or Block-by-Block operation with Optional Stop, Block Delete.

33. Dry run modes: NO Z, Maximum Feedrate, NO XYZ, Break Point.

34. Automatic tool withdrawl to quill home.

35. COOLANT FLOOD/MIST control (automatic, manual).

36. SPEED INCREASE/DECREASE control (manual).

37. Serial Port A interface, RS-232C compatible/or 20ma active current loop. Serial Port B interface, RS-422 with built in DNC loading.

38. Single electrical power connection to fusible disconnect.

39. Diagnostic routine for system self check on power up and reset.

B.4 TOTAL SYSTEM FEATURES

1. Single electrical power connection to Fusible Disconnect.

2. Electrical construction complies with the intent of NFPA 70 and 79.

3. Control cabinet is mounted on the machine structure.

4. Interlock on feed if spindle is not operating.

5. Factory scheduled school for General Training in Operating/Programming (1 man - 1 week).

6. Factory scheduled school for Maintenance (1 week and special fee).

7. Factory trained Service Engineer's Startup and Operator Training (1 day).

8. Single Source Service Responsibility is Bridgeport.

9. One year warranty on materials and workmanship of Bridgeport's manufacture.

B.5 LEADING DATA (SERIES I R2E3)

RANGE	INCH	METRIC
Table travel (X axis)	17.5 in.	444mm
Saddle travel (Y axis)	11.1 in.	282mm
Quill travel (Z axis)	5 in.	127mm
Knee travel (manual)	14 1/2 in.	368mm
Throat distance	14 1/2 in.	368mm
Table to spindle up at gage line	7 1/8 in.	181mm
Maximum vertical load uniform distribution	300 lbs.	136kg

TABLE		
Overall size	42 x 16 1/8 in.	1067 x 410mm
Working surface	34 x 12 1/2 in.	864 x 318mm
T-slots	3 on 4 3/8 in. centers	3 on 111mm centers
T-slot size	5/8 in.	15mm
Positioning speed	250 ipm	6350mm/min
Height above floor max.	47 1/2 in.	1207mm

SPINDLE		
Motor rating	2 HP	1.5kW
Taper	#30 for quick change holders	
Speed range	60-4200 RPM	
Transmission ratios	1:1 and 8.92:1	
Rapid approach rate (Z axis)	200 ipm	5080mm/min
Controlled downfeed range	.1-100.0 ipm	2-2540mm/min

(Z axis)		
Drilling capacity mild steel	3/4 in. dia.	19mm dia.
Milling capacity mild steel	1.5 cu in/min	25 cc/min
Boring range	To 4 in. dia.	To 102mm dia.
Spindle diameter	1 3/8 in.	35mm
Quill diameter	3 3/8 in.	86mm

MILLING

Feedrate	.1-100.0 ipm	2-2540mm/min
Feed increments	0.1 ipm	1mm/min
Override infinitely variable	10-125% with feed hold	
Vector feedrate control (XYZ)	Constant to 100 ipm	2540mm/min

POSITIONING

Rapid traverse X Y	250 ipm	6350mm/min
Rapid traverse Z	200 ipm	5080mm/min

MACHINE AND CONTROL PERFORMANCE

Positioning accuracy	+/- .0008 in.	0.02mm
Positioning repeatability	+/- .0003 in.	0.01mm
Servo resolution	.0001 in.	0.0025mm
Input resolution	.0001 in.	0.001mm

CONTROL SYSTEM

System	Absolute/incremental CNC
Format	Interchangeable variable block
Format detail	:5N4G3X+34Y+34Z+34U+34V+34I+34J+34K+34R3 A+33P+34F31S4T2M2
Reference EIA Standards	RS-227,RS-274D,RS-358
Axis Drive	3KVA DC servo motors with encoder feedback

R2E3 FEATURES

Storage capacity	100 ft (30M) of equivalent EIA RS-358 tape
Subroutines	40 macros and 4 levels of nested loops
Editing	22 command characters
Part program loading	Paper tape or remote DNC LINK
Data Port A	Serial line interface @ 20ma or

Data Port B	RS-232 Serial line interface @ RS-232C or RS-422 with RS-491 protocol
Maintenance	Diagnostics routines embedded in system

SPACE AND WEIGHT

Floor area (doors open)	108 x 99	(2743mm x 2515mm)
Floor area (doors closed)	64 x 64	(1626mm x 1626mm)
Height	92"	(2337mm)
Weight (with control)	3150 lbs.	(1429 kg.)
Shipping weight	3550 lbs.	(1610 kg.)

POWER

Electrical supply 60Hz, 3 phase	230V/460V single connection or 208V on special order
Main power breaker	25A/15A per phase
Electrical rating	6 KVA
Pneumatic rating kg/c2)	4 cfm (.06cm/mim) @75 psi (5.6 11 cfm (0.18cm/min) instantaneous

COLOR

Standard	Two tone gray for machine tools

APPENDIX C

CONNECTORS

All BOSS 8 serial ports are 8 pin AMP connectors. The mate will be the AMP quick connect P/N 206434-1.

PORT A - 20 MA CURRENT LOOP ACTIVE

PIN #	FUNCTION	DIRECTION	POLARITY
1	TRANSMIT	OUTPUT	NEGATIVE
2	TRANSMIT	OUTPUT	POSITIVE
3	RECEIVE	INPUT	NEGATIVE
4	RECEIVE	INPUT	POSITIVE
5	SHIELD		GROUND

PORT B - RS-422

PIN #	FUNCTION	DIRECTION	POLARITY
1	RECEIVE	INPUT	POSITIVE
2	RECEIVE	INPUT	NEGATIVE
3	TRANSMIT	OUTPUT	NEGATIVE
4	TRANSMIT	OUTPUT	POSITIVE
5	SHIELD		GROUND

PORT A/B - RS-232C

PIN #	FUNCTION	DIRECTION	POLARITY
5	SHIELD		GROUND
6	RECEIVE	INPUT	
7	SIGNAL GND		GROUND
8	TRANSMIT	OUTOUT	

APPENDIX D

GLOSSARY

ABSOLUTE DIMENSION: A dimension expressed with respect to a fixed point or zero origin.

ACCELERATION: Instantaneous rate of change of velocity. Acceleration is positive if the velocity is increasing.

ACCURACY: The closeness of a measured value to its true value. Accuracy is the difference between the actual target and the average from that target plus or minus three standard deviations.

ACTIVE STORAGE: Registers which hold the data which is actively being processed. In the Bridgeport Control, this consists of the interpolation registers and the N, F, S, T, M function registers.

ALIGNMENT TOLERANCE: Tolerance specified with respect to mutual perpendicularity of the machine spindle and the X and Y axes.

ALPHANUMERIC CODE: Code whose character set contains combinations of the 26 letters, 10 numerals, and/or special characters, "-", "+", "/", etc.

ANSI: American National Standards Institute

APPROACH: Manner in which an axis moves in the immediate vicinity of its destination as it nears the end of a move.

ARC CENTER OFFSET: Specification of a coordinate pair as the center of the circle segment to be machined by a circular arc move. The center coordinates are derived from the coordinates of the tool prior to the move by defining the incremental coordinates (offset) of the circle center. Offsets along the X, Y, or Z axes are given the variable names I, J, or K, respectively.

ARGUMENT: The independent variable of a function.

ASCII CODE: (American Standard Code for Information Interchange) This standardized code is used extensively in data transmission. It consists of 128 upper and lower case letters, numerals and special purpose symbols each encoded by a unique 7 bit binary number.

ASYNCHRONOUS: Describes the operation of a digital circuit in which a free running signal triggers successive instructions. The completion of one instruction triggers the next.

AUXILIARY FUNCTION: Programmable function other than the control of the machine along an axis.

AXIS: (1) A reference line of a coordinate system; for example, the X, Y and Z axis of the Cartesian coordinate system. (2) A direction along which a movement of the workpiece occurs.

AXIS OF MOTION: The Z axis is parallel to the machine spindle with +Z as the direction from the workholding means toward the toolholding means. The X axis is horizontal and parallel to the workholding surface with +X as the direction to the right, looking from the spindle toward its supporting column. The Y axis is perpendicular to both Z and X. +Y is the direction required to make a right handed Cartesian coordinate system +X, +Y, +Z.

AXIS REVERSAL: The reversal of the sign (plus or minus) of the X and Y input values on a selective basis to permit machining "left handed" parts from "right handed" part programs.

BACKLASH: Relative motion between interacting mechanical parts caused by less than absolute precision of mating surfaces.

BACKLASH TAKEUP: Correction of backlash error implemented by the control system.

BAUD RATE: Bits per second; used as a measure of serial data flow between a computer and/or communication devices.

BINARY: A number system utilizing a base of two. Binary Code is notated by 0's and 1's. For example, the number 92 is represented by 1011100. Control systems utilize binary logic because the switching components within them have two states: "ON" and "OFF". In general, X, Y, Z, I, J and K dimensions, which are input to the control in decimal notation, are converted internally to binary values so that the arithmetic functions may be more conveniently implemented.

BIT: A binary digit which can be one of the two states (0 or 1) in the binary number system. A bit is the smallest unit of data in a digital computer.

BLOCK: A command line; single line of a part program which is

sufficient to be considered as a discrete working unit of program.

BORE: To pierce with a rotary tool.

BOSS 8: (Bridgeport Operating System Software) The binary code embedded in nonvolatile read only memory (ROM) and which is responsible for inherent control of the machine.

BUFFER: Storage device used to compensate for a difference in the rate of data flow from one device to another.

BUFFER STORAGE: Storage reigsters for X, Y, Z, I, J, K, F and M data which act as an intermediate storage area between the Tape Reader and active storage. This data is available for rapid transfer to active storage.

BYTE: A set of eight binary bits, which are operated on as a unit. A byte is a subset of a computer word.

CAD: Computer Aided Design.

CAM: Computer Aided Manufacturing.

CANNED CYCLE: A preset sequence of events initiated by a single command. For example, G84 is a tapping cycle that provides a feed in, feed out sequence.

CAPACITY, MACHINE: Specification which describes total X, Y, Z displacements.

CARTESIAN COORDINATES: A dimensioning system whereby the position of a point can be defined with reference to a set of axes at right angles to each other.

CHARACTER: One of a set of letters, numerals or symbols which may be combined to represent information in a program. In the Bridgeport system, the characters used are: letters N, G, XYZ, etc.; decimal digits 0 to 9; and the characters "-", "tab", "end of block", and "rewind stop". The characters are used to address specific registers.

CHATTER: Vibration caused by harmonic vibration of a tool in contact with the work piece during a move.

CIRCULAR INTERPOLATION: A mode of contouring control which uses the information contained in a single block to produce an arc of a circle.

CLOCKWISE: Spindle rotation direction such that a right handed screw installed in the tool holder would drive into the work piece. Counterclockwise is the reverse of clockwise.

CLOSED LOOP SYSTEM: A feedback system whereby a signal from the machine control is acted upon by the machine tool and a monitoring unit then returns the acted upon signal for comparison. The difference between the two signals is the rate loop error or "following error" which is amplified and compared with a velocity (tachometer) signal and output to the power amplifier. The power amplifier accepts the error signal and supplies the necessary output for the servo drive which then attempts to reduce the error to zero.

CNC: (Computer Numerical Control) A numerical control system wherein a dedicated, stored program computer is used to perform some or all of the basic numerical control functions.

COMPENSATION, CUTTER: The ability of a control to accept differences between a programmed tool diameter and the actual tool diameter. This compensation generates an entirely new milling path parallel with the old and equidistant from it by the compensation amount at all times.

COMPUTER: A device capable of accepting information, operating on the information according to preprogrammed instructions and supplying the results ot these operations. A typical computer consists of a CPU (central processing unit containing control, arithmetic and logic, and register elements), main memory and I/O (Input/Output) devices.

COORDINATE SYSTEM, STANDARD: Coordinate system which defines the coordinates of a moving tool (or draftsman's pencil) with respect to a stationary workpiece. (Ref. EIA 267 definition of Standard Coordinate System.) COORDINATES, ABSOLUTE: The values of the X, Y, Z coordinates with respect to the origin.

COORDINATES, CONTROL: The absolute tool coordinate values currently stored in the control system memory.

COORDINATES, INCREMENTAL: Values of X, Y, Z coordinates as a measurement from the preceeding coordinate value, resulting in the coordinates of a new point being specified as if the previous point were the origin.

COORDINATES, MACHINE: Values of X, Y, Z coordinates referenced to the Home position to an origin which is the specified origin of the physical part.

COUNTERCLOCKWISE: See CLOCKWISE.

CURRENT LOOP: A communication line on which the presence or absence of electrical current is used to represent transmitted data.

CUTTER COMPENSATION: See COMPENSATION, CUTTER

CUTTER PATH: The path described by the cutter in order to generate the desired part configuration.

CYCLE: A sequence of operations that is repeated regularly. Examples: bore mill, canned, facing, pocket, quill, Z.

DECELERATION: Instantaneous rate of change of decreasing velocity in the direction of tool motion.

DEFLECTION: Error in tool tip XY position caused by excessive sideloading of the tool during a cut.

DEPARTURE: Characteristics of the motion of a tool as it initiates a move from the current location to a new one.

DIAMETER, NOMINAL TOOL: Diameter specified by the tool manufacturer and subject to manufacturer's tolerance specification.

DISTANCE: Length of a line segment connecting two points.

DISTANCE, PECK: Incremental -Z travel of a drill motion specified in a deep hole or chip break cycle.

DOWNFEED: The motion of the tool in the -Z direction.

DOWNLINE LOADER: See LOADER

DRIFT: Motion of the tool which occurs without directive from the control system.

DWELL: The time delay programmed during a canned cycle.

EDITOR: A program which permits a user to create new files or to modify existing files.

EIA STANDARD CODE: (Electrical Industries Association) two EIA Standards for N/C character coding are: RS-244-A Character code for Numerical Machine Control Perforated Tape, commonly called EIA code; and RS-358 Subset of the USA Standard Code for Information Interchange for Numerical Machine Control Perforated Tape, commonly called ASCII Code. Bridgeport Controls conform to both code character sets.

EMERGENCY STOP - A button that cuts off power to the three axes.

END OF BLOCK CHARACTER (EOB): A character that represents the end of a line or block of information contained on a machine control tape. (See EIA STANDARD CODE).

END OF PROGRAM: An 'M02' code indicating completion of the workpiece. Stops spindle, coolant and feed after completion of all commands in the block. The tape is rewound back to the

rewind stop code at the beginning of the program.

EQUIVALENT PAPER TAPE LENGTH: One foot of paper tape contains 120 characters or bytes of data.

EXECUTE: To perform a specified computer instruction; to run a program.

FEED FUNCTION: The relative motion between the tool or instrument and the work piece. It is caused by motion of the axis or axes.

FEEDBACK: The control signal derived as the result of an output action which is used to modify the input creating that action.

FEEDRATE OVERRIDE: A variable manual control function used to reduce or increase the programmed feedrate.

FLOATING ZERO: A characteristic of a machine tool controller permitting the zero reference point on any axis to be easily established at any point in the travel. (Refer to G92)

FOLLOWING ERROR: See CLOSED LOOP SYSTEM.

INITIALIZE: To set the system logic (counters, switches, registers) to zero or other starting values at the beginning of a computer program.

INTEGRATED CIRCUIT (IC): A solid state microcircuit consisting of interconnected active and passive semiconductor devices diffused into a single silicon chip.

INTERFACE: The portion of the machine tool controller that connects the control system to the outside world. This can include a data link to a remote computer or connection to peripheral machine tool equipment. Special consideration has to be given in the interface design so that the control system is effectively isolated from externally generated electrical "noise" transients.

INTERPOLATION: A function of a control whereby data points are generated between given coordinate positions to allow simultaneous movement of two or more axes of motion in a defined geometric pattern, linear, circular and parabolic.

JOG: Fixed incremental tool position change along a single axis (X, Y or Z) executed by the machine as a result of operator input.

MACRO: A subroutine consisting of a group of instructions which can be stored and then recalled as a group to avoid reprogramming the subroutine in a new location. The macro call statement may assign values to the variables, if any, in the macro.

MANUAL FEEDRATE OVERRIDE: A control that enables the operator to increase or to reduce the feedrate if the tape programmed rate is not optimal for the material being machined.

MDI: Manual Data Input, a method of operation in which data is entered manually by keyboard or other means instead of by program.

MISCELLANEOUS FUNCTION: A one or two digit "M" code which sets a particular auxiliary machine function such as spindle/on-off, coolant/on-off, etc.

MODAL: Remains in effect until changed.

NONVOLATILE MEMORY: A type of computer system memory offering preservation of data storage during power loss or system shutdown.

NUMERICAL CONTROL (NC): A method of controlling moving machine parts and auxiliary equipment using an input medium which consists of coded alphanumeric characters.

OVERRIDE: To manually or otherwise deliberately override an automatic control system or circuit and thereby render it ineffective.

PARITY CHECK: A method of checking the correctness of binary data after that data has been transferred. The single digit sum of all the binary digits in the word or character and its logical state represents either an even or an odd number of 1's making up the binary word.

PART PROGRAM: Specific and complete set of data and instructions written for the operation of a numerically controlled machine tool.

PECK: A canned cycle for deep hole drilling whereby the Z axis feed is reversed at regular intervals for chip relieving.

POINT, CLEARANCE: Program point for tool changing or other operator activity. It has a distance reference to the part, and therefore to program zero.

POINT, PART PROGRAM ZERO: The absolute zero about which all programmed absolute coordinates originate. These coordinates usually match the part coordinates for simplicity. However, the turn on state is such that program zero must be shifted. Further, the turn on state is such that the control coordinate must be synchronized with the machine and part.

POINT, PART REFERENCE: A point which may be referred to by the dial indicator or edge finder. This reference point may have coordinates other than part zero. This is usually displayed in

machine coordinates.

POINT TO POINT CONTROL: A positioning system that controls the discrete positions at which a machine operation is performed. The path and rate of movement between points is not under continuous control in every system. The most common application of point to point control is drilling.

POINT, XYZ HOME: A fixed mechanical point in three dimensional space, which defines the active travel limits of the machine and is referenced to a right handed Cartesian coordinate system centered about the table (X,Y) and quill (Z). With respect to table motion, the X, Y home position is table extreme right (X), table extreme in (Y). With respect to tool motion, the X,Y home is tool left (X), tool out (Y). Z home position is quill up.

POLAR COORDINATES: A mathematical system for locating a point in a plane by the length of its radius vector and the angle this vector makes with a fixed line.

PRECISION: Measure of repeatability of a series of measurements of the same true value without regard to the difference from the true value.

PROGRAM STOP: Miscellaneous function command that stops the feed after completion of other commands in the block. It may also electromagnetically disconnect line power from other machine tool auxiliary functions.

PUNCHED TAPE: A tape with holes produced in such a manner so as to represent a particular set of data. The standard geometry is specified in EIA RS-227.

QUADRANT: One of the four quarters of the rectangular coordinate dimensioning system.

R2E3: Acronym for the Rigid RAM, 2 horsepower spindle motor, E type control, 3 axes milling machine.

RANGE OF TRAVEL: Absolute distance between the XYZ HOME POINT and the X,Y, or Z limit switch design trip point.

RANDOM ACCESS MEMORY (RAM): A storage unit in which direct access is provided to data, independent of memory location.

RAPID TRAVERSE: Maximum rate of travel of tool with respect to the workpiece achievable with the tool not in contact with the part.

READ ONLY MEMORY (ROM): A storage unit generally used for control programs whose contents are not alterable (cannot be erased or changed).

REALTIME: Control system operations in which the system is controlling a process while that process is actually occurring.

REPEATABILITY: Worse case steady state condition between commanded X, Y, Z tool position and true X, Y, Z tool position, achievable with the machine. Repeatability is measured in terms of plus or minus three standard deviations from the average position of a statistically significant number of identical machine moves without regard to the target.

RESET: Occurs under the following conditions: 1) power ON 2) Reset Switch activated 3) power OFF for more than 100 seconds. At Reset, the screen clears and the system reads, writes and verifies the system RAM and reads and verifies the system ROM.

RESOLUTION: Smallest increment of output action obtainable from the smallest increment of input.

RESOLUTION, CONTROL LOGIC: Smallest measure of numeric data achievable in the control system hardware.

RESOLUTION, DISPLAY: Smallest significant digit increment of a numeric value displayable with the display hardware.

RESOLUTION, INPUT: Smallest unit of numeric data input achievable with the input hardware.

RESOLUTION, OUTPUT: Smallest X, Y, or Z move possible under program control.

RS-358: (Commonly called EIA code) Subset of the USA Standard Code for Information Interchange for Numerical Machine Control Perforated Tape (commonly called ASCII).

SEQUENCE NUMBER: A multidigit "N" number identifying the block or group of blocks on the NC tape. This sequence number is displayed on the operator's console.

SIGN REVERSAL: Inversion of the current direction (sign) of an axis under program control.

SPEED, SPINDLE: Angular velocity of the spindle, specified in RPM.

SYNCHRONOUS COMMUNICATION: A method of transferring serial binary data, transmitted at a fixed rate, with the transmitter and receiver synchronized by characters located at the beginning of each block of data.

TOLERANCE: The largest difference between a specified value and the true value which permits treating the two values as if they were identical.

TOOL ASSEMBLY: A complete assembly usually consisting of the tool holder with collet, etc. where necessary, the cutter, and if applicable, the tool insert. The tool holder fits directly into the spindle nose of the machine.

TOOL LENGTH OFFSET: The numeric value of an error correction to compensate for less than absoutely accurate tool length specification.

TRAVEL: The tool motion.

VECTOR VELOCITY: The resulting speed of a particular combination of axes motion. The individual axes move slower than the programmed rate, but the resultant rate, or vector, is equal to the programmed rate.

ZERO SHIFT: A characteristic of a machine tool controller permitting the zero point on an axis to be shifted readily over a specified range.

ZERO SUPRESSION: The elimination of nonsignificant zeroes to the left of the decimal point or nonsignificant zeroes to the right of the first digit after the decimal point. The Bridgeport control permits both modes provided that the decimal point appears in the word.