# CHAPTER 3

## MACHINE COMPONENTS AND SYSTEMS

### 3.1 THE SERIES I CNC MACHINE

The R2E4 is a vertical spindle, knee-type multifunction machine tool as shown in Figure 3-1. The equipment is built around a base assembly with a rigid ram to carry the 2HP Milling Head. The ram is mounted to the column of the machine and is secured and pinned. The milling head is provided with limited adjustment (see the Installation chapter in the User Manual).

Mounted to the machine column are the major accessories and control equipment shown in Figure 3-1:

- Power Equipment Enclosure for Magnetic and Power Distribution
- Axis Drive Enclosure for the Servo System
- Operator Control Enclosure for the Operator's Control Station
- Auxiliaries Cabinet for Lubrication and Pneumatics Systems

#### 3.1.1 The Base Assembly

The Series I CNC machine is an entirely different version of the familiar Standard Series I Vertical Milling Machine. It is specifically designed to enable its full dedication to the needs of numerical control. It has special dual knee locks to clamp the knee (manually adjusted) to the column. The knee has additional way area at the top to carry the extended deep saddle, and the table is designed for an automatic machine tool. The machine ways are chrome plated for long life, and an automatic one-shot lubrication system is provided. The X and Y axis drives are suspended clear of the operator's working area. This arrangement eliminates any bending moment on the table. The X-axis drive motor is mounted on the saddle where it gets better support and drives the ballnut of a stationary ballscrew. The Y-Axis motor is mounted on the knee and rotates the Y-axis ballscrew. Ballscrews are totally enclosed and mounted in the center of the guideways.

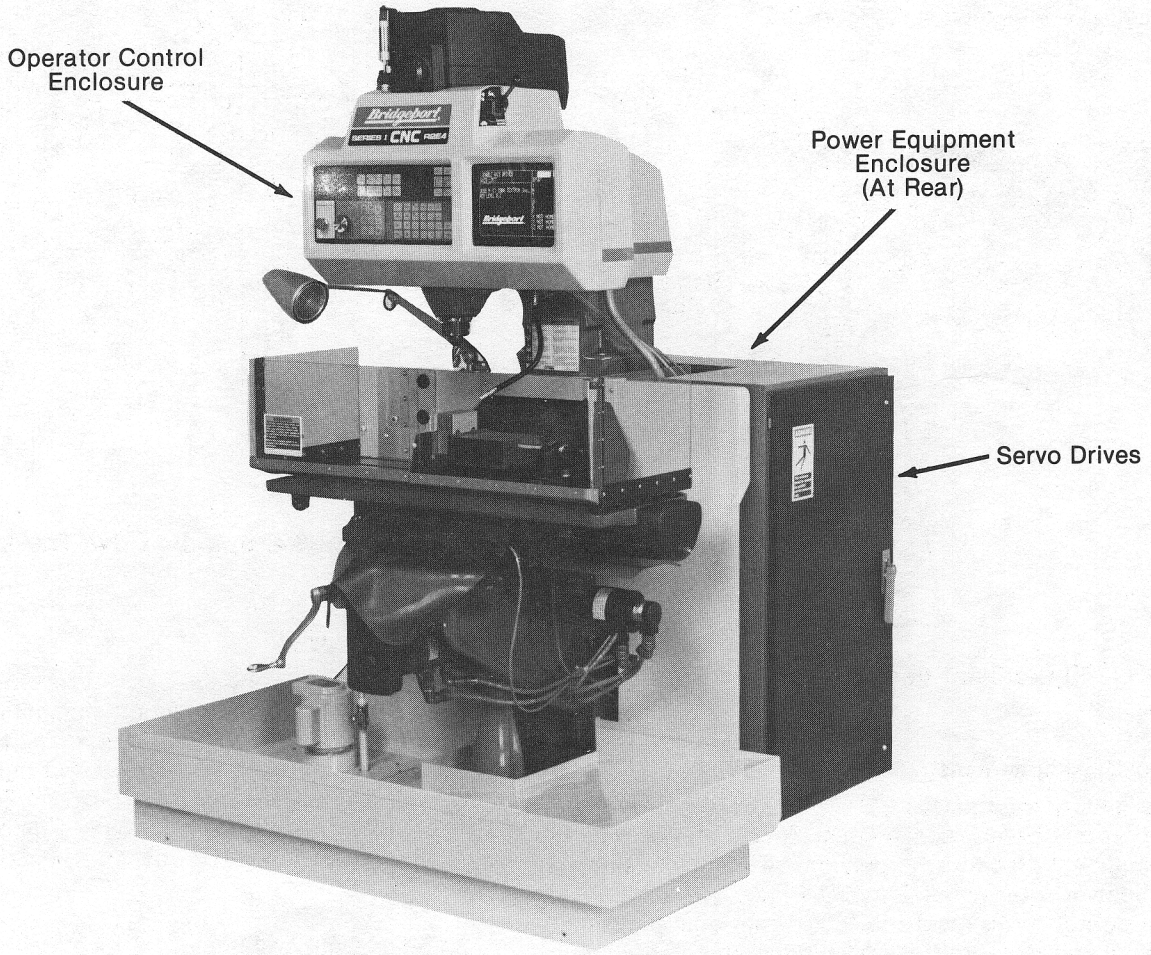


**Figure 3-1.** Series I R2E4

**Knee Drive** The knee is elevated by a 5-pitch Acme screw. A friction dial is provided, calibrated in increments of 0.001 inch (0.0254mm).

To change the knee elevation, push the knee elevating crank in until the clutch meshes; then turn the crank clockwise to elevate the knee, or counterclockwise to lower it.

***NOTE***

*Two knee lock wrenches (Figure 3-2) control the clamps on the knee-column ways and must be released before the knee will raise or lower.*

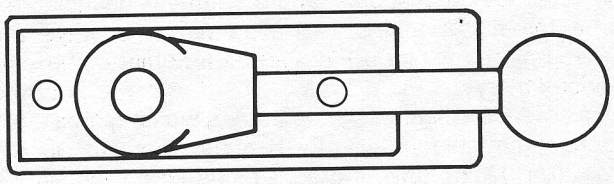

**Figure 3-2.** Column Knee Clamps

To clamp the knee, firmly turn the knee lock wrench handles clockwise. To release, turn them the other way. Keep the knee clamped while cutting.

The knee is supported on an Acme screw, and the nut is mounted on the pedestal, Figure 3-3.

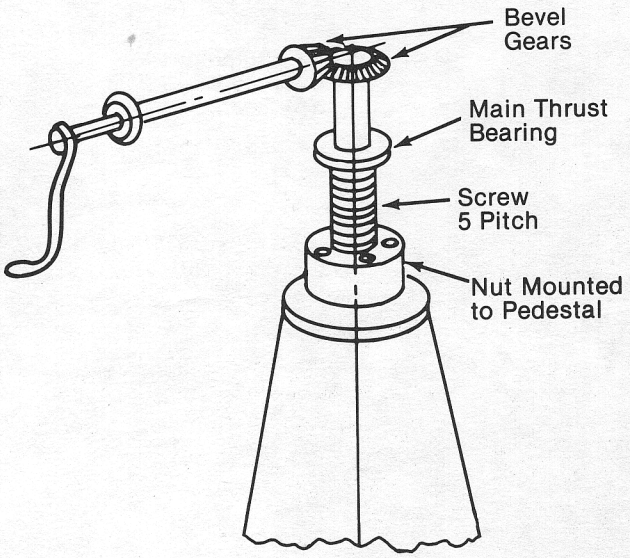


**Figure 3-3.** Knee Drive Transmission

### 3.1.2 Gib Adjustment

**Preliminary Information** The gibs are set properly at the factory before acceptance testing and alignment. Adjustment procedures apply only when misposition is evident or after about 6 months' use. We recommend you do not try to reset the factory set gibs unless absolutely necessary. However, if gib adjustments are required, refer to Chapter 10, Section 10.7 for the correct procedures.

### 3.1.3 The Milling, Drilling and Boring Head — Figure 3-5

**Transmission** The spindle drive motor is a 3 phase, 2 HP (1.5W) AC induction motor. The following motors are available:

| | |
|---|---|
| 200/400V | 50/60 Hz |
| 230/460V | 60 Hz |
| 575V | 60 Hz |

An internal cooling fan located within the motor casing draws ambient air into the front of the head, around the main drive belt and through the motor. See Figure 3-4.

Speed changing is affected by forcing the drive belt to ride at a large or small radius on the conically tapered varidisc sheaves. Each varidisc assembly is precision dynamically balanced to prevent vibration and promote long belt life.

When the high/low shifter is in high, the output of the varidisc drives the spindle directly through the clutch. A shift into back gear (low) disengages the clutch and engages the bullgear. The power now travels through a toothed belt drive to a countershaft and back to the spindle through the bullgear for an overall reduction of 8:3:1. A pneumatically operated spindle brake and speed changer are standard. See Section 3.5 for pneumatics.

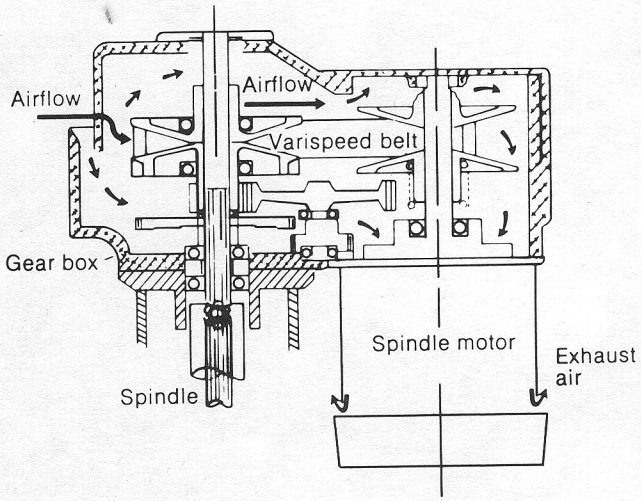


**Figure 3-4.** Spindle Drive Transmission

### 3.1.4 Z-Axis Drive

The quill is driven by the same type of servo motor as the X and Y-axes. A timing belt connects the feed drive motor and the ball quill extension. The ball quill has a 5-pitch thread carrying a recirculating ballnut with suitable internal preload. With proper adjustment of the timing belt, lost motion is virtually eliminated. The quill has a working travel of 5 inches. The Drive Ratio is 2:1 (.2 lead).

### 3.1.5 The Quill and Spindle

The quill is a 3-⅜ inch diameter steel tube ground and chrome plated to a tolerance of .0002″. The quill


**Figure 3-5.** Milling, Drilling and Boring Head

secures the outer races of the angular contact special precision preloaded bearings mounted to the spindle. The spindle itself is alloy steel hardened and ground, with an involute spline at its upper end to slide internally in the power transmission train. At the lower end of the spindle, a taper is ground for Erickson #30 quick change tool holders or similar units. A Universal 200 taper is also available.

## 3.2 THE CNC SYSTEM

The following provides a functional description of each subsystem in the R2E4 system. Figure 3-6 is a functional block diagram of the system.

### 3.2.1 Operator Control Subsystem

Most operator input is accomplished through this subsystem. It accepts keypad, keyboard and some switch control inputs and also provides machine status outputs through the CRT and LEDs. The CRT provides displays of programs, commands and axis positions, along with any error messages detected by the Central Processing subsystem. This subsystem contains the Front Panel membrane and one PC board, see Figure 3-7.

**SFP (Serial Front Panel) Board** This board interfaces the Front Panel controls with BOSS 9.0. The SFP board sends Front Panel key closures to the BSP board, and receives data and commands for the status LEDs and CRT.

***NOTE***

*The BSP board sends signals to the EZIO board to enable translation of data for CRT display.*

### 3.2.2 Central Processing Subsystem

All operator and electronic input are analyzed by this subsystem. Appropriate commands and responses are sent to the Operator Control, Axis Drive or Interface subsystems. There is one board in this subsystem:

**BSP (Bridgeport Standard Processor) Board** This board contains a 68000, 16-bit microprocessor and controls system operations. It also contains memory space for both BOSS 9.0 and part program input.

### 3.2.3 Power Subsystem

This subsystem contains two line voltage transformers and two power supplies providing operating voltages to the entire R2E4 system. Incoming power enters at the main disconnect and is conditioned and distributed by this subsystem. The FPU board monitors line voltage for spikes and power downs. It contains four standard alkaline cells which maintain control memory at power down.

### 3.2.4 Interface Subsystem

This subsystem provides Central Processing with control and status of the Electromechanical components in the system and provides an interface between the R2E4

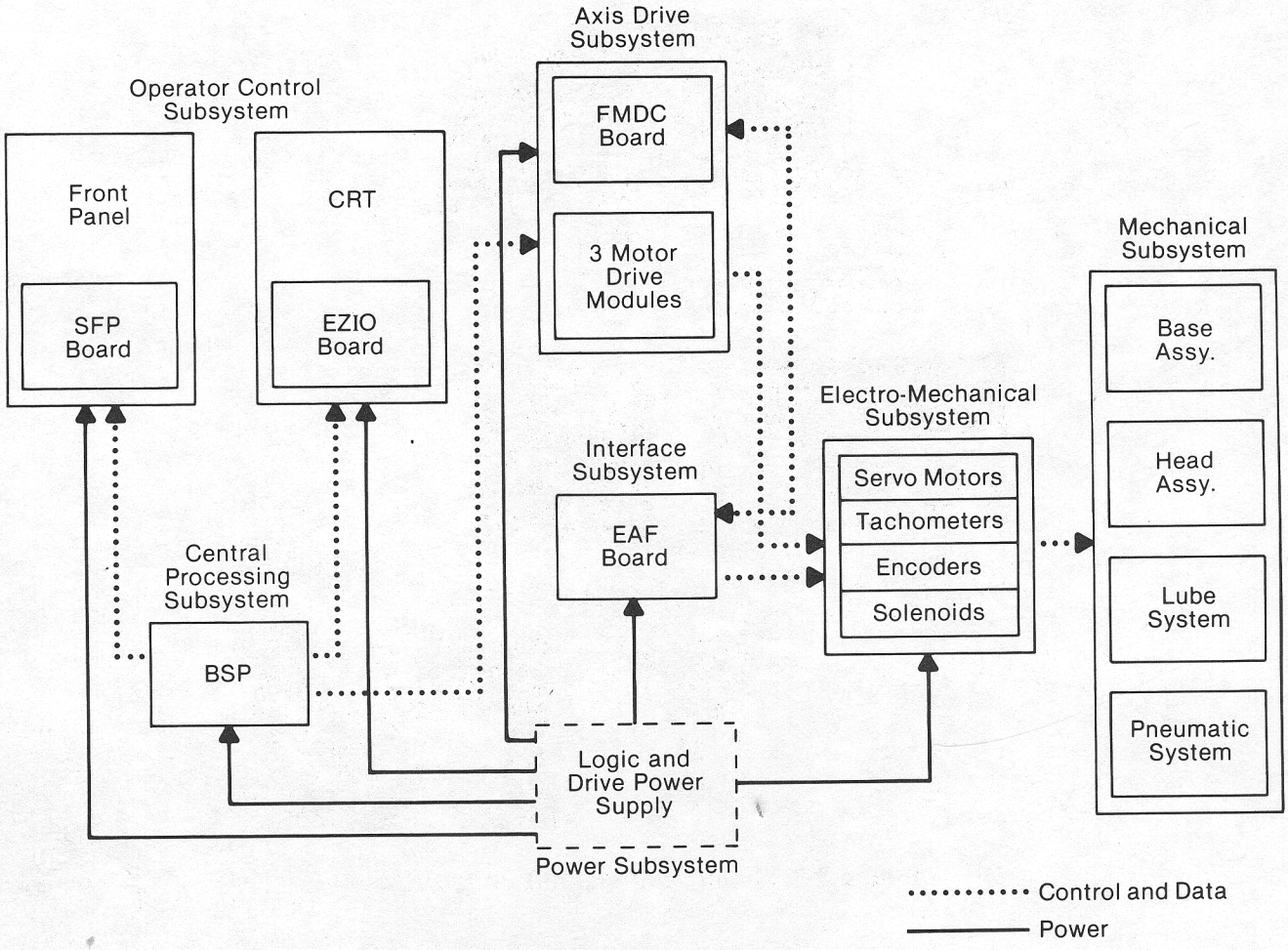


**Figure 3-6.** R2E4 Series I System — Functional Block Diagram

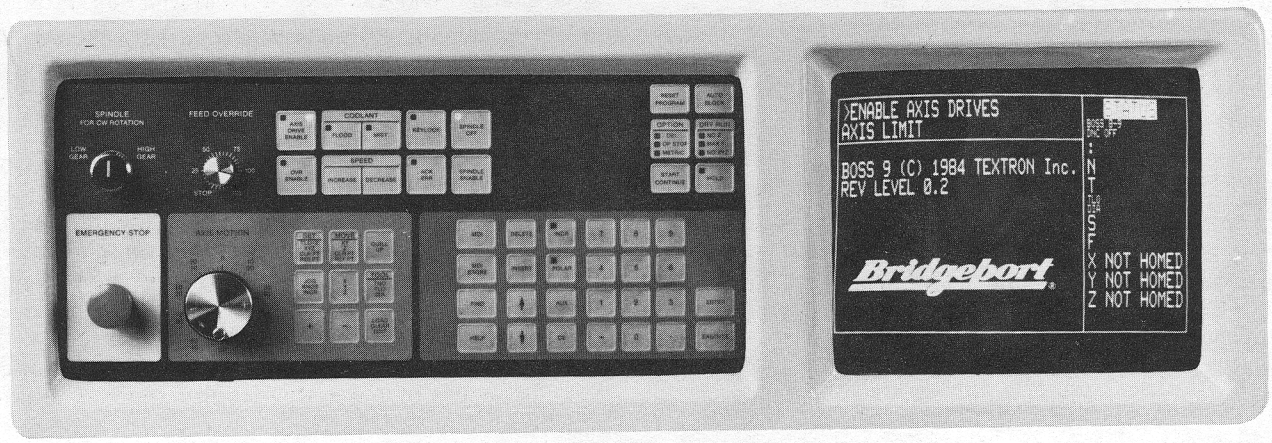


**Figure 3-7.** Operator's Control Panel

system and the outside world. This subsystem contains one board:

**EAF (Auxiliary Function) Board** This board interfaces the Central Processing subsystem to both the Electromechanical subsystem and the outside world. It contains the circuitry needed to establish RS-232 and RS-422 links. It also contains optocouplers and transistors used to control and monitor various electromechanical components.

### 3.3 AXIS DRIVES

#### 3.3.1 Axis Drive Subsystem

This subsystem receives positioning signals from the FMDC board and translates these signals into command and direction signals for the DC servo motors. It also transfers signals between the BSP board and the EAF board.

The Axis Drive subsystem consists of printed circuit boards and motor drive boards.

**FMDC Board** The FMDC board receives position signals from the BSP board and converts them to drive signals for the motor drive boards. This board also monitors the home switches and communicates with the EAF board.

**IFC Board** The IFC board acts as an interface between the FMDC and the axis drive motors.

**HBD Board** The HBD board monitors drive current for the output drive transistors.

**DCS Board** The DCS board processes the velocity command and the tachometer signals. It also generates error signals to the HBD board.

**DPS Board** The DPS board is a power supply board which supplies + 15 VDC.

#### 3.3.2 Electromechanical Subsystem

This subsystem receives commands and power from the Servo Drive subsystem and provides axis motion for the milling machine. Each axis of the milling machine contains the following electromechanical assemblies:

1. Motor The motor is a DC servo motor and receives current signals from the servo drive subsystem. The motor converts the signals into mechanical axis motion.
2. Encoder The encoder converts the position of the axis into a two phase pulse stream which the Axis Drive subsystem can decode.
3. Tachometer The tachometer converts the velocity of the axis into an analog voltage signal for the Axis Drive subsystem.

### 3.4 MECHANICAL SUBSYSTEM

This subsytem contains two assemblies:

1. Head Assembly This consists of all the mechanical components of the quill (Z-axis), the Z-axis drive motor and the spindle motor.
2. Base Assembly This contains the saddle (Y-axis), table (X-axis), knee, their support structures and the X and Y-axis drive motors.

### 3.5 LUBRICATION SYSTEM

#### 3.5.1 Overview

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

#### 3.5.2 Way System Lubricant

The automatic one-shot way lubricator system is shown as installed in Figure 3-8.

All moving members are fed from a central lubricating tank, the TM-5 lubricator, which contains a filter and motorized timed plunger pump.

For more information on the lubrication system, refer to Chapter 12.

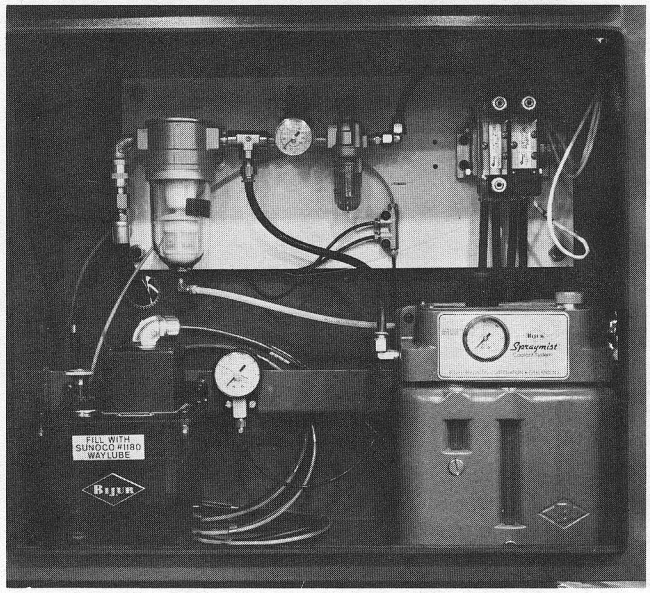


**Figure 3-8.** Auxiliaries Cabinet Assembly

### 3.6 PNEUMATIC SYSTEM

#### 3.6.1 General Distribution

The entire pneumatic system is self-contained and requires no special startup procedures other than the need of 85-125 PSI service, along with adequately sized lines and plant equipment capacity.

The system consists of an air hose, a lubrication bowl, a manual pressure relief valve and a regulating valve set at 75 psi (482.5 kilo pascals). Average air consumption is 4 cfm. Instantaneous flow is 12 cfm, requiring lines and external equipment to be sized for 12 cfm.

Refer to Chapter 12 for more information on the Pneumatic System.