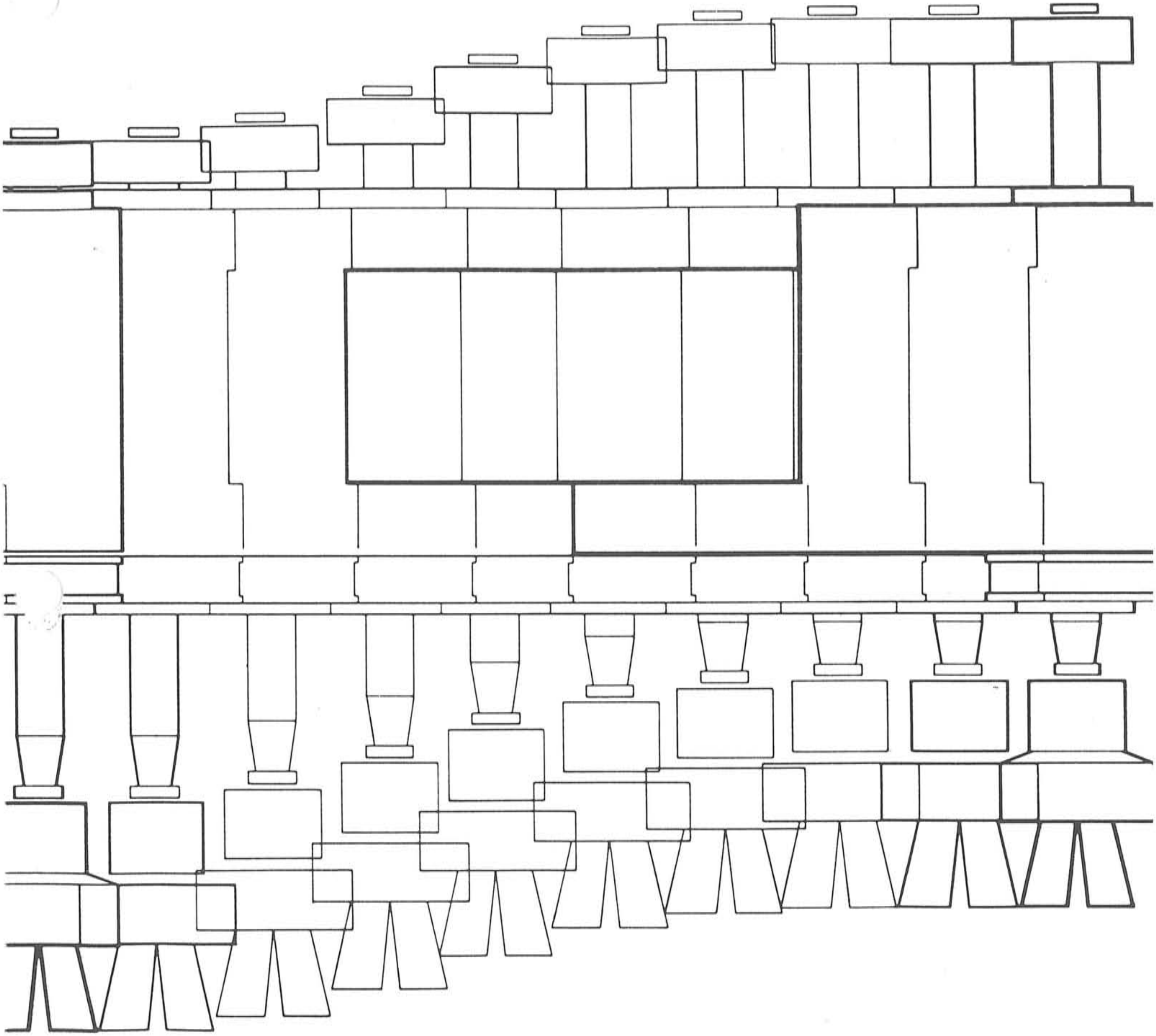
IBM 7535/7540 Manufacturing System
Hardware Library



Maintenance Information

Warning: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

Ordering information...

- This manual and binder can be ordered as a unit using order number 08011.
- Requests for copies of IBM publications should be made to your IBM Marketing Representative.

Second Edition (September 1983)

This is a major revision of, and obsoletes, the First Edition of 8508978.

Changes are periodically made to the information herein; any such changes will be reported in subsequent revisions or Technical Newsletters.

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This publication could contain technical inaccuracies or typographical errors. Also, illustrations contained herein may show prototype equipment. Your system configuration may differ slightly. A form for reader's comments is provided at the back of this publication. If the form has been removed, address your comments to IBM Corporation, RS Information Development, Department 8C6, P.O. Box 1328, Boca Raton, Florida, 33432. IBM may use or distribute any of the information you supply in any way it believes appropriate without incurring any obligation whatever.

SAFETY NOTICES

Safety precautions should always be observed by all personnel operating or servicing the IBM Manufacturing System. As with any electromechanical machine, unpredictable failures can occur while the system is in operation. Since the manipulator arm moves with such force and speed, serious injury could result from failure to observe caution whenever the work area is penetrated. Power to the manipulator must **always** be removed first. Keep this in mind when performing any maintenance or service on the system. Also:

- Ensure compliance to all local and national safety codes for the installation and operation of the system.
- Observe power and grounding instructions.
- The system must not be installed in an explosive atmosphere.
- Observe safe access routes to and from the system.
- Consider installing intrusion devices or safety mats around the manipulator to drop power if the work area is penetrated.
- Utilize signs around the system when servicing it to alert others to potential hazards.
- Consider installing additional emergency-off switches for feeders and other fixtures.
- Stay out of the manipulator work area when power is on. The manipulator arm moves rapidly with a lot of force.
- Always wear safety glasses around the manipulator.
- Remove watches and jewelry when servicing the system.
- Use the **Stop** pushbutton on the control panel to stop the manipulator in emergencies.
- Always check the work area for adequate clearance before applying power. **Be absolutely sure no one is in the manipulator work area.**
- All personnel working with the system must have (as a minimum) instructions on:
  - Safety devices for the system.
  - Use of safety devices. Safety procedures should be practiced to ensure familiarity.
- Fire extinguishers must be located within easy access.

Safety Inspection

Before you service the IBM Manufacturing System, it is recommended that the following inspection be performed. This will ensure the system is safe to service.

- The frame ground of the controller is attached to an approved electrical ground.
- The AC power source is properly grounded.
- All attachments that are not part of the manufacturing system are properly grounded.
- The Stop pushbutton on the operator panel and the circuit breaker on the controller are working properly.
- All safety labels are in place and readable.
- All machine covers are in place.
- All of the safety sheilds are in place on the system.

PREFACE

This manual provides maintenance information for the IBM 7535 Model A04 Manufacturing System and the IBM 7540 Model A02 Manufacturing System.

Before you begin using this document, you should be familiar with the operation of the system as described in the prerequisite publications listed later in this section.

This manual is intended to provide adequate information for the maintenance of the IBM 7535/7540 Manufacturing Systems. It is assumed that the person maintaining the system has received IBM Maintenance Education training or equivalent. Detailed information on operating and programming the system is provided in the User's Guide.

The subjects are presented in 11 sections:

- Section 1 contains location drawings for key components of the system.
- Section 2 contains the theory of operation for the system. The theory section starts with a description of major components and then describes the functions of the system during specific operations.
- Section 3 contains step-by-step procedures for removal and replacement of the major FRUs of the system. Reference drawings, indicating the location of the parts to be removed, are provided with each procedure.
- Section 4 contains step-by-step procedures for adjusting the different components of the system. Reference drawings, showing the locations, dimensions, and any special tool setup, are provided with each procedure.
- Section 5 contains reference drawings showing the parts location of the system. The reference numbers are tabulated on the facing page of each drawing and include the part name and part number.
- Section 6 contains detailed instructions for the installation of the controller, control panel, and manipulator.
- Section 7 contains the description of the various switches found in the controller.
- Section 8 contains the description of the system exerciser programs.
- Section 9 contains a list of recommended preventive maintenance procedures.
- Section 10 contains maintenance aids for troubleshooting problems on the system. The section contains various failure symptoms, likely fixes, and a problem-isolation procedure.
- Section 11 contains point-to-point wiring diagrams of the controller, control panel, and manipulator. It includes diagrams for the interface cabling between the boards but does not include individual board wiring diagrams.

Prerequisite Publications

- IBM Manufacturing System User's Guide (8508974)

Related Publications

- IBM Manufacturing System Site Preparation Guide (8508972)

TOOLS

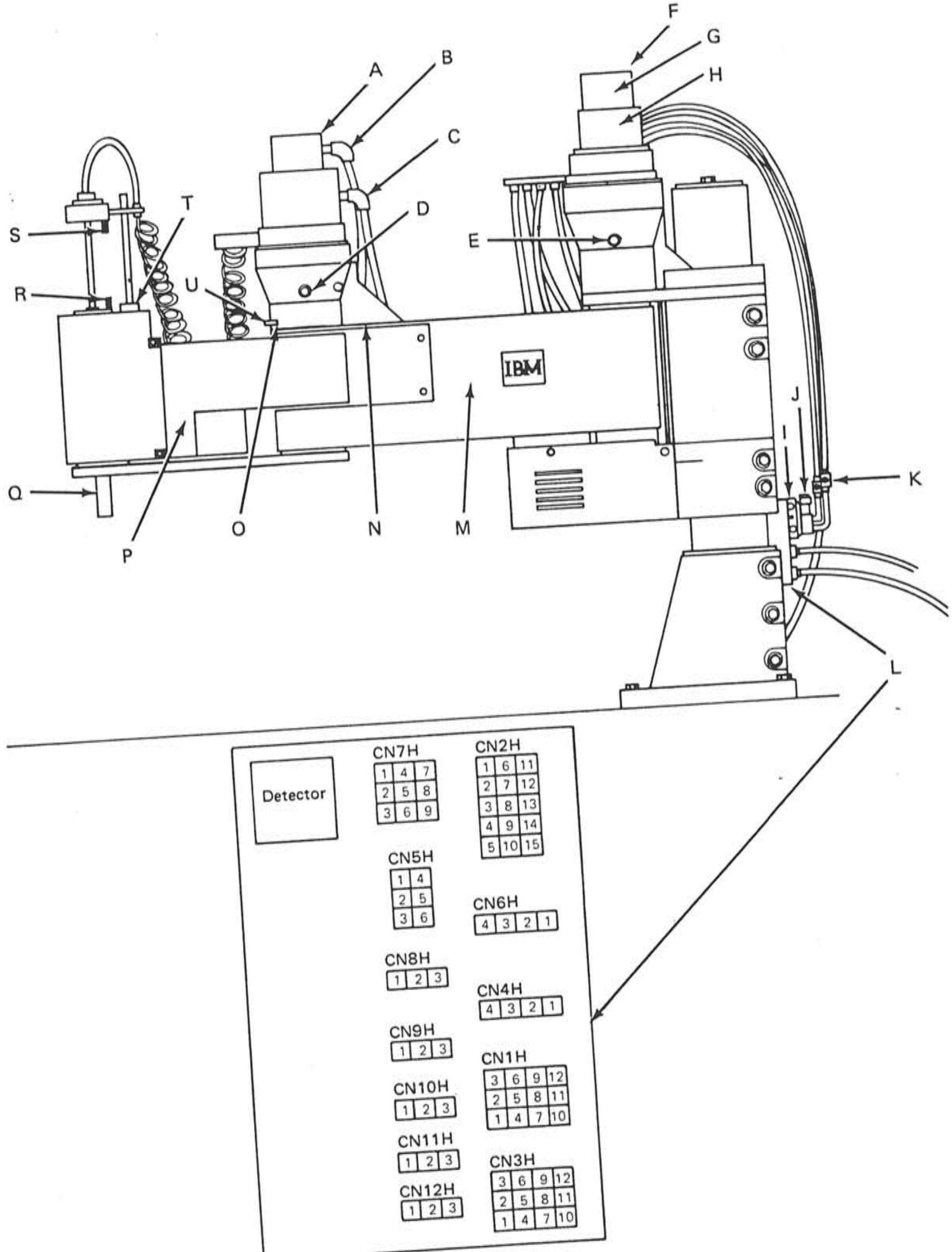
The 7535/7540 Systems are assembled with metric nuts, bolts, and screws. Therefore, it is recommended that only metric tools be used to service the equipment. The following is a recommended tools list:

- Safety glasses
- Screwdriver
- Phillips screwdriver
- Hammer
- 2-mm Allen wrench
- 2.5-mm Allen wrench
- 3-mm Allen wrench
- 4-mm Allen wrench
- 5-mm Allen wrench
- 6-mm Allen wrench
- 7-mm Allen wrench
- 8-mm Allen wrench
- 10-mm Allen wrench
- 7-mm open-end wrench
- 8-mm open-end wrench
- 9-mm open-end wrench
- 10-mm open-end wrench
- 11-mm open-end wrench
- 13-mm open-end wrench
- 14-mm open-end wrench
- 19-mm open-end wrench
- 30-mm open-end wrench
- Digital voltmeter
- Analog volt ohm-meter
- Feeler gauges
- 1/2-inch diameter pin
- Retaining-ring tool
- Roll punch
- 2-inch travel dial gauge
- 60-ft.lb. torque wrench
- Pin-removal tools

  (AMP PN 465644-1 or equivalent)

  (AMP PN 724668-1 or equivalent)

CONTENTS



Inside outlet box

MANIPULATOR - SIDE VIEW

Air Cylinder....................................T

Air Manifold....................................I

Air Solenoids...................................J

CN13H through CN18H.............................M

CN19H, CN20H....................................P

CN31H...H

CN32H...G

CN33H...C

CN34H...B

Outlet Box......................................L

Speed Controls..................................K

Theta 1 Motor, Encoder, and Tach Assembly.......F

Theta 1 Oil Level Port..........................E

Theta 2 Home Switch.............................O

Theta 2 Minus Overrun Switch....................U

Theta 2 Motor, Encoder, and Tach Assembly.......A

Theta 2 Oil Level Port..........................D

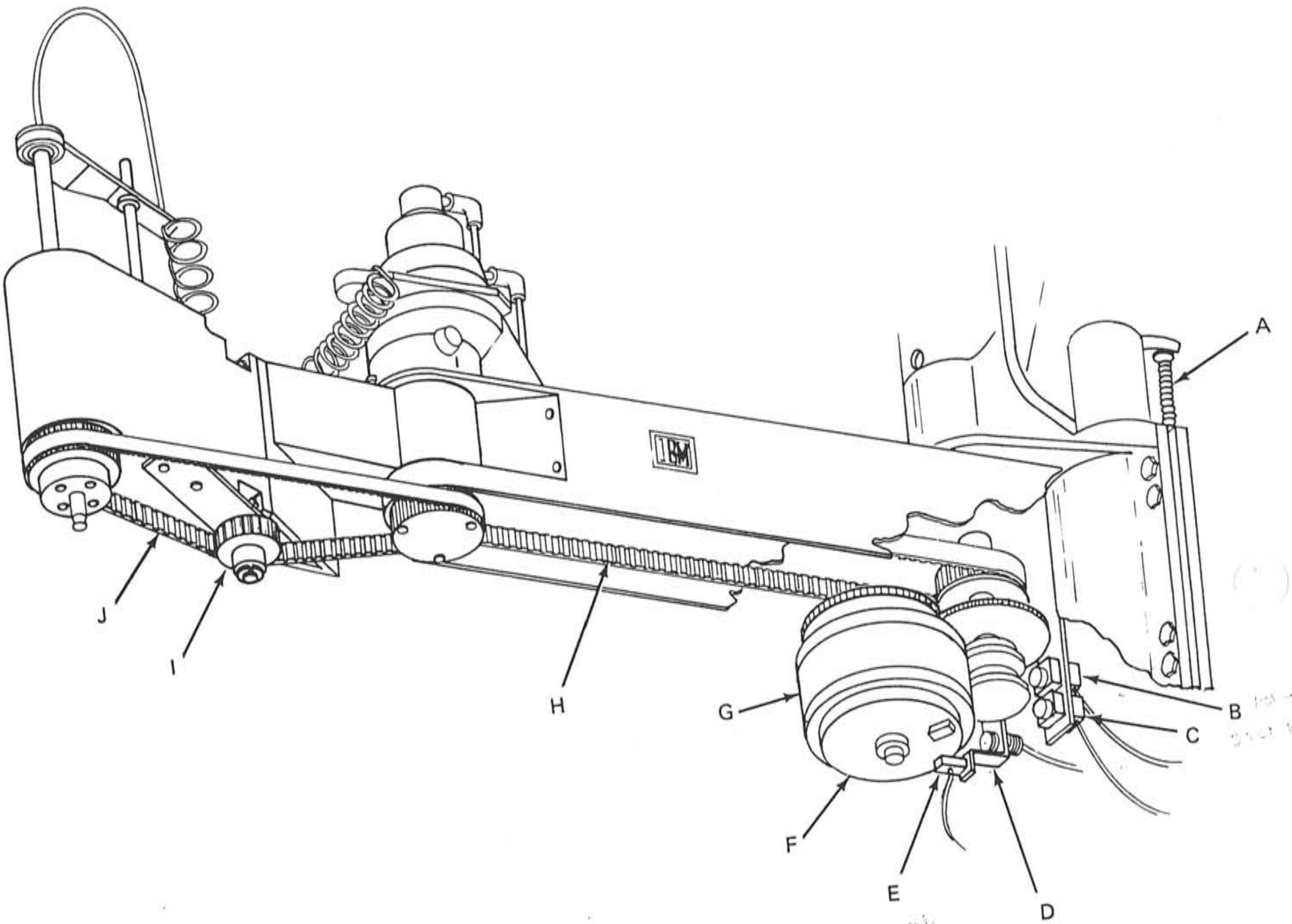
Theta 2 Plus Overrun Switch.....................N

Z Shaft...Q

Z Shaft Height Adjusting Screw..................S

Z Shaft Stop....................................R

Manipulator - Bottom View



MANIPULATOR - BOTTOM VIEW

Drive Belt....................................H

Driven Belt...................................J

Height Adjusting Screw........................A

Roll Axis Home Cam............................F

Roll Axis Home Position Sensor................E

Roll Axis Plus Area Sensor....................D

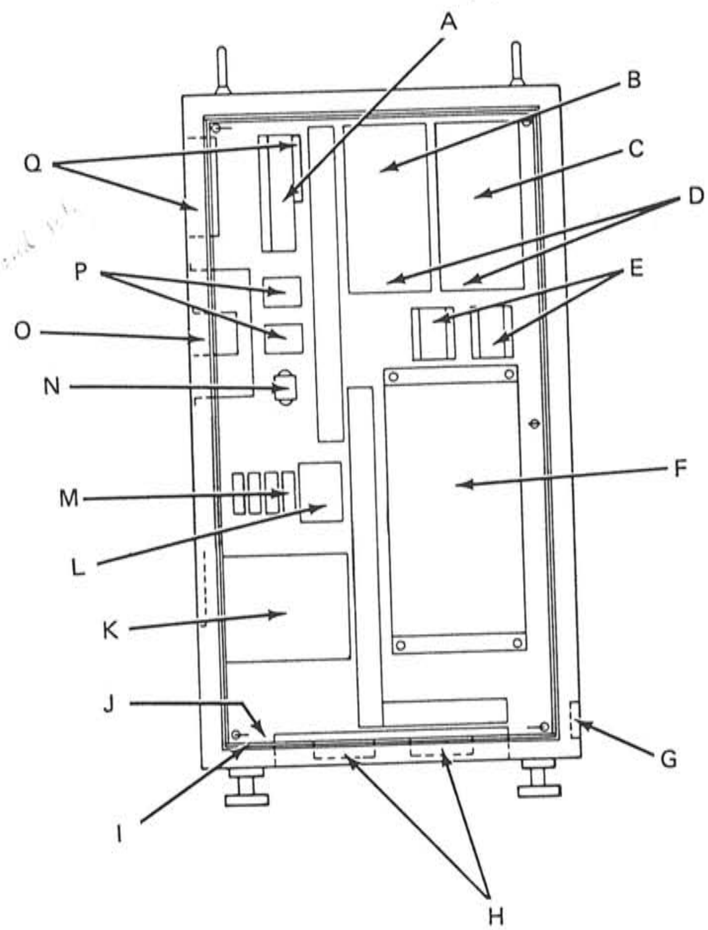
Stepper Motor.................................G

Tension Adjusting Pulley......................I

Theta 1 Home Sensor...........................B

Theta 1 Overrun Sensor........................C

Controller - Inside View (7535)



CONTROLLER - INSIDE VIEW (7535)

AC Fans....................................Q

AC Input Terminal Block.........................J

AC Line Filters................................H

Arc Suppression Network........................M

Controller Interface Connectors................G

CR100 Relay....................................N

DC Power Supply Assembly.......................F

Frame Ground...................................I

Fuses..D

L1 and L2 Filters..............................E

MS1 Contactor..................................L

OL1 and OL2....................................P

Power-On Circuit Breaker.......................O

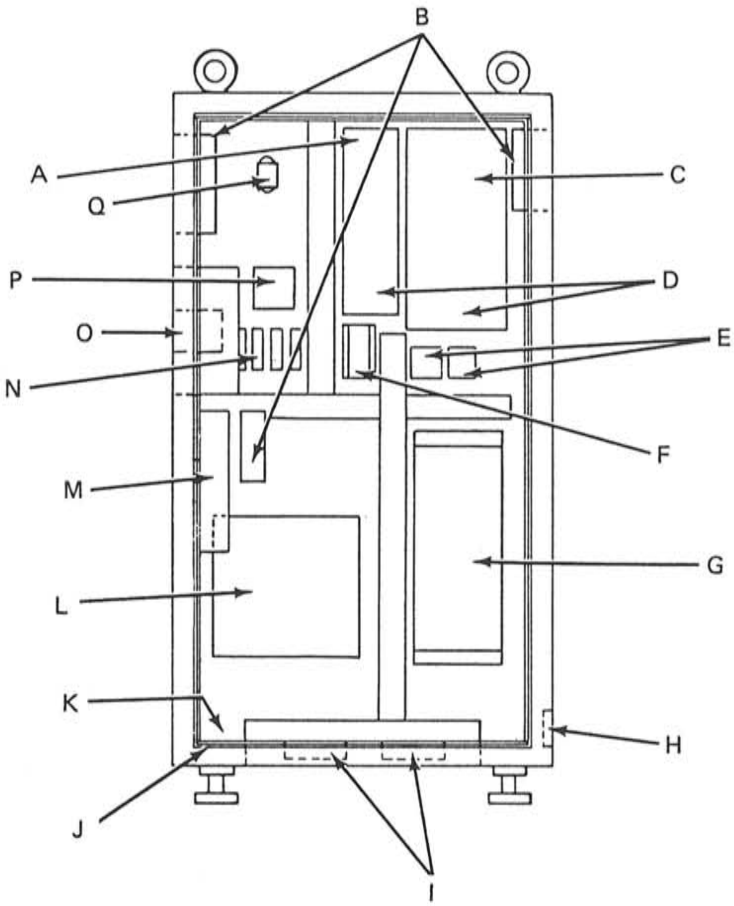
Servo Pack Transformer.........................K

Stepper Motor Driver Card......................A

Theta 1 Servo Pack.............................B

Theta 2 Servo Pack.............................C

Controller - Inside View (7540)



CONTROLLER - INSIDE VIEW (7540)

AC Input Terminal Block........................K

AC Fans..B

AC Line Filters................................I

Arc Suppression Network........................N

Controller Interface Connectors................H

CR100 Relay....................................Q

DC Power Supply Assembly.......................G

Frame Ground...................................J

Fuses..D

L2 Filter......................................F

MS1 Contactor..................................P

OL1 and OL2....................................E

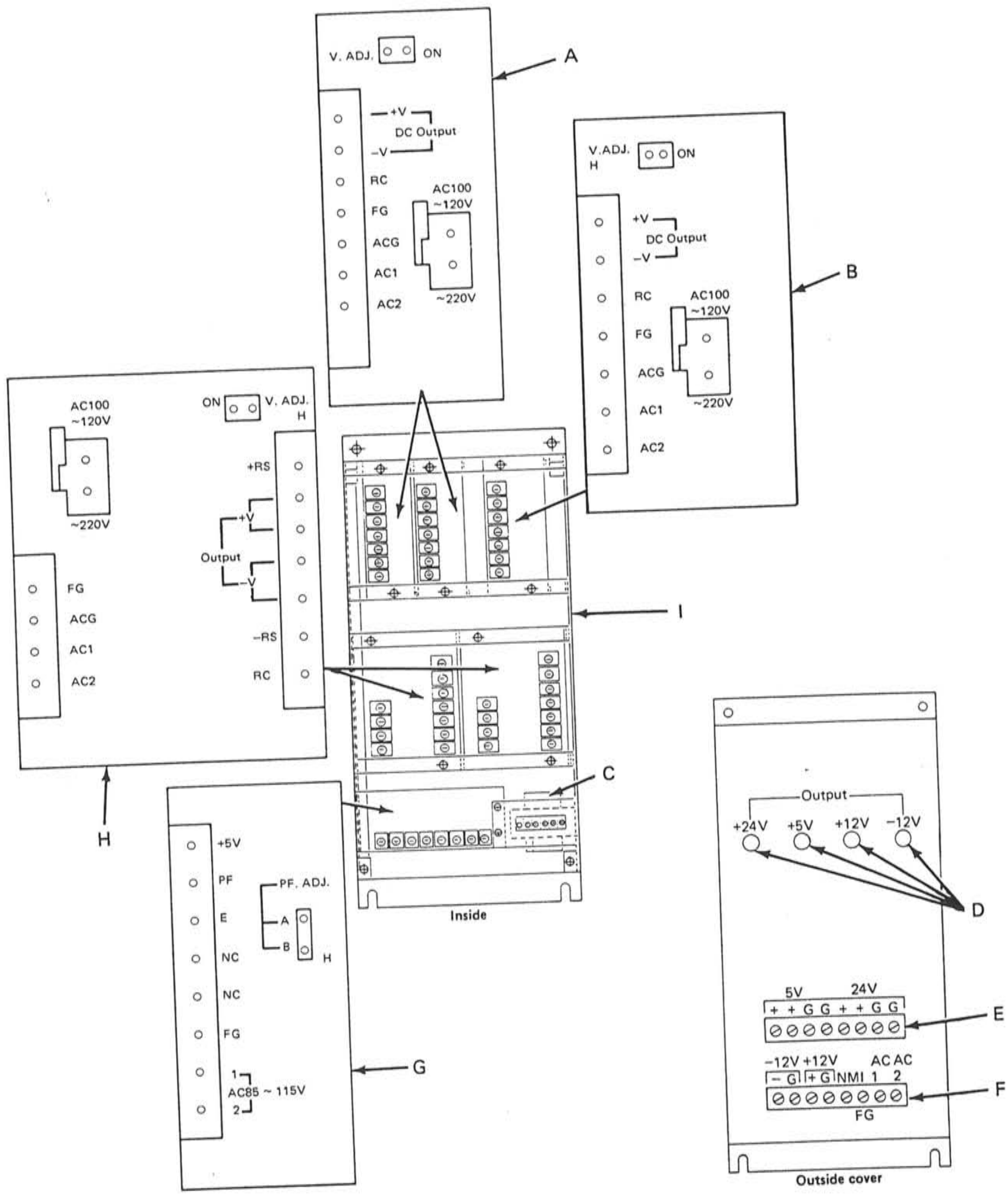
Power-On Circuit Breaker.......................O

Roll Motor Driver Card.........................M

Servo Pack Transformer.........................L

Theta 1 Servo Pack.............................C

Theta 2 Servo Pack.............................A


A
V. ADJ.
ON
+V
DC Output
-V
RC
FG
ACG
AC1
AC2
AC100
~120V
~220V
B
V.ADJ.
H
ON
+V
DC Output
-V
RC
FG
ACG
AC1
AC2
AC100
~120V
~220V
AC100
~120V
~220V
ON
V. ADJ.
H
+RS
+V
Output
-V
-RS
RC
FG
ACG
AC1
AC2
H
I
C
Inside
+5V
PF
E
NC
NC
FG
1
AC85 ~ 115V
2
PF. ADJ.
A
B
H
G
Output
+24V
+5V
+12V
-12V
D
5V
24V
+ + G G + + G G
E
-12V +12V
AC AC
- G + G NMI 1 2
FG
F
Outside cover

CONTROLLER - POWER SUPPLY

5 Vdc 10 A Power Supply........................B

12 Vdc 2.5 A Power Supply (2)..................A

12 Vdc 10 A Power Supply (2)...................H

Power Failure (PF) Module......................G

Power Failure (PF) Module Transformer..........C

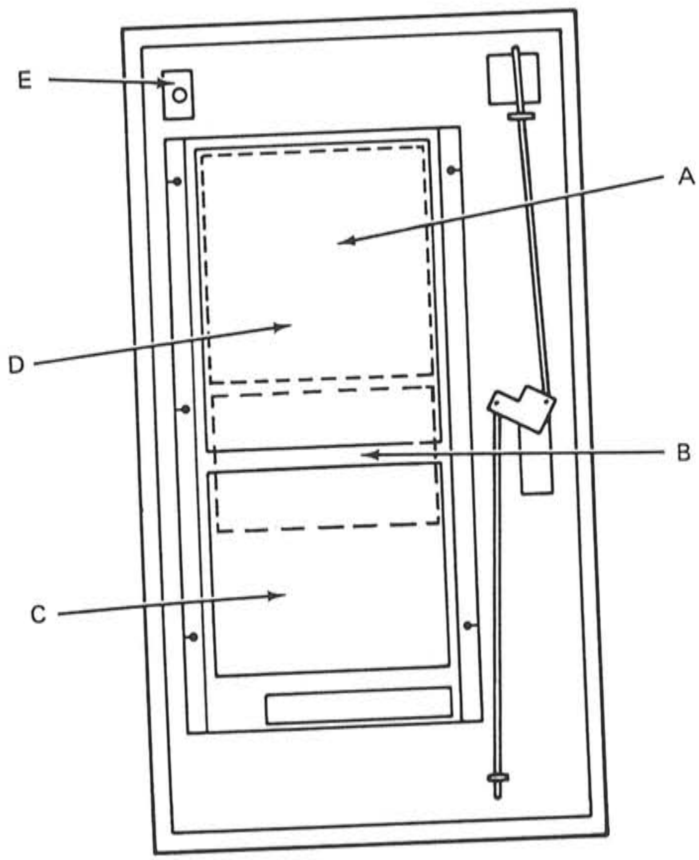
Power Good LEDs................................D

PSTB1..E

PSTB2..F

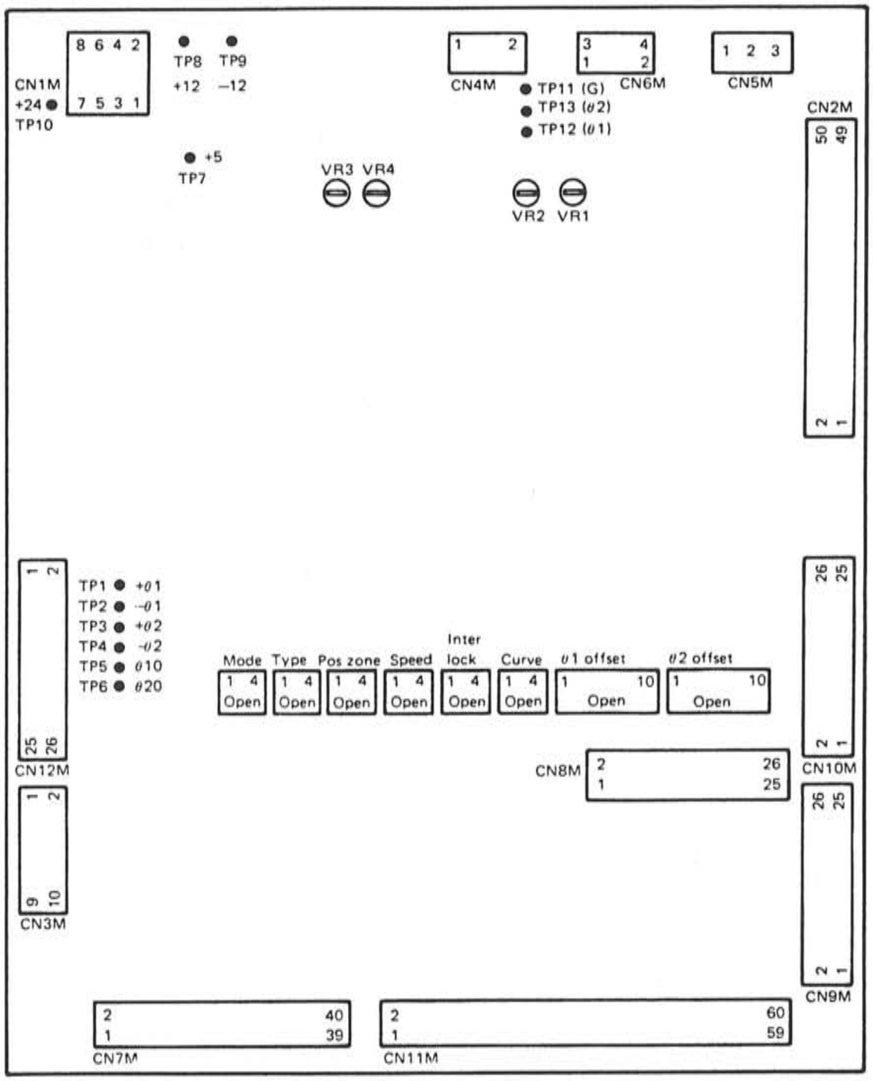
Power Supply Assembly..........................I

CONTROLLER - DOOR

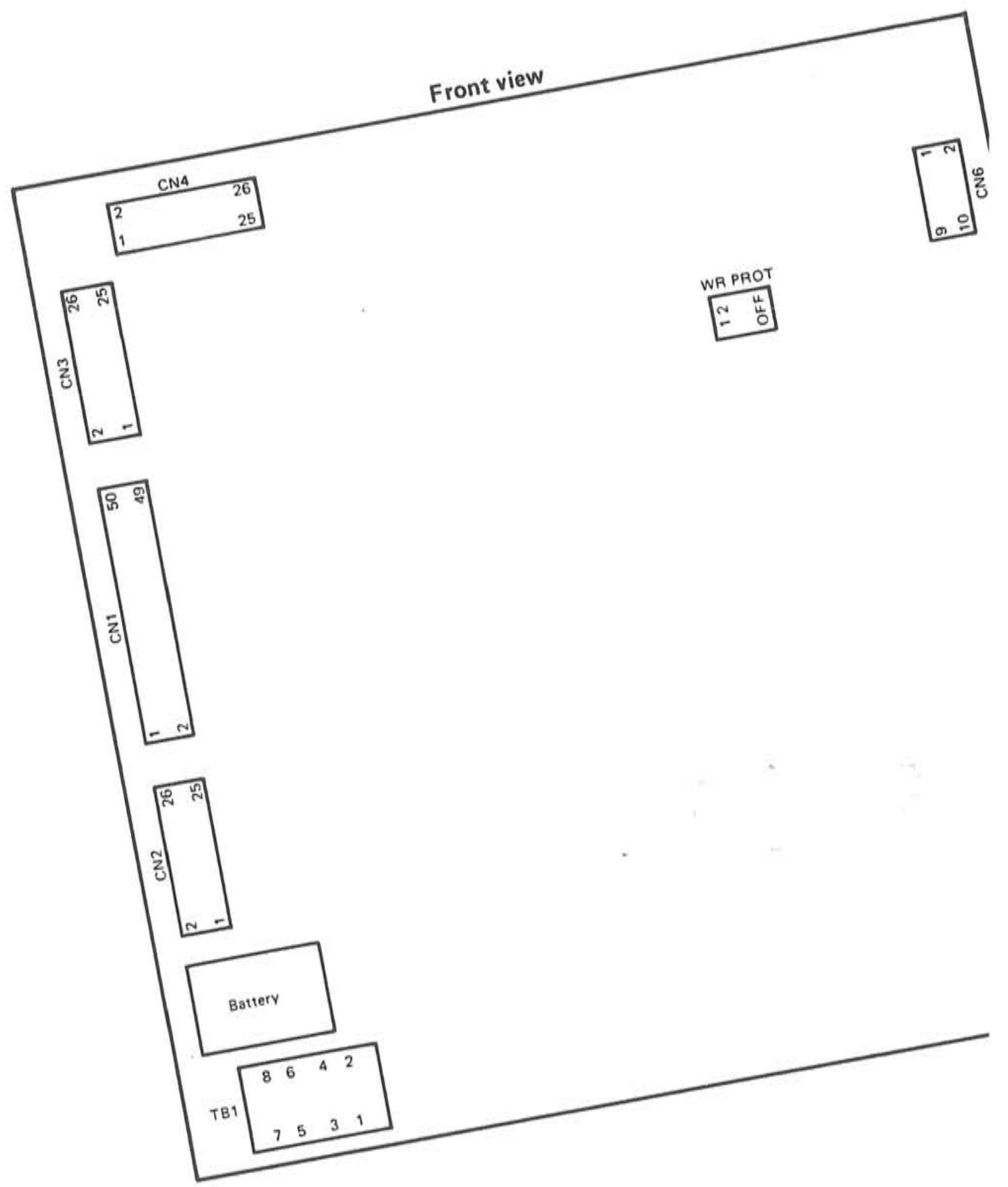


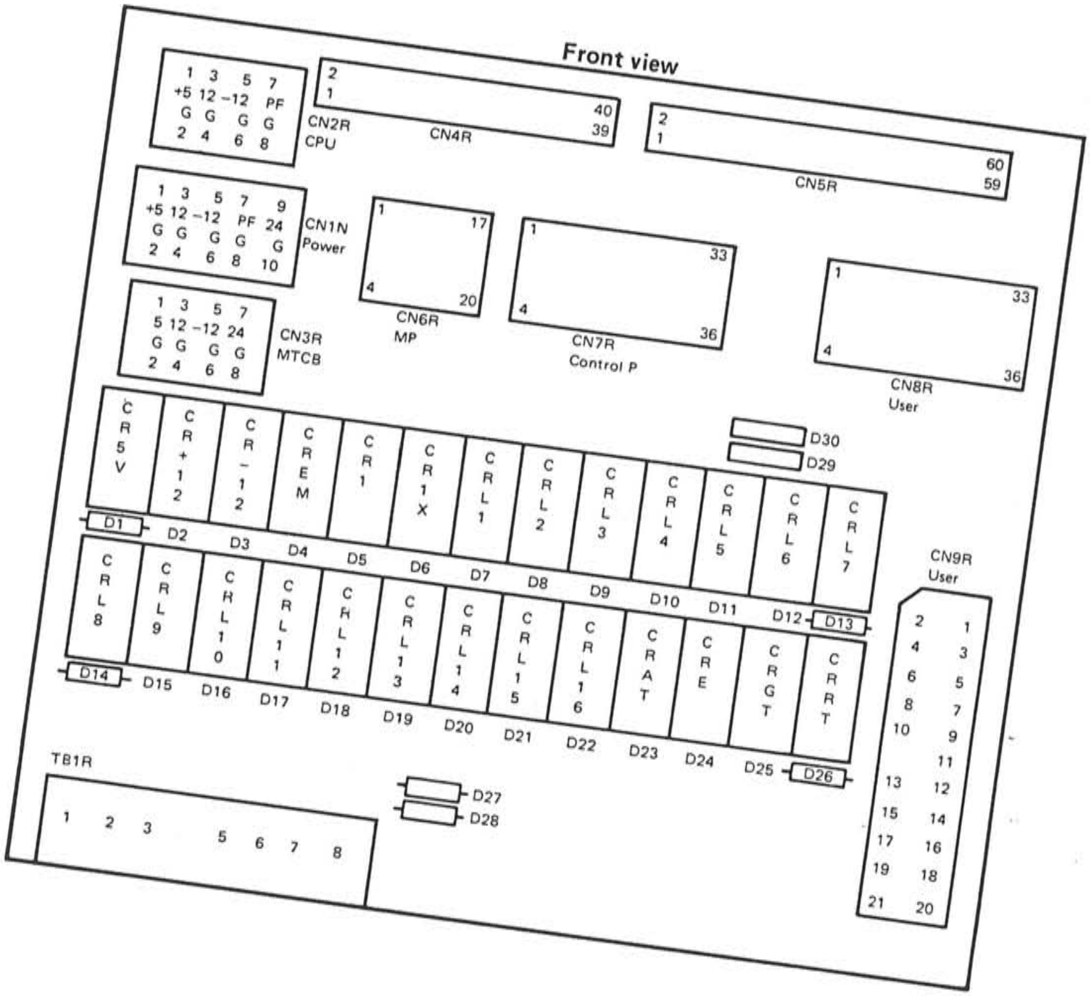
CONTROLLER - DOOR

CONTROLLER - MOTOR CONTROL BOARD (MTCB)

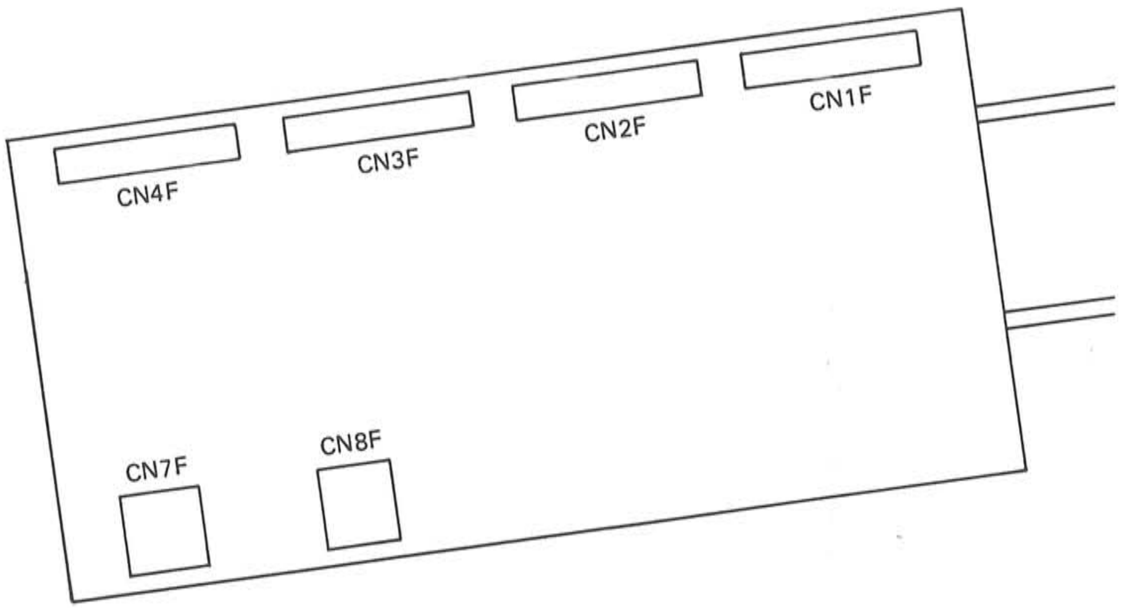


CONTROLLER - CPU BOARD

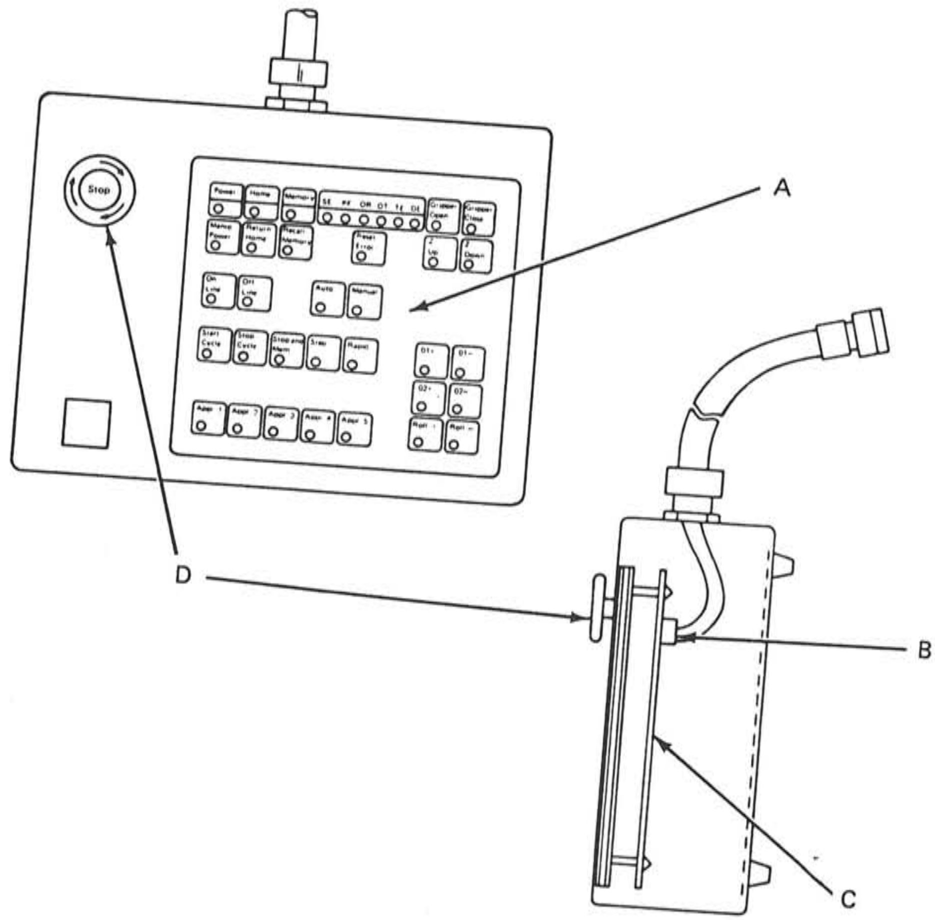



Front view
CN2R
CPU
CN4R
CN5R
CN1N
Power
CN6R
MP
CN7R
Control P
CN8R
User
CN3R
MTCB
CN9R
User
TB1R
D27
D28
D29
D30

CONTROLLER - FUNCTION ENHANCEMENT CARD

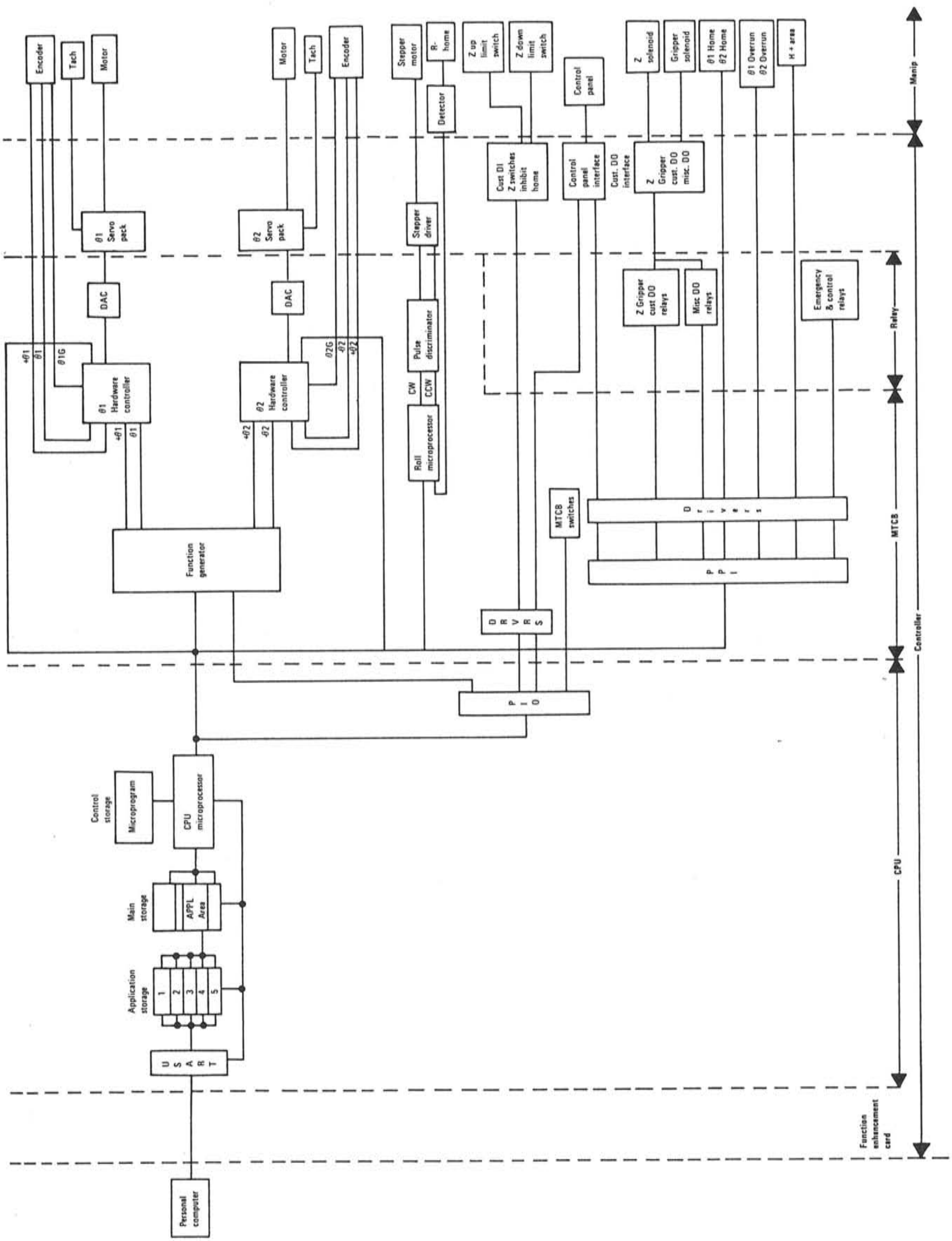


Section 1 - Locations


Stop
A
B
C
D

CONTROL PANEL

SYSTEM DATA FLOW



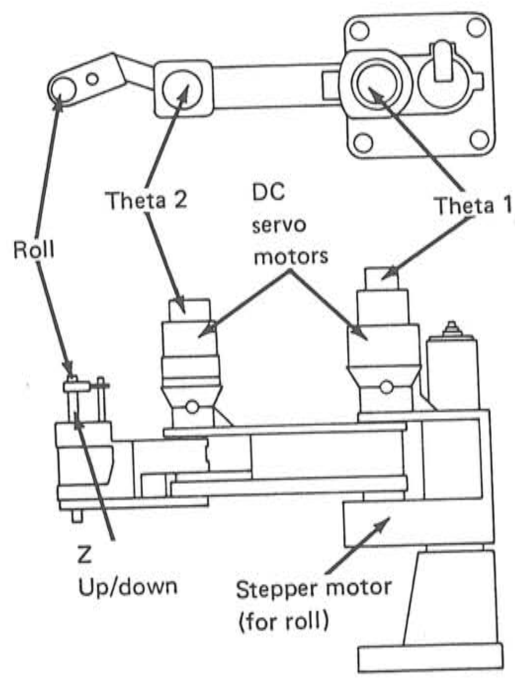
SYSTEM OVERVIEW

This section contains the theory of operation for the IBM 7535 Model A04 and 7540 Model A02 Manufacturing Systems. The System Data Flow diagram on the preceding page can be used as a reference while reading this section.

There are three main components of the manufacturing system: the manipulator, the controller, and the control panel.

Manipulator

The manipulator is a two-jointed arm structure with four degrees of freedom. The joints of the arm, called Theta-1 axis and Theta 2-axis, provide 2 degrees of freedom through their swivel motion. The end-of-arm rotation, called the roll axis, provides a third degree of freedom. The end-of-arm also provides a fourth degree of freedom through a vertical shaft called the Z-axis.



Controller

The controller contains most of the electronics for control of manipulator operation. A microprocessor coordinates the manipulator's movement and monitors its speed and positioning. External devices are also synchronized with the manipulator through the use of digital input (DI) and digital output (DO) ports. These ports monitor switch closures (DI) external to the system or close relays (DO), allowing events to occur. The controller receives and stores its control programs from the programming device, and then drives the manipulator by executing the programs. The application programs instruct the controller as to which ports to monitor, the amount of time to wait for the event, and the type of condition to expect.The three main boards inside the controller are: the CPU board, the motor control board (MTCB), and the relay board. The function enhancement card, which contains some communications and straight line motion circuits, is also installed in the controller.

CPU Board: The CPU board contains a microprocessor, storage, interface circuits, and communications circuits.

Motor Control Board: The MTCB contains the roll microprocessor and circuits to control movement, as directed by the CPU. The MTCB keeps track of movements through the use of inputs from the manipulator.

Relay Board: The relay board contains relays, power distribution, and interface circuits.

Control Panel

The control panel is the operator interface to the controller and the manipulator, attached to the controller by a cable. The control panel uses pressure sensitive keys, light-emitting diodes (LEDs) and an audio feedback device.

Programming Device

The IBM Personal Computer offers application flexibility by providing application program development for the system. One IBM Personal Computer can support multiple manufacturing systems. It must be connected to the controller when teaching application coordinates or when transferring programs to the controller application storage partitions. The IBM Personal Computer may be disconnected from the controller and used for developing programs or other non-related applications, or may remain connected to monitor system operation.

POWER

DC Power Supplies

There are five DC power supplies in the controller that su
ious system components. The tables below show the devel
various DC voltages.

Voltage	Developed By
+5	One, 5 V, 10 A Supply
+12	One, 12 V, 2.5 A Supply
-12	One, 12 V, 2.5 A Supply
+24	Two, 12 V, 10 A Supplies

Power Supply Voltages

Voltage	Usage
+5, +24	Control Panel
+5, ±12, +24	Motor Control Boa
+5, ±12	Microprocessor Bo
+5, ±12, +24	Relay Board
+5, +24	Stepper Motor Ca

Power Supply Usages

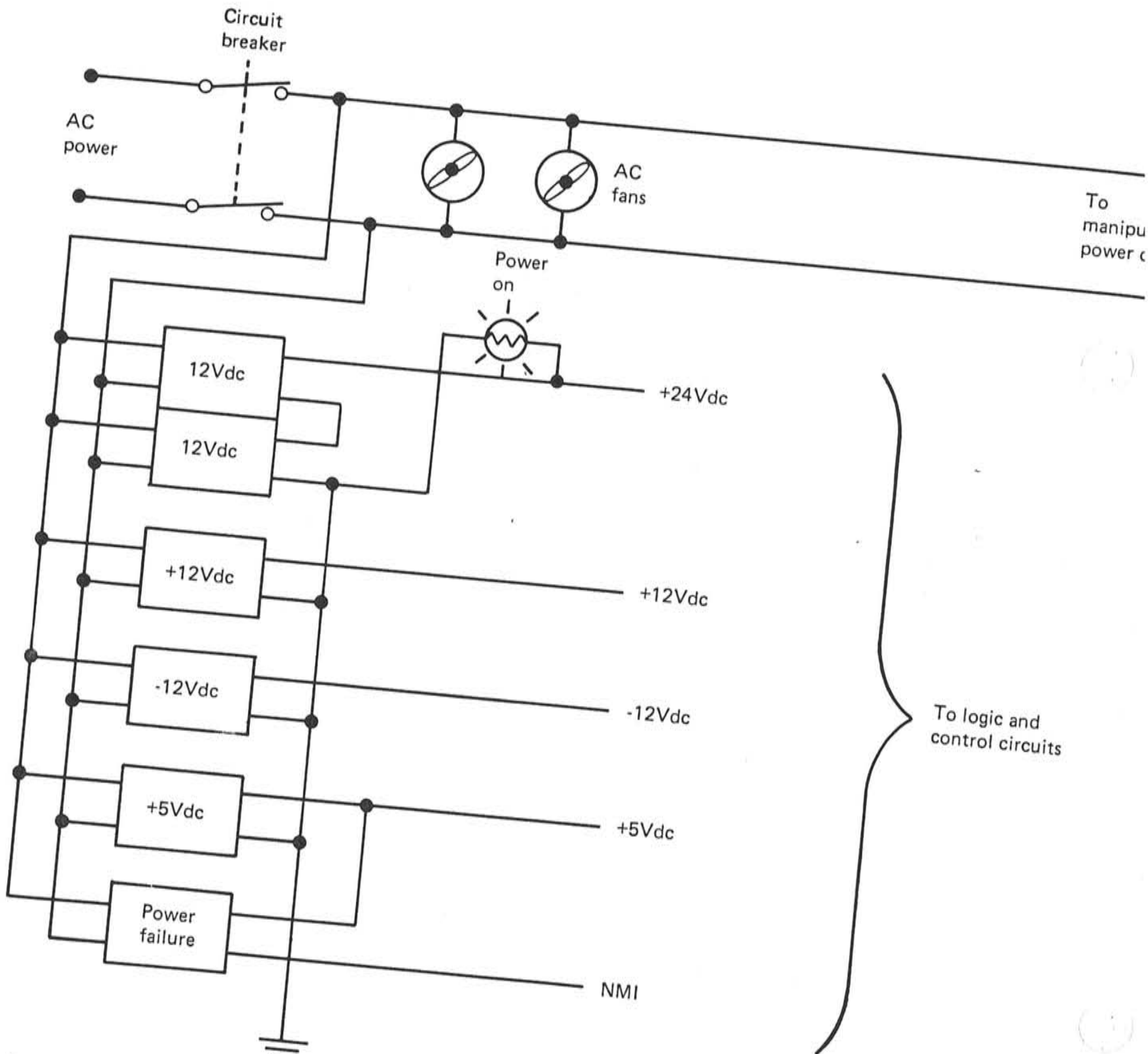
Note: The +24 Vdc is developed by two 12-volt, 10-
in series. See "Section 11 - Wiring Diagrams" for

The power supply enclosure also contains the p
monitors the AC line voltage. If the AC line v
83V (7535) or 170V (7540) for 10 milliseconds, a
the CPU causes the CPU to branch to an NMI rou
emergency stop is performed, and error D0 is act

The power supplies may be individually replace

Controller Power-On

1. The controller circuit breaker enables the AC circuit to the fans [illegible] power supplies.
2. The +24 Vdc supply turns on the power light mounted on the cabinet door.
3. The +12 Vdc supply energizes relay CR+12.
4. The -12 Vdc supply energizes relay CR-12.
5. The +5 Vdc supply energizes relay CR+5 and the power failure module.



Manipulator Power-On

1. Normally open (NO) relay contacts CR5V-2, CR+12V-2, and CR-12V-2 are closed when the appropriate power supplies are energized.

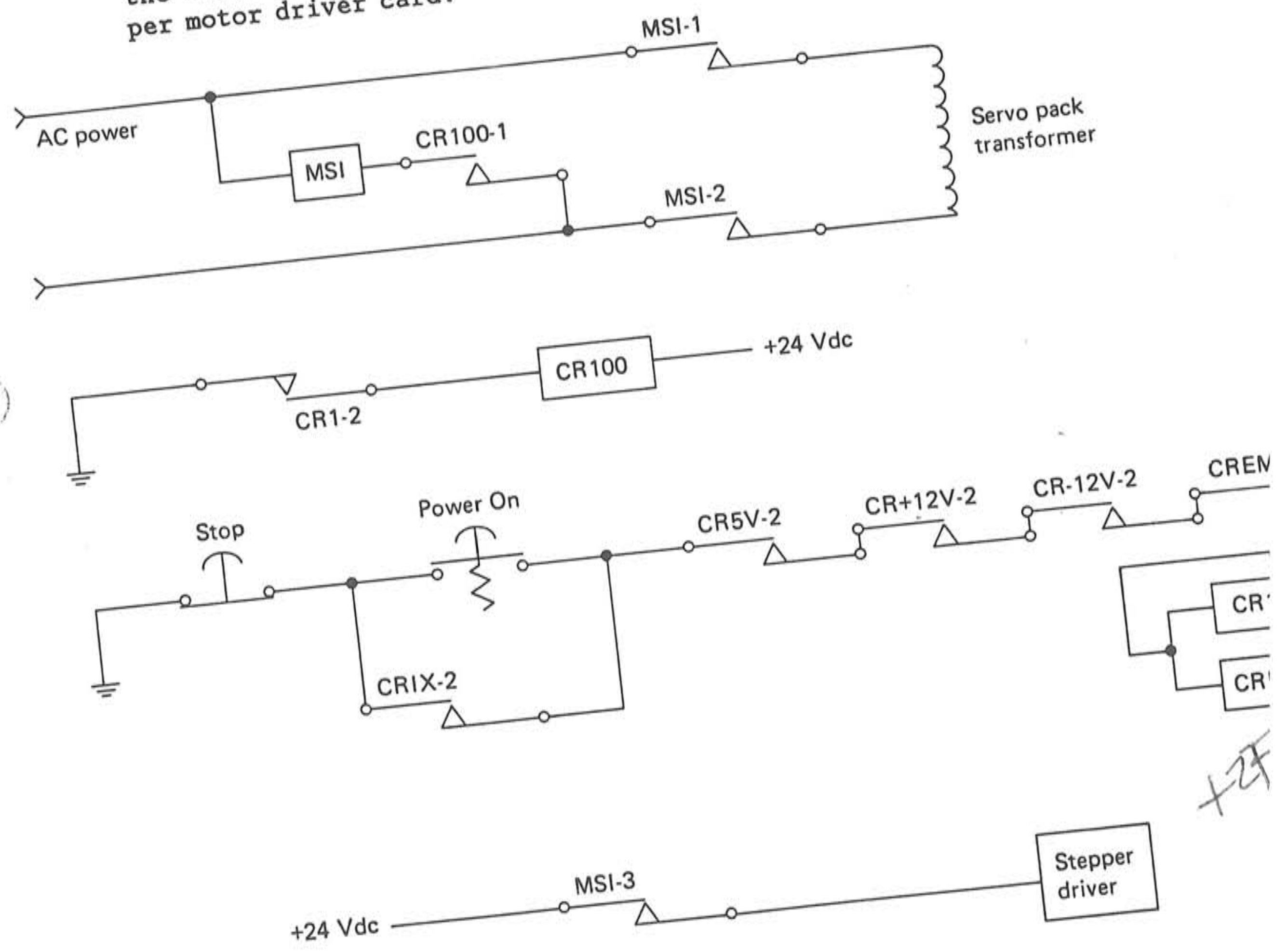
2. Normally closed (NC) relay contact CREM-2 is closed unless opened by an emergency stop, servo overload, fuse, thermal, overrun, or system error.

3. When the Power On pushbutton is pressed, relays CR1 and CR1X are energized, causing relay point CR1X-2 to close and hold the completed circuit.

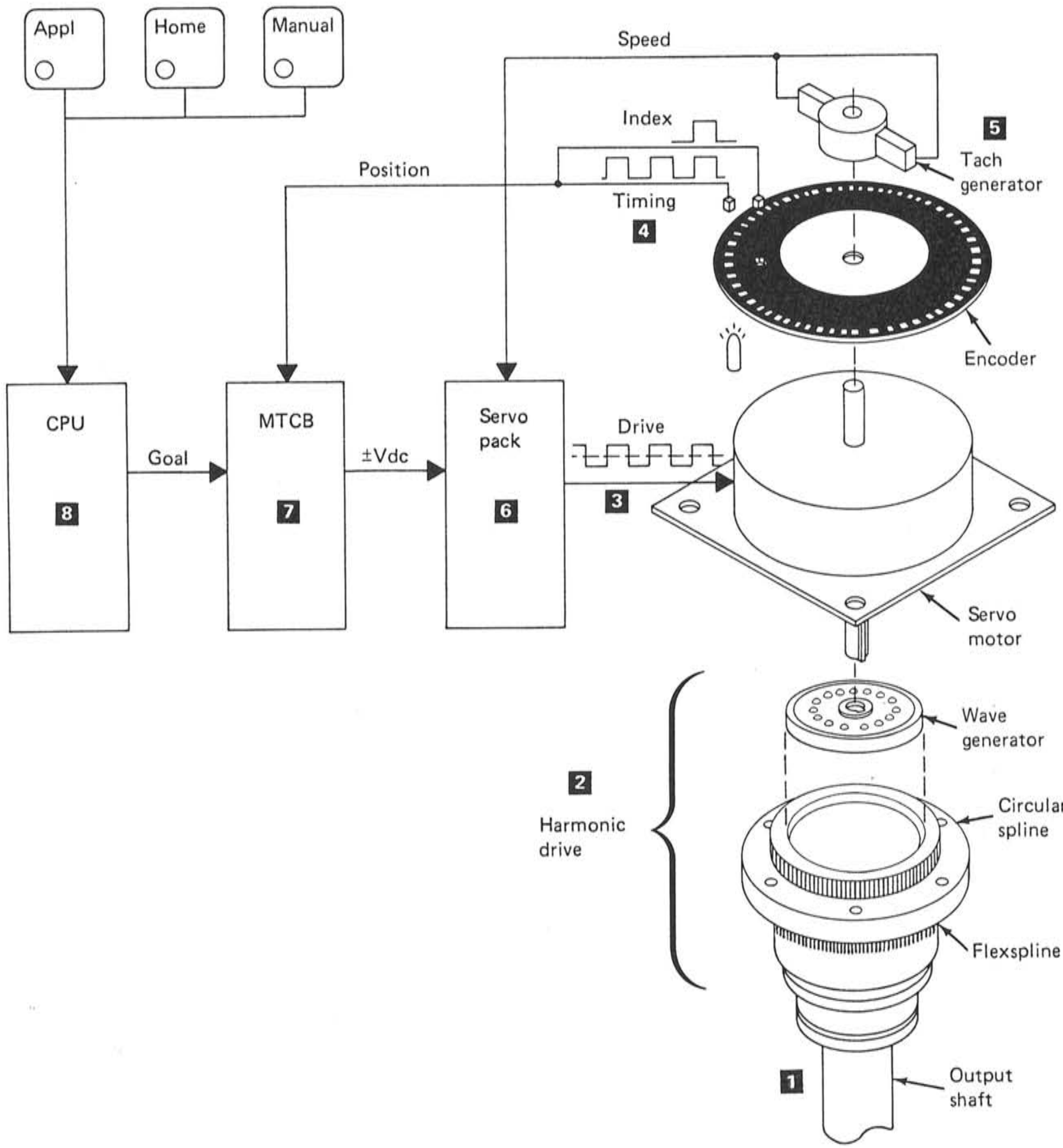
4. Relay point CR1-2 also closes, causing relay CR100 to energize.

5. Relay point CR100 then closes, causing relay MS1 to energize.

6. Points 1 through 3 of relay MS1 close, causing AC current to be delivered to the servo pack transformer and +24 Vdc current to be delivered to the stepper motor driver card.



THETA AXES MOVEMENT



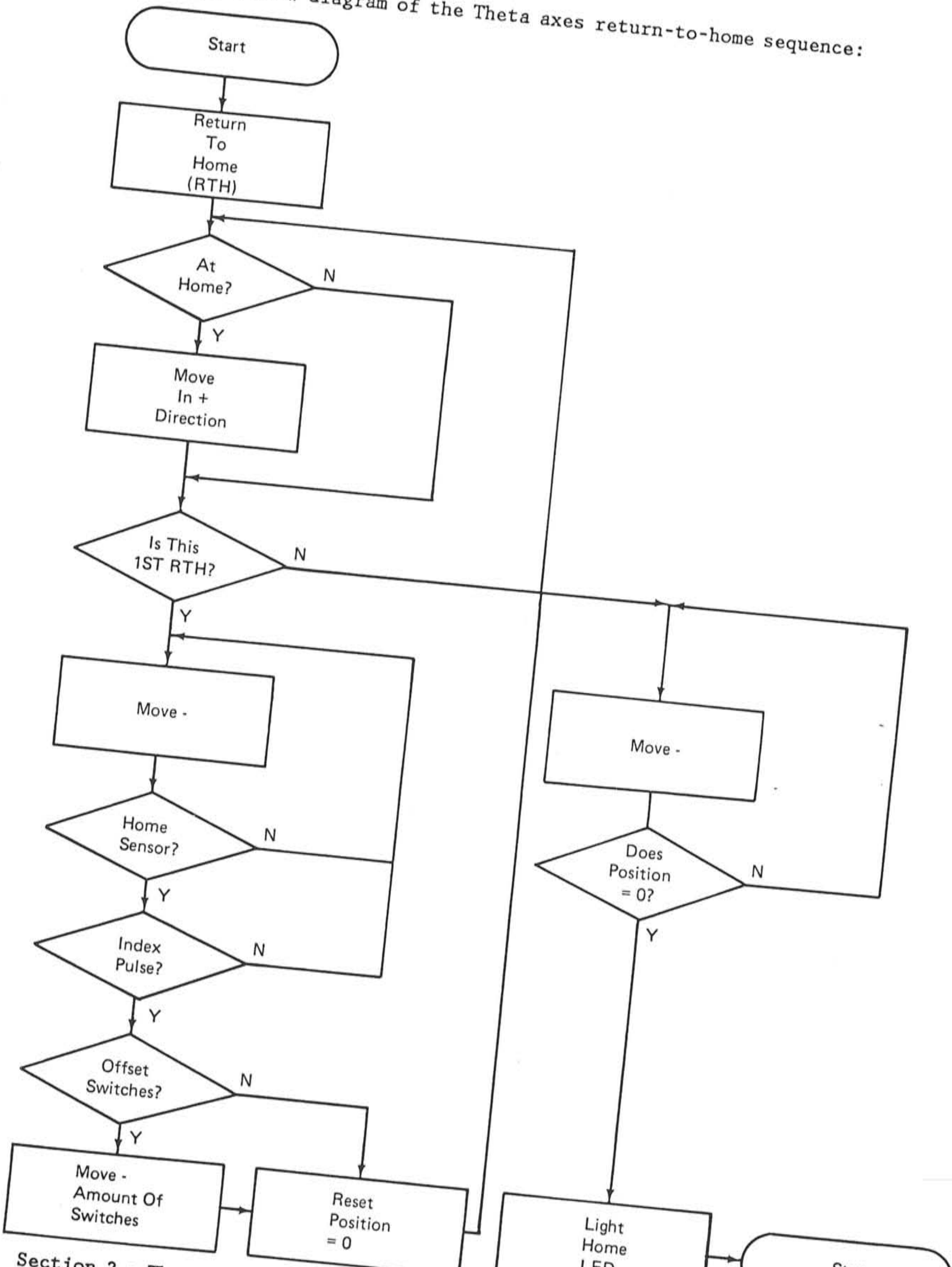
Refer to the figure on the previous page as you read the following items:

1. The output shaft is pinned to the manipulator arm.
2. The flexspline of the harmonic reduction drive is welded to the outp and is driven by the wave generator which is keyed to the motor sha "Harmonic Drives" later in this section.)
3. The DC servo motor is pulse driven.
4. The 500 timing pulses and one index pulse from the encode "position" information to the motor control board (MTCB).
5. The DC tach generator provides the motor speed feedback signal of DC voltage that is proportional to speed.
6. The servo pack receives input from the motor control board (MTCB the servo motor at the proper speed and direction.
7. The MTCB compares "position" (from item 4) with "goal" (from sends the proper control voltage to the servo pack.
8. The CPU receives instructions and calculates the "goal." The by the CPU to the MTCB.

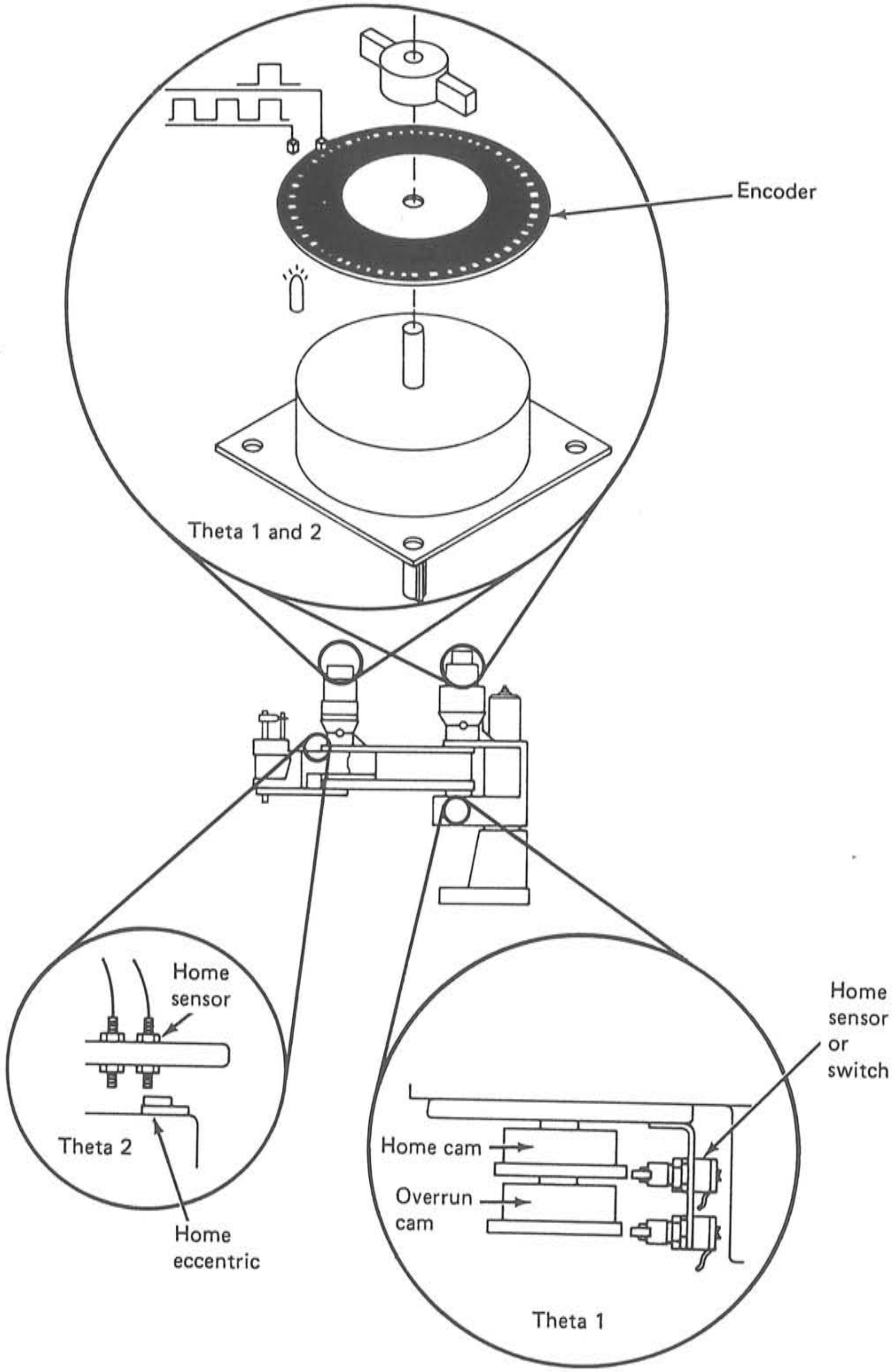
Note: This is a closed loop circuit.

THETA AXES RETURN TO HOME SEQUENCE

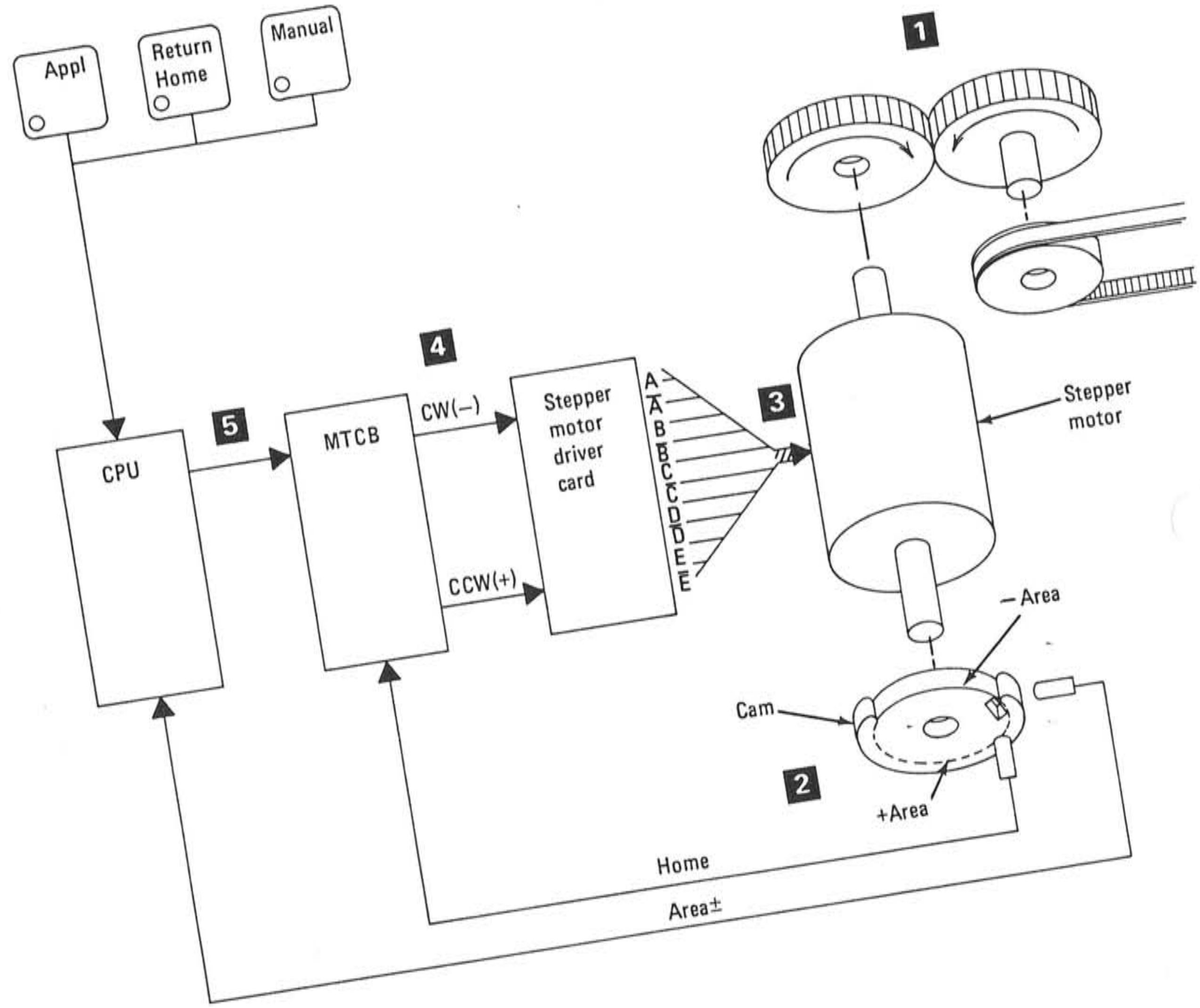
This is a flow diagram of the Theta axes return-to-home sequence:



This figure shows the home sensors of the Theta axes:



ROLL AXIS MOVEMENT



Refer to the figure on the previous page as you read the following items:

1. The top shaft of the stepper motor turns the roll axis through a system of gears, belts, and pulleys.

2. A cam on the bottom shaft of the stepper motor is used to provide home and position information.

3. The source voltage for the stepper driver card is +24 Vdc.

4. The stepper motor driver card sends a sequence of phases to the stepper motor, which cause the motor to step.

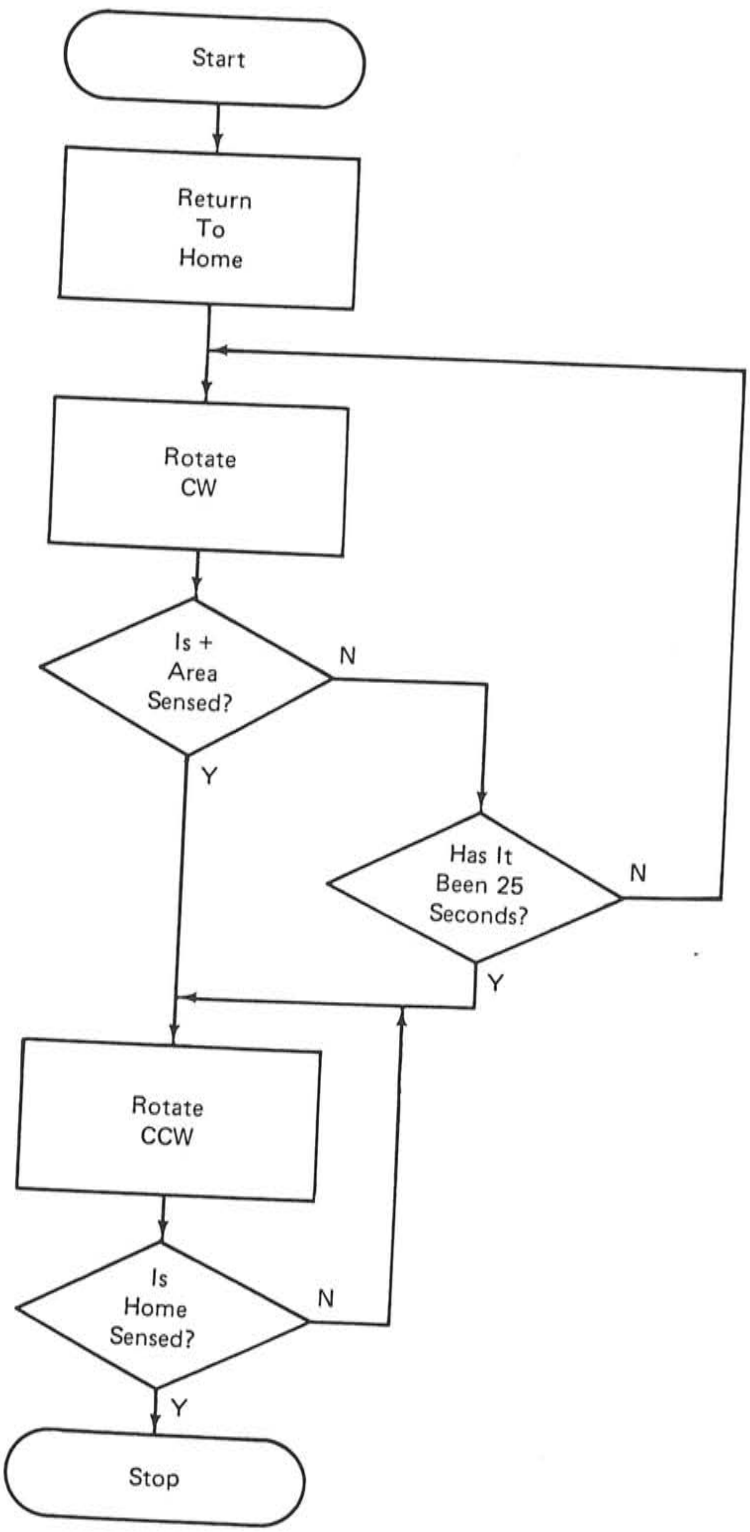
5. The motor control board (MTCB) sends the direction signals to the stepper motor driver card until the move is complete.

6. The CPU sends the direction and amount of move to the MTCB.

Note: This is an open loop drive circuit. No position feedback is provided.

ROLL AXIS RETURN TO HOME

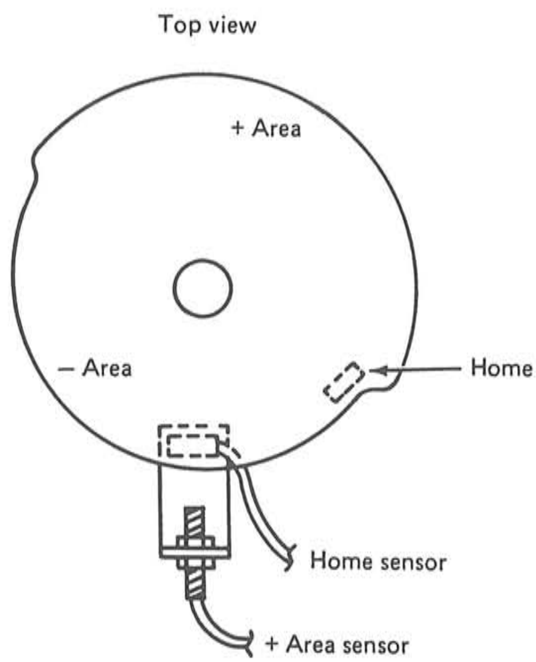
This is a flow diagram of the roll axis return-to-home sequence:



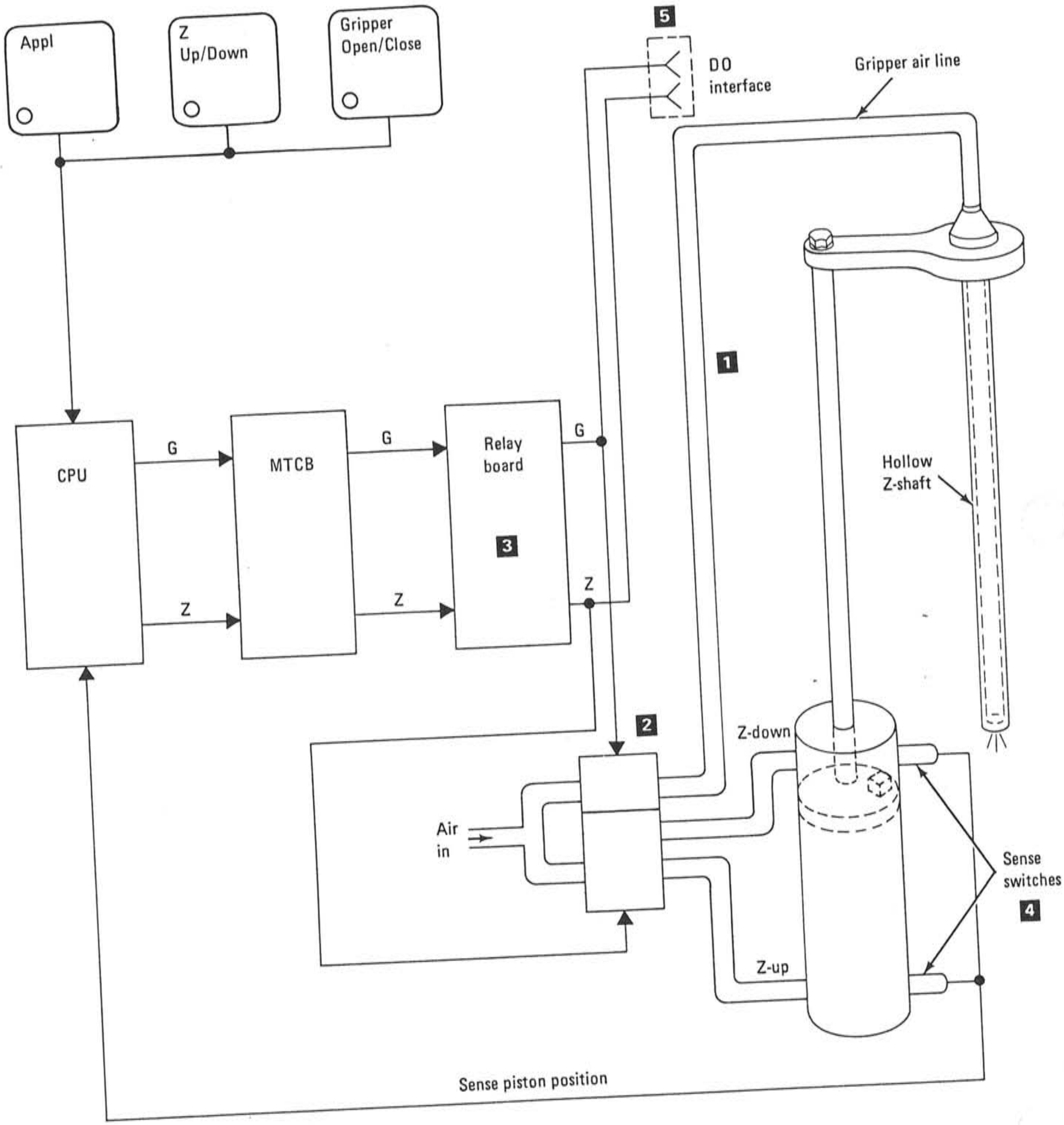
- When a return-to-home (RTH) is initiated, the cam rotates clockwise (CW)(from the top).
- The area sensor looks for the +area of the cam.
- When the +area of the cam is found, the stepper motor rotates in the counterclockwise (CCW) direction until the home sensor senses the home mark.

Note: If the stepper motor has been rotated too far CW before the RTH, the stepper motor attempts to rotate CW for approximately 25 seconds and then reverses in the CCW direction until the home mark is found.

This figure shows a top view of the stepper motor cam:



Z AXIS AND GRIPPER OPERATION



1. The Z-shaft is driven by an air cylinder that is connected to a flow control valve.

2. Gripper air is also connected to a flow control valve.

3. The solenoid-operated flow control valves are opened and closed by relays on the relay board.

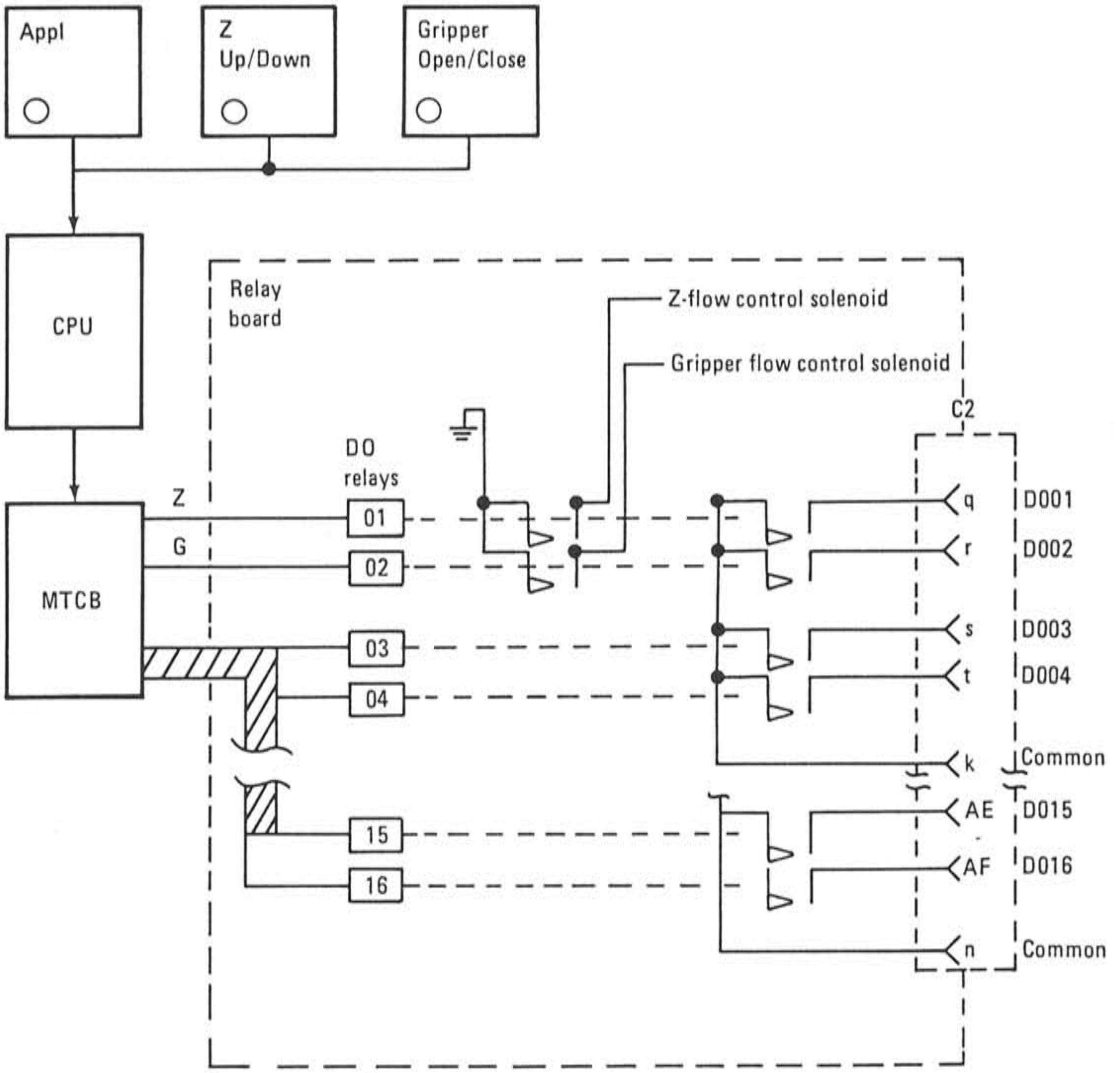
4. These relays have two sets of points: one set is for the solenoid operation, and the other set is for the external DO interface. The external DO interface allows the application program to monitor the signal to the solenoid valves.

5. Sense switches on the air cylinder provide feedback to the CPU via DI points when testing for a completed move. $DI_1 - DI_2$

DIGITAL OUTPUT

The figure below is a block diagram of the DO circuit.

Output commands from the application program or the operator panel will energize DO relays, providing a contact closure for external devices. The external devices must provide voltage (24 Vdc, maximum) and current is limited to 2 amperes per contact.



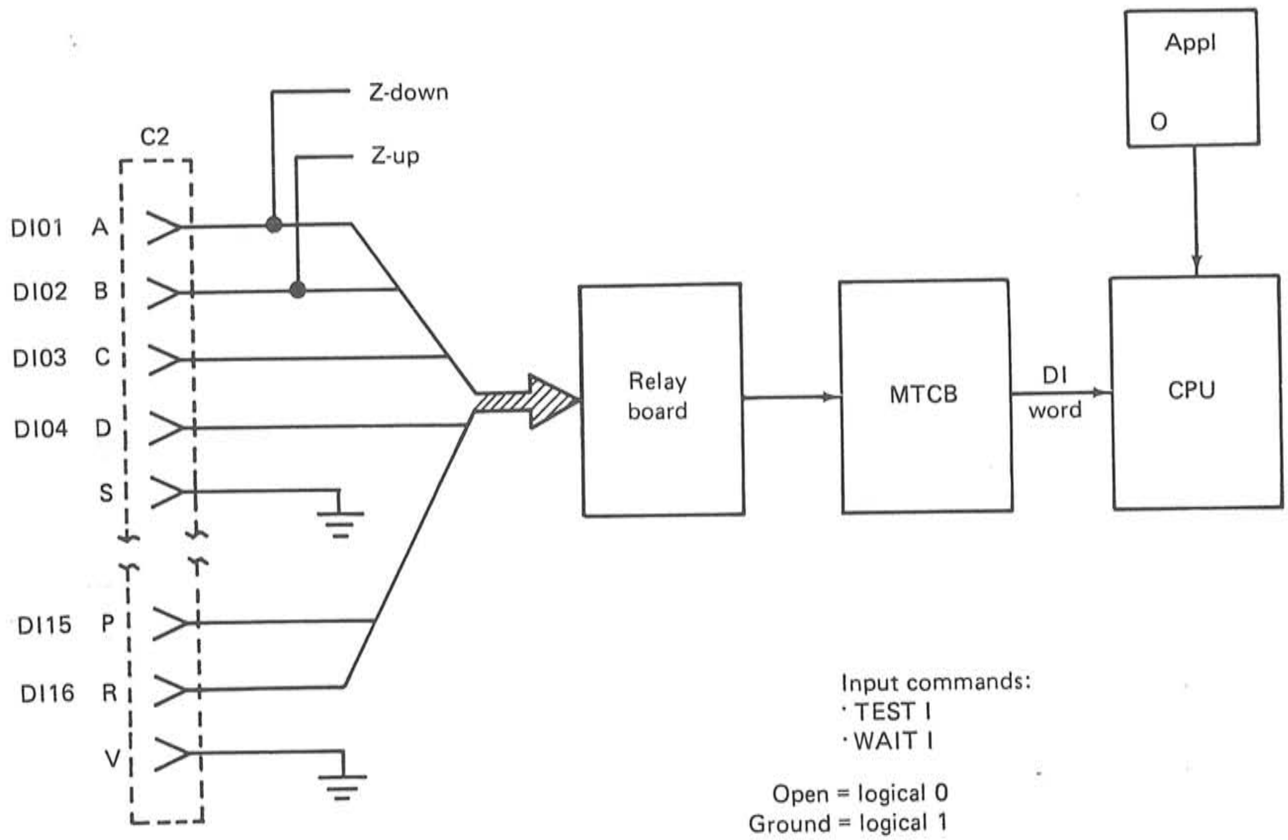
Output commands:
- WRITE O
- GRASP
- RELEASE
- DOWN
- UP

Note: The relays for activating the Z and gripper solenoids have two normally-open contacts each. One contact activates the solenoid and the other the user DO point. Refer to "Section 11 - Wiring Diagrams" for detailed wiring of the DO relay points.

DIGITAL INPUT

The figure below is a block diagram of the DI circuit.

Input commands from the application program test the DI points for an open (logical 0) or ground (logical 1) input from external devices.



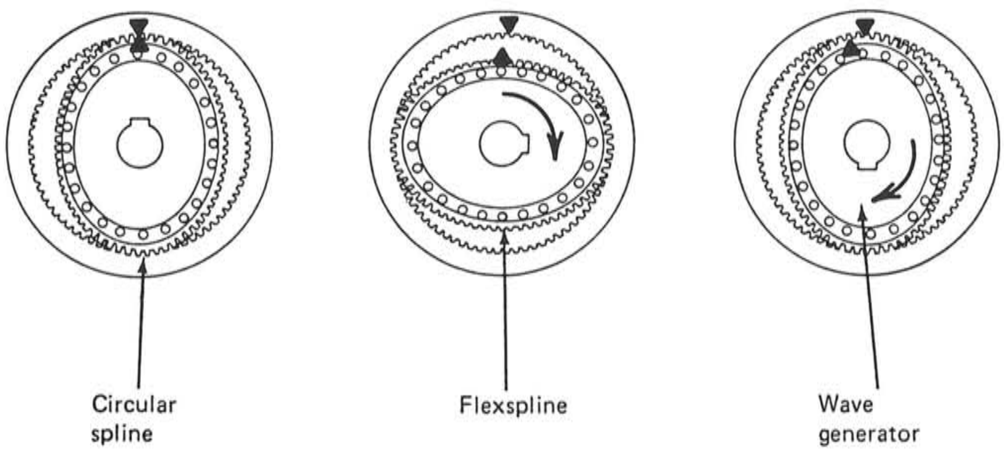
Note: DI points 1 and 2 are used by the system to detect the position of the Z-axis shaft. These points may be used in the user application in conjunction with the up and down positions of the Z-axis.

The harmonic drive is a reduction drive composed of three main components: the circular spline, the wave generator, and the flexspline.

The circular spline has two more teeth than the flexspline and the wave generator is elliptical in shape. The wave generator is attached to the motor and the flexspline is attached to the output shaft. When assembled the flexspline assumes the shape of the wave generator.

The figure below shows how the wave generator rotates and "walks" the flexspline teeth around the circular spline.

See also "Theta Axis Movement", in this section.



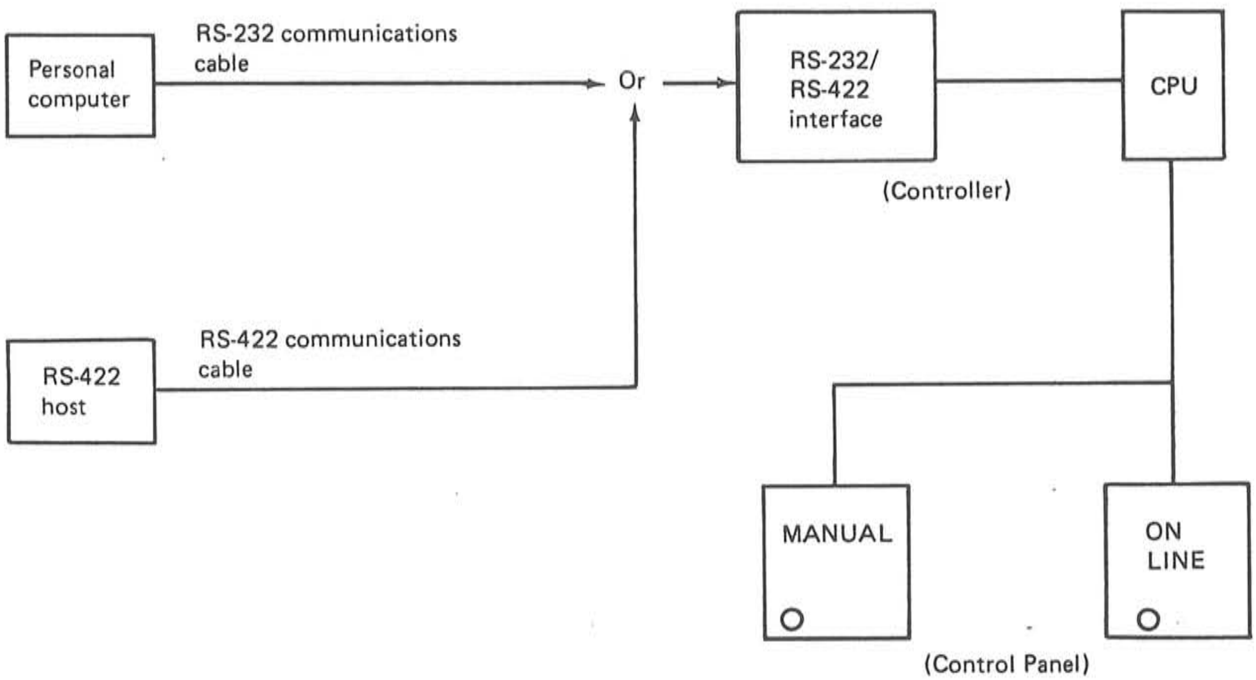
The reduction ratio of the Theta axes can be found in this table:

	Axis	Ratio
7535 Model A04	Theta 1	157:1
7535 Model A04	Theta 2	80:1
7540 Model A02	Theta 1	242:1
7540 Model A02	Theta 2	157:1

COMMUNICATIONS

Communication to the controller is accomplished by using asynchronous communications line protocol. All data is sent as 7 bit (plus parity) American National Standard Code for Information Interchange (ASCII), even parity, at 4800 baud (bits per second), with two stop bits. An Electronic Industry Association (EIA) Recommended Standard (RS)-232-C interface communicates with the IBM Personal Computer. An EIA RS-422 interface is also provided by the controller for local communications of up to 4000 feet with hosts having RS-422 interfaces.

The figure below is a block diagram of the communications data flow.



The cable wiring for an RS-232-C interface between the IBM Personal Computer and the controller is shown below.

```
                                                   Controller
                                                       |
                                                     1 | Gnd
            Personal computer                          |
                    |                                  |
                    |    ------------------------- 3 | RD
                    |   /                              |
               TD   | 2 -  ------------------------- 2 | TD
                    |     /                            |
               RD   | 3 -                        ---- 4 | RTS
                    |                           |      |
              RTS   | 4 ----                     ---> 5 | CTS
                    |       |                          |
              CTS   | 5 <---                     ---> 6 | DSR
                    |                           |      |
              DSR   | 6 <---                    |      |
                    |       |                   |      |
              GND   | 7 ---------------------------- 7 | GND
                    |       |                   |      |
               CD   | 20 ---------------------X---> 8 | CD
                    |       |                          |
              DTR   | 8 <---X------------------------ 20 | DTR
                    |                                  |
```

Local RS-232-C Cable Wiring

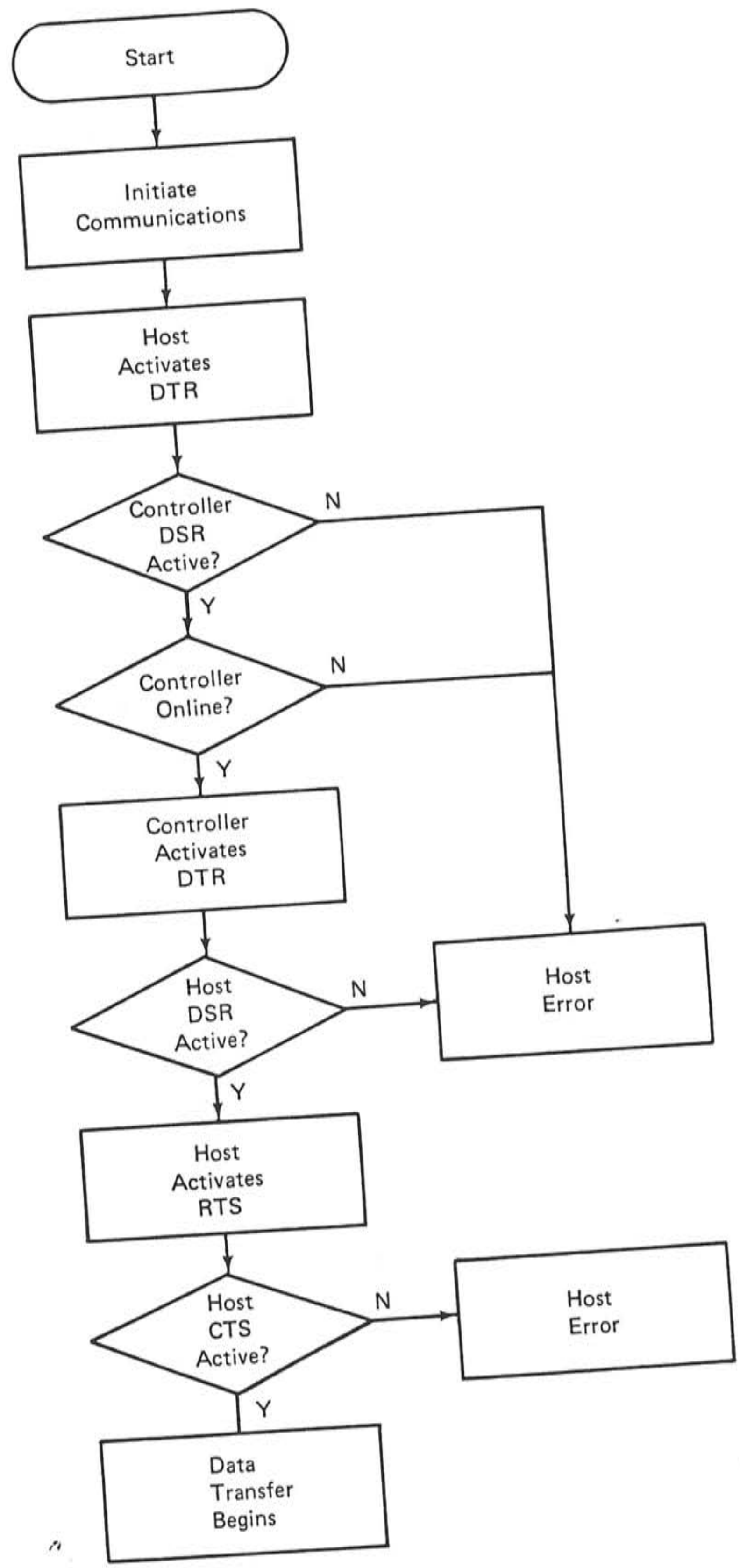
The cable wiring for an RS-422 interface between a local host with an RS-422 interface and the controller is shown below.

```
         Host                              Controller
           |                                   |
     RTS   | 4 ----                   ---- 4   | RTS
           |      |                   |        |
     CTS   | 5 <---                   ---> 5   | CTS
           |                                   |
           |                          ---- 7   | GND
           |                          |        |
           |                          --> 18   | (See Note)
           |                                   |
     +TD   | 19 ------------------------> 15   | +RD
           |                                   |
     -TD   | 25 ------------------------> 17   | -RD
           |                                   |
     +RD   | 15 <------------------------ 19   | +TD
           |                                   |
     -RD   | 17 <------------------------ 25   | -TD
           |                                   |
     DSR   | 6 <---                   ---> 6   | DSR
           |      |                   |        |
     GND   | 7 --------------------------- 7   | GND
           |      |                   |        |
      CD   | 20 ----------------------X---> 8  | CD
           |      |                            |
     DTR   | 8 <---X--------------------- 20   | DTR
           |                                   |
```

Local RS-422 Cable Wiring

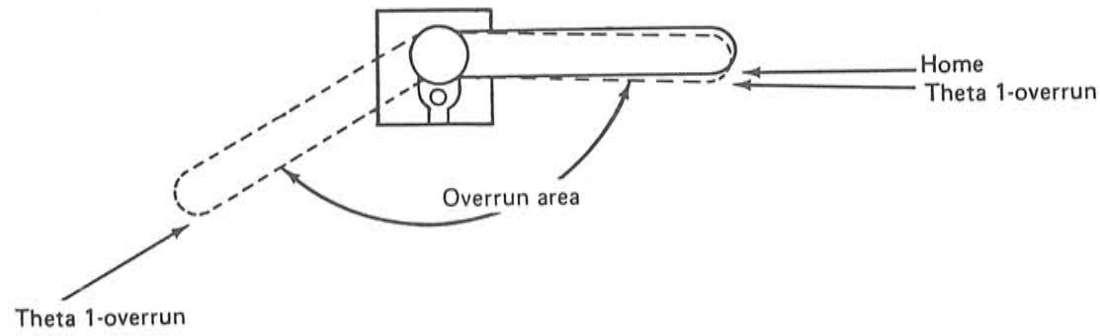
Note: A ground on pin 18 indicates to the controller that an RS-422 interface is selected.

This is a flow diagram of the communications connection sequence ("handshaking").

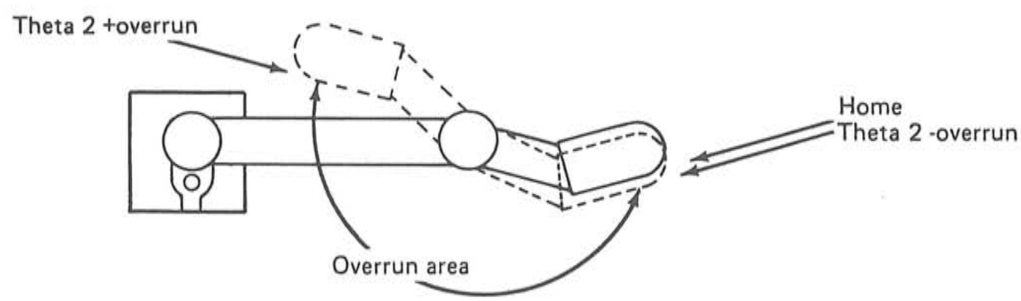


OVERRUN CONDITIONS

The following figures represent the overrun areas for the Theta 1 and Theta 2 axes. An overrun is detected by proximity sensors on the manipulator when an arm is moved outside its normal work area. The overrun sensors prevent the arm from driving into the stops. Once the arm is in an overrun condition, it must be moved manually to clear the condition.

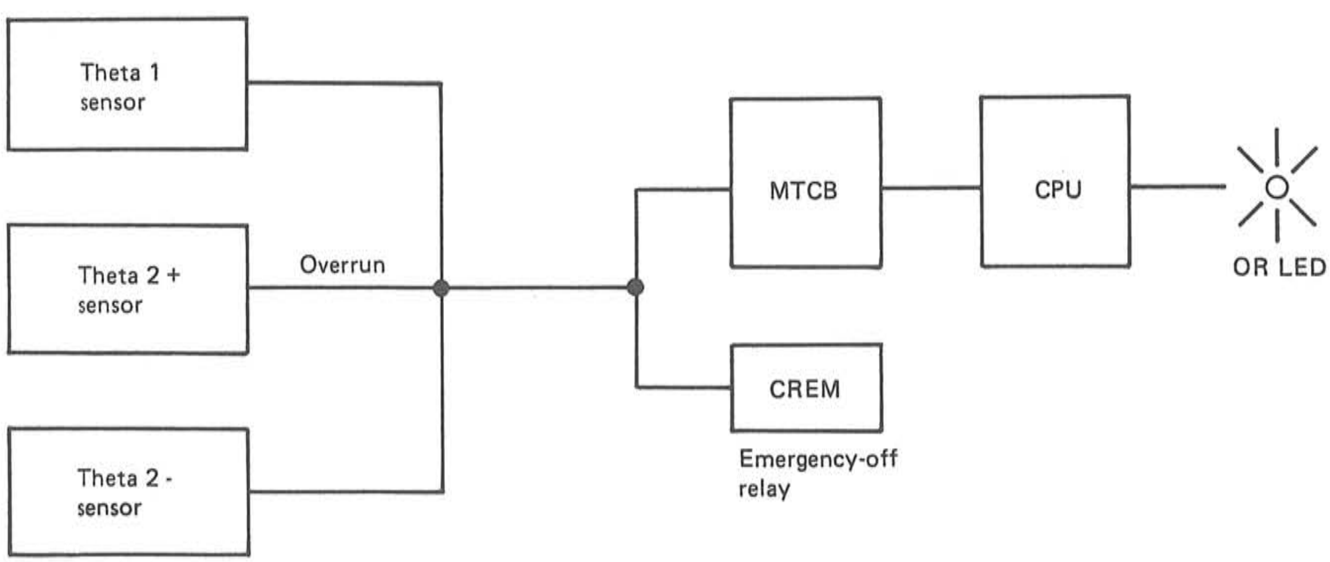


Theta 1 overrun: < 0-degrees or > 200 degrees



Theta 2 overrun - < 0-degrees or > 160 degrees

The figure below is a block diagram of the overrun circuit.



CONTROL PANEL

The control panel contains pressure-sensitive keys and light-emitting diode (LED) indicators. The keys are your interface to the controller.

The LEDs provide indications to you of the controller and manipulator status. The functions and names of the keys and LEDs are described in the following:

STOP This latching pushbutton removes power to the manipulator when in the down position. Manipulator power cannot be energized when this pushbutton is latched in the down position.

Power The Power LED lights when the power switch at the controller is in the | (on) position.

Home The Home LED lights when the manipulator is in the Home position. At this position, the controller calibrates its servo and stepper motor positions through the limit switches.

Memory The Memory LED lights after you press the Stop and Mem key when an application, running in automatic mode, has encountered a BREAKPOINT program statement. The LED remains on until you press the Start Cycle key.

SE The servo error (SE) LED lights when a servo fault is detected.

PF The power failure (PF) LED lights if an under-voltage condition is detected by the controller.

OR The Overrun (OR) LED lights when the 01 or 02 axis joint on the manipulator is beyond the maximum working envelope range.

OT The over-time (OT) LED lights when a time-limit value for a WAI TI, UP, or DOWN in an application program has exceeded its pro grammed value.

TE The transmission error (TE) LED lights when a transmission ror occurs between the IBM Personal Computer or a host compu and the controller.

DE The DE (Data Error) LED lights if a data error occurs in a plication program.

Gripper Open This key opens the optional gripper when you are operat manual mode. The LED stays lit only while you are pressi Gripper Open key.

Gripper Close This key closes the optional gripper when you are opera manual mode. The LED stays lit while the gripper is clos

Manip Power This key energizes the control and servo circuits. Lights when you press the key and remains lit until the Stop pushbutton, or remove the power from the cont

Return Home This key causes the controller to return the manipulator to the Home position, where the servo motors and the stepper motor are calibrated against limit switches. When you press the Return Home key, the LED lights and then goes off when the manipulator finds the home position.

Memory This key instructs the manipulator to resume execution of an application after a BREAKPOINT command. The LED lights when the key is pressed and remains on until the Start Cycle is pressed.

Reset Error This key resets the error LEDs if the error condition no longer exists.

Z Up Pressing this key raises the Z-axis shaft when you are using the manual mode. The LED stays lit until the Z-axis shaft reaches the up position.

Z Down Pressing this key lowers the Z-axis shaft when you are using the manual mode. The LED for this key lights when the key is pressed and remains lit until the Z-axis shaft is raised.

On Line Pressing this key causes the controller to enter the on-line state. The LED remains lit until the mode is ended. In this mode, a host computer or the IBM Personal Computer can communicate with the controller.

Caution: The manipulator will respond to the remote host commands in this mode. The manipulator may move without warning when in this mode.

Off Line Pressing this key ends the on-line state. Communications with a host or IBM Personal Computer is not possible in this mode. The LED lights when this mode is active.

Auto This key permits automatic or continuous execution of one of the application programs. The LED lights when the key is pressed.

Manual This key allows operator control of the manipulator, including stepping through an application program one line at a time. The LED lights when this key is pressed.

Start Cycle This key starts or resumes an application program. The LED lights when the key is pressed and goes off if the program stops.

Stop Cycle Pressing this key terminates an application program execution when the end of the program is reached. The LED lights when the key is pressed and goes off when the program stops or step mode is started.

Stop and Mem This key instructs the controller to stop at a BREAKPOINT statement or at the last line of an executing application program, depending on which one is encountered first. The controller then stores the present state of its memory. This includes instructions, counters, and variables for a subsequent recall by a recall memory command. The LED lights when the key is pressed and goes off when the application program stops. If the Memory LED does not light, the controller has stopped at the end statement of the program and the program must be started without using the Recall Memory key.

Step This key, while the controller is in manual or automatic mode with an application program selected, instructs the microprocessor to execute a single command of the application program and then to wait for the key to be pressed again. The LED lights when the key is pressed and goes off when the line has executed.

Rapid Pressing this key in conjunction with a Θ key speeds up the movement of the manipulator during manual mode positioning. The LED stays lit while you press the key.

Θ1+ Pressing this key moves the Θ1 axis of the manipulator in a counterclockwise direction as long as you hold it. The controller must be in the manual mode and off-line. The LED stays lit while you press the key.

Θ1- Pressing this key moves the Θ1 axis of the manipulator in a clockwise direction as long as you hold it. The controller must be in the manual mode and off-line. The LED stays lit while you press the key.

Θ2+ Pressing this key moves the Θ2 axis of the manipulator in a counterclockwise direction as long as you press it. The controller must be in the manual mode and off-line. The LED stays lit while you press the key.

Θ2- Pressing this key moves the Θ2 axis of the manipulator in a clockwise direction as long as you press it. The controller must be in the manual mode and off-line. The LED stays lit while you press the key.

Appl Each Appl key selects its respectively stored application for execution when the Start Cycle key is pressed.

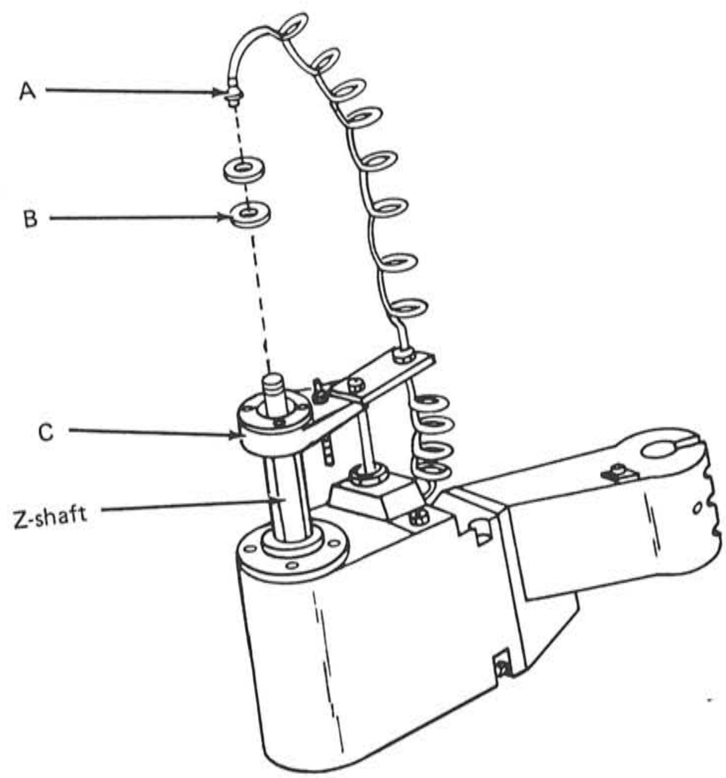
Roll + Pressing this key moves the R-axis in a clockwise direction while you press it. The controller must be in the manual mode. The LED stays lit when you press the key.

Roll - Pressing this key moves the R-axis in a counterclockwise direction while you press the key. The controller must be in the manual mode. The LED stays lit when you press the key.

SECTION 3 - REMOVAL / REPLACEMENT PROCEDURES

Note: If you are not familiar with the safety notices located in the front of this manual, you should review them before proceeding.

Z-Shaft (7535 Only)



3001 Z-SHAFT REMOVAL (7535 ONLY)

Note: When replacing the Z-shaft with a new one, the upper and lower ball splines must also be replaced, because these three are a matched set. Refer to the upper (3003) and lower (3005) ball spline removal procedures, as needed.

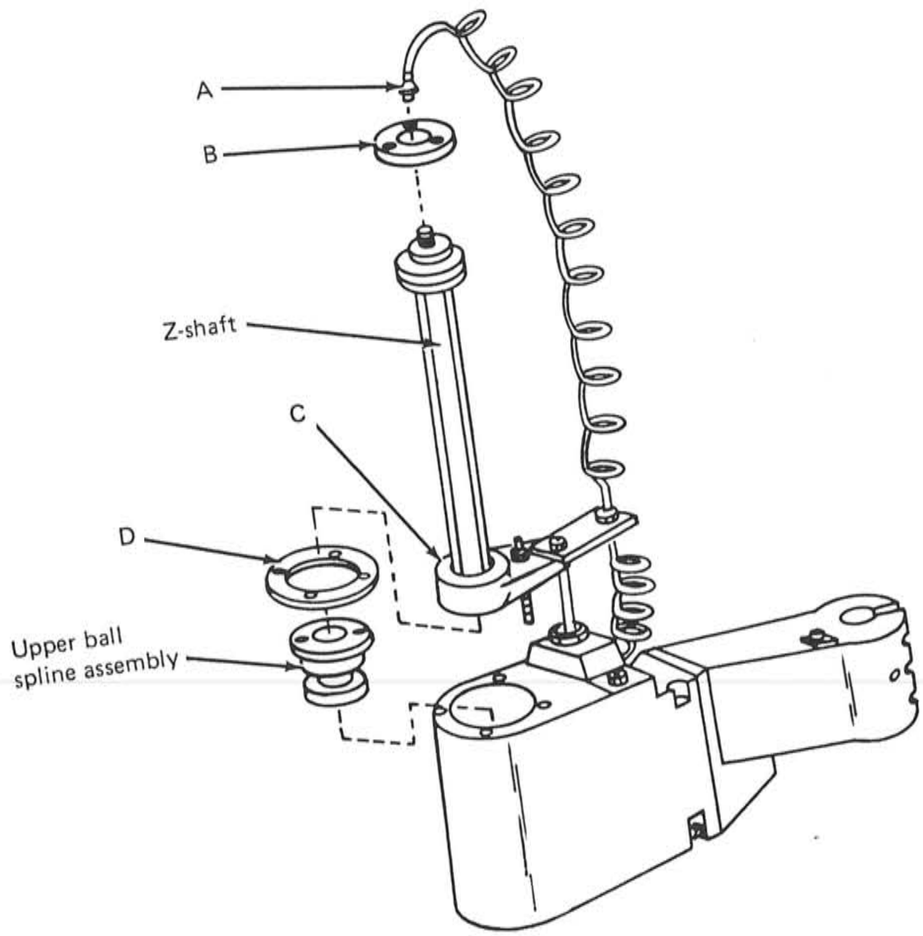
1. Turn off the air supply to the manipulator.
2. Power off the system before entering the workspace.
3. Remove any fixture or gripper attached to the Z-shaft.
4. Unscrew the air-hose fitting (A) from the top of the Z-shaft.

   Note: Secure the Z-shaft so that it does not fall out of the arm when the next step is performed.

5. Unscrew the two circular nuts (B) from the top of the Z-shaft. To do this, place a screwdriver in the slot on the top circular nut and tap it with a hammer.
6. Lower the Z-shaft until it clears the air bracket assembly (C); rotate the assembly out of the way.
7. Slide the Z-shaft out of the top of the Theta 2 arm.

3002 Z-SHAFT REPLACEMENT (7535 ONLY)

1. Align the splines on the Z-shaft with the slots in the upper and lower ball spline assemblies. Slide the Z-shaft down through the upper ball spline, the Theta 2 arm, and the lower ball spline assembly.
2. Rotate the air bracket assembly into place and slide the Z-shaft up through it.
3. Replace the two circular nuts on top of the shaft. Finger-tighten the first nut. Tighten the second nut by placing a screwdriver in the slot on the top nut and tapping it with a hammer.
4. Screw the air-hose fitting into the top of the Z-shaft.
5. Replace the fixture or gripper on the Z-shaft.


A
B
Z-shaft
C
D
Upper ball
spline assembly

3003 UPPER BALL SPLINE REMOVAL (7535 ONLY)

Note: When replacing the upper ball spline with a new one, the lower ball spline and Z-shaft must also be replaced, because these three are a matched set. Refer to the lower ball spline (3005) and Z-shaft (3001) removal procedures as needed.

1. Turn off the air supply to the manipulator.
2. Power off the system before entering the workspace.
3. Remove any fixture or gripper attached to the Z-shaft.
4. Unscrew the air-hose fitting (A) from the top of the Z-shaft.
5. Remove the three bearing cap screws on the air bracket assembly and remove the bearing cap (B).
6. Remove the Z-shaft up through the air bracket assembly (C) and set it aside.
7. Rotate the air bracket assembly clockwise out of the way.
8. Remove the four screws from the upper ball spline end cap (D).
9. Lift the ball spline assembly from its position in the Theta 2 arm.

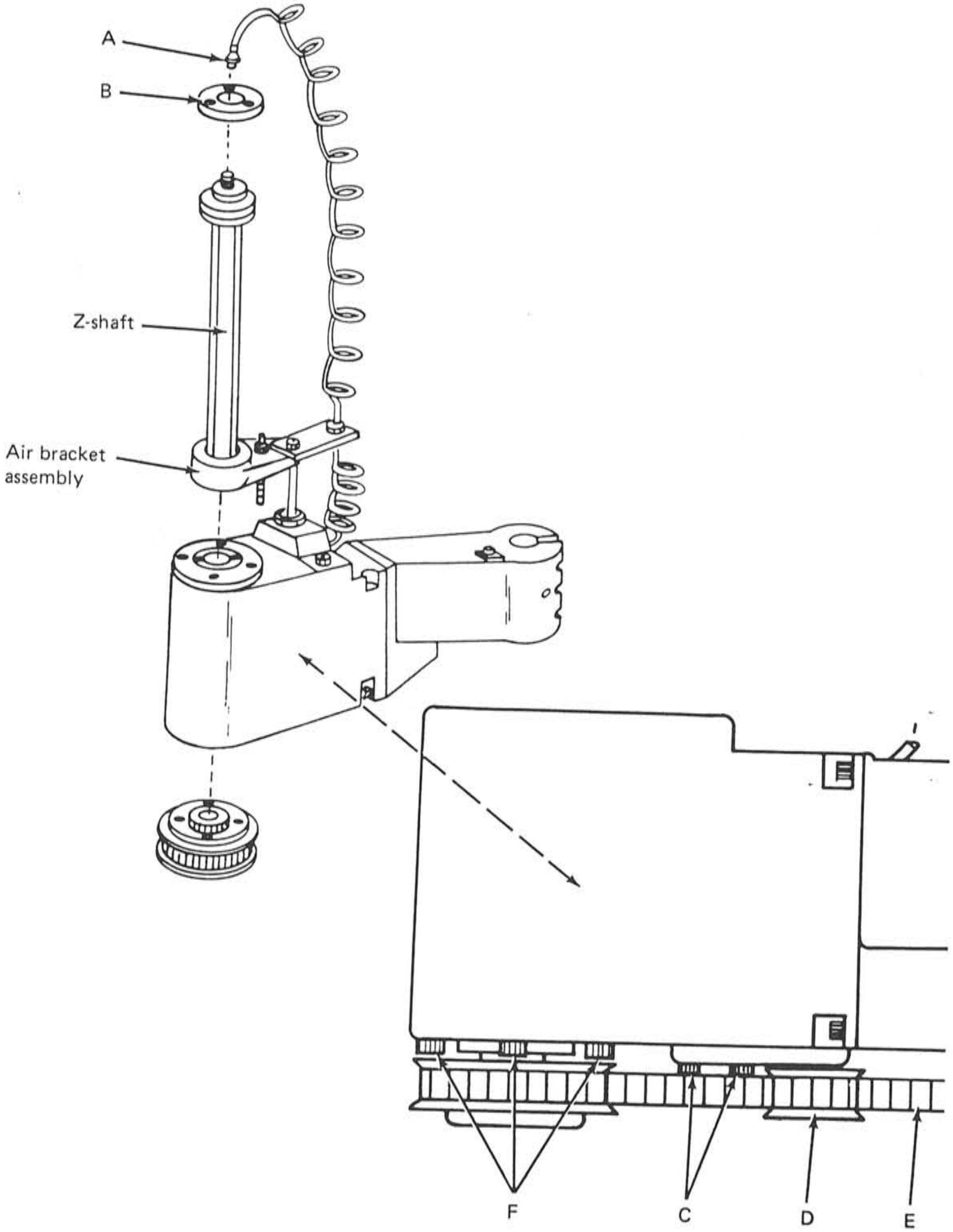
3004 UPPER BALL SPLINE REPLACEMENT (7535 ONLY)

1. Slide the upper ball spline assembly down into the opening in the Theta 2 arm.

   Note: Be sure to align the lower stop on the bearing cap with the adjustable stop screw on the air bracket assembly.

2. Replace the four screws in the upper ball spline end cap (D).
3. Align the air bracket assembly and insert the Z-shaft through the air bracket assembly, the upper ball spline assembly, the Theta 2 arm, and the lower ball spline assembly.
4. Replace the bearing cap (B) and the three bearing cap screws on the air bracket assembly.
5. Screw the air-hose fitting into the top of the Z-shaft.
6. Replace the fixture or gripper on the Z-shaft.

Lower Ball Spline (7535 Only)



3005 LOWER BALL SPLINE REMOVAL (7535 ONLY)

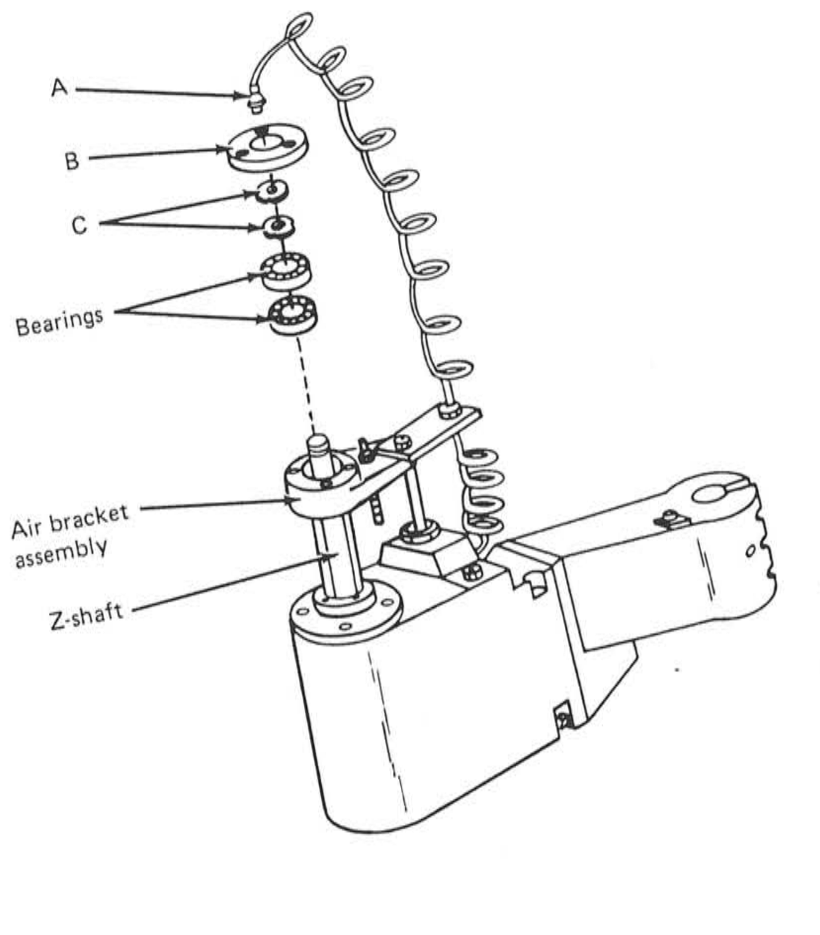
Note: When replacing the lower ball spline with a new one, the upper ball spline and Z-shaft must also be replaced, because these three are a matched set. Refer to the upper ball spline (3003) and Z-shaft (3001) removal procedures as needed.

1. Turn off the air supply to the manipulator.
2. Power off the system before entering the workspace.
3. Remove any fixture or gripper attached to the Z-shaft.
4. Unscrew the air-hose fitting (A) from the top of the Z-shaft and remove bearing cap (B).
5. Remove the Z-shaft up through the air bracket assembly and set it aside.
6. Rotate the air bracket assembly clockwise out of the way.
7. Loosen the tension pulley adjustment screws (C) and move the tension pulley (D) to relieve belt tension.
8. Unscrew the four screws (F) holding the lower ball spline end cap to the Theta 2 arm. Alternately loosen each screw and lower the ball spline assembly.
9. Slide the lower ball spline assembly down out of the Theta 2 arm. The pulley attached to the lower ball spline assembly can now be removed.
10. Remove the driven belt (E).

3006 LOWER BALL SPLINE REPLACEMENT (7535 ONLY)

1. Attach the pulley to the lower ball spline.
2. Place the driven belt (E) around the tension pulley (D) and the lower pulley. Position and hold the driven belt in place on the roll axis pulley while sliding the lower ball spline assembly up into the opening in the Theta 2 arm. Replace the four screws (F).
3. Align the air bracket assembly and insert the Z-shaft through the air bracket assembly, the upper ball spline assembly, the Theta 2 arm, and the lower ball spline assembly.
4. Replace the bearing cap (B) and the three bearing cap screws on the air bracket assembly.
5. Screw the air-hose fitting (A) into the top of the Z-shaft.
6. Perform the roll axis driven belt adjustment procedure (4012).
7. Replace the fixture or gripper on the Z-shaft.

Z-Shaft Roller Bearings (7535 Only)



3007 Z-SHAFT ROLLER BEARINGS REMOVAL (7535 ONLY)

1. Turn off the air supply to the manipulator.
2. Power off the system before entering the workspace.
3. Remove any fixture or gripper attached to the Z-shaft.
4. Unscrew the air-hose fitting (A) from the top of the Z-shaft.

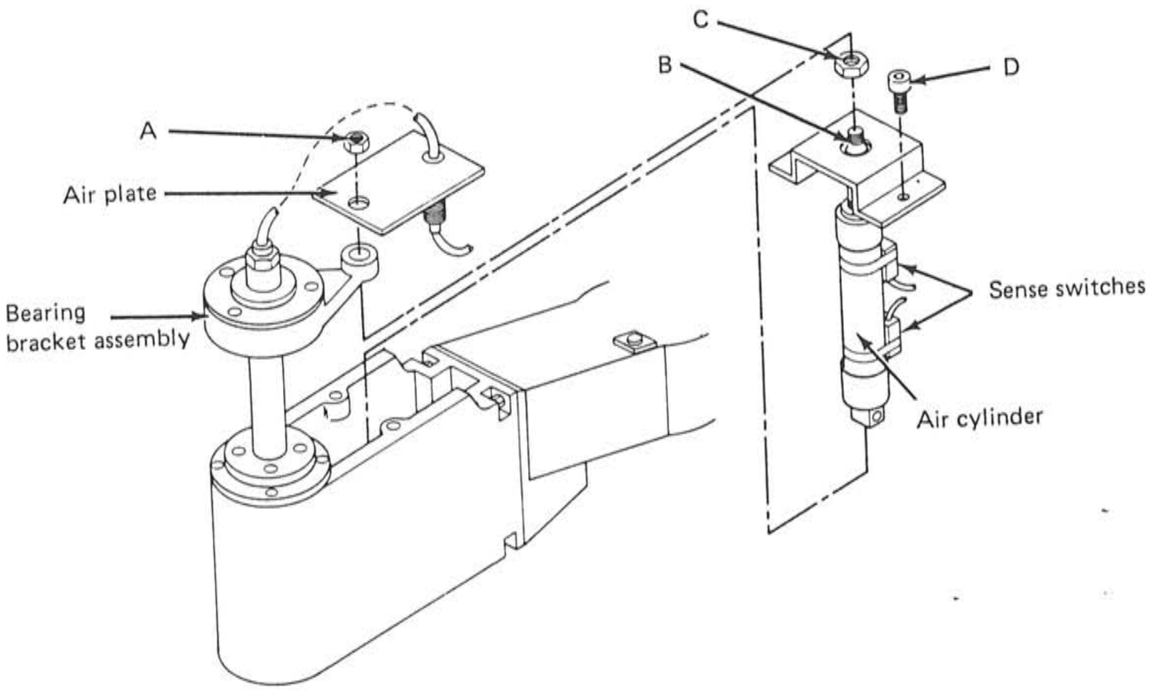
   Note: Secure the Z-shaft so that it does not fall out of the arm when the next step is performed.

5. Unscrew the two circular nuts (C) from the top of the Z-shaft. To do this, place a screwdriver in the slot on the top circular nut and tap it with a hammer.
6. Lower the Z-shaft until it clears the air bracket assembly; replace one circular nut (C) to prevent the Z-shaft from dropping through the Theta 2 arm.
7. Remove the three screws holding the bearing end cap (B) on the bracket.
8. Slide the bearings up and out of the air bracket.

3008 Z-SHAFT ROLLER BEARINGS REPLACEMENT (7535 ONLY)

1. Slide the bearings into the air bracket.
2. Replace the bearing end cap (B) and the three screws.
3. Remove the circular nut and slide the Z-shaft up through the air bracket assembly.
4. Replace the two circular nuts (C) on top of the shaft. Finger-tighten the first nut. Tighten the second nut by placing a screwdriver in the slot on the top nut and tapping it with a hammer.
5. Screw the air-hose fitting (A) into the top of the Z-shaft.
6. Replace the fixture or gripper to the Z-shaft.

Air Cylinder (7535 Only)



3009 AIR CYLINDER REMOVAL (7535 ONLY)

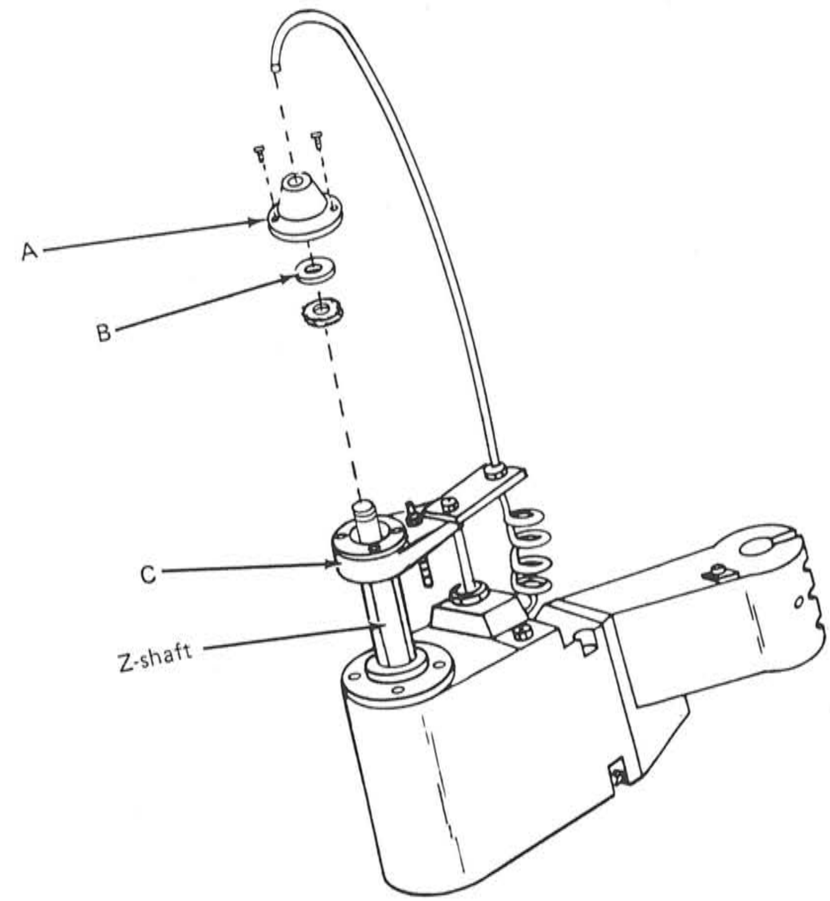
1. Turn off the air supply to the air cylinder.
2. Power off the system before entering the workspace.
3. Remove the nut (A) holding the air plate to the air cylinder shaft.
4. Slide the air plate off the air cylinder shaft.
5. Hold the bearing bracket assembly and unscrew the air cylinder shaft (B) from it. Rotate the bracket assembly 180 degrees.
6. Loosen the nut (C) attaching the air cylinder to the air cylinder bracket.
7. Remove the two screws (D) holding the air cylinder bracket; remove the bracket and air cylinder.
8. Remove the nut (C) loosened in step 6.
9. Remove the hoses from the air cylinder fittings. Each hose connection should be labeled for correct reassembly. Remove the hoses by sliding the collars away from the fittings and pulling the hoses off the fittings.

   Note: When replacing an air cylinder with a new one, the sense switches must be removed from the old cylinder and placed on the new one. Mark the position of the switches on the old air cylinder and replace them in the same position on the new cylinder.

3010 AIR CYLINDER REPLACEMENT (7535 ONLY)

1. Replace the hoses on the air cylinder fittings and slide the collars over the fittings.
2. Attach the air cylinder to the air cylinder bracket by replacing and hand-tightening the nut (C).
3. Place the air cylinder inside the Theta 2 arm, aligning the air cylinder bracket. Replace the two bracket screws (D), but do not tighten them at this time.
4. Tighten the nut (C) on the air cylinder.
5. Align the bearing bracket with the air cylinder shaft and screw the shaft into the bracket.
6. Tighten the air cylinder bracket screws (D).
7. Replace the air plate and the cylinder shaft nut (A).
8. Turn on the air supply to the air cylinder.
9. Test sense switch operation and adjust as necessary (4004).

Z-Shaft (7540 Only)



3011 Z-SHAFT REMOVAL (7540 ONLY)

Note: When replacing the Z-shaft with a new one, the upper and lower ball splines must also be replaced, because these three are a matched set. Refer to the upper (3013) and lower (3015) ball spline removal procedures as needed.

1. Turn off the air supply to the manipulator.

2. Power off the system before entering the workspace.

3. Remove any fixture or gripper attached to the Z-shaft.

4. Remove cone-shaped cover (A) secured by three hex-head bolts.

   Note: Secure the Z-shaft so that it does not fall out of the arm when the next step is performed.

5. Unscrew the circular nut (B) from the top of the Z-shaft. To do this, place a screwdriver in the slot on the circular nut and tap it with a hammer.

6. Lower the Z-shaft until it clears the air bracket assembly (C); rotate the assembly out of the way.

7. Slide the Z-shaft out of the top of the Theta 2 arm.

3012 Z-SHAFT REPLACEMENT (7540 ONLY)

1. Align the splines on the Z-shaft with the slots in the upper and lower ball spline assemblies. Slide the Z-shaft down through the upper ball spline, Theta 2 arm, and the lower ball spline assembly.

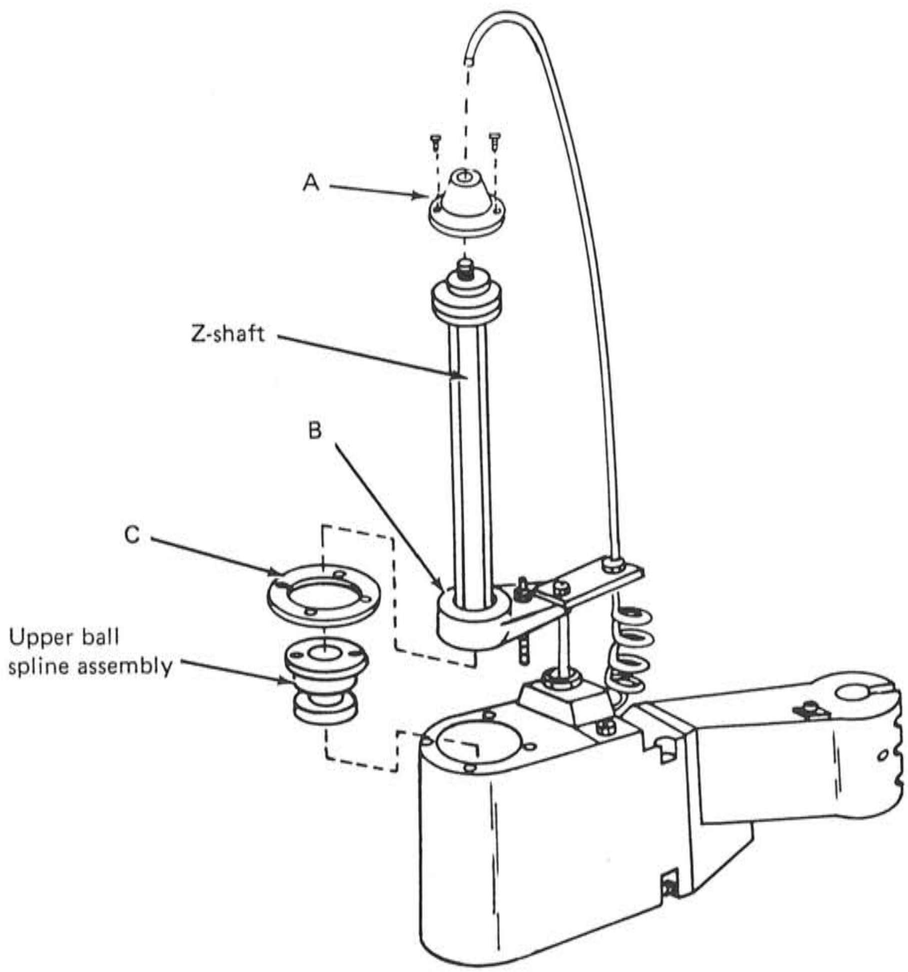
2. Rotate the air bracket assembly (C) into place and slide the Z-shaft up through it.

3. Replace the circular nut (B) on top of the shaft. Tighten the nut by placing a screwdriver in the slot on the nut and tapping it with a hammer.

4. Replace cone-shaped cover (A) secured by three hex-head bolts.

5. Replace the fixture or gripper on the Z-shaft.

Upper Ball Spline (7540 Only)



3013 UPPER BALL SPLINE REMOVAL (7540 ONLY)

Note: When replacing the upper ball spline with a new one, the lower ball spline and Z-shaft must also be replaced, because these three are a matched set. Refer to the lower ball spline (3015) and Z-shaft (3011) removal procedures as needed.

1. Turn off the air supply to the manipulator.
2. Power off the system before entering the workspace.
3. Remove any fixture or gripper attached to the Z-shaft.
4. Remove cone-shaped cover (A) secured by three hex-head bolts.
5. Remove the Z-shaft up through the air bracket assembly (B) and set it aside.
6. Rotate the air bracket assembly clockwise out of the way.
7. Remove the four screws from the upper ball spline end cap (C).
8. Lift the ball spline assembly from its position in the Theta 2 arm.

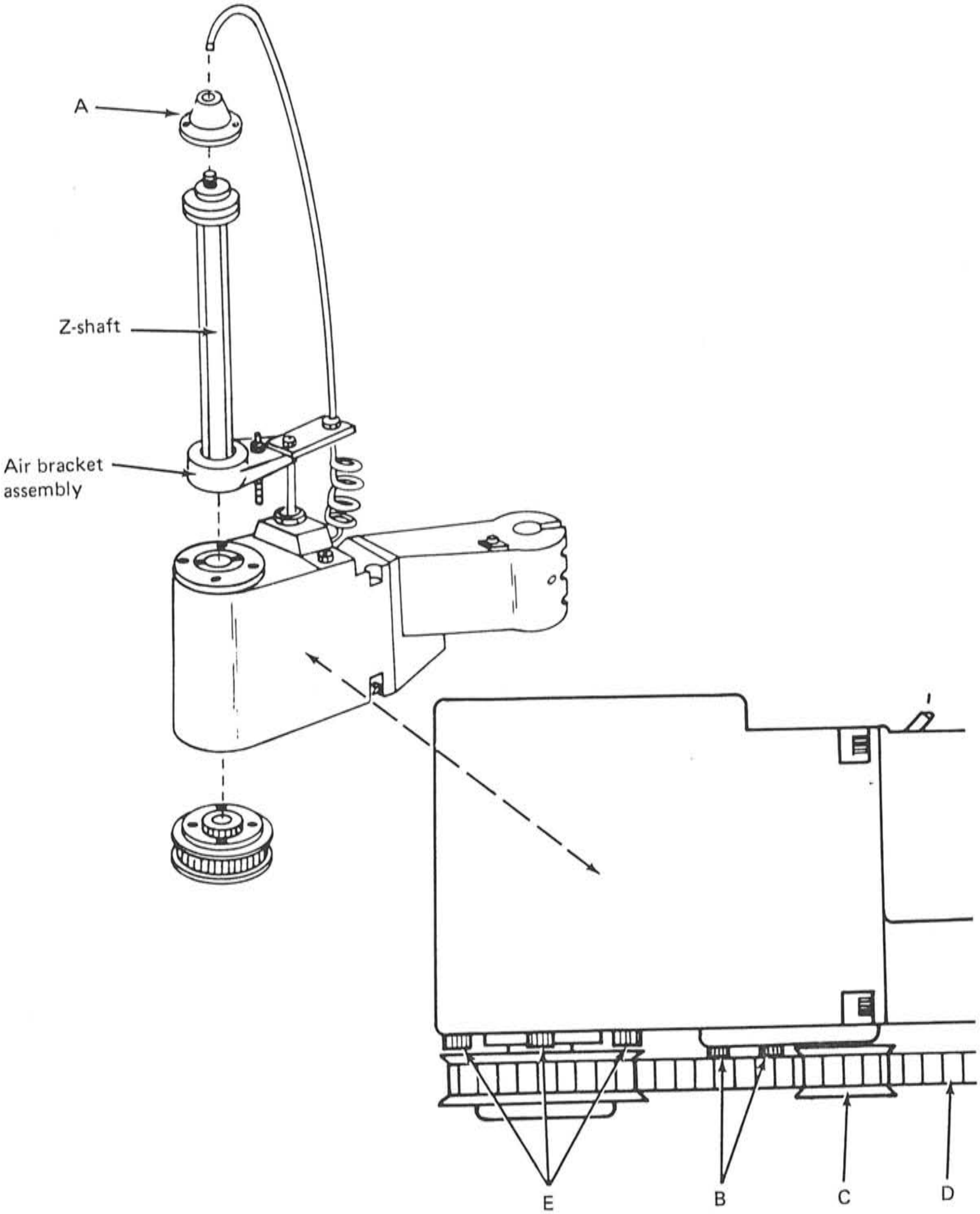
3014 UPPER BALL SPLINE REPLACEMENT (7540 ONLY)

1. Slide the upper ball spline assembly down into the opening in the Theta 2 arm.

   Note: Be sure to align the lower stop on the bearing cap with the adjustable stop screw on the air bracket assembly.

2. Replace the four screws in the upper ball spline end cap (C).
3. Align the air bracket assembly (B) and insert the Z-shaft through the air bracket assembly, the upper ball spline assembly, the Theta 2 arm, and the lower ball spline assembly.
4. Replace cone-shaped cover (A) secured by three hex-head bolts.
5. Replace the fixture or gripper on the Z-shaft.

Lower Ball Spline (7540 Only)



3015 LOWER BALL SPLINE REMOVAL (7540 ONLY)

Note: When replacing the lower ball spline with a new one, the upper ball spline and Z-shaft must also be replaced, because these three are a matched set. Refer to the upper ball spline (3013) and Z-shaft (3011) removal procedures as needed.

1. Turn off the air supply to the manipulator.

2. Power off the system before entering the workspace.

3. Remove any fixture or gripper attached to the Z-shaft.

4. Remove cone-shaped cover (A) secured by three hex-head bolts.

5. Remove the Z-shaft up through the air bracket assembly and set it aside.

6. Rotate the air bracket assembly clockwise out of the way.

7. Loosen the tension pulley adjustment screws (B) and move the tension pulley (C) to relieve belt tension.

8. Unscrew the four screws (E) holding the lower ball spline end cap to the Theta 2 arm. Alternately loosen each bolt and lower the ball spline assembly.

9. Slide the lower ball spline assembly down out of the Theta 2 arm. The pulley attached to the lower ball spline assembly remains intact.

10. Remove the driven belt (D).

3016 LOWER BALL SPLINE REPLACEMENT (7540 ONLY)

1. Place the driven belt (D) around the tension pulley (C) and the lower pulley and hold it in place on the Roll axis pulley while sliding the lower ball spline assembly up into the opening in the Theta 2 arm. Replace the four screws (E).

2. Align the air bracket assembly and insert the Z-shaft through the air bracket assembly, the upper ball spline assembly, the Theta 2 arm, and the lower ball spline assembly.

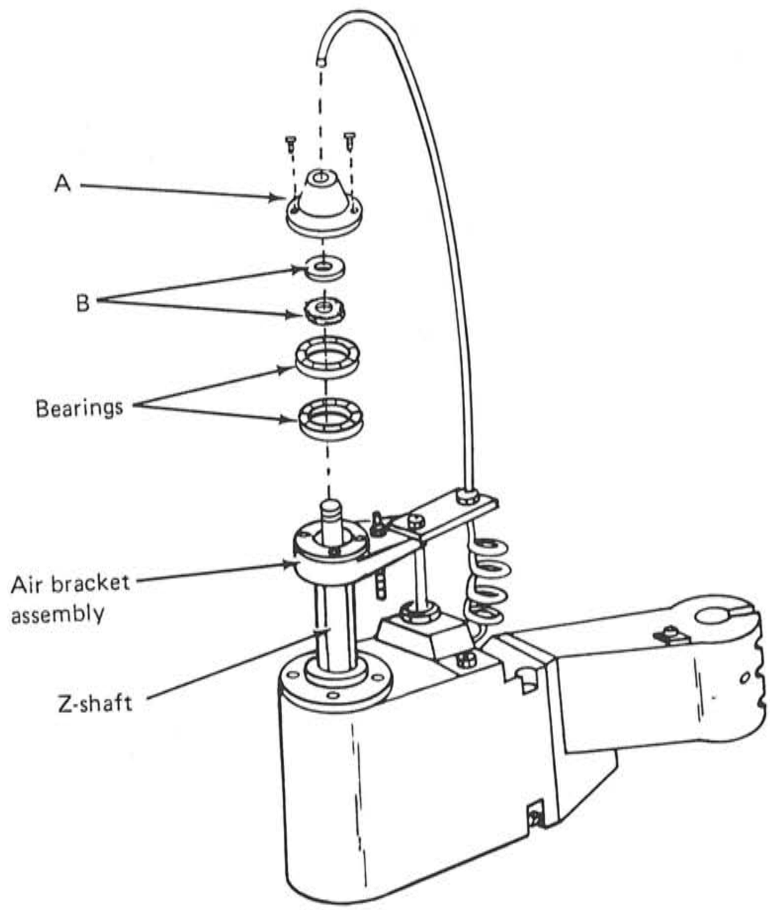
3. Replace cone-shaped cover (A) secured by three hex-head bolts.

4. Adjust the tension pulley (C) so that the belt does not slip when the Z-shaft is turned (4012).

5. Tighten the adjustment screws (B) on the tension pulley.

6. Replace the fixture or gripper on the Z-shaft.

Z-Shaft Roller Bearings (7540 Only)



3017 Z-SHAFT ROLLER BEARINGS REMOVAL (7540 ONLY)

1. Turn off the air supply to the manipulator.

2. Power off the system before entering the workspace.

3. Remove any fixture or gripper attached to the Z-shaft.

4. Remove cone-shaped cover (A) secured by three hex-head bolts.

   Note: Secure the Z-shaft so that it does not fall out of the arm when the next step is performed.

5. Unscrew the two circular nuts (B) from the top of the Z-shaft. To do this, place a screwdriver in the slot on the top circular nut and tap it with a hammer.

6. Lower the Z-shaft until it clears the air bracket assembly; replace one circular nut (B) to prevent the Z-shaft from dropping through the Theta 2 arm.

7. Slide the bearings up and out of the air bracket.

3018 Z-SHAFT ROLLER BEARINGS REPLACEMENT (7540 ONLY)

1. Slide the bearings into the air bracket.

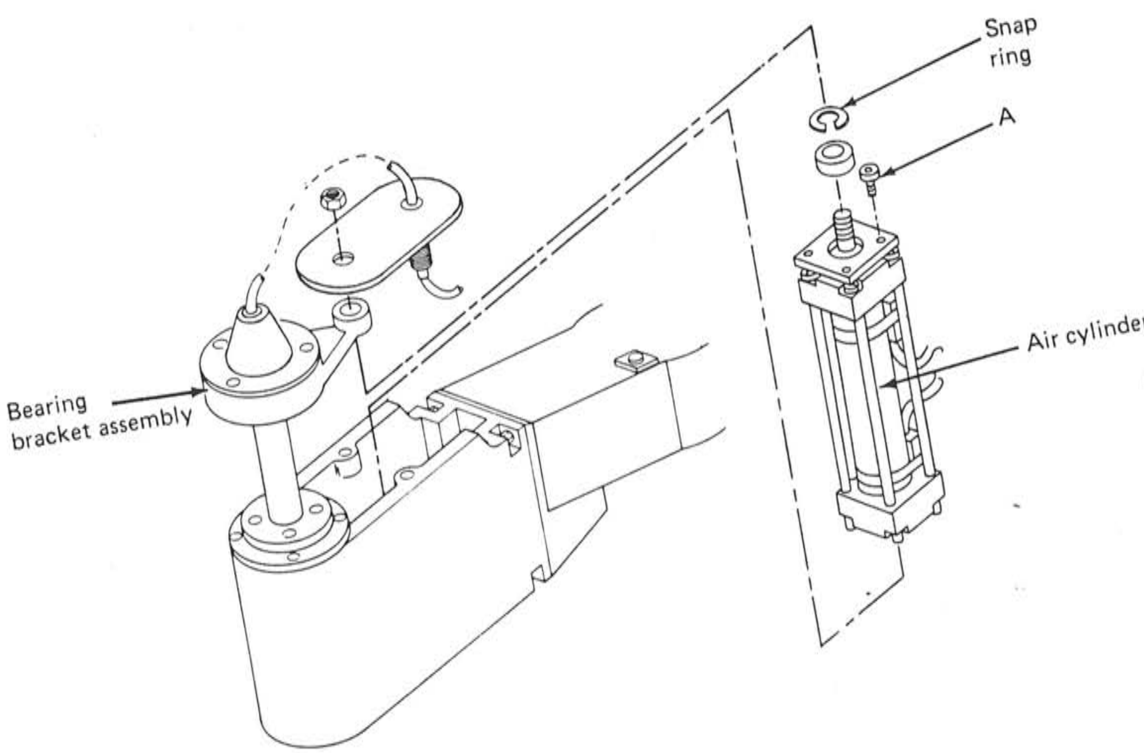
2. Remove the circular nut and slide the Z-shaft up through the air bracket assembly.

3. Replace the two circular nuts (B) on top of the shaft. Finger tighten the first nut. Tighten the second nut by placing a screwdriver in the slot on the top nut and tapping it with a hammer.

4. Replace cone-shaped cover (A) secured by three hex-head bolts.

5. Replace the fixture or gripper on the Z-shaft.

Air Cylinder (7540 Only)



3019 AIR CYLINDER REMOVAL (7540 ONLY)

1. Turn off the air supply to the air cylinder.

2. Power off the system before entering the workspace.

3. Remove the hoses from the air cylinder fittings. Each hose connection should be labeled for correct reassembly. Remove the hoses by sliding the collars away from the fittings and pulling the hoses off the fittings.

4. Remove the four screws (A) holding the air cylinder bracket.

5. Lift the air cylinder and Z-shaft out of the casting.

6. Unscrew the air cylinder from the bearing bracket assembly.

   Note: When replacing an air cylinder with a new one, the limit switches will have to be removed from the old cylinder and placed on the new one. Mark the position of the switches on the old air cylinder and replace in the same position on the new cylinder.

3020 AIR CYLINDER REPLACEMENT (7540 ONLY)

1. Screw the air cylinder into the bearing bracket assembly.

2. Lower the air cylinder and Z-shaft into the casting.

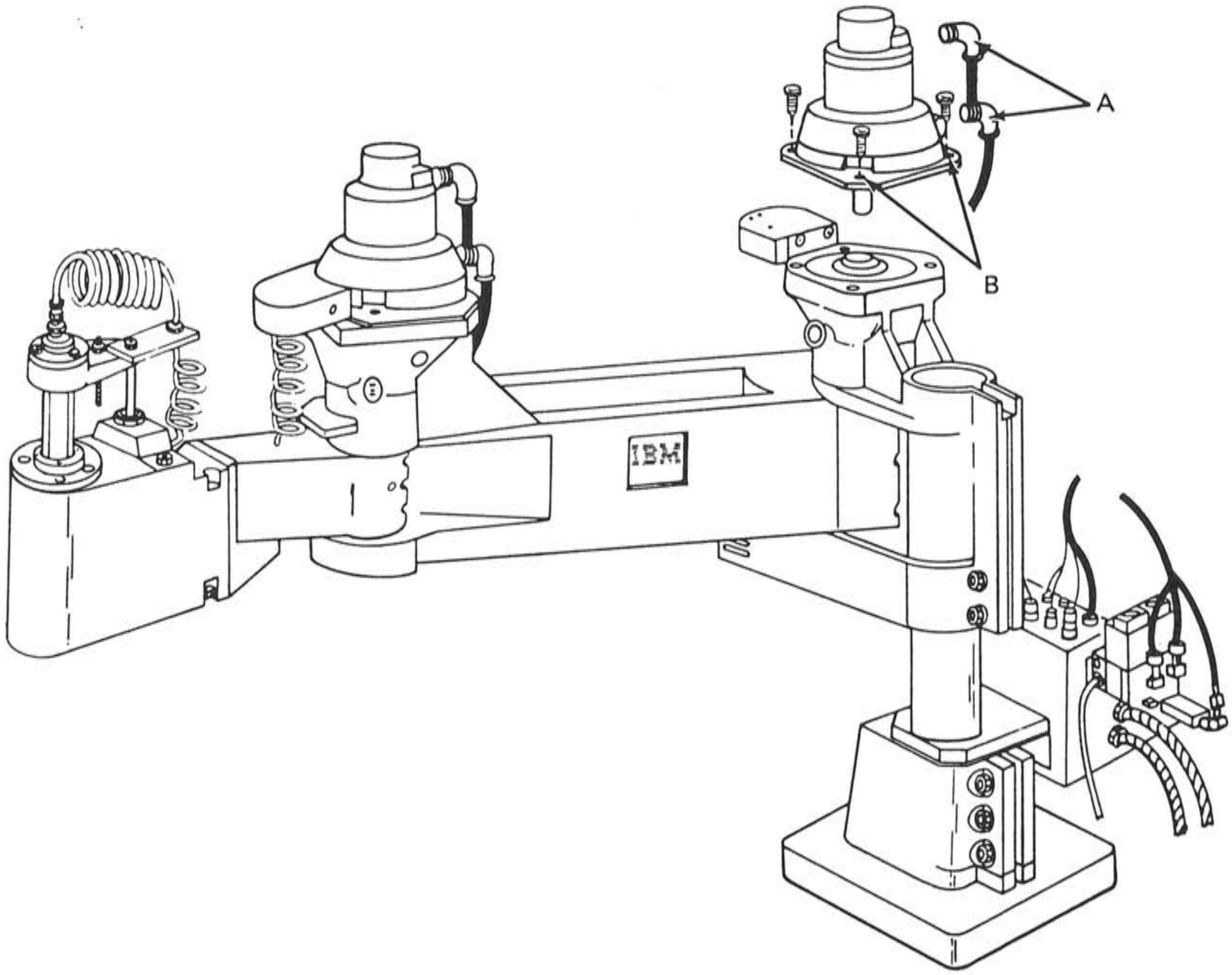
3. Replace and tighten the air cylinder bracket screws (A).

4. Replace the hoses on the air cylinder fittings and slide the collars over the fittings.

5. Turn on the air supply to the air cylinder.

6. Test limit switch operation and adjust as necessary (4004).

Theta 1 DC Motor-Encoder



3021 THETA 1 DC MOTOR-ENCODER REMOVAL

Caution: Removal of the Theta 1 motor or encoder changes the home position adjustment of the manipulator. This adjustment and the Theta 2 home position adjustment should never be disturbed at the same time. Therefore, DO NOT remove the Theta 2 motor or encoder until the Theta 1 home position adjustment is correctly reset.

1. Power off the system before entering the workspace.

2. Remove the electrical connectors (A) from the motor-encoder casing.

3. Remove the four motor mounting screws (B).

4. Remove the motor ("jiggle" the Theta 1 arm while lifting the motor to free the wave generator from the flexspline).

   Note: When replacing the motor with a new motor, the wave generator bearing assembly must be removed from the motor shaft and installed on the new motor shaft. See the wave generator removal and replacement procedure (3027 and 3028).

3022 THETA 1 DC MOTOR-ENCODER REPLACEMENT

Note: New DC motors have a rust-preventive paint on the end shafts and flange surfaces, which is for protection during shipment. This paint should be cleaned off the motors using paint thinner prior to installation.

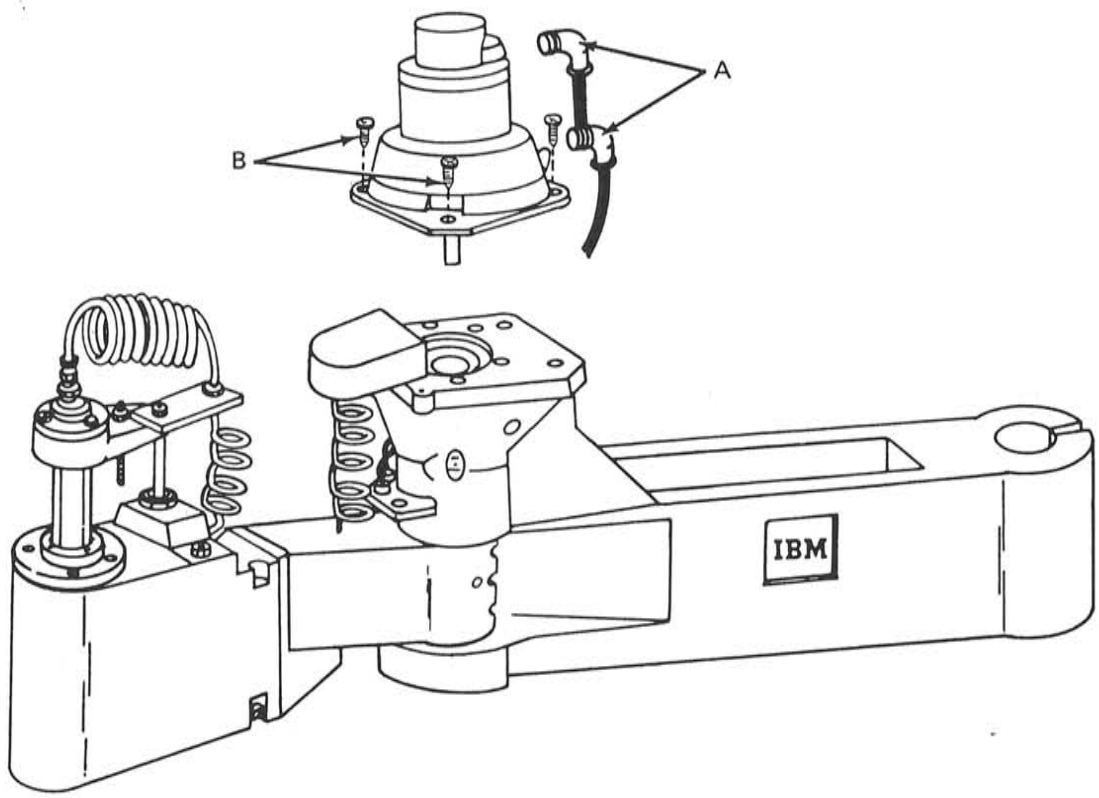
1. Position the motor-encoder assembly over the joint and slide the wave generator into the flexspline.

2. "Jiggle" the Theta 1 arm while pushing down on the motor to seat it properly.

3. Replace the four screws (B) that hold the motor to the joint.

4. Replace the electrical connectors (A) on the motor and encoder.

5. Perform the Theta 1 home position adjustment procedure (4005).


A
B
IBM

3023 THETA 2 DC MOTOR-ENCODER REMOVAL

Caution: Removal of the Theta 2 motor or encoder changes the home position adjustment of the manipulator. This adjustment and the Theta 1 home position adjustment should never be disturbed at the same time. Therefore, DO NOT remove the Theta 1 motor or encoder until the Theta 2 home position adjustment is correctly reset.

1. Power off the system before entering the workspace.

2. Remove the electrical connectors (A) from the motor-encoder casing.

3. Remove the four screws (B) holding the motor to the arm.

4. Remove the motor (jiggle the Theta 2 arm while lifting the motor to free the wave generator from the flexspline).

   Note: When replacing the motor with a new motor, the wave generator bearing assembly must be removed from the motor shaft and installed on the new motor shaft. See the wave generator removal and replacement procedure (3027 and 3028).

3024 THETA 2 DC MOTOR-ENCODER REPLACEMENT

Note: New DC motors have a rust-preventive paint on the end shafts and flange surfaces, which is for protection during shipment. This paint should be cleaned off the motors using paint thinner prior to installation.

1. Position the motor-encoder assembly over the joint and slide the wave generator into the flexspline.

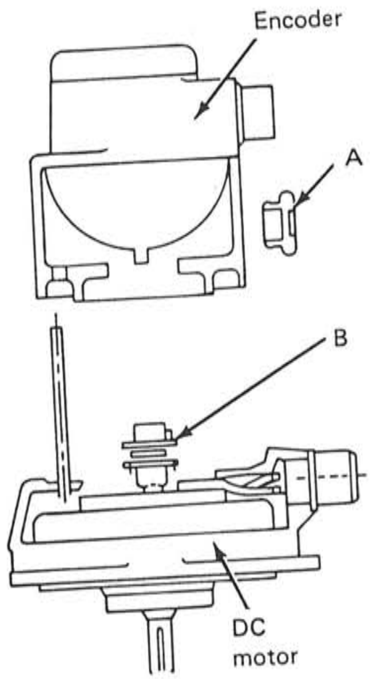
2. "Jiggle" the Theta 2 arm while pushing down on the motor to seat it properly.

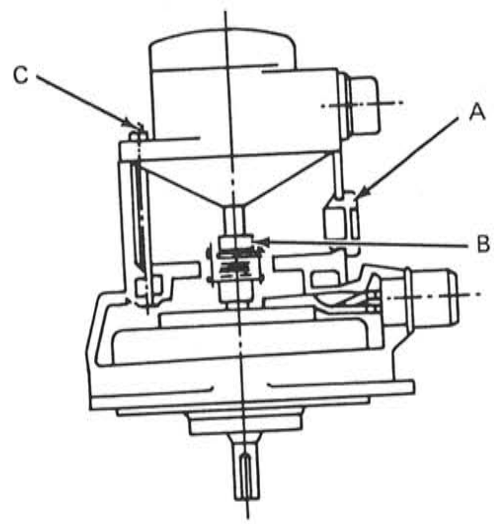
3. Replace the four screws (B) that hold the motor to the joint.

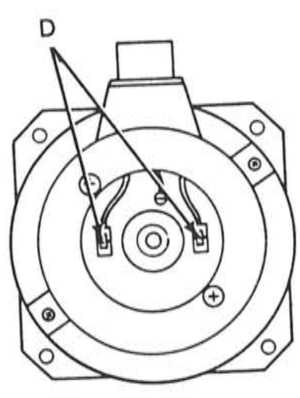
4. Replace the electrical connectors (A) on the motor and encoder.

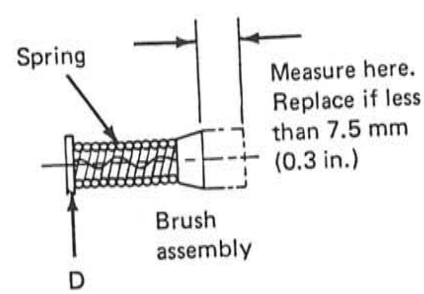
5. Perform the Theta 2 home position adjustment procedure (4006).

DC Motor Brushes









3025 DC MOTOR BRUSHES REMOVAL

Caution: Removal of either the Theta 1 or Theta 2 motor or encoder changes the home position adjustment of the manipulator. The adjustment of the Theta 1 and Theta 2 home positions should never be disturbed at the same time. Therefore, DO NOT remove a second motor or encoder until the home position adjustment is correctly reset on the first.

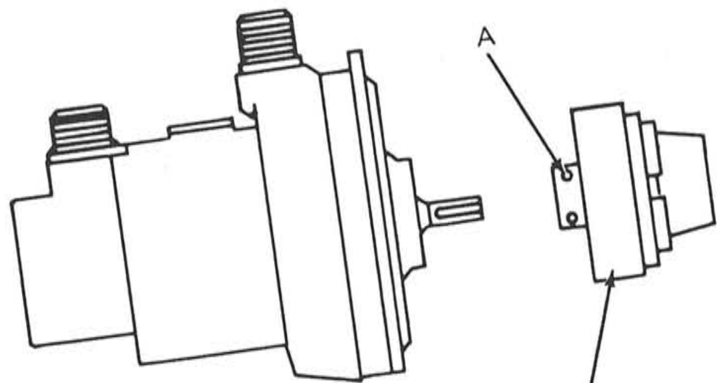
Note: The encoder can be removed from the motor while the motor remains attached to the joint.

1. Power off the system before entering the workspace.
2. Remove the electrical connector from the motor.
3. Remove the dustcover plug (A) from between the motor-encoder electrical connectors.
4. Loosen the coupling screw (B) accessed through the uncovered hole in the motor-encoder spacer.
5. Remove the two nuts (C) holding the encoder.
6. Carefully separate the encoder from the motor.
7. Unscrew the brushes (D), located on the top of the motor plate, from the motor and slide them out of their slots.
8. Measure the brush length. If less than 7.5 mm (0.3 in.), replace them.

3026 DC MOTOR BRUSHES REPLACEMENT

1. Slide the brush and attached spring (D) into the brush hole on the motor plate.
2. Replace the screw in the mounting hole and tighten.
3. Replace the encoder on the motor.
4. Replace the encoder mounting nuts (C).
5. Tighten the coupling screw (B).
6. Replace the dustcover plug (A).
7. Replace the electrical connector to the motor.
8. Perform the home position adjustment procedure for Theta 1 (4005) or Theta 2 (4006).

Wave Generator Assembly



3027 WAVE GENERATOR ASSEMBLY REMOVAL

Caution: Removal of either the Theta 1 or Theta 2 motor or encoder changes the home position adjustment of the manipulator. The adjustment of the Theta 1 and Theta 2 home positions should never be disturbed at the same time. Therefore, DO NOT remove a second motor or encoder until the home position adjustment is correctly reset on the first.

1. Power off the system before entering the workspace.

2. Remove the motor-encoder from the joint. Use the motor-encoder removal procedure for Theta 1 (3021) or Theta 2 (3023).

3. Loosen the setscrews (A) holding the wave generator to the motor shaft.

4. Slide the wave generator assembly off the motor shaft (pull away from the motor).

3028 WAVE GENERATOR REPLACEMENT

1. Slide the wave generator assembly onto the motor shaft. Make sure that the setscrews are over the flat of the motor shaft.

2. Adjust the assembly for the correct clearance between the bottom of the motor and the wave generator hub.

   Theta 1 (7535) = 3.45 mm (0.135 in.)

   Theta 2 (7535) = 1.27 mm (0.050 in.)

   Theta 1 (7540) = 4.25 mm (0.167 in.)

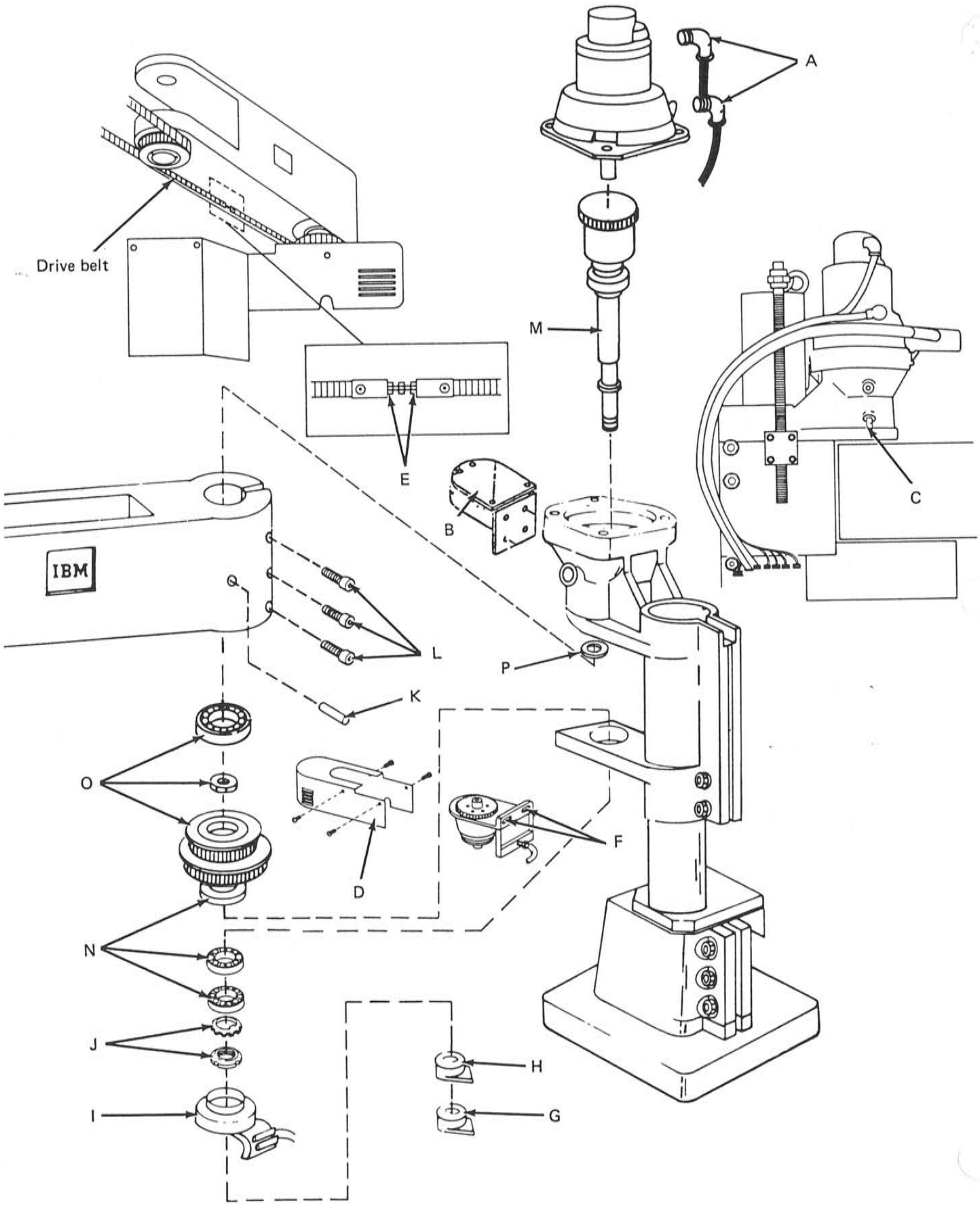
   Theta 2 (7540) = 3.45 mm (0.135 in.)

3. Tighten the setscrews that hold the assembly to the shaft.

4. Replace the motor using the replacement procedure for Theta 1 (3022) or Theta 2 (3024).

5. Perform the home position adjustment procedure for Theta 1 (4005) or Theta 2 (4006).

Theta 1 Arm and Harmonic Shaft



3029 THETA 1 ARM AND HARMONIC SHAFT REMOVAL

Caution: Removal of the Theta 1 harmonic shaft changes the home position adjustment of the manipulator. This adjustment and the Theta 2 home position adjustment should never be disturbed at the same time. Therefore, DO NOT remove the Theta 2 motor-encoder or harmonic shaft until the Theta 1 home position adjustment is correctly reset.

DANGER

This removal procedure requires two persons. One person must support and remove/replace the manipulator arm while the second person removes/replaces the harmonic shaft. Do not attempt it alone.

1. Power off the system before entering the workspace.

2. Remove the electrical connectors from the motor (A).

3. Place a 1-quart-capacity container beneath the oil drain plug (C). Remove the drain and oil filler plugs and allow the oil to drain while you perform the next steps.

4. Remove the two wiring duct mounting screws and remove the wiring duct (B).

5. Remove the Theta 1 motor (3021).

6. Remove the stepper motor (3045) steps 1-6 only.

7. Remove the roll axis drive belt (3041).

   Note: The overrun cam and home cam are removed in the next step. Please note that they are not interchangeable. Label the cams to allow replacement in the correct positions.

8. Loosen the setscrews; remove the overrun cam (G) and the home cam (H) from the shaft.

9. Remove the two limit switches and bearing end cap (I) from the base by removing the four mounting screws.

   Note: In the next step, the two bearings and the spacer (N) may come out from the bottom after the circular nut (J) is removed. If so, remove them at this time. If they are still tightly held in place, wait to remove them after the Theta 1 shaft has been removed. Also, the two bearings must be replaced in the same order they were removed, with the same sides of the bearings touching.

10. Pry the lock washer tab from the slot in the circular nut and remove the nut and washer (J).

11. Remove the taper pin (K) and 3 cap screws (L) from the Theta 1 arm. To remove the taper pin, insert a roll punch on the opposite side of the pin and tap it with a hammer.

12. While one person holds the manipulator arm assembly, another person should place a small wood block against the bottom of the shaft (M) and tap on it to loosen the shaft. When loosened, remove the shaft up out of the joint.

13. Remove the upper bearing, the spacer, and the gear and pulley assembly (O).

14. Remove the Theta 1 harmonic shaft (M).

15. Remove the lower shaft bearings and spacer (N), if not removed in step 12. Note the positioning of the bearings for proper replacement.

    Note: Upon removal of the shaft, inspect the inner oil seal (P). If there are any signs of wear or damage, replace the seal. Refer to the replacement procedure if the seal needs replacement (3039 and 3040).

3030 THETA 1 ARM AND HARMONIC SHAFT REPLACEMENT

1. Place the upper bearing, spacer, and the gear and pulley assembly (O) into the bottom of the manipulator arm assembly.

   Note: At this time, replace only the upper bearing into the gear and pulley assembly (O). The lower bearing and spacer (N) can be replaced easier from the bottom after the shaft is installed.

   Note: A removable wedge carefully driven into the clamping slot in the arm facilitates insertion of the harmonic shaft. Remove the wedge after the shaft is in place.

2. Place the manipulator arm assembly into position and insert the Theta 1 harmonic shaft (M) into the joint. Ensure that the large end of the taper pin hole in the shaft is aligned with the large end of the hole in the Theta 1 arm. The shaft may require tapping with a hammer to fully seat into position. Use a 0.5-inch diameter pin to tap on the center of the shaft.

3. Replace the taper pin (K) and 3 cap screws (L).

   Note: It is important that the taper pin be fully seated into the hole in the harmonic shaft to remove all play in the arm.

   Note: If a new harmonic shaft or Theta 1 arm is being installed, a new hole must be drilled in the shaft and the Theta 1 arm and a new taper pin installed. The new hole can be drilled above or below the original hole.

4. Insert the spacer and bearing into the lower end of the gear and pulley assembly (O).

5. Install the spacer and lower matched bearings (N). Ensure that the bearings are installed in the same order they were removed.

   Note: For correct installation of the bearings, the inner side of the bearings should face each other. The inner side is the side with the largest opening between the races.

6. Replace the washer and circular nut (J). Tighten the circular nut and form a tab of the washer into the slot in the circular nut.

7. Replace the bearing end cap and limit switches (I). Replace and tighten the four end cap screws.

8. Replace the home cam (H) and the overrun cam (G); tighten one setscrew in each cam to just hold the cam to the shaft.

9. Replace the stepper motor bracket and stepper motor (F). Adjust the bracket left or right for minimum clearance between the gears with no binds.

10. Install the roll axis drive belt so that the adjusting screw (E) is centered between the pulleys and the roll axis sensing magnet is over the sensing switch.

    Note: This is only a preliminary setting. Final adjustment should be made after completing this replacement procedure.

11. Close the oil drain plug (C) and fill the housing, to the sight gauge, with oil.

    Note: The recommended oil to use is IBM No. 10 or equivalent.

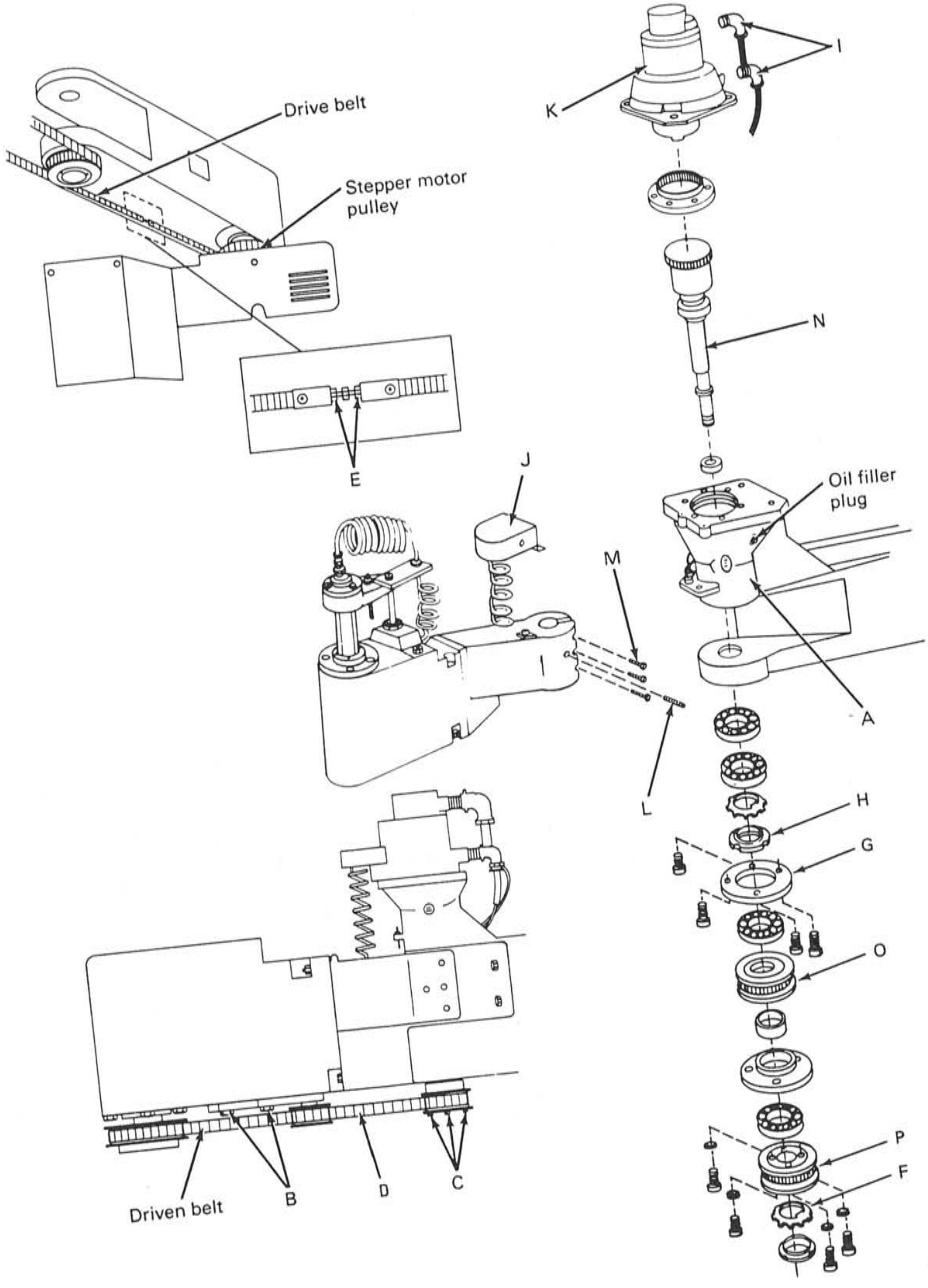
12. Replace the Theta 1 motor-encoder assembly and four mounting screws.

13. Replace the wiring duct (B) and two mounting screws.

14. Replace the motor-encoder electrical connectors (A).

15. Perform the Theta 1 home (4005), Theta 1 overrun (4007), and the roll axis drive belt (4011) adjustments.

Theta 2 Arm and Harmonic Shaft



3031 THETA 2 ARM AND HARMONIC SHAFT REMOVAL

Caution: Removal of the Theta 2 harmonic shaft changes the home position adjustment of the manipulator. This adjustment and the Theta 1 home position adjustment should never be disturbed at the same time. Therefore, DO NOT remove the Theta 1 motor or harmonic shaft until the Theta 2 home position adjustment is correctly reset.

1. Power off the system before entering the workspace.

2. Place a 1-quart container beneath the oil drain plug (A). Remove the drain and the oil filler plugs and allow the oil to drain while you perform the next steps.

3. Loosen the belt tension pulley adjustment screw(s) (B).

4. Remove the four screws (C) holding the Theta 2 pulley (P) and slide the pulley down from the shaft.

5. Remove the driven belt (D).

6. Loosen the lock nuts (E) on the drive belt adjusting screw and loosen the screw.

   Note: One lock nut has reverse threads.

7. Slide the belt off the driven pulley (O), but do not remove it from the stepper motor pulley.

8. Pry the washer locking tab from the slot in the lower circular nut (F) on the shaft and remove the nut, washer, bearing, spacer, and pulley (O).

9. Remove the 4 screws from the bearing end cap (G) and remove the cap.

10. Pry the washer locking tab from the slot in the upper circular nut (H) and remove the nut, washer, and spacer, but hold the bearings in place.

11. Replace the bearing end cap (G) to prevent the set of bearings in the joint from falling out. If the bearings are removed, they should be installed so that the inner surfaces of each bearing face each other. The inner side of the bearing is the side with the largest opening between the races.

12. Remove the electrical connectors (I) from the motor-encoder casing.

13. Remove the screws holding the Theta 2 duct bracket (J) to the joint.

14. Move the bracket out of the way.

15. Remove the four screws holding the DC motor assembly (K) to the joint.

16. Remove the motor ("jiggle" the Theta 2 arm while lifting the motor to free the wave generator from the flexspline).

17. Remove the taper pin (L) and 3 cap screws (M) that hold the Theta 2 arm to the Theta 2 arm shaft. To remove the taper pin, insert a roll punch on the opposite side of the pin and tap it with a hammer.

Note: To avoid damage to the threads on the shaft, temporarily replace the lower circular nut (F) and position a small block against the nut on which to tap.

18. While holding the Theta 2 arm, tap the bottom of the harmonic shaft (N) to loosen the flexspline; then remove the circular nut.

19. Remove the harmonic shaft from the top of the joint, being careful not to damage the seal in the bottom of the joint.

3032 THETA 2 ARM AND HARMONIC SHAFT REPLACEMENT

1. Place the Theta 2 arm in position and insert the harmonic shaft (N) through the circular spline, the Theta 2 arm, and the lower bearing sets, being careful not to damage the seal. Ensure that the taper pin hole in the shaft is properly aligned with the hole in the Theta 2 arm. The shaft may require tapping with a hammer to fully seat it into position. Use a 0.5-inch diameter pin to tap on the center of the shaft.

2. Replace the taper pin (L) and cap screws (M) in the Theta 2 arm.

   Note: It is important that the taper pin be fully seated into the hole in the harmonic shaft to remove all play in the arm. Also, if a new harmonic shaft or Theta 2 arm is being installed, a new hole must be drilled in the shaft and the Theta 2 arm and a new taper pin installed. The new hole can be drilled above or below the original hole.

3. Remove the bearing end cap (G) replaced in step 9 of the removals procedure, taking care that the bearings do not fall out.

4. Replace the upper circular nut (H) and washer on the bottom of the shaft.

   Note: Place the key on the inner part of the washer in the slot on the shaft.

5. Tighten the nut until snug; then line up one of the tabs on the washer with slot on the nut and bend it into the slot.

6. Replace the bearing end cap (G).

7. Place the driven pulley (O) and bearing on the shaft.

8. Replace the spacer and the washer, with the inner key in the slot on shaft, and replace the circular nut (F). Tighten the nut until snug; line up one of the locking tabs on the washer with a slot on the nut and the tab into the slot.

9. Slide the drive belt over the driven pulley (O) and locate the adj screw midway between the pulleys.

   Note: This is only a preliminary setting. Final adjustment should b after completing this replacement procedure.

10. Place the driven belt (D) around the tension pulley and the Roll Axis pulley. Hold the belt in place on the lower pulley (P) while replacing the lower pulley on the harmonic shaft.

11. Replace the four pulley mounting screws (C).

12. Perform the drive belt adjustment (4011).

13. Perform the driven belt adjustment (4012).

14. Close the oil drain plug (A) and fill the crankcase with oil.

    Note: The recommended oil to use is IBM No. 10 or equivalent.

15. Position the Theta 2 motor assembly (K) over the joint and slide the wave generator onto the flexspline.

16. "Jiggle" the Theta 2 arm while pushing down on the motor to seat it properly.

17. Replace the four screws that hold the motor to the joint.

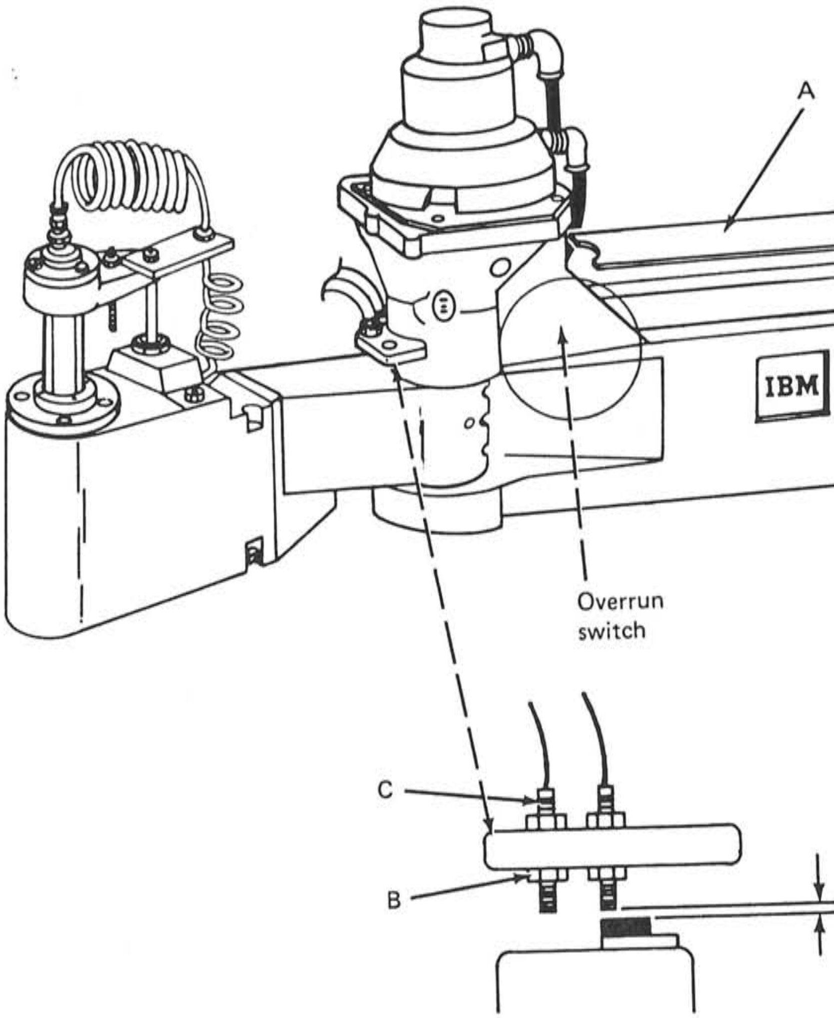
18. Replace the duct bracket (J) and screws on the joint.

19. Replace the electrical connectors (I) on the motor and encoder.

20. Perform the following adjustments:

    - Theta 2 home switch (4008)
    - Theta 2 minus overrun switch (4010)
    - Theta 2 home position (4006)
    - Roll axis home position (4013)

Theta 2 Home and Overrun Switches



3033 THETA 2 HOME AND OVERRUN SWITCHES REMOVAL

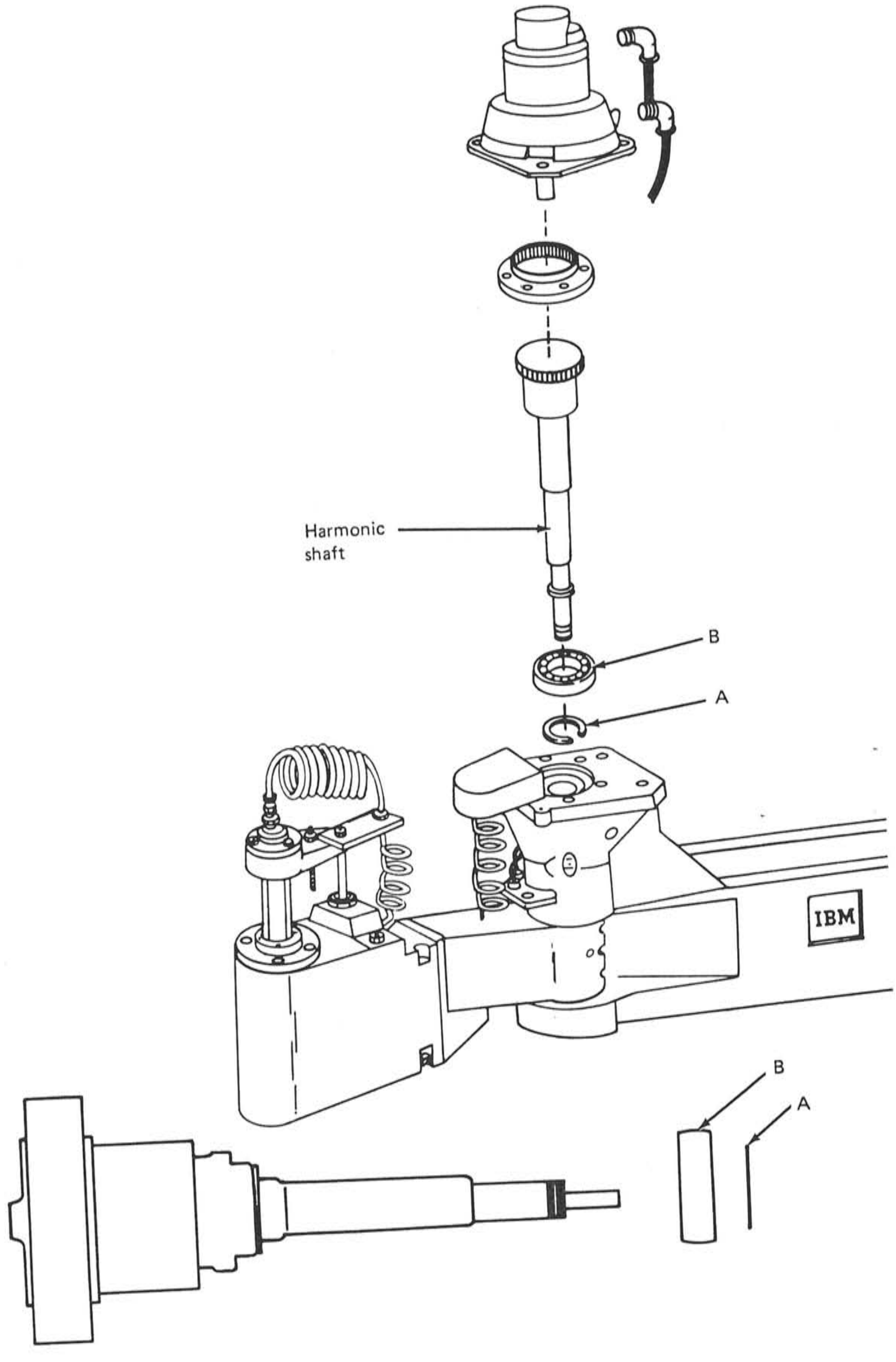
1. Power off the system before entering the workspace.
2. Remove the four mounting screws that hold the dustcover plate (A) to the Theta 1 arm.
3. Trace the wires of the switch being removed to their connector; then cut the nylon ties holding the connector and wires.
4. Disconnect the switch wires from the connector.
5. Remove the bottom nut (B) on the selected switch.
6. Slide the switch (C) out of the joint.

3034 THETA 2 HOME AND OVERRUN SWITCHES REPLACEMENT

1. Replace the switch wires into the connector.
2. Replace the switch (C) into position.
3. Replace the bottom nut (B) on the switch.
4. Secure the switch wires to the cables and air lines.
5. Adjust the switch for the correct clearance of 0.65 mm ± 0.15 mm (0.026 in. ± 0.006 in.) between the magnet and the switch.

   Note: In the next step, ensure that the rubber grommets are in position in the cutouts to protect the wiring.
6. Replace the dust cover plate (A), keeping the end with the deeper cutout closer to the Theta 1 axis. Replace the four mounting screws.
7. Check the Theta 2 home position adjustment (4006).

Theta 1 or Theta 2 Inner Bearing



3035 THETA 1 OR THETA 2 INNER BEARING REMOVAL

1. Remove the harmonic shaft of the inner bearing to be removed. Use the harmonic shaft removal procedure for 7535 (3029) or for 7540 (3031).

2. Remove the retaining ring (A) that holds the bearing to the shaft.

3. Slide the inner bearing (B) off the shaft.

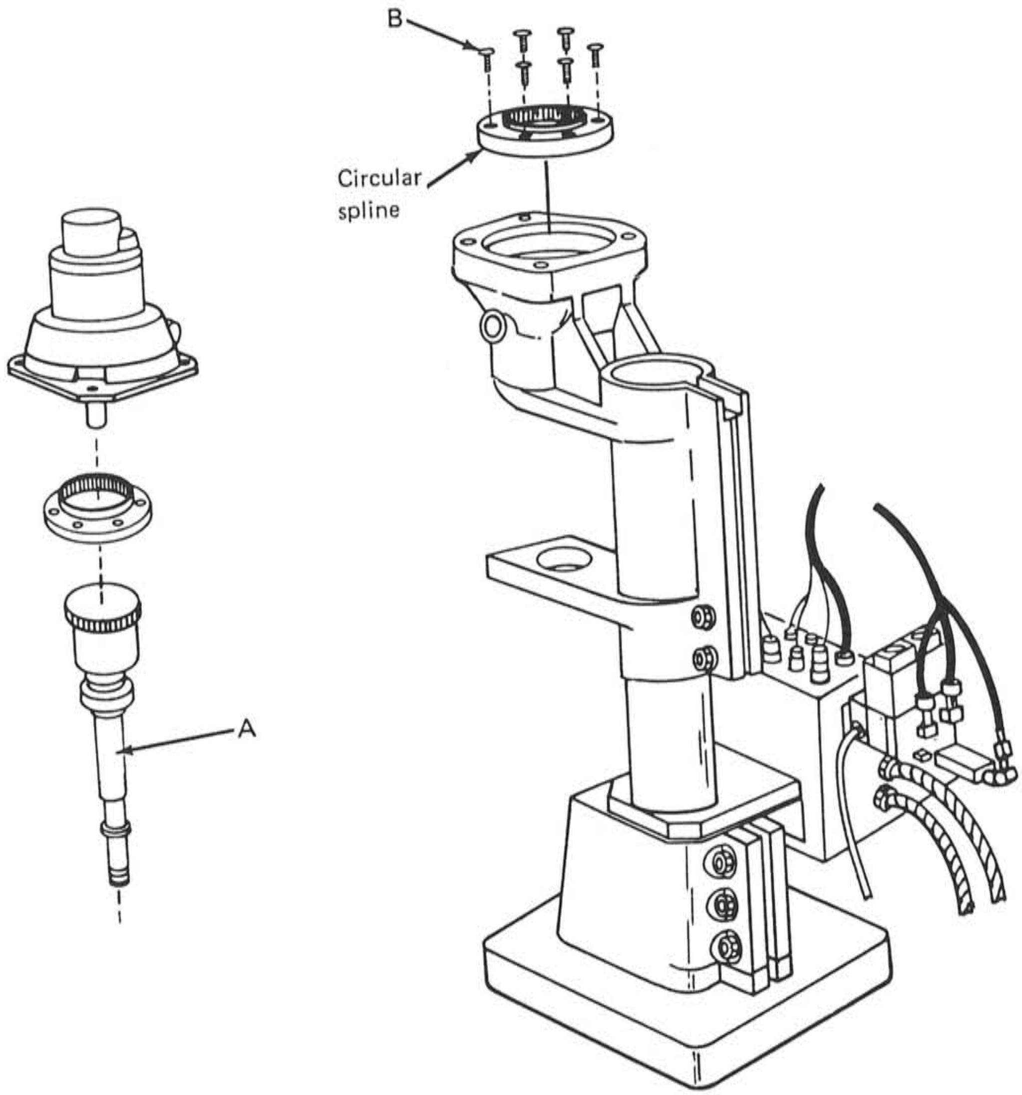
3036 THETA 1 OR THETA 2 INNER BEARING REPLACEMENT

1. Slide the inner bearing (B) onto the shaft.

2. Replace the retaining ring (A).

3. Replace the harmonic shaft. Use the harmonic shaft replacement procedure for Theta 1 (3030) or Theta 2 (3032).

Theta 1 or Theta 2 Circular Spline



3037 THETA 1 OR THETA 2 CIRCULAR SPLINE REMOVAL

1. Remove the harmonic shaft (A) associated with the circular spline to be replaced. Use the harmonic shaft removal procedure (3029) for 7535 or (3031) for 7540.

2. Remove the six screws (B) that mount the circular spline to the joint.

3. Remove the circular spline from the joint.

   Note: The circular spline has a tight fit within the joint and may require a puller to remove. Be careful not to damage the teeth on the inner portion of the part.

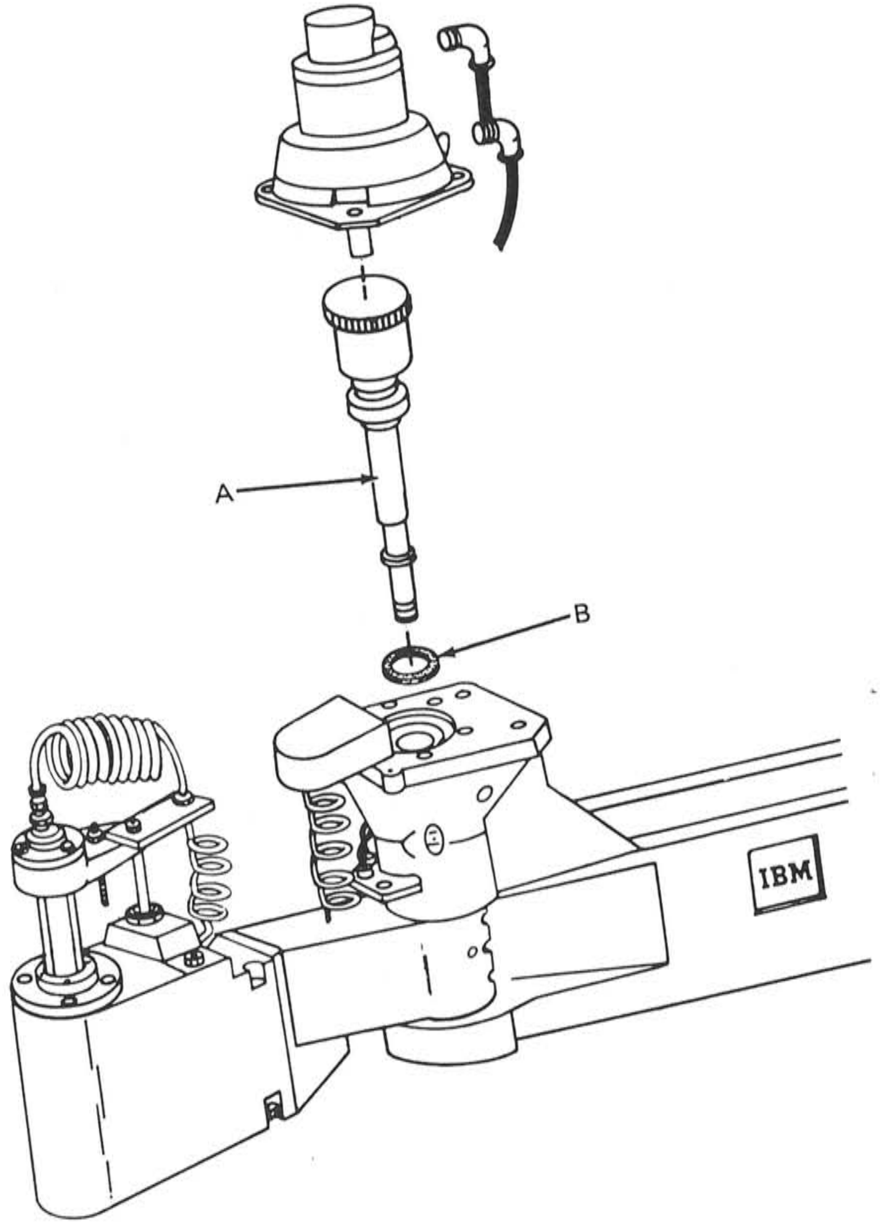
3038 THETA 1 OR THETA 2 CIRCULAR SPLINE REPLACEMENT

1. Replace the circular spline in the joint.

2. Replace the six mounting screws (B).

3. Replace the harmonic shaft (A). Use the harmonic shaft replacement procedure for Theta 1 (3030) or Theta 2 (3032).

Theta 1 or Theta 2 Inner Oil Seal



3039 THETA 1 OR THETA 2 INNER OIL SEAL REMOVAL

1. Remove the harmonic shaft (A) associated with the seal to be replaced. Use the harmonic shaft removal procedure for 7535 (3029) or for 7540 (3031).

   Note: The seal is pressed into the joint and should only be removed if it is to be replaced.

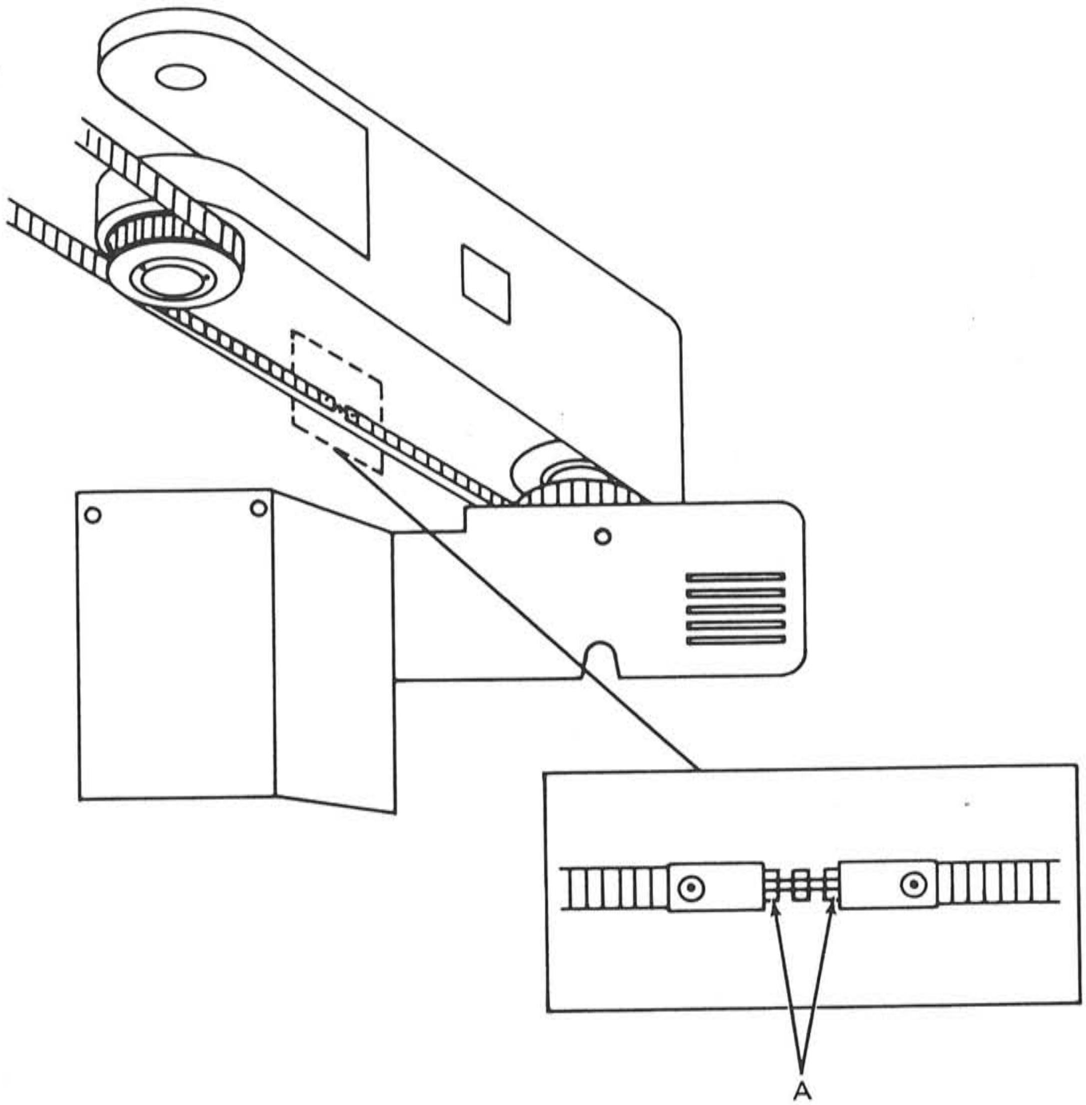
2. Force the seal (B) up out of the joint from below.

3040 THETA 1 OR THETA 2 INNER OIL SEAL REPLACEMENT

1. Lightly lubricate the new seal (B).

2. Press the new seal into the joint (flat side down).

3. Replace the harmonic shaft (A). Use the harmonic shaft replacement procedure for Theta 1 (3030) or Theta 2 (3032).


A

3041 ROLL AXIS DRIVE BELT REMOVAL

1. Return the manipulator to its home position.

   Note: Avoid moving the arms during this procedure.

2. Power off the system before entering the workspace.

3. Loosen the lock nuts (A) on the drive belt adjusting screw.

   Note: The lock nut on the right has reverse threads.

4. Turn the adjusting screw until it is unscrewed at one end.

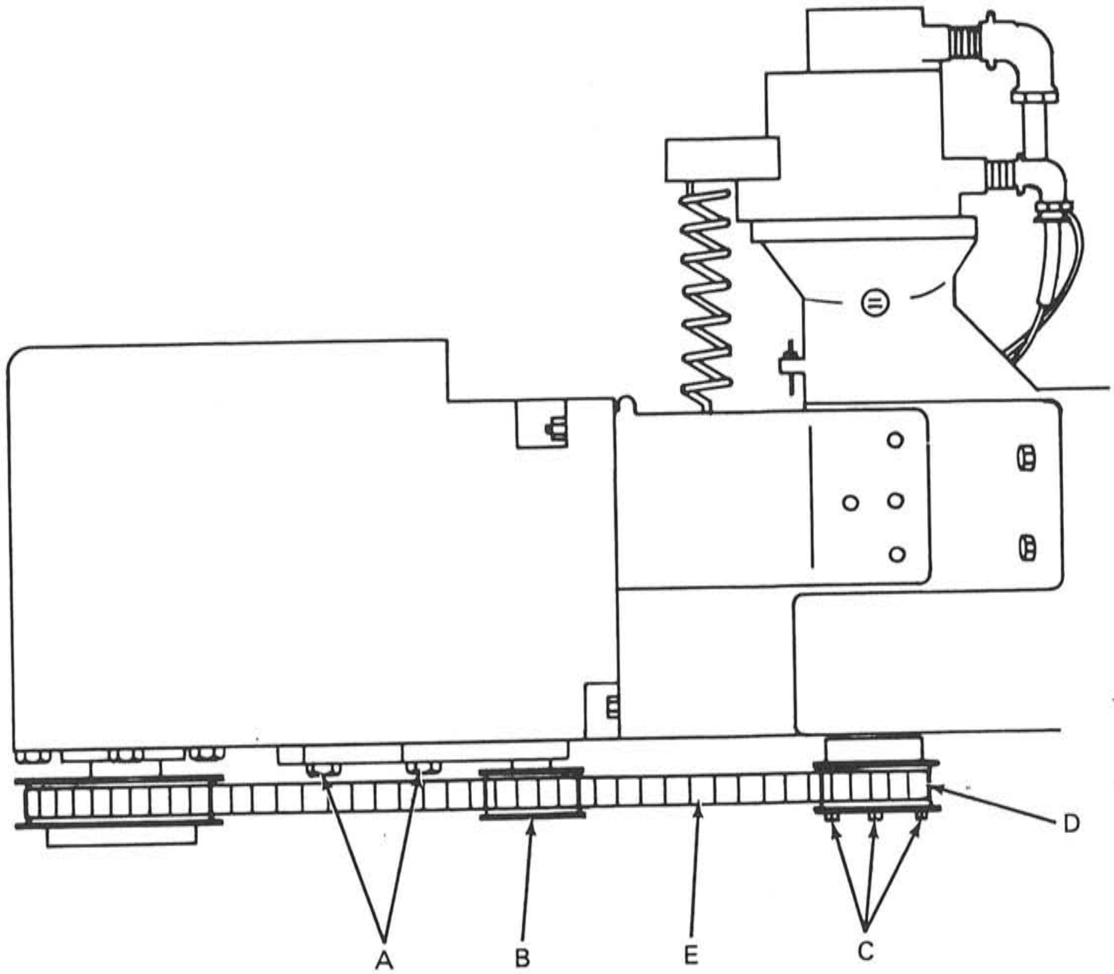
5. Remove the drive belt.

3042 ROLL AXIS DRIVE BELT REPLACEMENT

1. Install the belt loosely.

2. Refer to the drive belt adjustment procedure (4011), and then to the roll axis home position adjustment procedure (4013).

Roll Axis Driven Belt



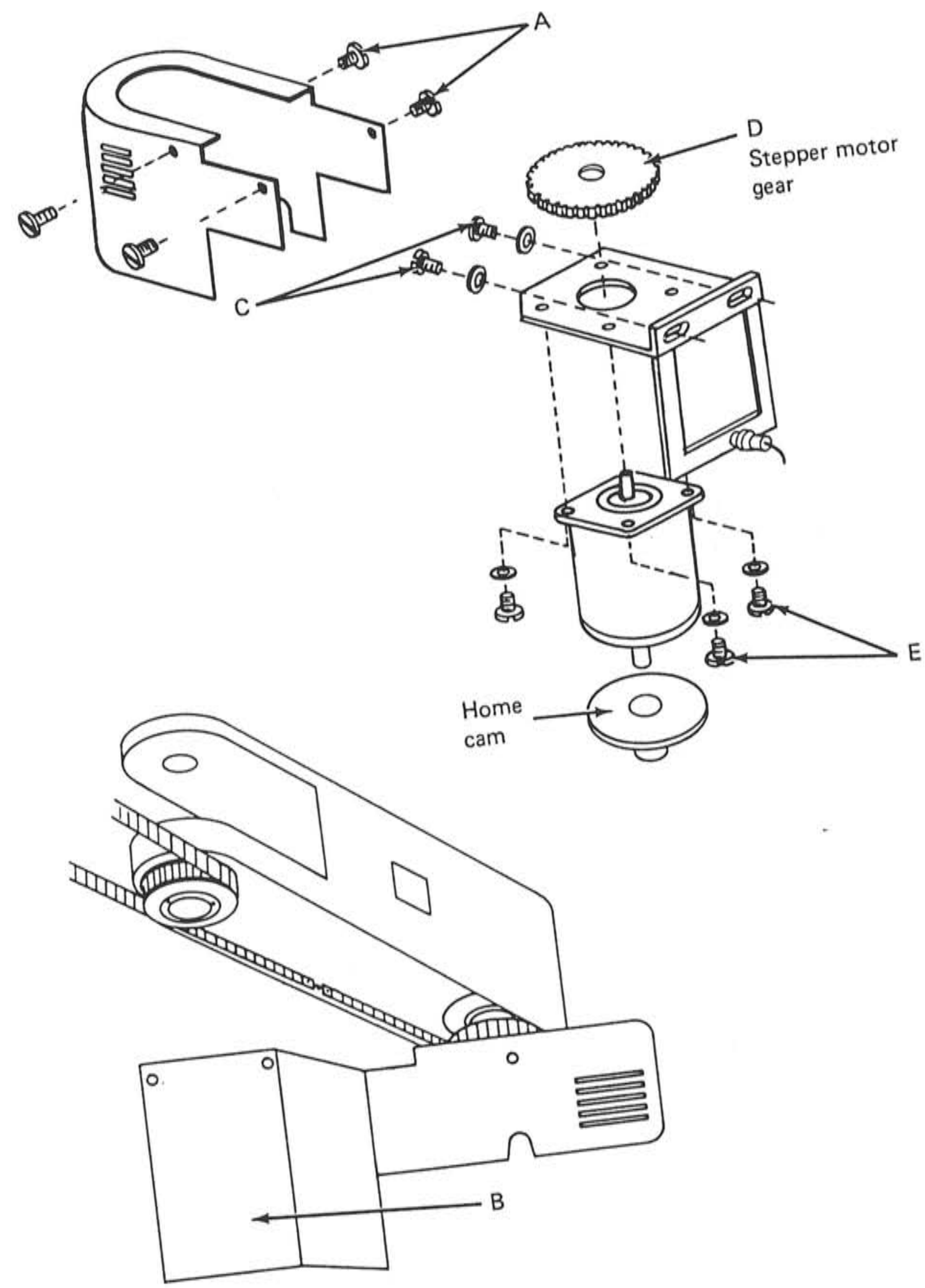
3043 ROLL AXIS DRIVEN BELT REMOVAL

1. Power off the system before entering the workspace.
2. Loosen the tension pulley adjustment screws (A).
3. Move the tension pulley (B) away from the belt.
4. Remove the four Theta 2 pulley mounting screws (C).
5. Remove the Theta 2 pulley (D).
6. Remove the driven belt (E) off the Z-shaft and tension pulleys.

3044 ROLL AXIS DRIVEN BELT REPLACEMENT

1. Place the belt (E) on the pulleys and install the Theta 2 pulley (D).
2. Replace the four Theta 2 pulley mounting screws (C).
3. Refer to the driven belt adjustment procedure (4012)

Stepper Motor



3045 STEPPER MOTOR REMOVAL

1. Return the manipulator to its home position.

   Note: Avoid moving the arms during this procedure.

2. Power-off the system before entering the workspace.

3. Remove the four screws (A) mounting the stepper motor cover and remove the cover.

4. Remove the cover to the connector box (B).

5. Remove the electrical connector for the stepper motor (CN1H).

6. Remove the two mounting screws (C) that hold the motor assembly to the joint and remove the motor and bracket.

7. Loosen the two setscrews holding the stepper motor gear (D) and remove the gear.

8. Remove the four stepper motor mounting screws and washers (E).

9. Remove the stepper motor.

   Note: When replacing a stepper motor, the home cam must be removed from the old motor and installed in the same position on the new one.

3046 STEPPER MOTOR REPLACEMENT

1. Replace the four stepper motor mounting screws and washers (E).

2. Replace the gear (D) and tighten the setscrews.

   Note: Before placing the stepper motor into position in the next step, ensure that the turnbuckle on the drive belt is approximately centered between the pulleys and the arms are at their home positions. This is only a preliminary setting.

3. Place the motor bracket on the joint and replace the two mounting screws (C). Install the motor so that the gear setscrews are accessible for a later adjustment.

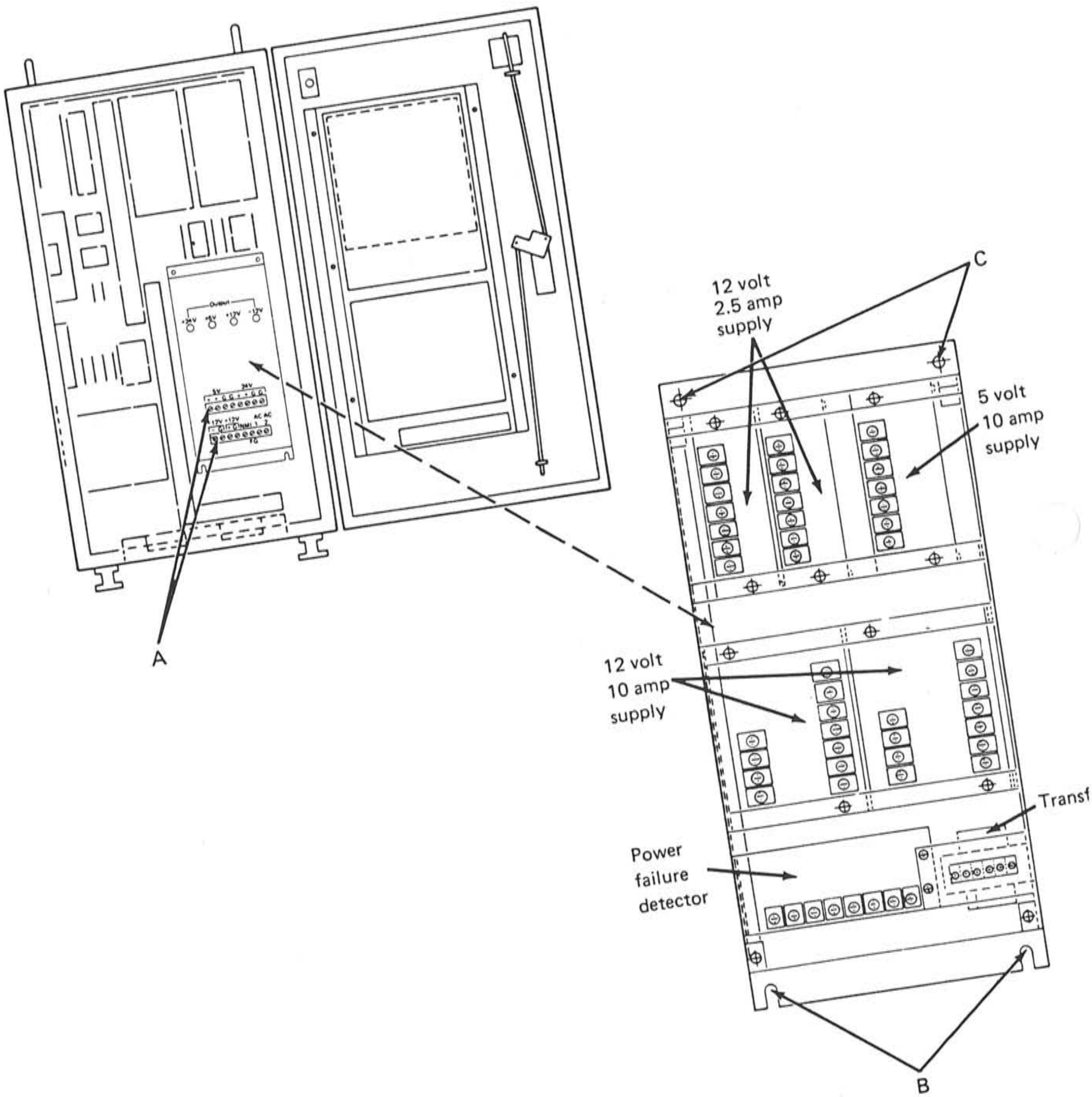
4. Adjust the motor bracket left or right for a minimum clearance, without binding, between the gear teeth of the two gears and tighten the screws (C).

5. Replace the electrical connector CN1H.

6. Replace the cover (B) to the connector box.

7. Perform the roll axis home position adjustment procedure (4013).

DC Power Supply Modules



3047 DC POWER SUPPLY MODULE AND PF MODULE REMOVAL

1. Turn off controller power.
2. Remove the wires to the power supply assembly terminals (A).
3. Loosen, but do not remove, the bottom two mounting screws (B) of the power supply assembly.
4. Remove the top two mounting screws (C) of the power supply assembly.
5. Remove the power supply assembly from the controller.
6. Remove the two screws securing the power supply assembly door.
7. Locate the module to be removed.
8. Label and remove the terminal connectors.
9. Remove the screws mounting the upper and lower module retaining bars; remove the bars.
10. Remove the rear outside module mounting screws.
11. Remove the module.

3048 DC POWER SUPPLY MODULE AND PF MODULE REPLACEMENT

1. Place the module into position.
2. Replace the rear outside mounting screws.
3. Replace the upper and lower retaining bars and their mounting screws.
4. Replace the terminal connectors as labeled.
5. Replace the power supply assembly by placing the slots in the bottom of the power supply over the two mounting screws (B).
6. Install the two top mounting screws (C) and tighten all four screws.

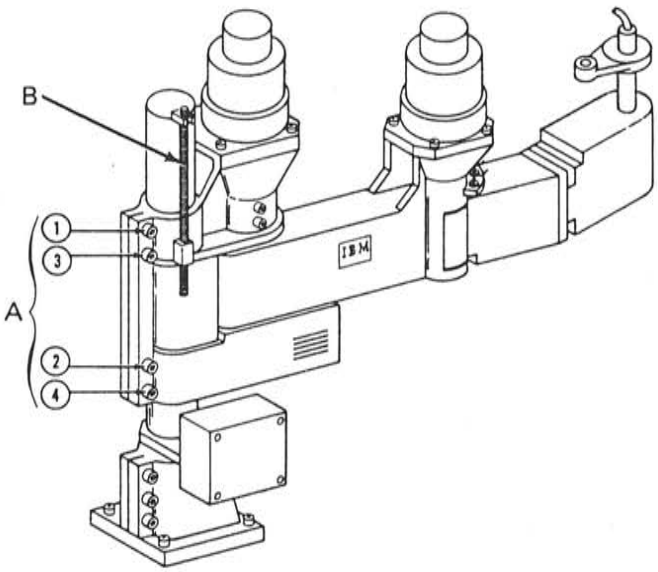
   Note: The wires to the power supply assembly are labeled. The AC wires should be connected with H3 to AC-1 and N3 to AC-2.

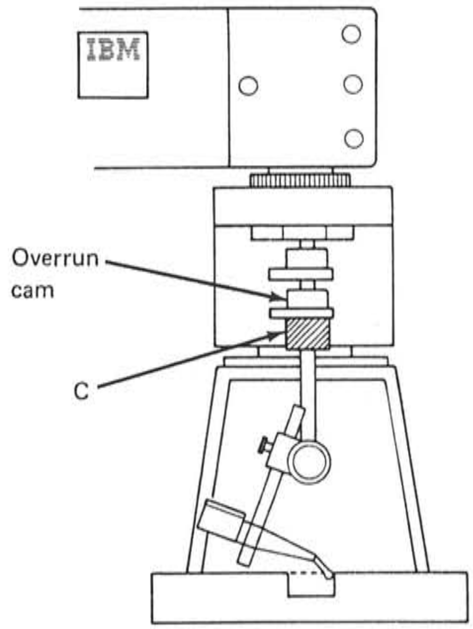
7. Attach the wires to the power supply assembly terminals (A).

NOTES

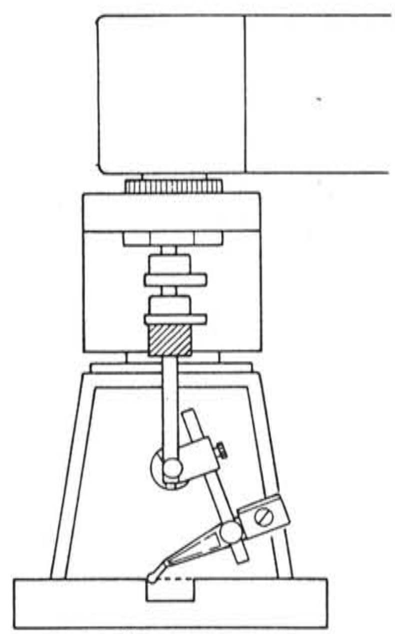
- If you are not familiar with the safety notices located in the front of this manual, you should review them before proceeding.
- Use of the terms clockwise (CW) and counterclockwise (CCW) motion are made with reference to a top view of the machine.

Theta 1 Axis Alignment





Home position


180° from home

4001 THETA 1 AXIS ALIGNMENT

1. Power off the system before entering the workspace.

2. Remove the stepper motor and bracket (3045).

3. Attach a magnetic base dial indicator (C) to the bottom of the Theta 1 over-run cam.

4. With the manipulator arm in the home position, place the dial indicator in position to touch the inside of the hole; read the dial.

5. Move the arm 180 degrees and read the dial through the other side of the hole. The readings should be equal.

6. If an adjustment is necessary, loosen the 4 bolts (A) and adjust the arm on the post. Repeat steps 4 and 5 until both readings are the same.

7. Step-tighten the four clamping bolts (A) in the sequence shown. Begin by tightening all bolts to 2 kg/m (12 ft/lb), and then to 4-6 kg/m (29-43 ft/lb) for 7535 or 6-8 kg/m (43-57 ft/lb) for 7540, in the correct sequence.

8. Check the adjustment and repeat if necessary.

9. Remove the magnetic base dial indicator.

10. Replace the stepper motor and bracket (3046).

4002 MANIPULATOR HEIGHT

Caution: Changing this adjustment affects the Theta 1 axis alignment. If it needs to be changed, the Theta 1 and Theta 2 motors should not be removed until this adjustment is correctly reset.

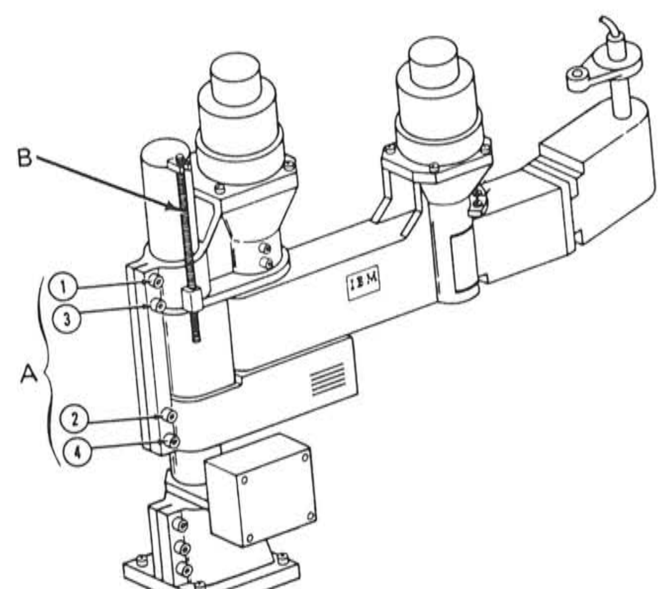
1. Power off the system before entering the workspace.

2. Loosen the four clamping bolts (A) in the arm support.

3. Turn the adjustable bolt (B) to raise or lower the arm in relation to the base.

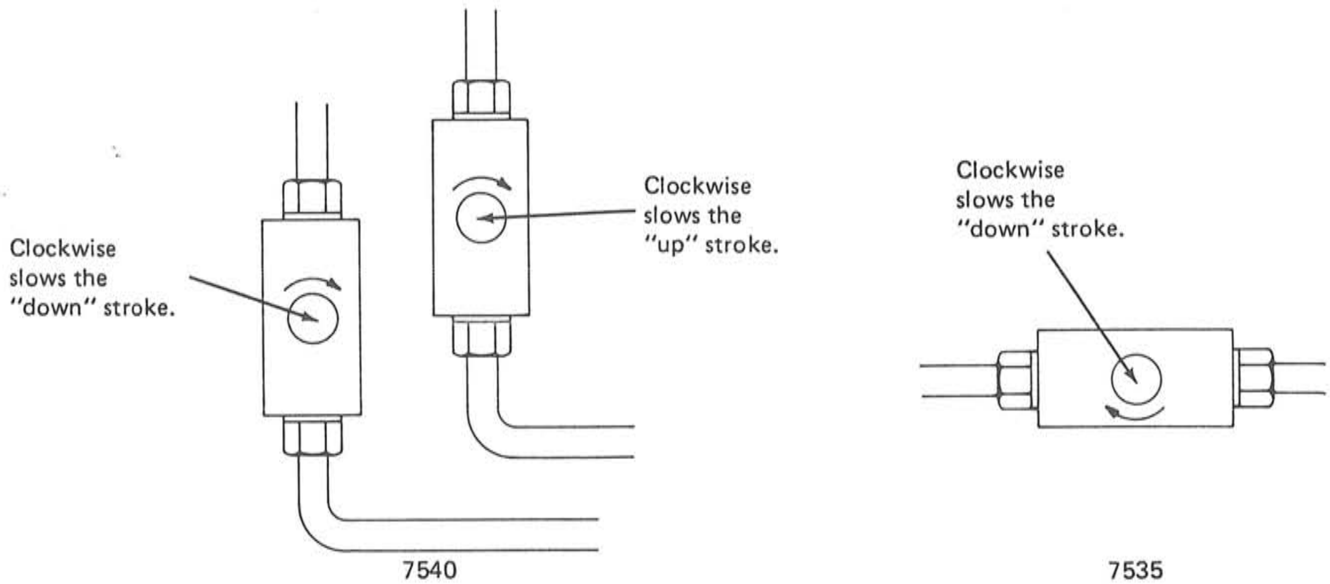
4. Tighten the four clamping bolts snugly, but loose enough so that the manipulator arm can be moved sideways by applying force.

5. Complete the Theta 1 axis alignment procedure (4001).

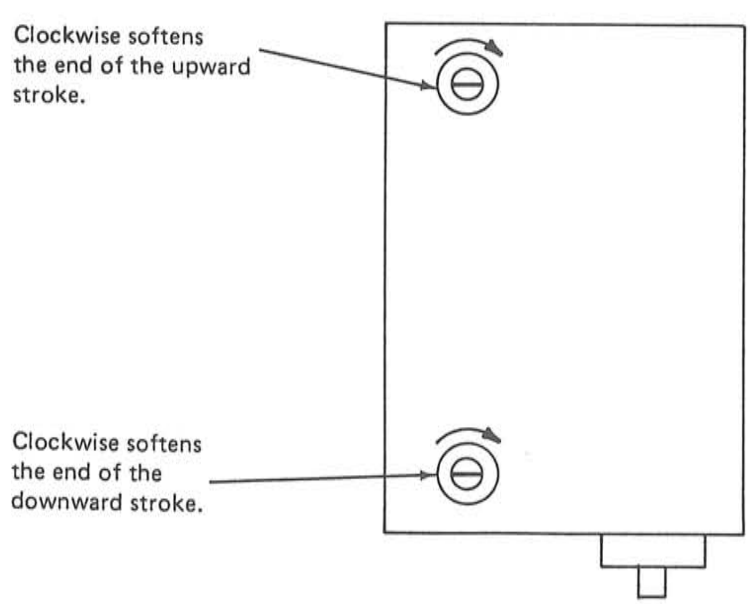


With the proper load on the Z-shaft, turn the speed control knob to adjust for the proper down speed.

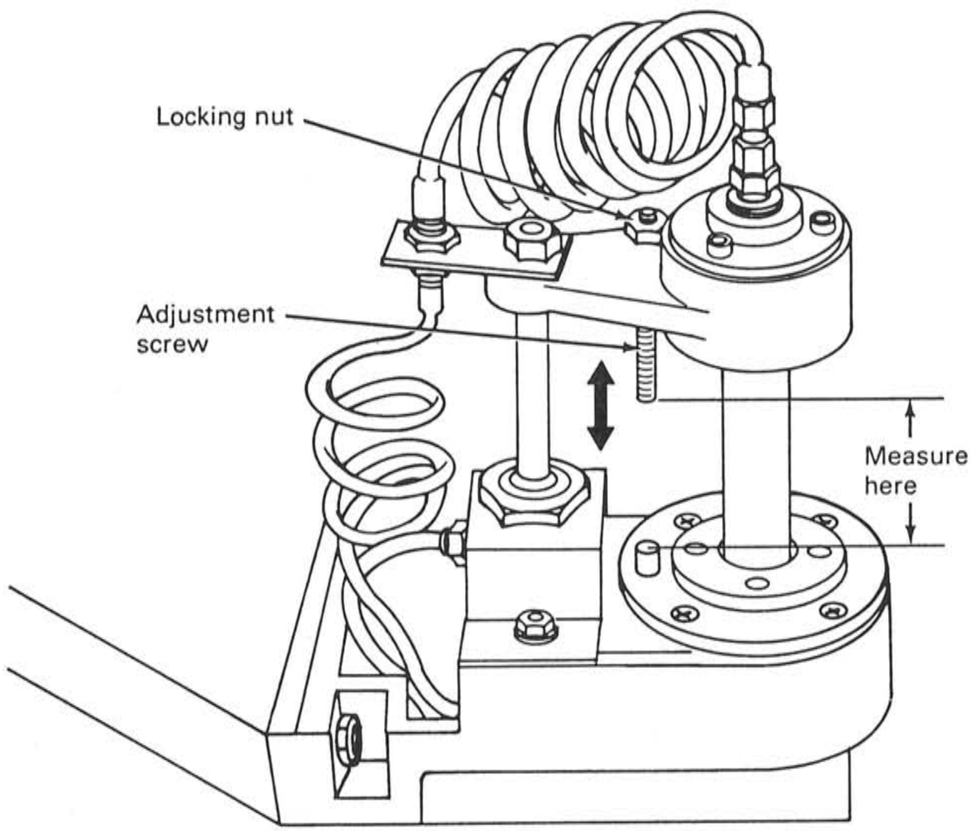
Note: The air pressure supplied to the manipulator should be 80 psi to obtain enough pressure to operate the Z-axis and any attached tools.



The 7540 has an air cushion adjustment for the end of stroke. Adjust as shown below:



Z-Axis Downward Travel



4004 Z-AXIS DOWNWARD TRAVEL

The adjustment screw provides fine adjustment of the downward travel of the Z-axis.

1. Turn off the manipulator power.

2. Measure and record the distance between the bottom of the adjustment screw and the stop. This measurement is used to adjust the bottom sense switch.

3. Turn off the air supply.

4. Push down the Z-shaft.

5. Loosen the locking nut on the adjusting screw.

6. Turn the adjustment screw until the desired height of the Z arm is reached.

7. Tighten the locking nut to hold the adjustment.

8. Turn on the air supply.

9. Measure and record the new distance between the bottom of the adjustment screw and the stop.

10. From the two distance measurements, determine the difference in travel after adjustment.

11. Remove the air cylinder for 7535 (3009) or for 7540 (3019).

    Note: Before loosening the locking screw on the bottom sense switch on the air cylinder, mark the present position of the switch to have a reference point from which to move it.

12. Loosen the locking screw on the bottom sense switch.

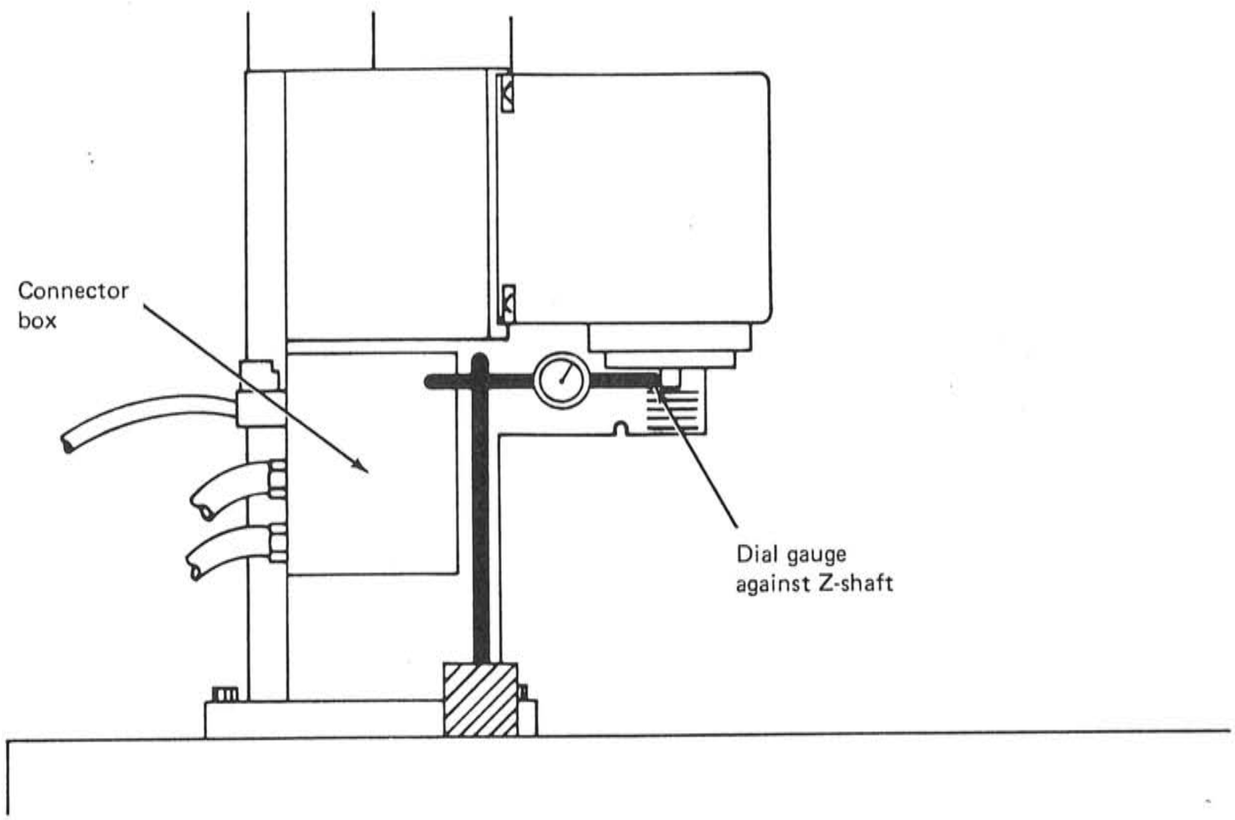
13. Adjust the bottom sense switch the same distance up or down as the difference in the adjustment of the downward travel recorded earlier. If the downward travel was shortened, the switch must be moved up the recorded distance. Conversely, if the travel was increased, the switch must be moved down.

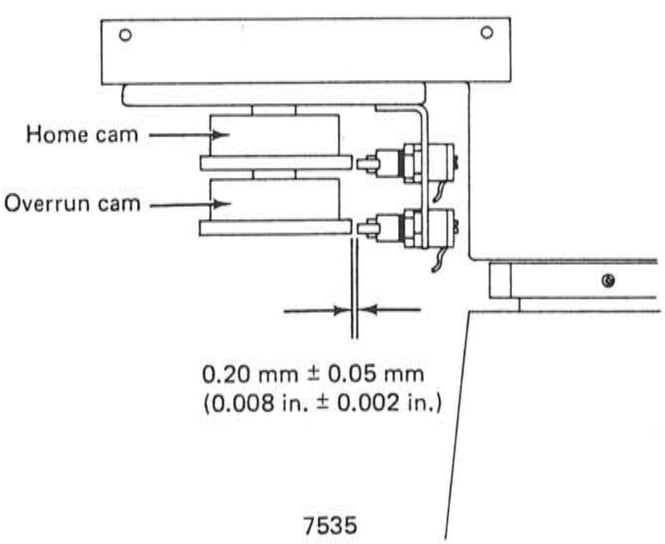
14. Tighten the locking screw on the bottom sense switch.

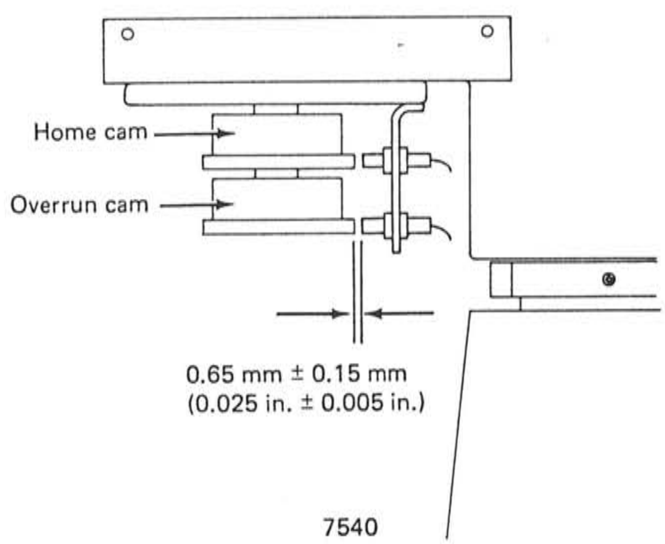
15. Replace the air cylinder for 7535 (3010) or for 7540 (3020).

16. Check the bottom sense switch operation and readjust, if necessary.

Theta 1 Home Position







4005 THETA 1 HOME POSITION

Caution: This adjustment and the Theta 2 home position adjustment should never be disturbed at the same time. The home position should not be changed unless it has already been disturbed because of removal or replacement of parts. If this adjustment needs to be changed, make sure that it is correctly reset before disturbing the Theta 2 adjustment.

Note: The 7540 home and overrun cams must be adjusted to a clearance of 0.65 mm ± 0.15 mm (0.025 in. ± 0.005 in.) between the sensor and the high dwell of the cam before doing this adjustment.

1. Turn off the controller power.
2. Remove the stepper motor cover.
3. Manually move the manipulator arm to its approximate home position.
4. Loosen the overrun cam setscrews and move the overrun cam to its low dwell.
5. Remove the cover from the connector box on the manipulator.
6. Turn on the controller power.
7. Connect a voltmeter, set for +24 Vdc, between pins 1 and 3 on CN10H for 7535 or CN8H for 7540.
8. Loosen the home cam setscrews and adjust the cam clockwise until the meter deflects to about 0 Vdc. Tighten only one setscrew.
9. Position the Theta 1 offset switches off (down). Press the Manip Power key; then press the Return Home key.
10. Mount a dial gauge against the Z-shaft on the Theta 2 arm to measure movement of the arm. Set the dial gauge for a base reading of 1 inch.
11. Press and hold the Theta 1+ key to move the arm away from the gauge about 2 inches.
12. Press and hold the Theta 1- key until the arm stops moving.
13. Read the dial gauge. The correct reading to show proper home cam adjustment is 0.500-inch ± 0.200 inch (0.500 inch travel).

    Note: If the reading is within tolerance, tighten the second setscrew on the home cam and go to step number 19 of this procedure. If it is not within tolerance, continue with the next step.
14. Press the Return Home key on the control panel.
15. Reset the dial gauge for a base reading of 2 inches.
16. Using the Theta 1+ key, move the arm until the dial gauge reads 1.500 inch ± 0.200 inch (0.500 inch travel).

17. Loosen the setscrew on the home cam. Turn the cam CCW until the meter deflects to about 24 Vdc; then clockwise until the meter just defects to 0 Vdc. Tighten the setscrew.

18. Repeat steps 10 through 13.

19. Remove the dial gauge.

    Note: If your system will operate on new application programs, the home position adjustment is accurate enough because the programs are written to new points. Go to step 33. If application programs already exist, continue.

20. Press the Return Home key on the control panel.

21. Find a critical tolerance point setting in an existing program and find its X- and Y-coordinates. Record this information.

22. Attach the IBM Personal Computer to the Controller.

23. Enter Teach Mode and move the arm to the critical point to get the present X- and Y-coordinates of the point.

24. Record the X- and Y-coordinates displayed on the CRT.

25. Load the offset calibration program (OFFSET) in the Personal Computer.

26. Enter the axis key as 1.

27. Enter the X- and Y-coordinates as XXX,YYY with no spaces. Disregard the roll axis.

    Note: If the Theta 1 arm is off in the minus direction, the CRT displays the message "See Maintenance Manual For Home Cam Adjustment." If this happens, go to the "Home Cam Adjustment", on the next page. If not, continue with the next steps.

28. Record the offset switch setting displayed on the CRT.

29. Position the Theta 1 offset switches to correspond with the settings displayed on the CRT (0=open, 1=closed). See "Section 7 - Switch Settings."

30. After setting the switches, press the Return Home key on the Control Panel.

31. Enter teach mode and move the arm to the critical point used earlier. Compare the X-, Y-coordinates shown on the CRT with the PMOVE coordinates of the existing program.

32. If the coordinates are not the same, repeat steps 23 through 31 until the coordinates are equal. As a final check, place the manipulator in Manual Mode and step through the program, ensuring that the arm stops at each critical point in the application program.

33. Press the Return Home key.

34. Adjust the overrun cam so that you can push the end of the Theta 1 arm about 25 mm (1 in.) in the minus direction before the OR LED lights.

Note: Push the Stop pushbutton to move the arm.

35. Tighten the setscrews on the overrun cam.

36. Replace the stepper motor cover.

37. Remove the ohmmeter and replace connector CN8H or CN10H.

Home Cam Adjustment (OFFSET Program Only)

1. Press the Return Home key on the Control Panel.

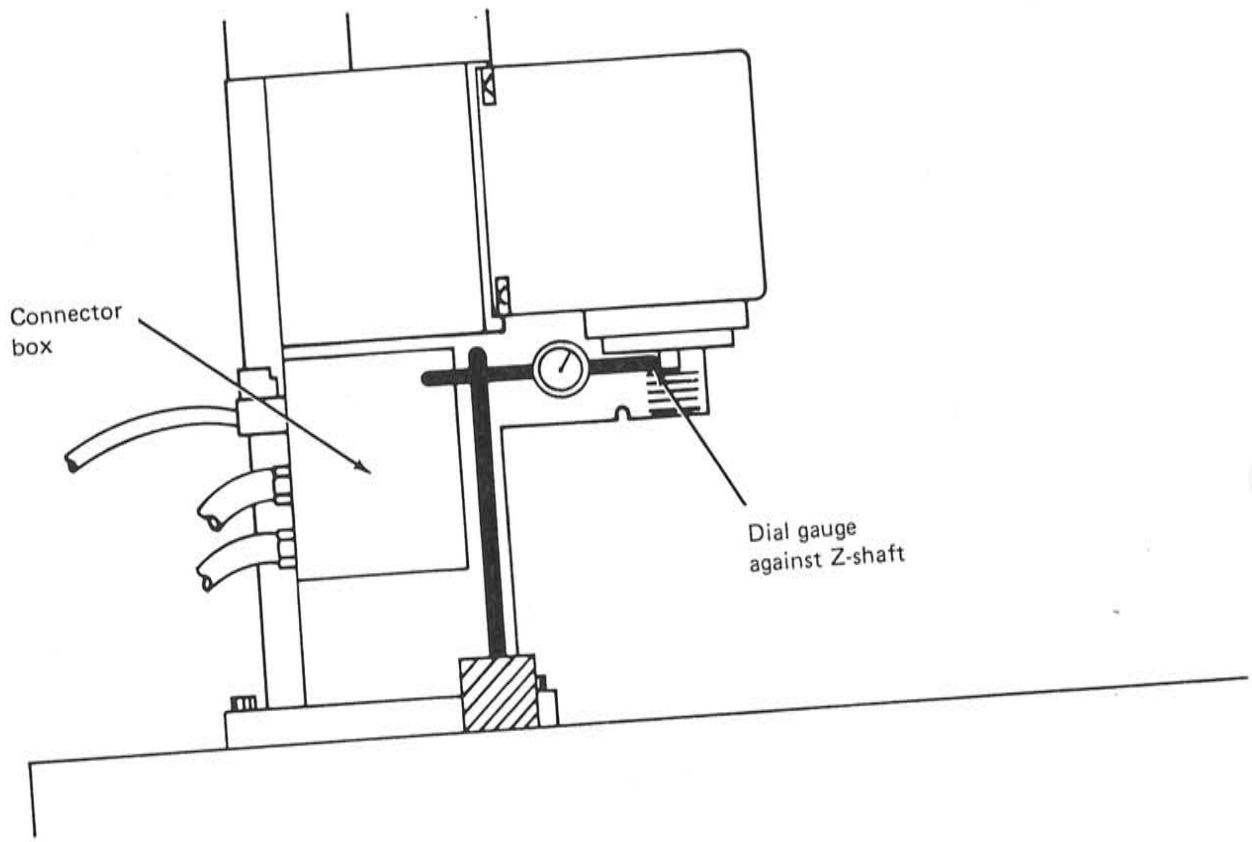
2. Mount the dial gauge against the Z-shaft on the Theta 2 arm to measure movement of the arm. Set the gauge for a base reading of 2 inches.

3. Use the Theta 1+ switch to move the arm 1.5 inches away from home.

4. Loosen the home cam and adjust it so that the home switch or sensor just closes. Tighten the cam.

5. Go to "Theta 1 Home Position" adjustment (4005).

Theta 2 Home Position



4006 THETA 2 HOME POSITION

Caution: This adjustment and the Theta 1 home position adjustment should never be disturbed at the same time. The home position should not be changed unless it has already been disturbed because of removal or replacement of parts. If this adjustment needs to be changed, make sure that it is correctly reset before disturbing the Theta 1 adjustment.

1. Apply power to the manipulator and press the Return Home key.

2. Mount a dial gauge against the Z-shaft on the Theta 2 arm to measure movement of the arm. Set the dial gauge for a base reading of 1 inch.

3. Press and hold the Theta 2+ key to move the arm away from the gauge about 2 inches.

4. Press and hold the Theta 2- key until the arm stops moving.

5. Read the dial gauge. The dial gauge should indicate a movement of 0.345 in. (± 0.200 in.) for a proper home adjustment. If the adjustment is within tolerance, see the following Note to determine the next step. If the adjustment is not within tolerance, continue with the next step.

6. Position the Theta 2 offset switches in the controller to the off (down) position.

7. Press the Return Home key.

8. Press and hold the Theta 2+ key until the dial gauge indicates 0.345 in. of movement.

9. Remove the cover from the connector box located on the manipulator.

10. Connect a voltmeter to CN2H-13 (+) and CN2H-10 (-) and leave the connector plugged in while measuring the voltage.

11. Loosen the home/overrun eccentric setscrew and adjust the eccentric until the switch closes; then tighten the setscrew. If the switch is outside the range of the eccentric go to the "Home Cam Adjustment" on page 4-17.

    Note: If your system will operate on new application programs, the home position adjustment is now accurate enough because the programs are written to new points. If application programs already exist,continue with the next step.

12. Turn on the manipulator power and press the Return Home key.

13. Find a critical tolerance point setting in an existing program and find its X- and Y-coordinates. Record this information.

14. Attach the Personal Computer to the controller.

15. Enter teach mode and move the arm to the critical point to obtain the present X- and Y-coordinates of the point.

16. Record the X- and Y-coordinates as displayed on the CRT.

17. Load the offset calibration program (OFFSET) into the Personal Computer.

18. Enter the axis number key as 2.

19. Enter the X- and Y-coordinates as XXX,YYY with no spaces. Disregard the roll axis.

    Note: If the Theta 2 arm is off in the minus direction, the CRT displays the message "See Maintenance Manual for Home Cam adjustment." If this happens, go to the "Home Cam Adjustment", on the next page. If not, continue with the next step.

20. If the Theta 2 arm is off in the positive direction, the CRT displays the correct switch settings for the Theta 2 offset switches on the motor control board.

21. Position the Theta 2 offset switches to correspond with the settings displayed on the CRT(0=open, 1=closed). See "Section 7 - Switch Settings."

22. After setting the switches, press the Return Home key.

23. Enter teach mode and move the arm to the critical point used earlier. Compare the X-, Y- coordinates shown on the CRT with the PMOVE coordinates of the existing program.

24. If they are not the same, repeat steps 16 through 24 until they are the same.

25. As a final check, place the manipulator in Manual Mode and step through the program, ensuring that the arm stops at each critical critical point in the application program.

26. Turn off the power to the manipulator.

27. Remove the voltmeter and replace the connector box cover.

Home Cam Adjustment (OFFSET Program Only)

1. Carefully remove the Theta 2 motor without turning the motor shaft or changing the position of the arm. Refer to the Theta 2 motor removal procedure (3023).

2. With the motor removed, rotate the motor shaft 1/2 turn in either direction from its present position.

3. Replace the motor on the joint without turning the shaft.

4. Adjust the home/overrun eccentric to its approximate midpoint.

5. Go to "Theta 2 Home Position" adjustment (4006).

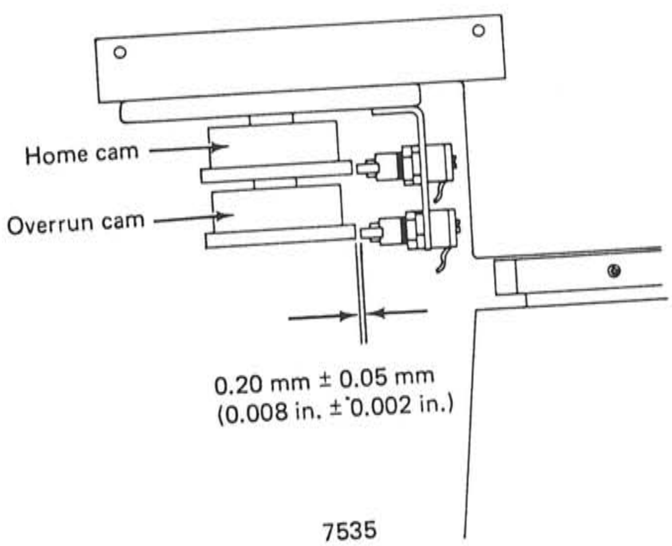
4007 THETA 1 OVERRUN CAM

Notes:

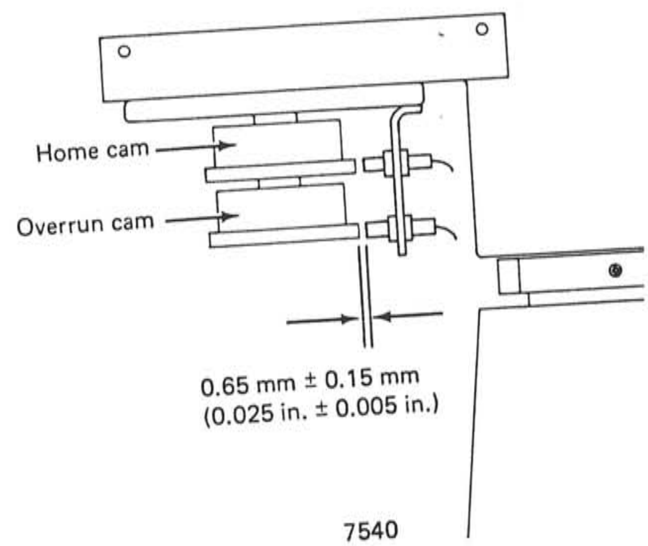
The Theta 1 home position adjustment must be correct before making this adjustment.

The 7540 home and overrun cams must be adjusted to a clearance of 0.65 mm ± 0.15 mm (0.025 in. ± 0.005 in.) between the sensor and the high dwell of the cam before doing this adjustment.

1. With power off, manually position the Theta 1 and Theta 2 arms near their home positions.
2. Remove the stepper motor cover.
3. Turn the manipulator power on.
4. Press the Return Home key; then press the Stop pushbutton.
5. Loosen the overrun cam setscrews.
6. Adjust the overrun cam timing, so that you can push the end of the Theta 1 arm about 25 mm (1 in.) in the minus direction before the OR LED lights.
7. Tighten the setscrews to hold this position.
8. Replace the stepper motor cover.



7535



7540

4008 THETA 2 HOME SWITCH

Note: This adjustment may affect the Theta 2 home position adjustment (4006).

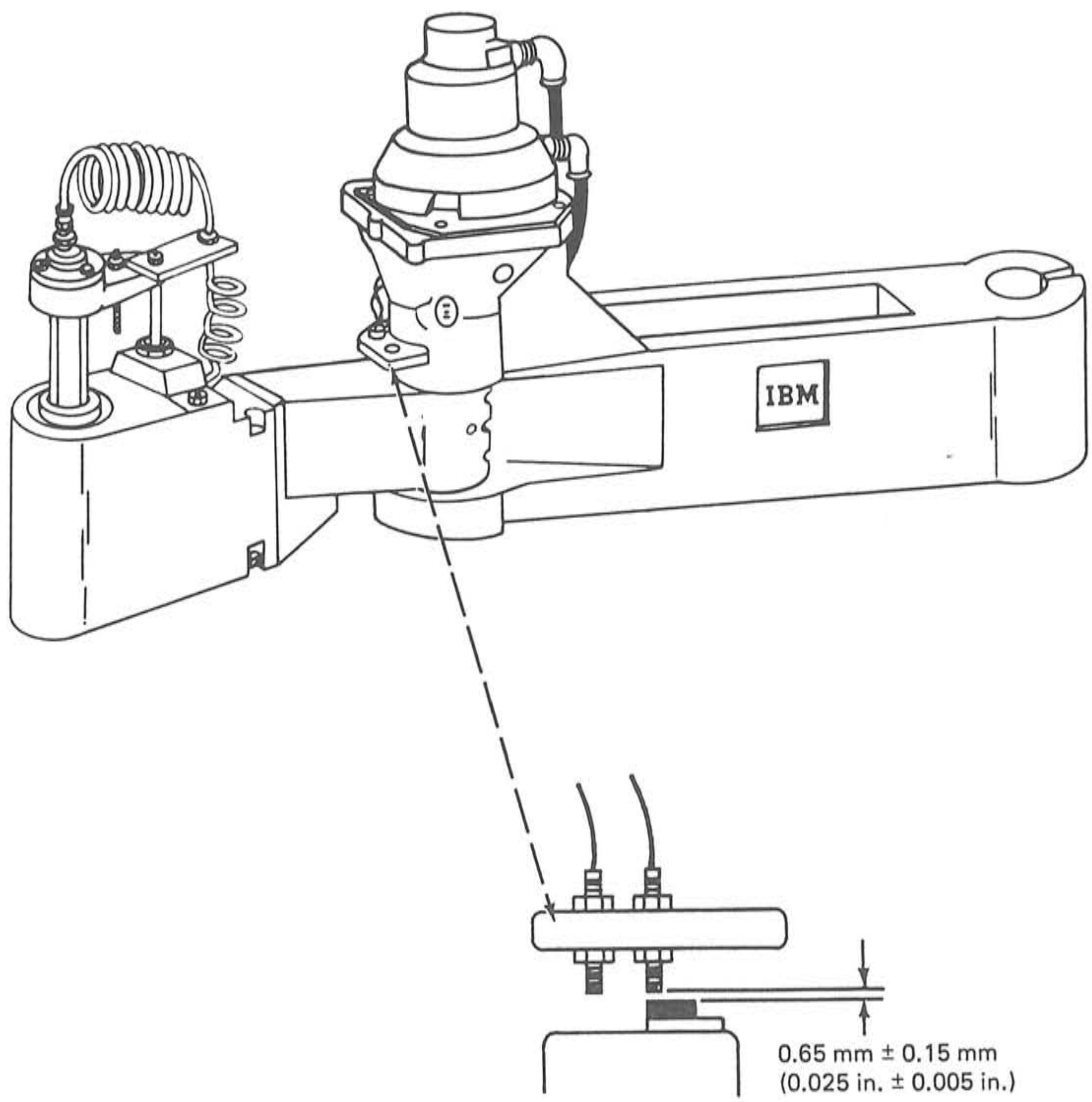
1. Power off the manipulator before entering the workspace.

2. Manually move the Theta 2 arm until the Theta 2 home switch is directly above the home/overrun eccentric.

3. Loosen the locking nuts and adjust the switch up or down to obtain a clearance of 0.65 mm ±0.15 mm (0.025 in. ±0.005 in.) between the switch and the eccentric.

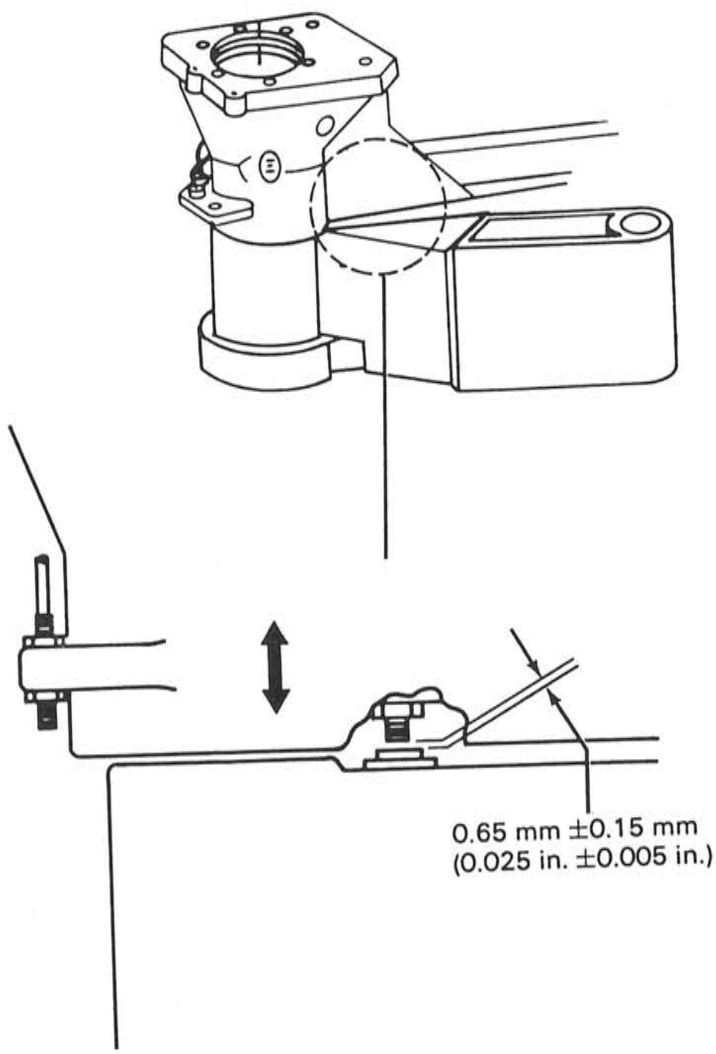
4. Tighten the locking nuts while maintaining the clearance.

5. Check the Theta 2 home position adjustment (4006).



4009 THETA 2 PLUS OVERRUN SWITCH

1. Power off the manipulator before entering the workspace.
2. Manually move the Theta 2 arm in the plus direction (away from home) until the plus overrun switch is positioned over the home/overrun eccentric.
3. Loosen the overrun switch locking nuts.
4. Adjust the switch up or down to obtain a clearance of 0.65 mm ± 0.15 mm (0.025 in. ±0.005 in.) between the switch and the eccentric.
5. Tighten the locking nuts and ensure that the clearance is maintained.



4010 THETA 2 MINUS OVERRUN SWITCH

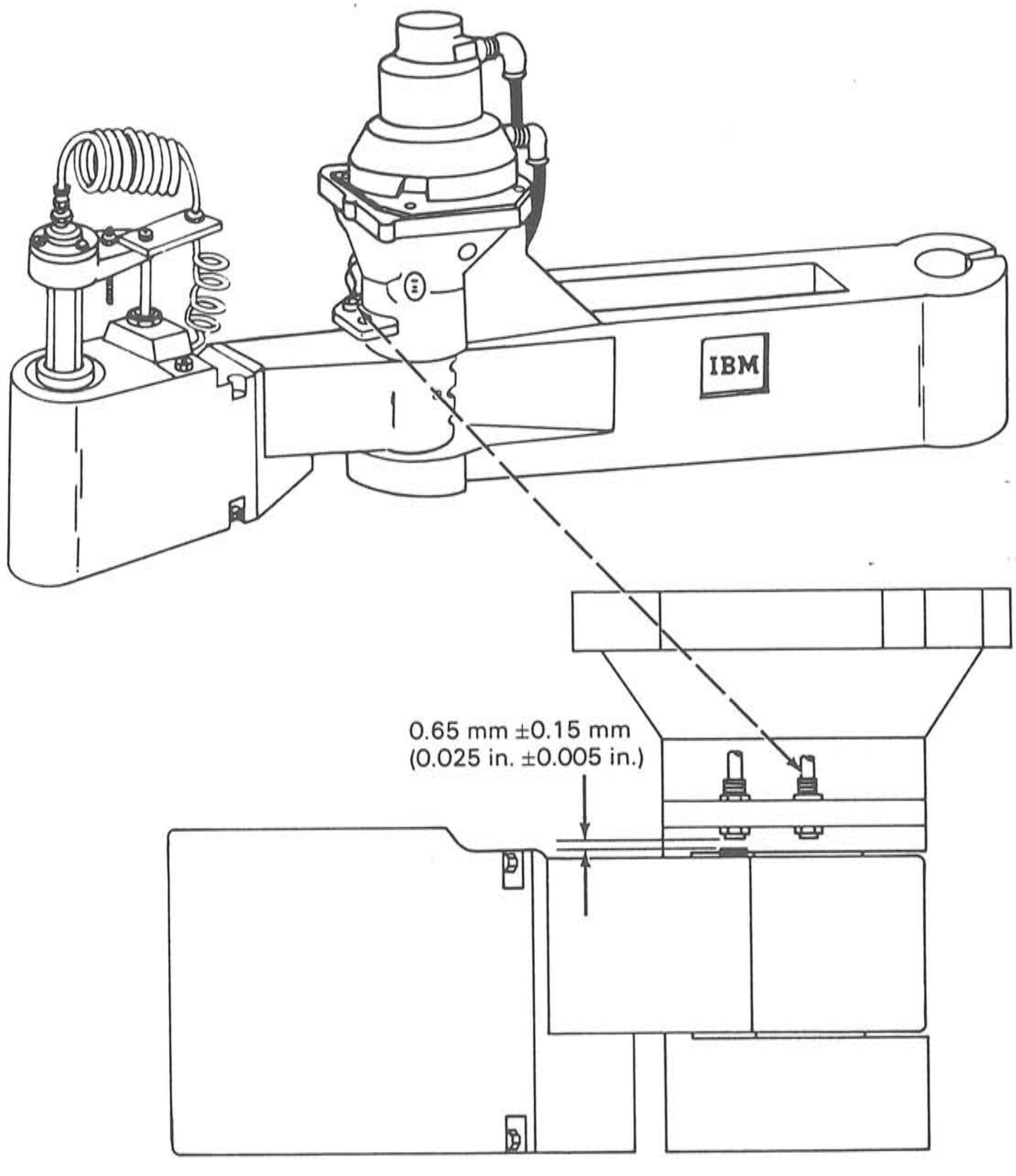
1. Power off the manipulator before entering the workspace.

2. Manually move the Theta 2 arm in the minus direction (toward home) until the minus overrun switch is positioned over the home/overrun eccentric.

3. Loosen the overrun switch locking nuts.

4. Adjust the switch up or down to obtain a clearance of 0.65 mm ± 0.15 mm (0.025 in. ±0.005 in.) between the switch and the eccentric.

5. Tighten the locking nuts and ensure that the clearance is maintained.



4011 ROLL AXIS DRIVE BELT

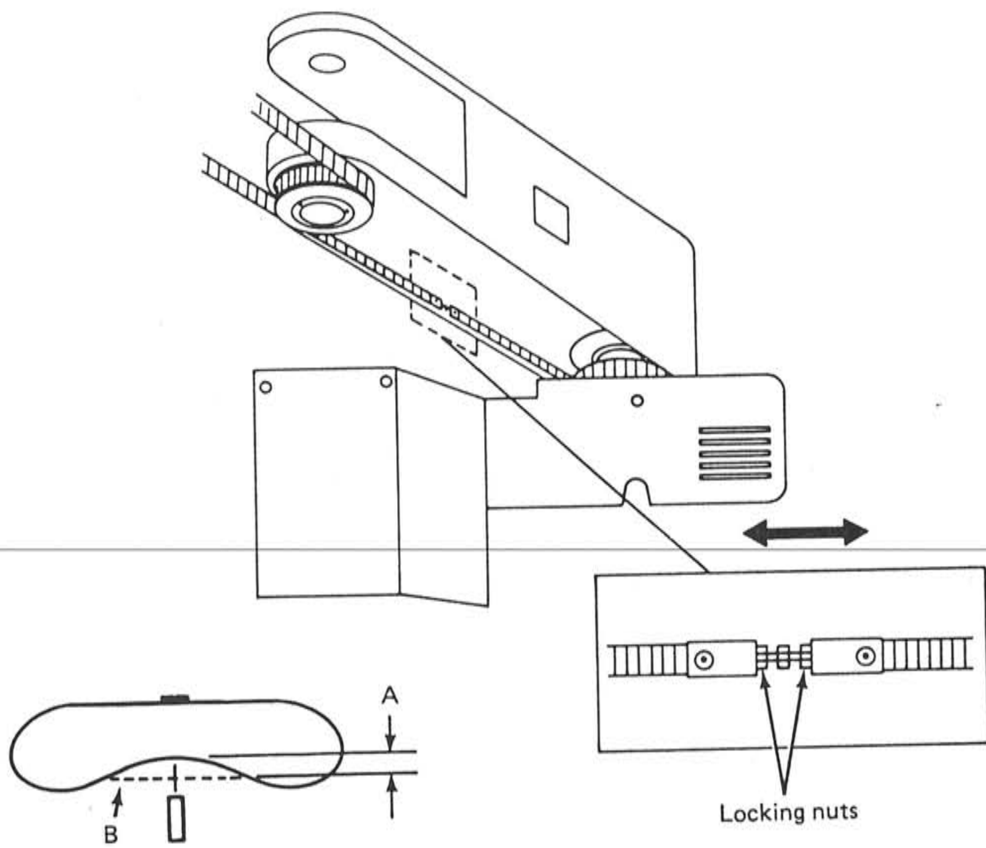
1. Power off the manipulator before entering the workspace.

2. Loosen the locking nuts.

3. Adjust the belt adjusting screw so that the center of the belt is deflected 4 mm (0.158 in.) for 7535 or 3 mm (0.118 in.) for 7540 with 0.3 Kg (0.66 lb.) of force applied to it.

4. Tighten the locking nuts.

Note: Home position for the Roll axis is established when the home sensing magnet is centered over the home sensing switch and the drive belt link is centered between the pulleys. Refer to the Roll axis home adjustment (4013) for further information.



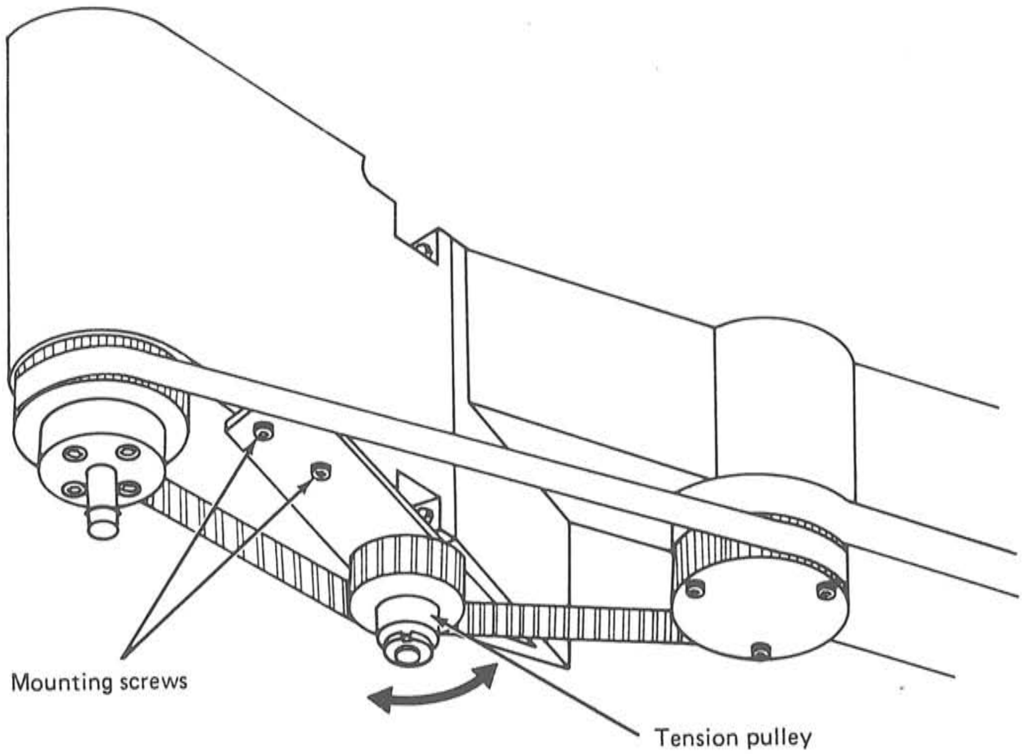
4012 ROLL AXIS DRIVEN BELT

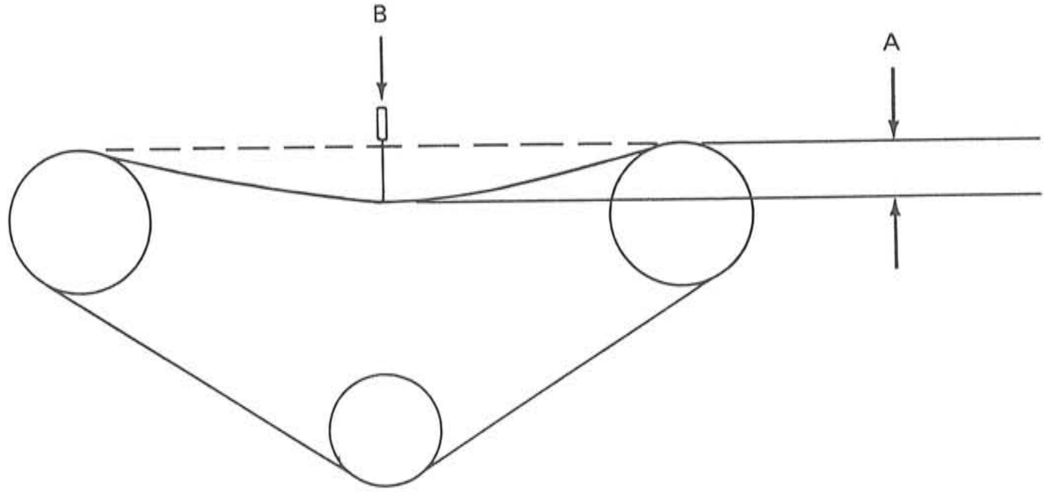
1. Power off the manipulator before entering the workspace.

2. Loosen the mounting screw(s).

3. Adjust the tension plate and pulley so that the belt is deflected 4 mm (0.158 in.) for 7535 or 2 mm (0.079 in.) for 7540 with 0.3 Kg (0.66 lb.) of force applied to it.

4. Tighten the mounting screws





4013 ROLL AXIS HOME POSITION

1. Power off the manipulator before entering the workspace.

2. Remove the stepper motor cover.

3. Loosen the home cam setscrews and adjust the cam for a clearance of 0.5 ± 0.1 mm (0.020 ± 0.004 in.) between the magnet on the cam and the home position switch. Tighten the setscrews.

4. Loosen the stepper motor gear setscrews.

5. Turn on manipulator power and push the Return To Home key.

6. Remove both servo pack fuses to prevent possible arm movements. Avoid disturbing the arm positions.

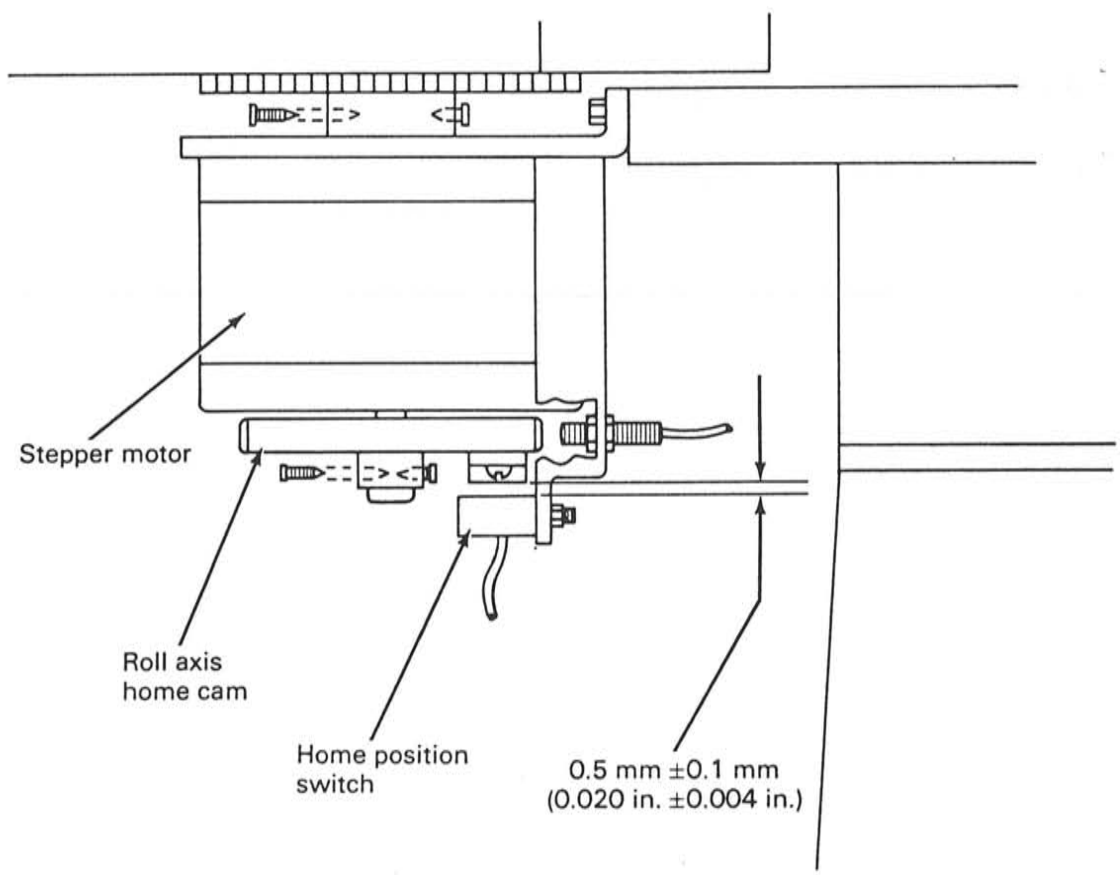
7. Rotate the Z-shaft until the link in the drive belt is centered between its pulleys.

8. Tighten the gear setscrews.

9. Check the adjustment by rotating the Z-shaft both directions until the drive belt link contacts the pulleys. The magnet on the cam should not align with the home position switch at either extremity of rotation.

10. Replace the stepper motor cover.

11. Replace the servo pack fuses.



4014 ROLL AXIS PLUS AREA POSITION SWITCH

1. Power off the manipulator before entering the workspace.

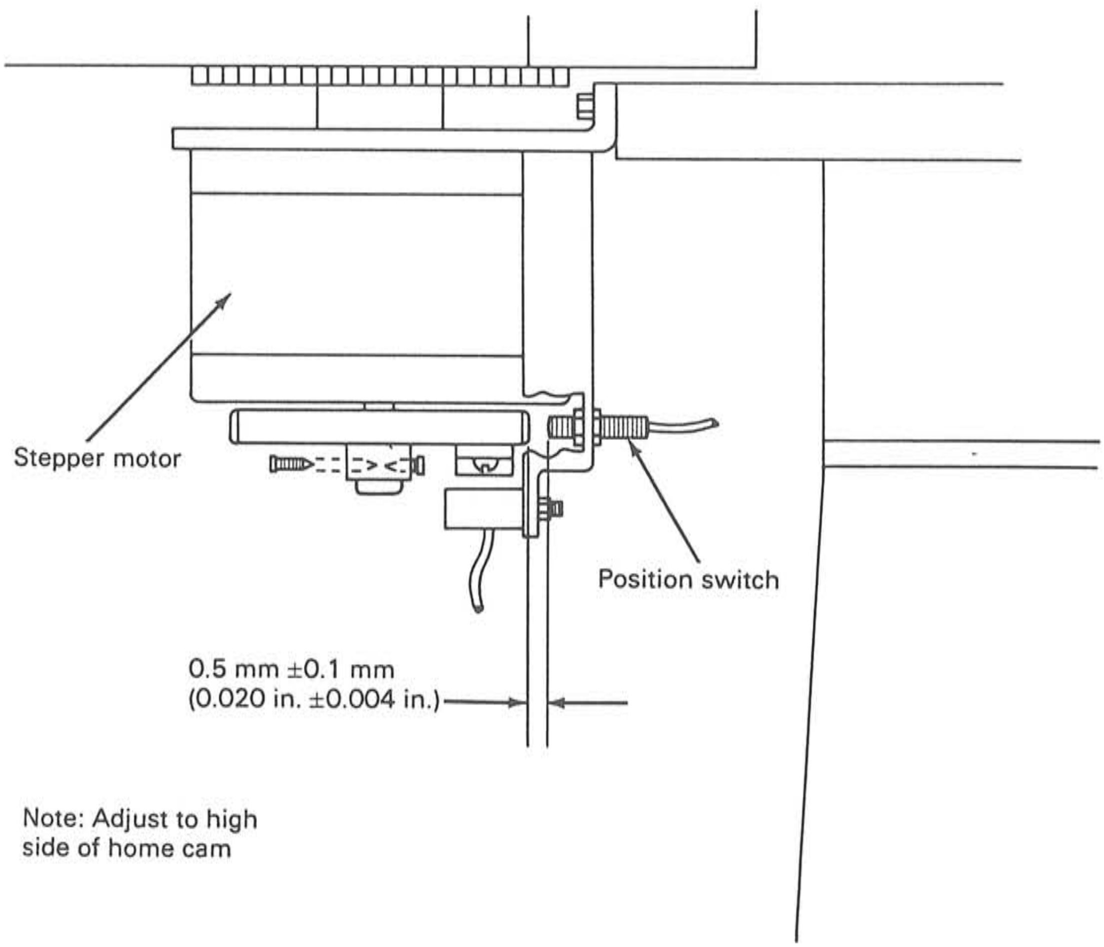
2. Remove the stepper motor cover.

3. Manually turn the Z-shaft until the high dwell of the cam faces the area position switch.

4. Loosen the locking nuts and adjust the area position switch to obtain a clearance between the switch and the high dwell of the cam of 0.5 mm ±.1 mm (0.020 inch ±0.004 inch).

5. Tighten the locking nuts and ensure that the clearance is maintained.

6. Replace the stepper motor cover.



4015 THETA 1 DIGITAL TO ANALOG CONVERTER

1. Ensure that the controller power has been turned on for at least 10 minutes to allow the temperature of the electronics to stabilize.

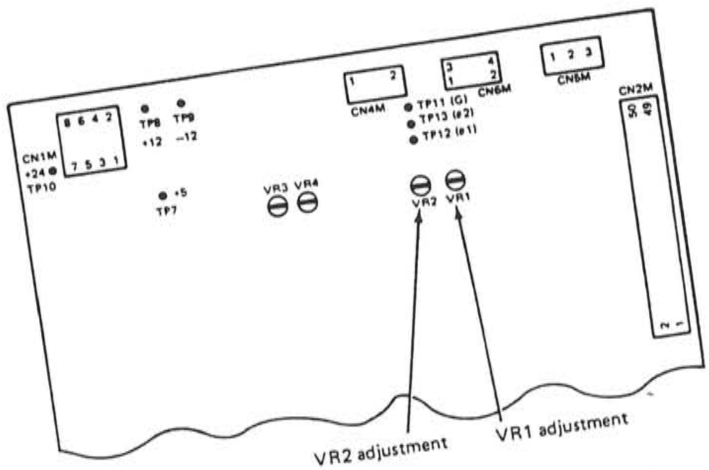
2. Press the red Stop pushbutton on the control panel to ensure that manipulator power is off.

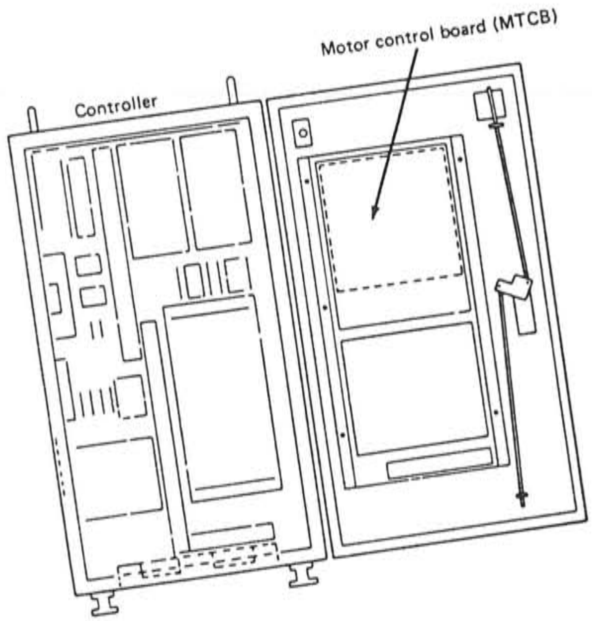
3. Locate TP11 and TP12 on the motor control board in the controller.

4. Attach a digital voltmeter to TP11 (-) and TP12 (+), DAC output.

5. Adjust potentiometer VR2 on the motor control board for a reading of 0 V ± 0.1 mV. If unable to obtain the 0-V reading by adjusting VR2, adjust VR1 for this reading.

Note: If you are going to adjust the Theta 1 Servo Pack Zero, the digital voltmeter can remain attached to TP11 (-) and TP12 (+).





1. Ensure that the controller power has been turned on for at least ten minutes to allow the temperature of the electronics to stabilize.

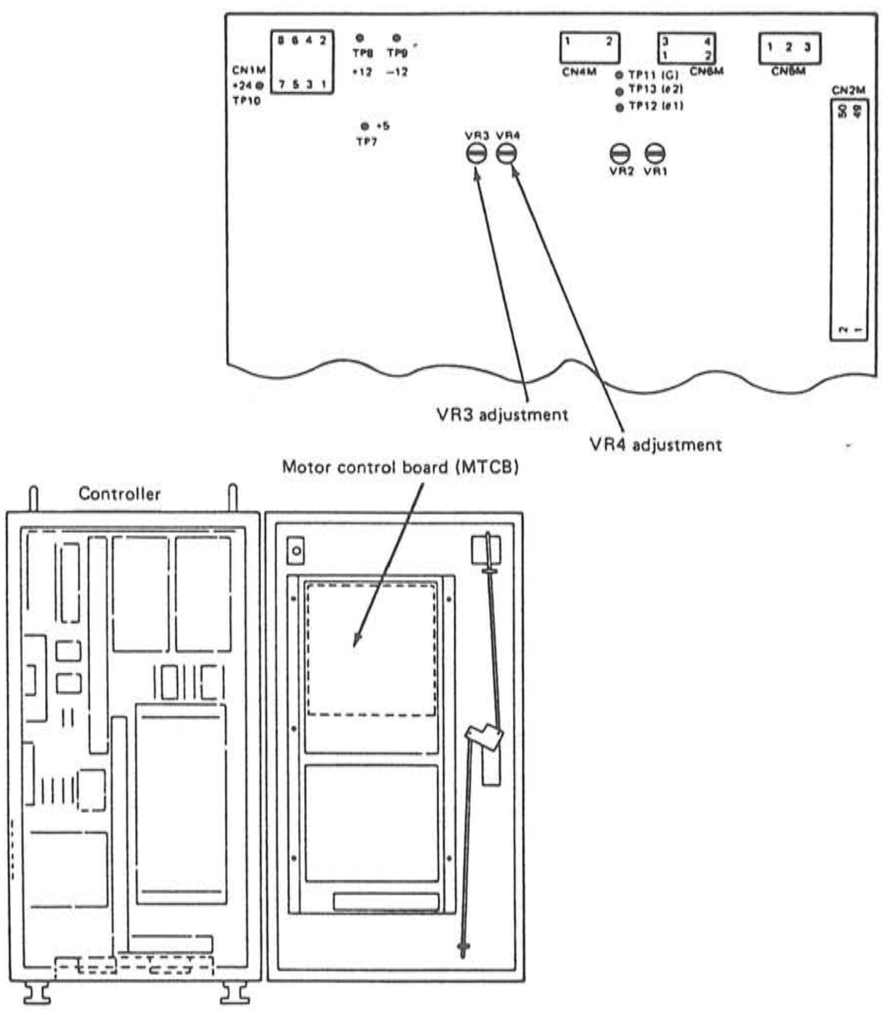
2. Press the red Stop pushbutton on the control panel to ensure that manipulator power is off.

3. Locate TP11 and TP13 on the motor control board in the controller.

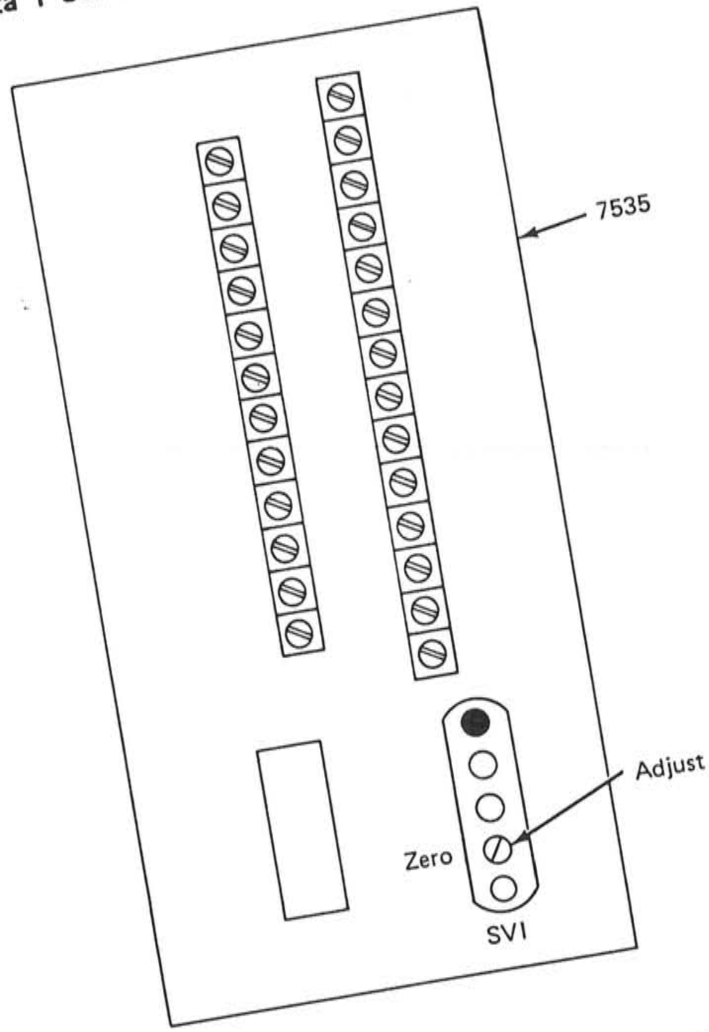
4. Attach a digital voltmeter to TP11 (-) and TP13 (+), DAC output.

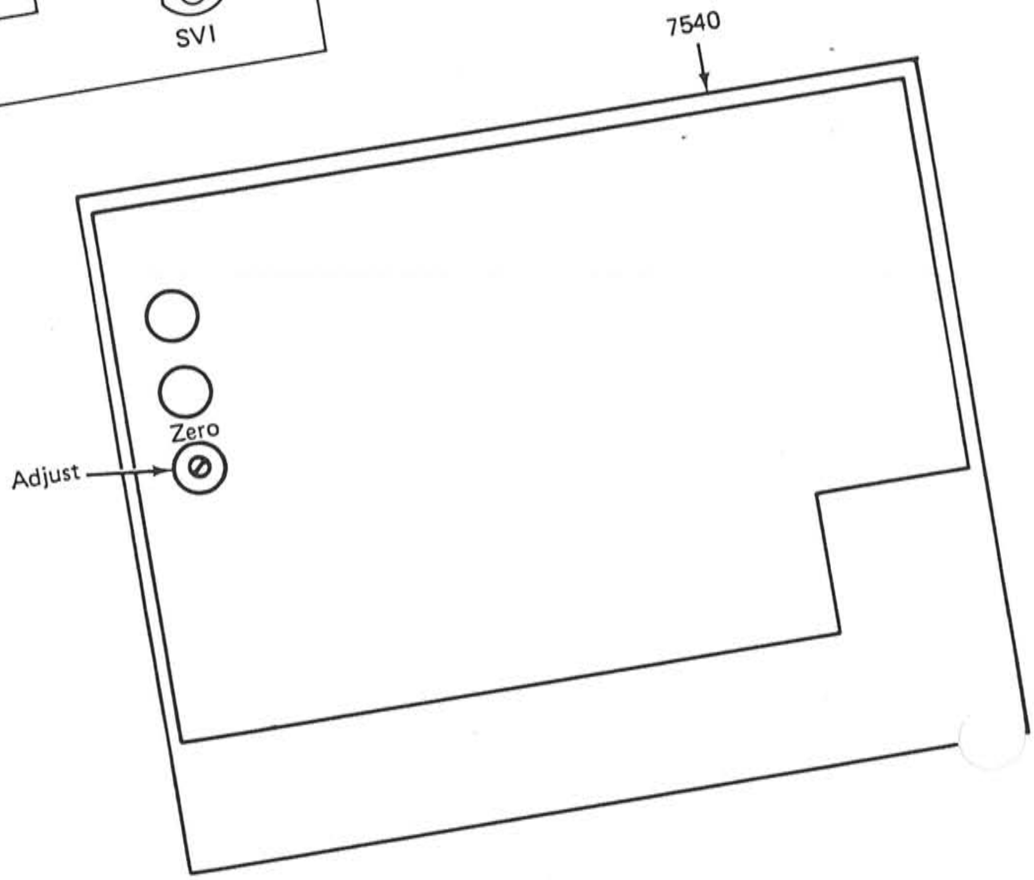
5. Adjust potentiometer VR4 on the motor control board for a reading of 0 V ± 0.1 mV. If unable to obtain the 0-V reading by adjusting VR4, adjust VR3 for this reading.

   Note: If you are going to adjust the Theta 2 Servo Pack Zero, the digital voltmeter can remain attached to TP11 (-) and TP13 (+).



Theta 1 Servo Pack Zero





4017 THETA 1 SERVO PACK ZERO

This adjustment ensures that there is a minimum amount of Theta 1 arm movement when the arm is at rest.

1. If you have not already done so, perform the Theta 1 DAC adjustment procedure; then return to this point.

2. Attach the Personal Computer to the controller.

3. Apply power to the Personal Computer and the controller.

4. Turn on manipulator power.

5. Load the exerciser program 7535EX9 for 7535 or 7540EX9 for 7540, from the Personal Computer.

6. Start the program and allow it to run for approximately 10 minutes to stabilize the temperature of the electronics.

7. Turn off controller power.

8. Locate the Theta 1 offset switches in the controller and record the settings.

9. Position all offset switches to the off (down) position.

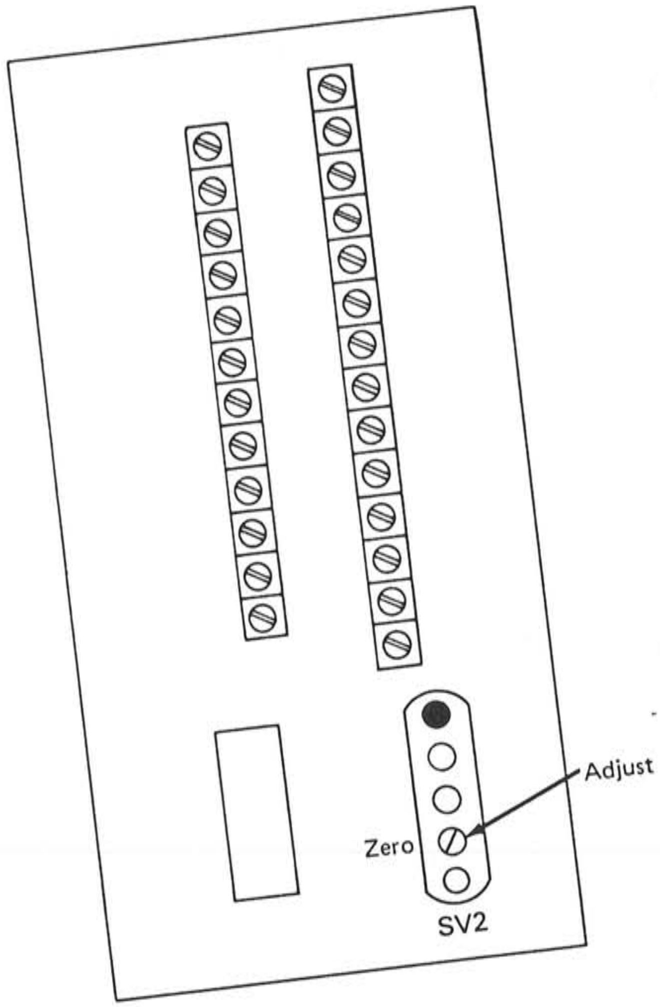
10. Turn on controller power.

11. Press the Manip Power key; then press the Return To Home key.

12. With a digital voltmeter attached to TP11 (-) and TP12 (+), adjust the Theta 1 Zero servo pack potentiometer using the following steps: First, adjust for a reading of 0 V ±0.1 mV, ignoring the pulsing; second, while maintaining the 0-V reading, refine the adjustment so that the pulses occur at least 2 to 3 seconds apart.

13. Reposition the Theta 1 offset switches to the settings recorded earlier.

Theta 2 Servo Pack Zero



4018 THETA 2 SERVO PACK ZERO

This adjustment ensures that there is a minimum amount of Theta 2 arm movement when the arm is at rest.

1. If you have not already done so, perform the Theta 2 DAC adjustment procedure; then return to this point.

2. Attach the Personal Computer to the controller.

3. Apply power to the Personal Computer and the controller.

4. Turn on the manipulator power.

5. Load the exerciser program 7535EX9 for 7535 or 7540EX9 for 7540, from the Personal Computer.

6. Start the program and allow it to run for approximately 10 minutes to stabilize the temperature of the electronics.

7. Turn off controller power.

8. Locate the Theta 2 offset switches in the controller and record the settings.

9. Position all offset switches to the off (down) position.

10. Turn on controller power.

11. Press the Manip Power key; then press the Return To Home key.

12. With a digital voltmeter attached to TP11 (-) and TP13 (+), adjust the Theta 2 servo pack Zero potentiometer using the following steps: First, adjust for a reading of 0 V ±0.1 mV, ignoring the pulsing; second, while maintaining the 0-V reading, refine the adjustment so that the pulses occur at least 2 to 3 seconds apart.

13. Reposition the Theta 2 offset switches to the settings recorded earlier.

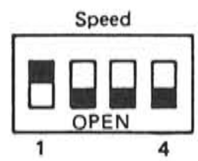
4019 THETA 1 SPEED

1. Attach the Personal Computer to the controller.

2. Apply power to the Personal Computer and the controller.

3. Turn on the manipulator power.

4. Set speed switches to low speed:



5. Load the exerciser program into the controller.

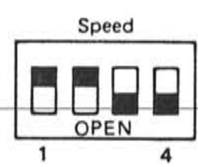
6. Select 7535EX1 for 7535 or 7540EX1 for 7540 from the Personal Computer.

7. Start the exerciser program.

8. Measure the DC voltage across T11(+) and T12(-) on the Theta 1 servo pack. Note only the positive peak voltage during the middle of the move.

9. Multiply the voltage you measured by 2.049 for 7535 or 1.856 for 7540. Record this calculated voltage.

10. Set the speed switches to high speed:



11. Repeat step 8. If the measured voltage differs from the calculated voltage by more than 5 percent, adjust the IN-B potentiometer on the servo pack until the measured voltage is correct.

12. Repeat the procedure to verify the adjustment.

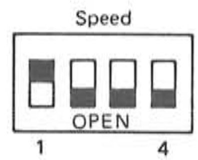
4020 THETA 2 SPEED

1. Attach the Personal Computer to the controller.

2. Apply power to the Personal Computer and the controller.

3. Turn on the manipulator power.

4. Set speed switches to low speed:



5. Load the exerciser program into the controller.

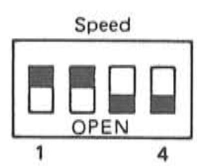
6. Select 7535EX2 for 7535 or 7540EX2 for 7540.

7. Start the exerciser program.

8. Measure the DC voltage across T21(+) and T22(-) on the Theta 2 servo pack. Note only the positive peak voltage during the middle of the move.

9. Multiply the voltage you measured by 1.872 for 7535 or 1.952 for 7540. Record this calculated voltage.

10. Set the speed switches to high speed:



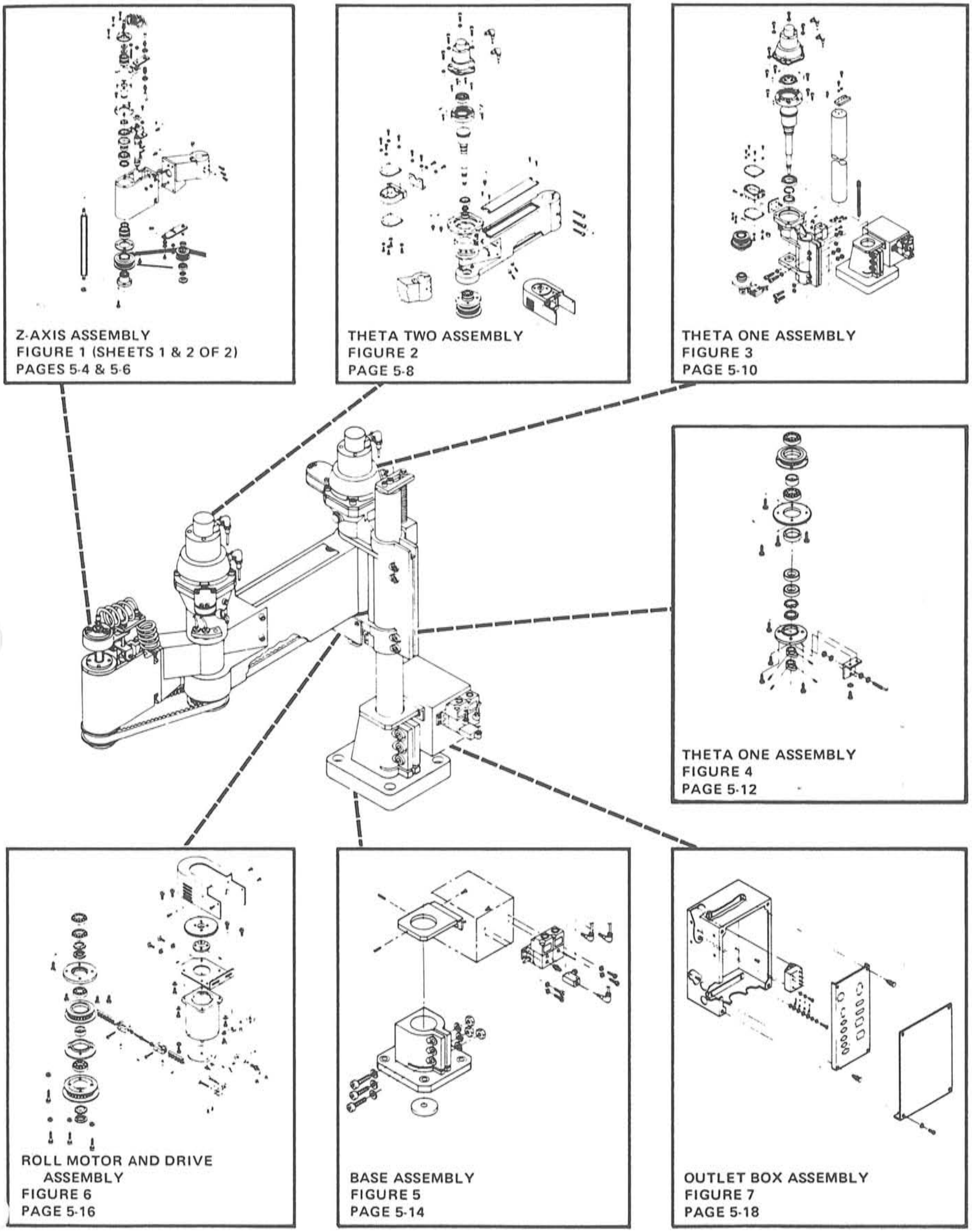
11. Repeat step 8. If the measured voltage differs from the calculated voltage by more than 5 percent, adjust the IN-B potentiometer on the servo pack until the measured voltage is correct.

12. Repeat the procedure to verify the adjustment.

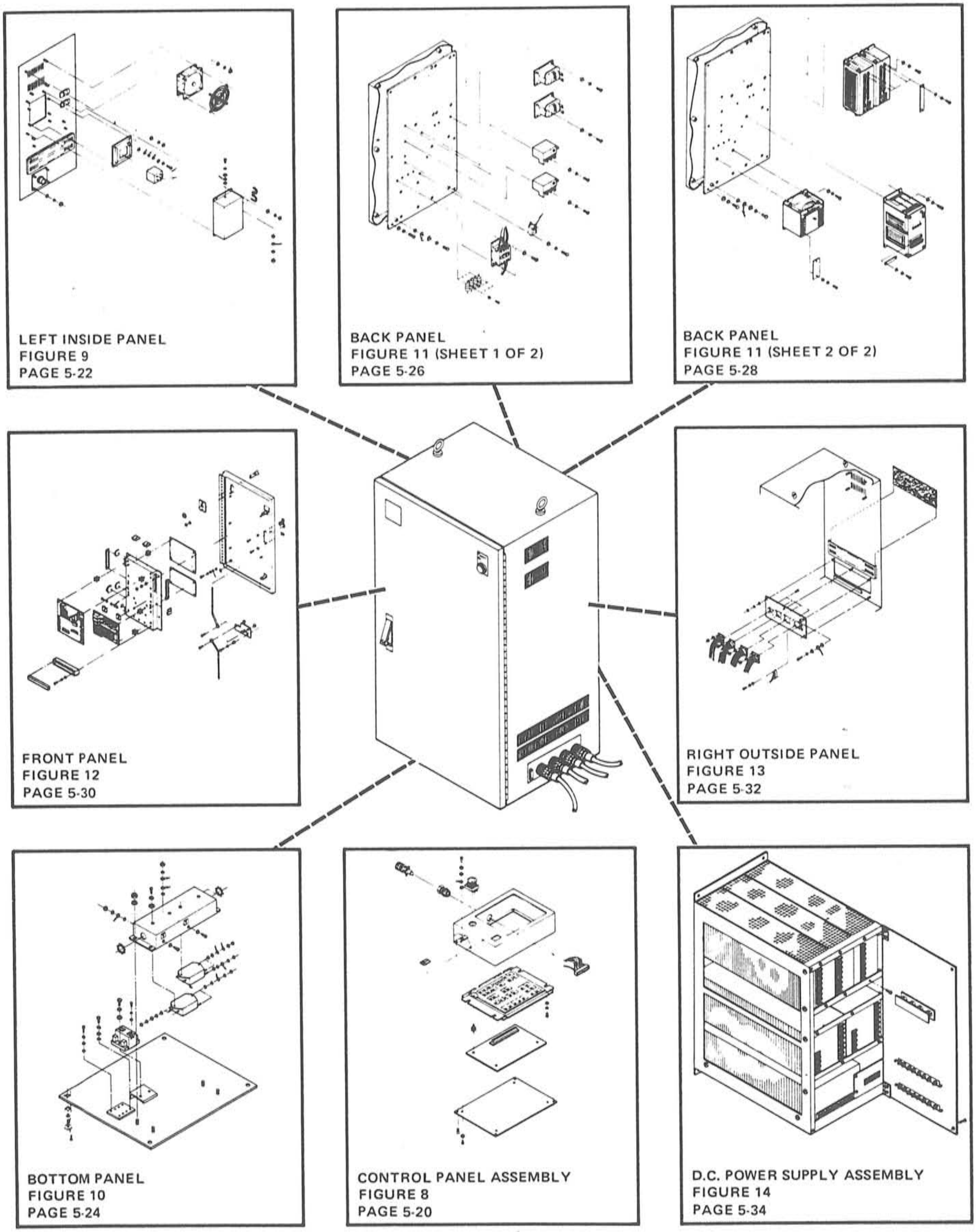
INTRODUCTION

The Parts Catalog is designed to enable you to quickly find replaceable parts and their part numbers. To use the catalog, start by locating the desired part on one of the figures in the Visual Index. Turn to the page indicated for that figure. Use the index numbers in the figure to cross reference the accompanying parts list. Some parts may be listed in the parts list but not referenced (NR) in the figure.

This section is divided as follows:



VISUAL INDEX I



VISUAL INDEX II

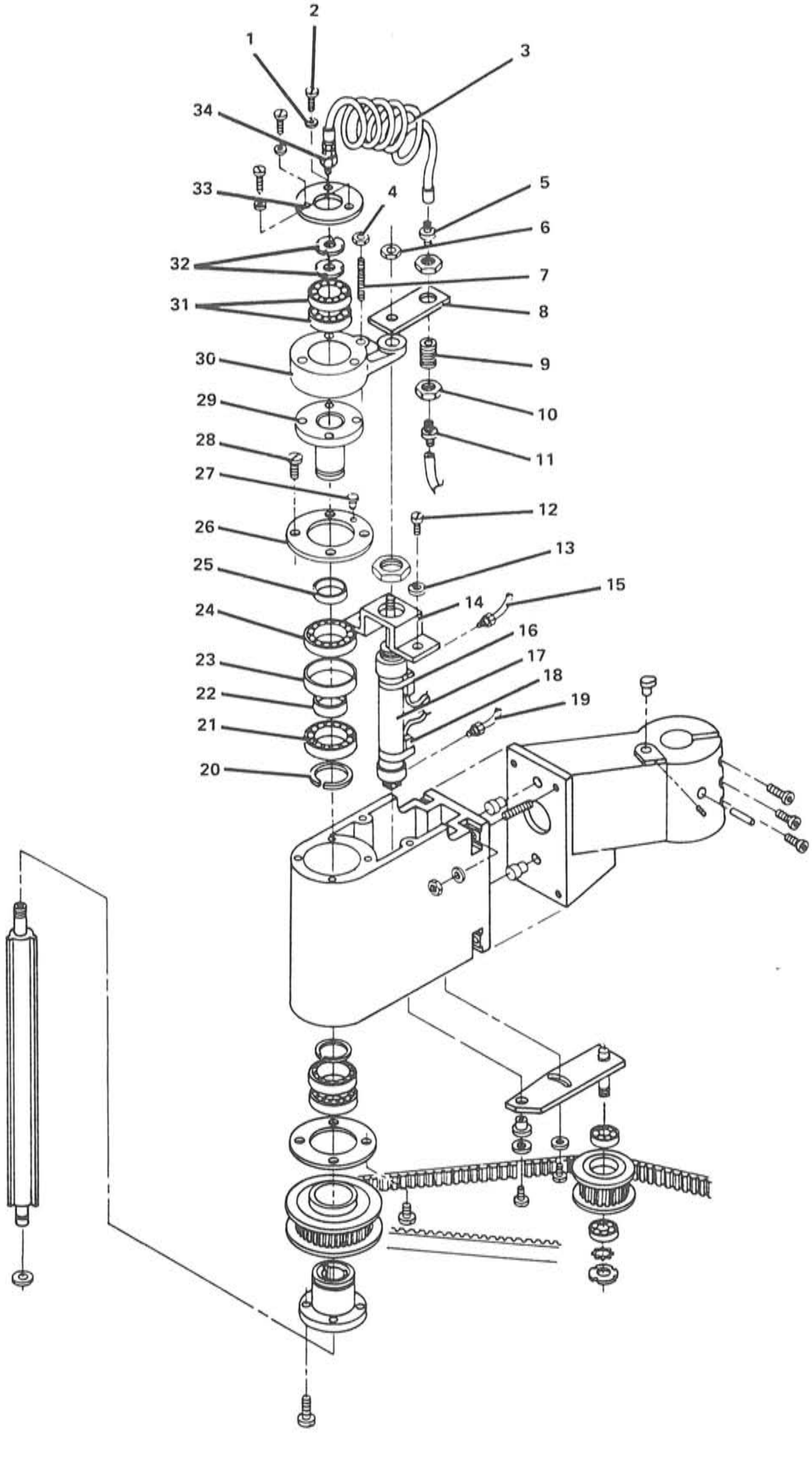


FIGURE 1. Z-AXIS ASSEMBLY. SHEET 1 OF 2. INDEX NOS. 1-34. SEE LIST 1.

Z-AXIS ASSEMBLY SHEET 1 OF 2

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
1-1	*	Washer, lock M4
-2	*	Screw, socket head M4 X 10
-3	J200002	Nylon tube
-4	*	Nut, hex M6
-5	J200001	Air tube joint
-6	*	Nut, hex M8
-7	*	Screw, socket head M6 X 54
-8	J200023	Air plate
-9	J200024	Joint
-10	*	Nut, hex
-11	J200001	Air tube joint
-12	*	Screw, socket head M6 X 12
-13	*	Washer, lock M6
-14	J200022	Cylinder bracket
-15	J200301	Air fitting
-16	J200302	Proximity switch with cable
-17	J200016	Air cylinder with proximity switches
-18	J200302	Proximity switch with cable
-19	J200301	Air fitting
-20	J200011	Retainer
-21	J200008	Bearing
-22	J200012	Spacer
-23	J200013	Spacer
-24	J200008	Bearing
-25	J200109	Spacer
-26	J200107	Bearing cap
-27	J200015	Stop, end pin
-28	*	Screw, cross head countersunk M4 X 7
-29	J200010	Z-shaft upper & lower ball splines
-30	J200017	Air bracket
-31	J200018	Bearing
-32	J200019	Nut, circular
-33	J200021	Bearing cap
-34	J200020	Turning joint
NR	J200293	Curl hose, single
NR	J200294	Curl hose, triple

* See Common Hardware Listing

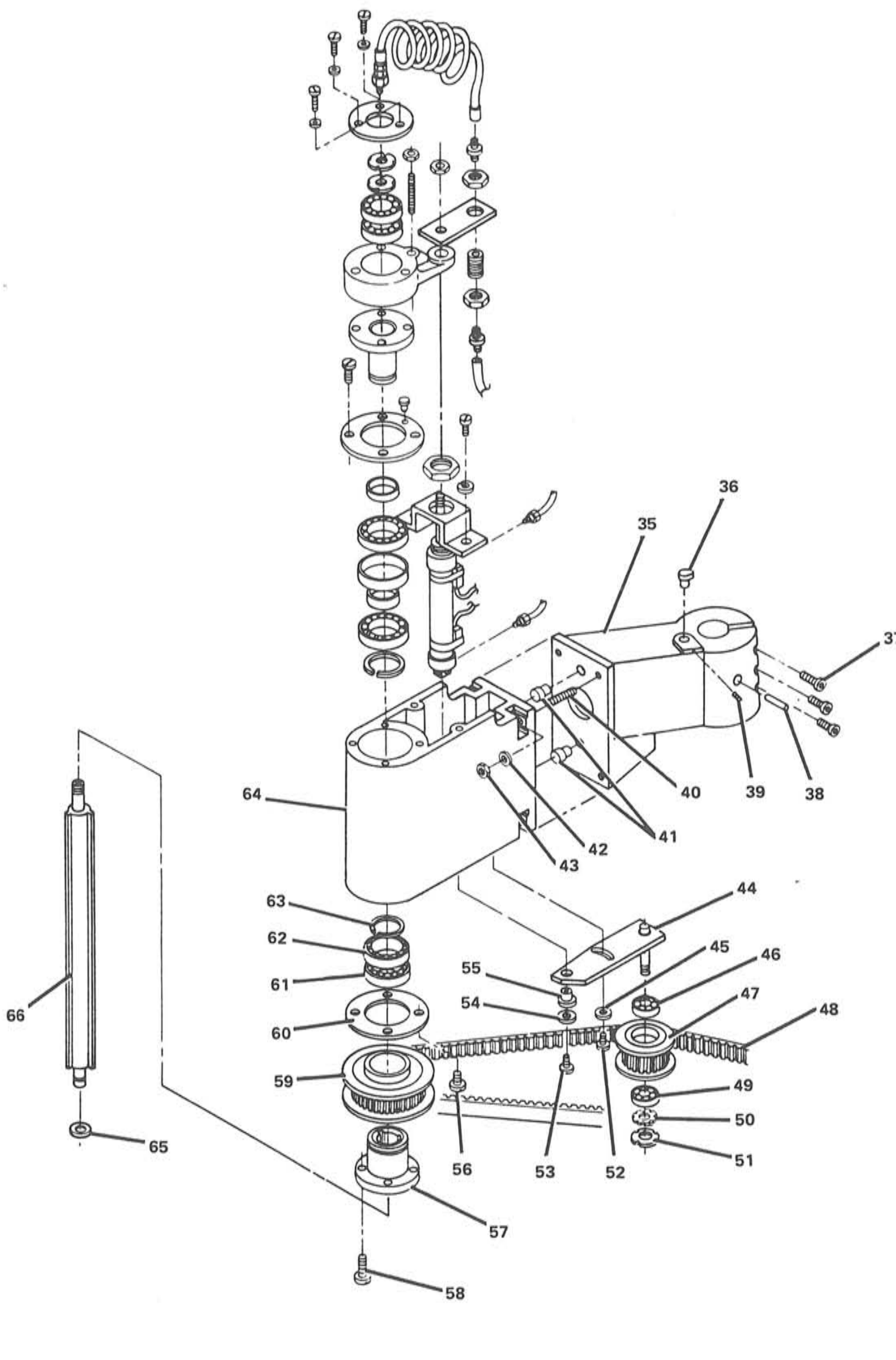


FIGURE 1. Z-AXIS ASSEMBLY. SHEET 2 OF 2. INDEX NOS. 35-66. SEE LIST 1.

Z-AXIS ASSEMBLY SHEET 2 OF 2

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
1-35	J200033	Theta 2 arm
-36	J200032	Home overrun eccentric
-37	*	Screw, socket head M6 X 30
-38	J200034	Pin
-39	*	Set screw, socket head M4 X 5
-40	*	Screw, socket head M6
-41	J200116	Positioning pin
-42	*	Washer, lock M6
-43	*	Nut, hex M6
-44	J200104	Tension plate with shaft
-45	*	Washer, flat M6
-46	J200102	Bearing
-47	J200103	Tension pulley
-48	J200105	Driven belt
-49	J200102	Bearing
-50	J200108	Washer
-51	J200100	Nut, circular
-52	*	Screw, socket head M6 X 15
-53	*	Screw, socket head M6 X 15
-54	*	Washer, flat M6
-55	J200106	Collar
-56	*	Screw, cross head countersunk M4 X 10
-57	J200014	Z-shaft upper & lower ball splines
-58	*	Screw, socket head M4 X 10
-59	J200006	Finger pulley
-60	J200007	Bearing cap
-61	J200008	Bearing
-62	J200008	Bearing
-63	J200011	Retainer
-64	J200009	Pickup head
-65	J200003	"O" Ring
-66	J200014	Z-shaft, upper & lower ball splines

* See Common Hardware Listing

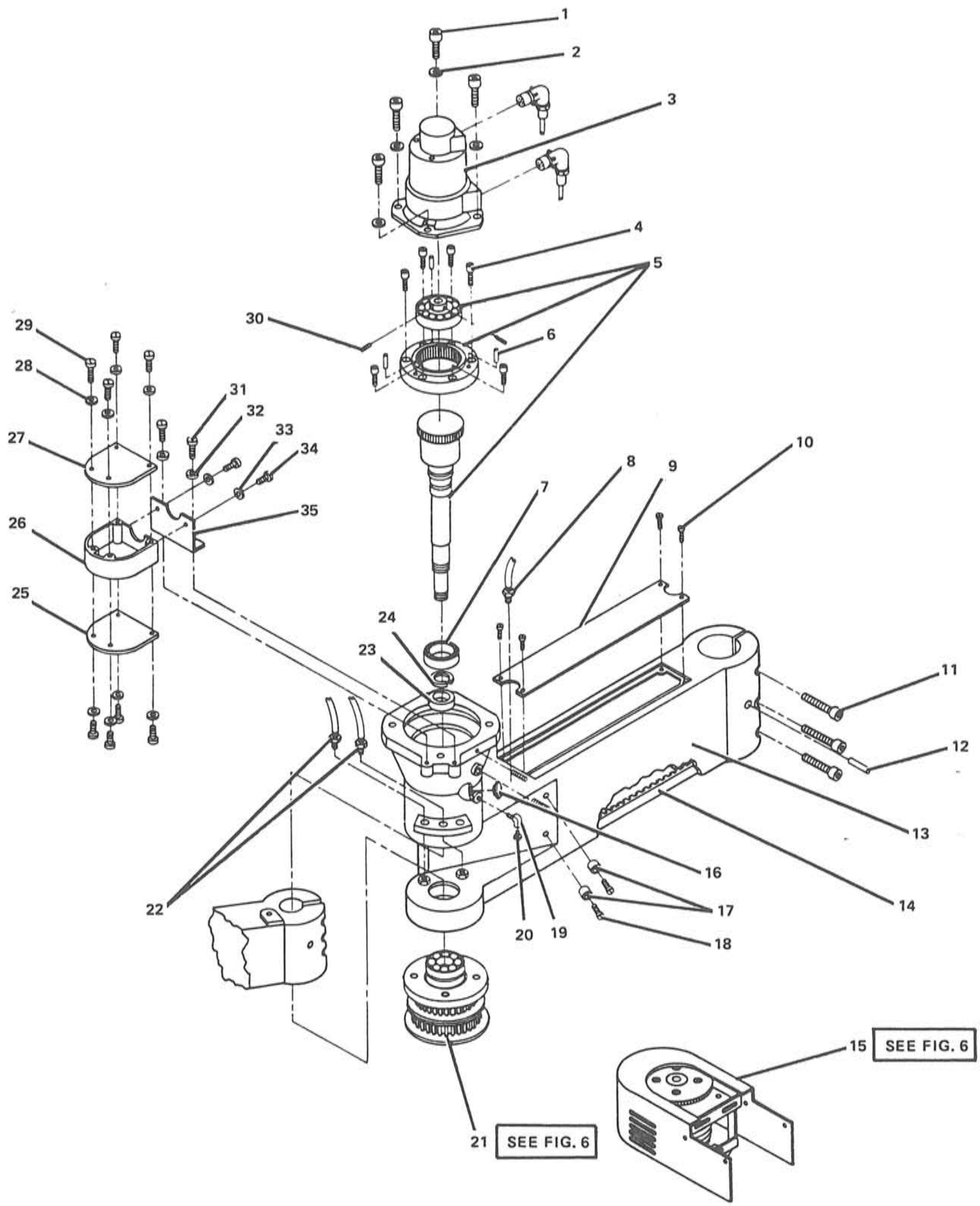


FIGURE 2. THETA TWO ASSEMBLY. SEE LIST 2.

THETA TWO ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
2-1	*	Screw, socket head M5 X 12
-2	*	Washer, lock M5
-3	J200036	Motor/encoder assembly
-4	*	Screw
-5	J200038	Harmonic drive assembly, includes: wave generator, circular spline, and shaft
-6		Pin, included with 2-5
-7	J200040	Bearing
-8	J200031	Proximity switch with cable nuts & washers
-9	J200042	Duct cover
-10	*	Screw, cross head countersunk M4 X 10
-11	*	Screw, socket head M8 X 40
-12	*	Pin, locating
-13	J200035	Theta 1 arm
-14	J200084	Roll drive belt
-15		Roll motor and drive assembly, see figure 6
-16	J200049	Oil level port
-17	J200110	Stopper
-18	*	Screw, socket head M5 X 15
-19	J200343	Drain elbow
-20	J200344	Drain plug
-21		Roll motor and drive assembly, see figure 6
-22	J200031	Proximity switch with cable nuts & washers
-23	J200029	Oil seal
-24	J200030	Retainer
-25	J200026	Lower duct cover
-26	J200025	Duct
-27	J200027	Upper duct cover
-28	*	Washer, lock M3
-29	*	Screw, cross head M3 X 5
-30	*	Set screw
-31	*	Screw, socket head M5 X 10
-32	*	Washer, lock M5
-33	*	Washer, lock M5
-34	*	Screw, socket head M5 X 10
-35	J200028	Duct bracket
-36	J200342	Theta 2 motor brushes

* See Common Hardware Listing

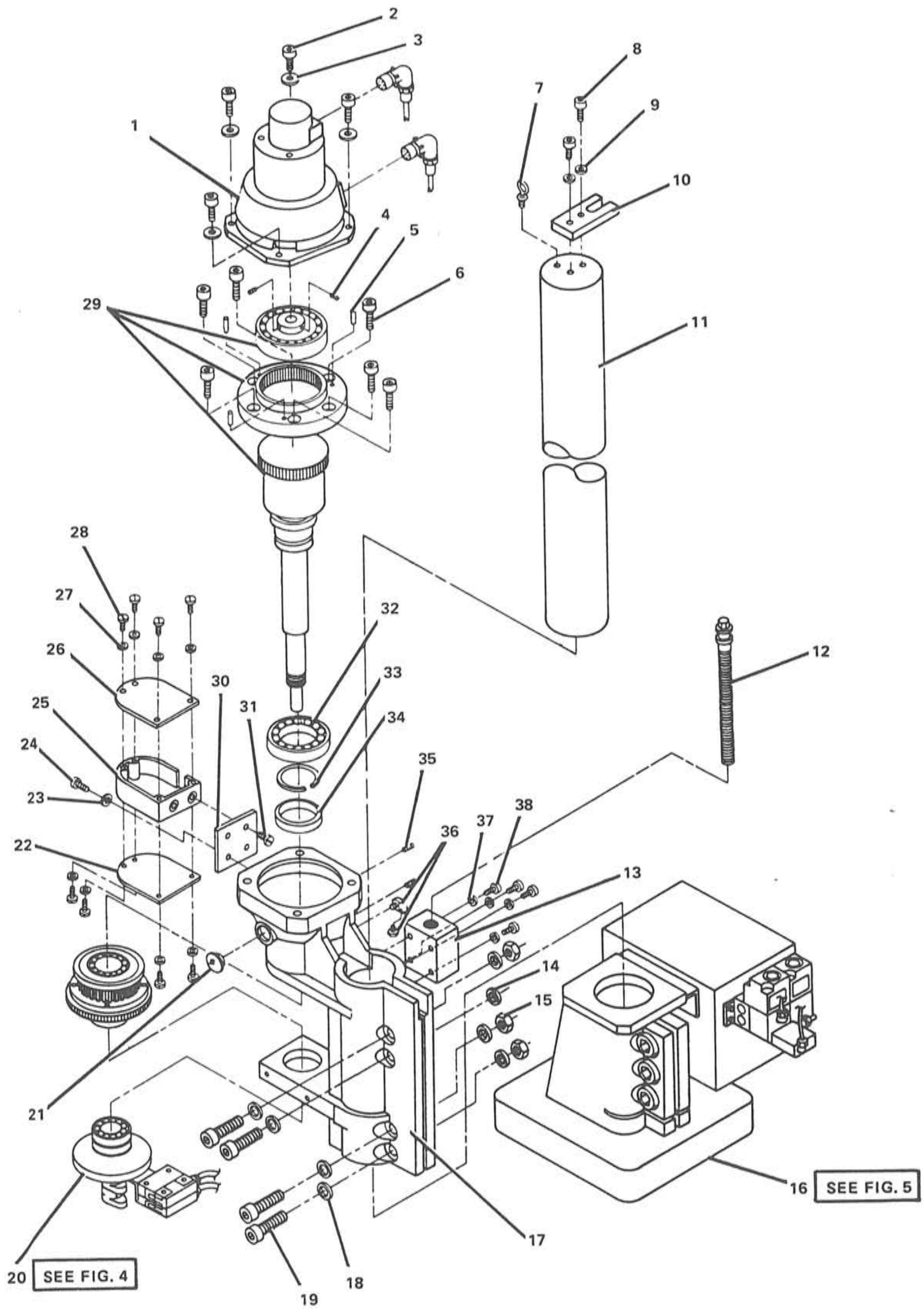


FIGURE 3. THETA ONE ASSEMBLY. SEE LIST 3.

THETA ONE ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
3-1	J200054	Theta 1 motor/encoder assembly
NR	J200341	Theta 1 motor brushes
-2	*	Screw, socket head M5 X 15
-3	*	Washer, lock M5
-4	*	Set screw
-5		Pin, included with 3-29
-6	*	Screw
-7		Eye bolt
-8	*	Screw, socket head M8 X 25
-9	*	Washer, flat M8
-10	J200057	Plate
-11	J200059	Main column
-12	J200055	Adjustable bolt
-13	J200060	Block
-14	*	Washer, flat M12
-15	*	Nut, hex M12
-16		Base assembly, see figure 5
-17	J200061	Arm support
-18	*	Washer, flat M12
-19	*	Screw, socket head M12 X 50
-20		Theta 1 assembly, see figure 4
-21	J200049	Oil level port
-22	J200052	Lower duct cover
-23	*	Washer, lock M5
-24	*	Screw, socket head M5 X 12
-25	J200050	Duct
-26	J200053	Upper duct assembly
-27	*	Washer, lock M3
-28	*	Screw, cross head M3 X 5
-29	J200056	Theta 1 harmonic drive assembly, includes: wave generator, circular spline, and shaft
-30	J200051	Duct bracket
-31	*	Screw, cross head countersunk M5 X 5
-32	J200047	Bearing
-33	J200046	Retainer
-34	J200045	Oil seal
-35	*	Set screw, socket head M6 X 10
-36	J200343	Drain elbow
NR	J200344	Drain plug
-37	*	Washer
-38	*	Screw
NR	J200293	Curl hose, single

* See Common Hardware Listing

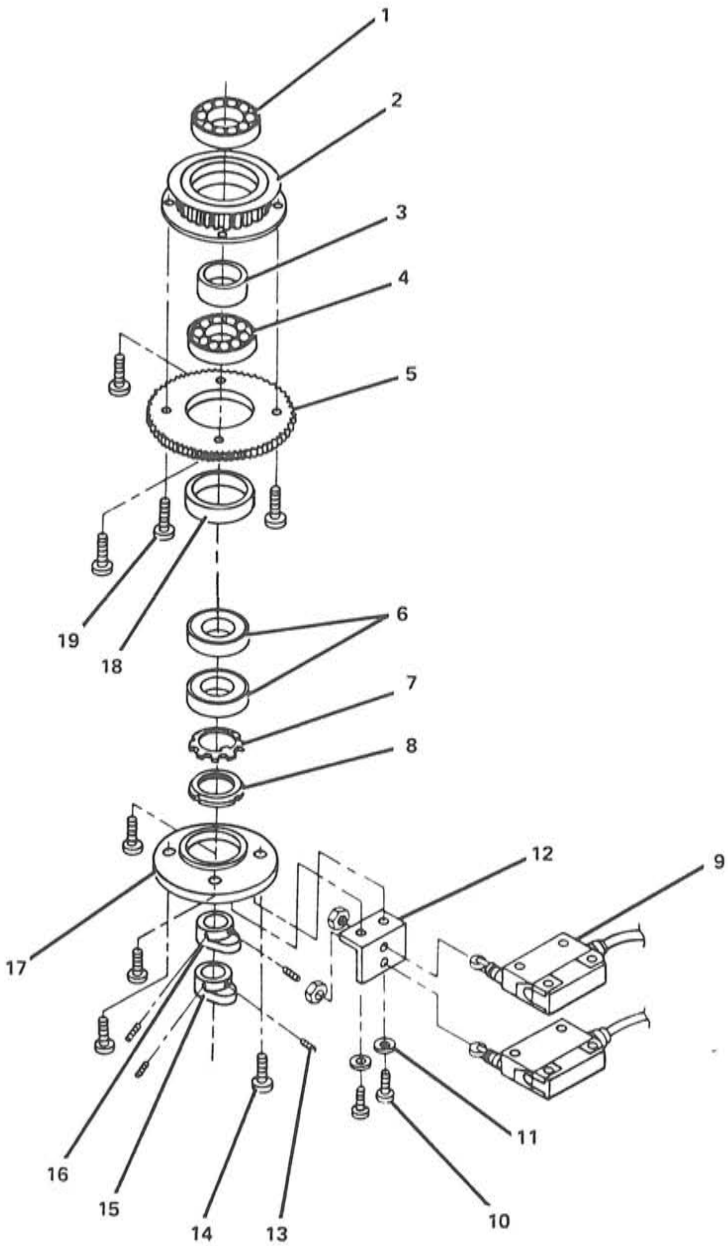


FIGURE 4. THETA ONE ASSEMBLY. SEE LIST 4.

THETA 2 ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
4-1	J200062	Bearing
-2	J200063	Drive pulley
-3	J200064	Spacer
-4	J200062	Bearing
-5	J200066	Gear
-6	J200068	Bearing set
-7	J200070	Washer
-8	J200069	Nut, circular
-9	J200072	Limit switches
-10	*	Screw, socket head M6 X 10
-11	*	Washer, lock M6
-12	J200073	Bracket
-13	*	Set screw, socket head M6 X 8
-14	*	Screw, socket head M6 X 10
-15	J200307	Theta 1 overrun cam
-16	J200074	Theta 1 home cam
-17	J200071	Bearing cap
-18	J200067	Spacer
-19	*	Screw, socket head M6 X 10

* See Common Hardware Listing

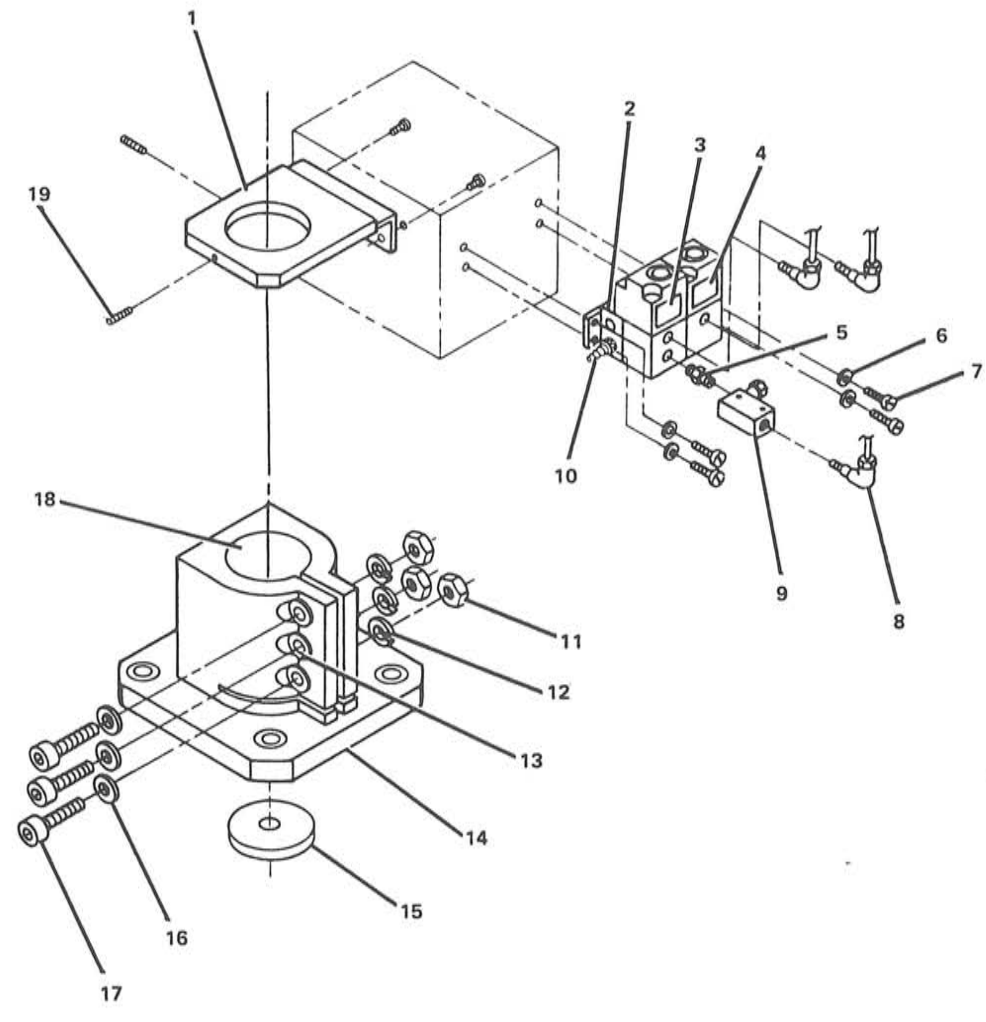


FIGURE 5. BASE ASSEMBLY. SEE LIST 5.

BASE ASSEMBLY

PART NUMBER	DESCRIPTION
J200118	Bracket
J200113	Manifold
J200111	SOL 1 Solenoid Valve
J200112	SOL 2 Solenoid Valve
	Union, 1/8" BSP
*	Washer, lock M4
*	Screw, socket head M4 X 8
J200339	Air fitting 90 degree
J200114	Speed controller
*	Muffler lock M5
*	Nut, hex M12
*	Washer, lock M12
J200118	Base, column
J200118	Base, column
J200115	Positioning collar
*	Washer, flat M20
*	Screw, socket head M12 X 50
J200118	Base, column
*	Set screw, socket head M6 X 10

ommon Hardware Listing

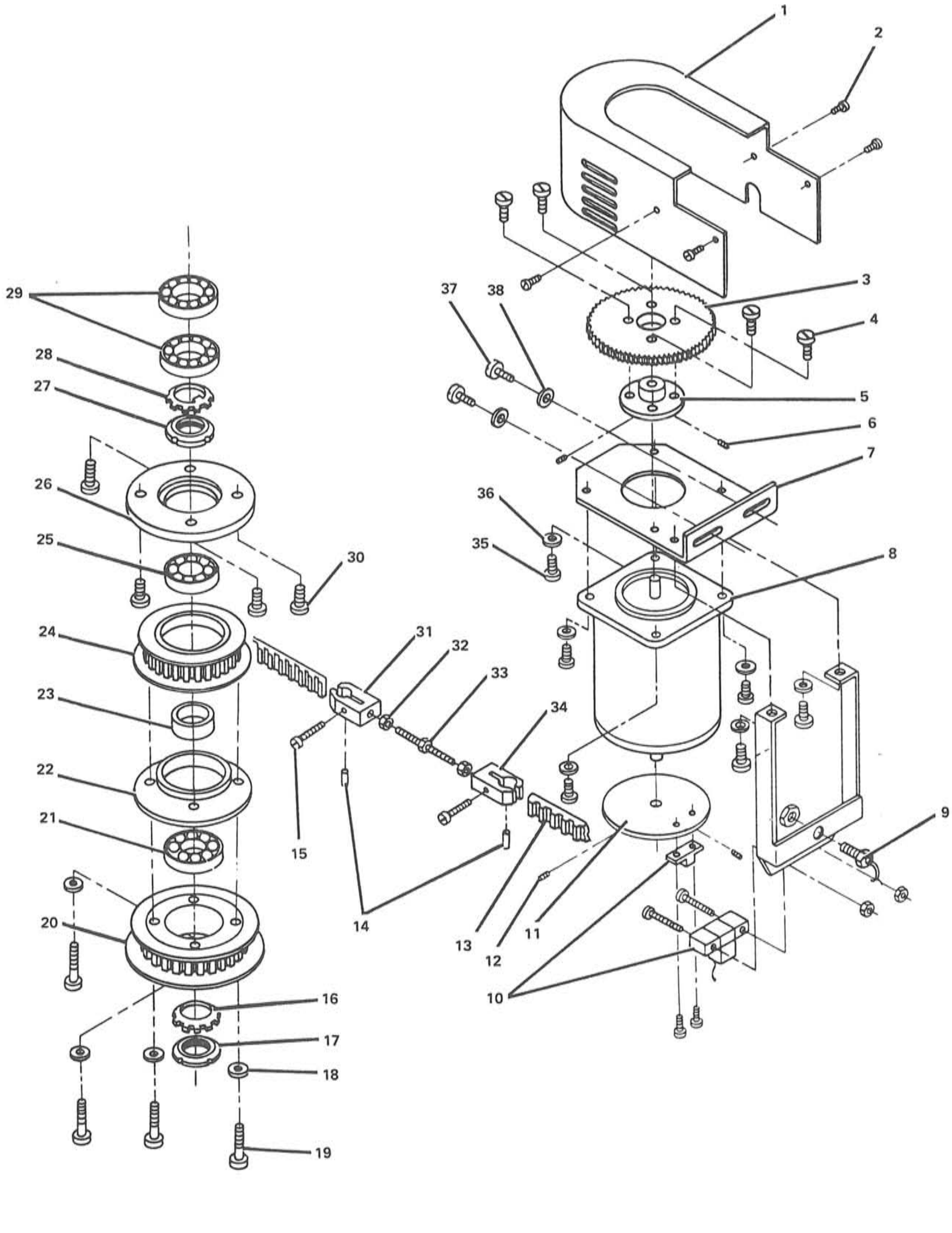


FIGURE 6. ROLL MOTOR AND DRIVE ASSEMBLY. SEE LIST 6.

ROLL MOTOR AND DRIVE ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
6-1	J200375	Cover
-2	*	Screw, socket head M5 X 10
-3	J200083	Gear
-4	*	Screw, socket head M5 X 12
-5	J200082	Gear hub
-6	*	Set screw, socket head M5 X 10
-7	J200081	Bracket
-8	J400059	Motor, roll
-9	J200076	Proximity switch with hardware
-10	J200078	Home sensor module with detector module and hardware
-11	J200077	Cam, roll motor home
-12	*	Set screw, socket head M4 X 5
-13	J200084	Drive belt
-14	J200088	Roll pin
-15	*	Screw, socket head M5 X 10
-16	J200092	Washer, lock M5
-17	J200093	Nut, circular
-18	*	Washer, M5
-19	*	Screw, socket head M5 X 30
-20	J200096	Theta 2 arm pulley
-21	J200095	Bearing
-22	J200097	Spacer
-23	J200094	Spacer
-24	J200098	Pulley
-25	J200095	Bearing
-26	J200089	Bearing cap
-27	J200090	Nut, circular
-28	J200094	Washer
-29	J200099	Bearing set
-30	*	Screw, socket head M5 X 10
-31	J200087	Nut, special L. H.
-32	*	Nut, hex M5 left hand thread
NR	*	Nut, hex M5
-33	J200086	Tension bolt
-34	J200085	Nut, special R. H.
-35	*	Screw socket head M5 X 12
-36	*	Washer, lock M5

* See Common Hardware Listing

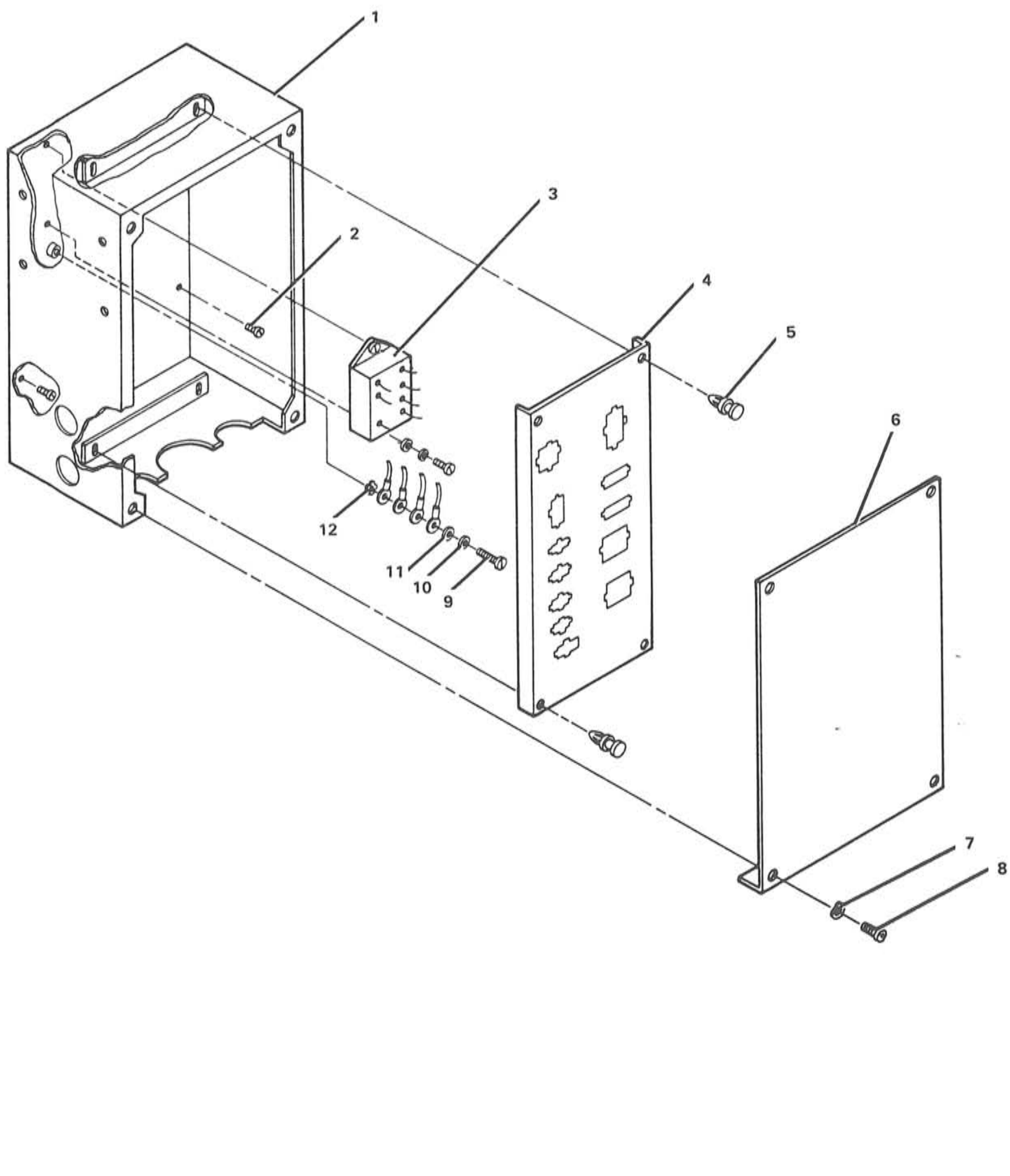


FIGURE 7. OUTLET BOX ASSEMBLY. SEE LIST 7.

OUTLET BOX ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
7-1		Box
-2	*	Screw, cross head M5 X 5
-3		Detector, included with 6-10
-4		Plate, receptacle mounting
-5		Fastener
-6		Plate, cover
-7	*	Screw, oval head M3 X 10
-8	*	Washer, cup M3
-9	*	Screw, cross head M5 X 9.5
-10	*	Washer, lock M5
-11	*	Washer, flat M5
-12	*	Washer, star M5

* See Common Hardware Listing

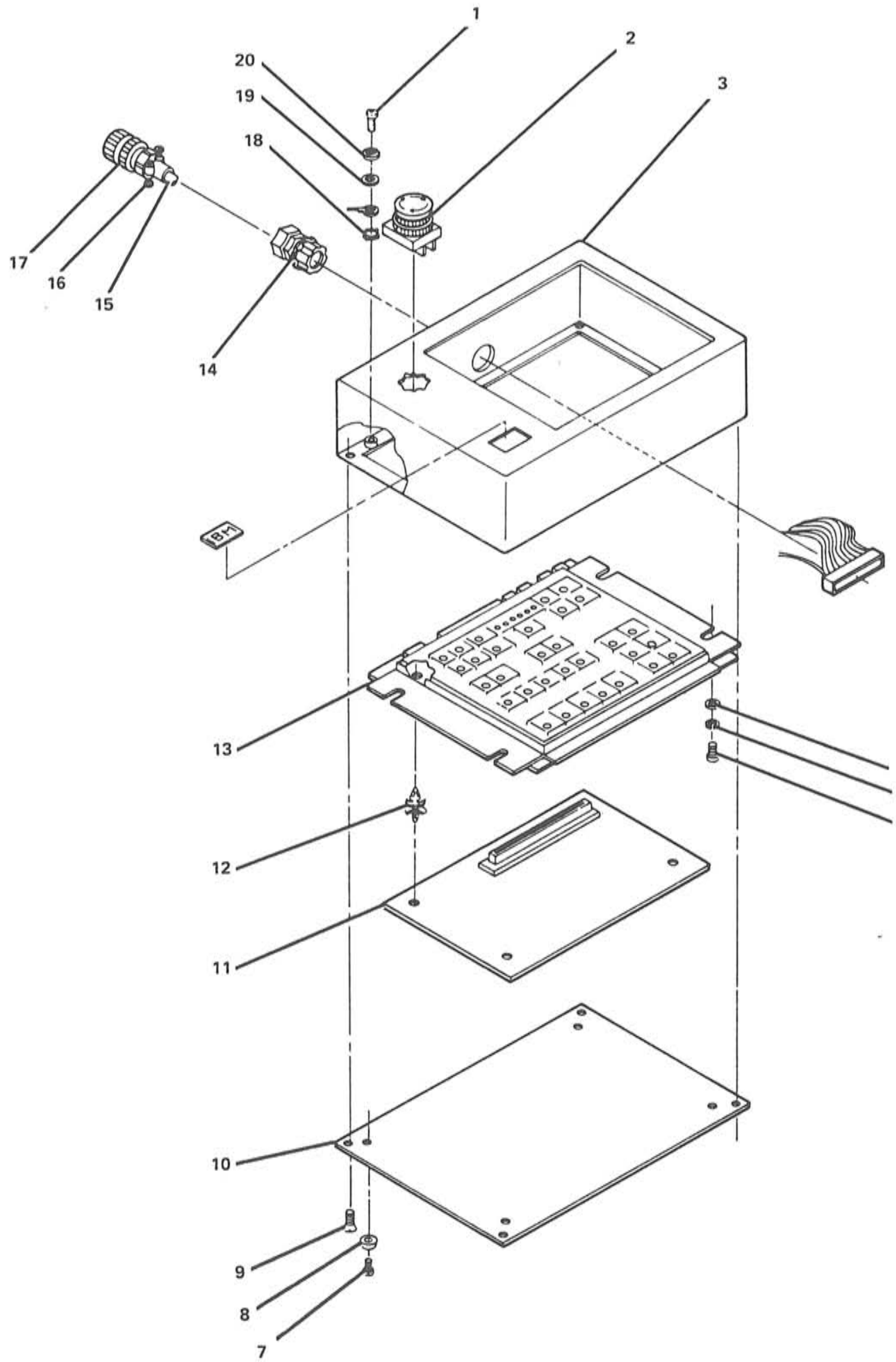


FIGURE 8. CONTROL PANEL ASSEMBLY. SEE LIST 8.

CONTROL PANEL ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
8-1	*	Screw, cross hd. M5 X 10
-2	J200148	Pushbutton assembly
-3	J200154	Box, control panel
-4	J200147	Keyboard, with plastic standoff
-5	*	Washer, flat M3
-6	*	Washer, lock M3
-7	*	Screw, cross head M3 X 8
-8	*	Screw, cross head M3 X 10
-9	J200150	Foot, rubber
-10	*	Screw, flat head countersunk M3 X 5
-11	J200155	Cover, bottom
-12	J200146	Board, key interface
-13		Standoff, plastic
-14	J200149	Connector asm
-15	J200151	Cable
-16	J200153	Clamp
-17	J200152	Plug
-18	*	Washer, star M5
-19	*	Washer, flat M5
-20	*	Washer, lock M5

* See Common Hardware Listing

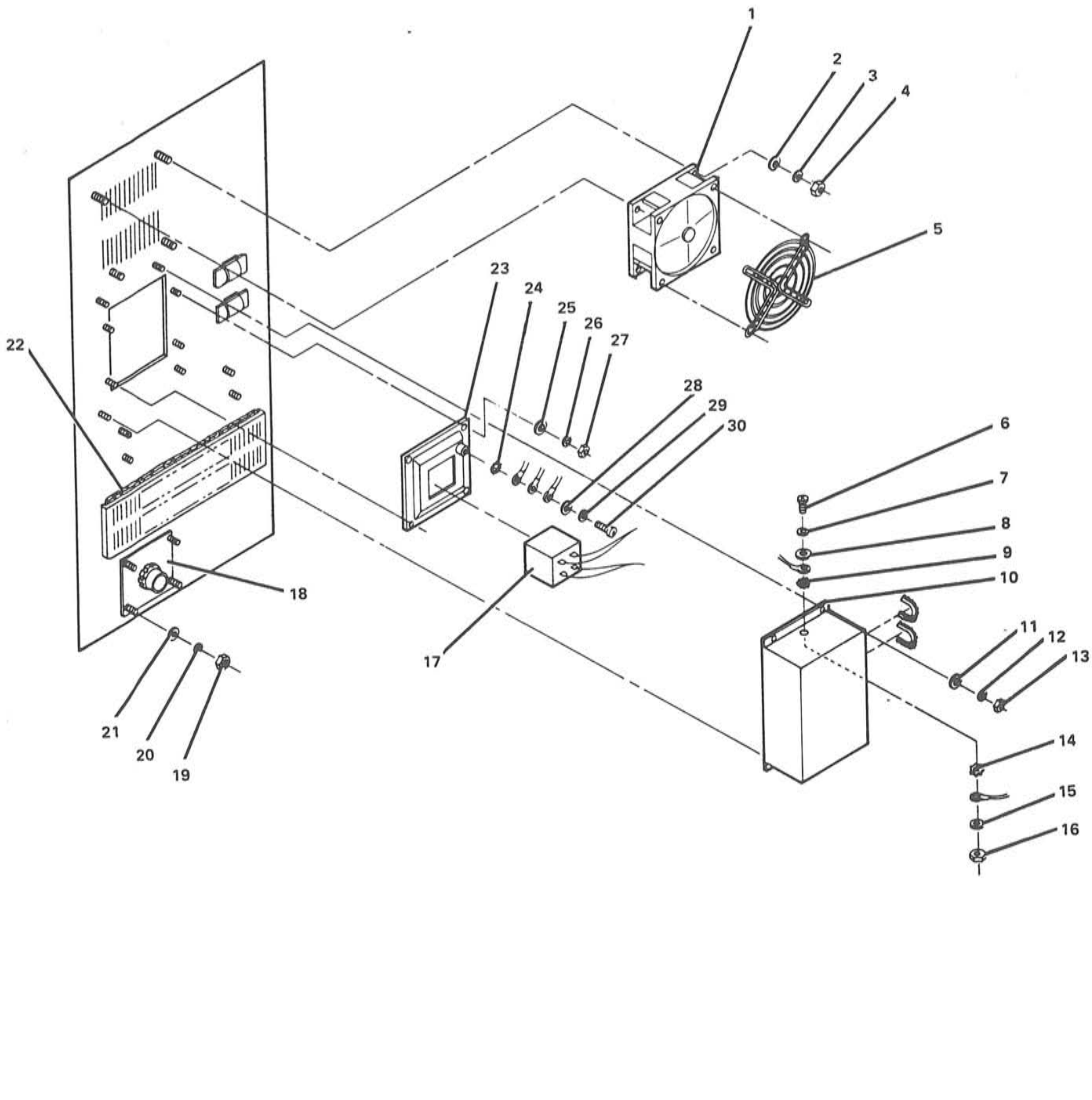


FIGURE 9. LEFT INSIDE PANEL. SEE LIST 9.

LEFT INSIDE PANEL

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
9-1	J200122	Fan, 110 Vac
-2	*	Washer, flat M3
-3	*	Washer, lock M3
-4	*	Nut, hex M3
-5		Fan shroud
-6	*	Screw, cross head M5 X 14.5
-7	*	Washer, lock M5
-8	*	Washer, flat M5
-9	*	Washer, star M5
-10	J200224	Circuit breaker cover
-11	*	Washer, flat M4
-12	*	Washer, lock M4
-13	*	Nut, hex M4
-14	*	Washer, star M5
-15	*	Washer, flat M5
-16	*	Nut, hex M5
-17	J200119	Circuit breaker assembly
-18		Line cord plate
-19	*	Nut, hex M4
-20	*	Washer, lock M4
-21	*	Washer, flat M4
-22	J200301	Air filter
-23		Circuit breaker bezel, included with 9-17
-24	*	Washer, star M5
-25	*	Washer, flat M5
-26	*	Washer, lock M4
-27	*	Nut, hex M4
-28	*	Washer, flat M5
-29	*	Washer, lock M5
-30	*	Screw, cross head M5 X 12

* See Common Hardware Listing

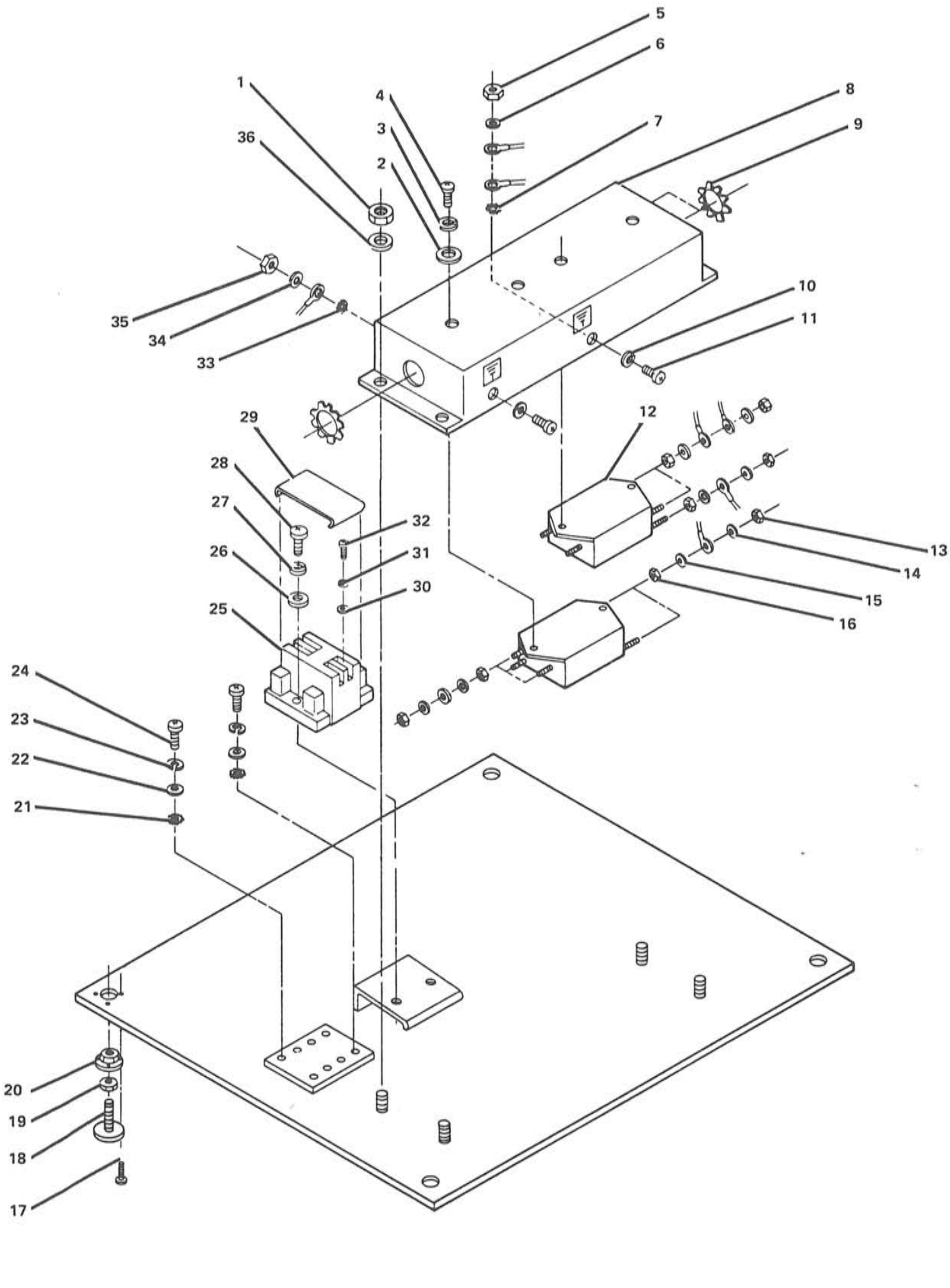


FIGURE 10. BOTTOM PANEL. SEE LIST 10.

BOTTOM PANEL

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
10-1	*	Nut, hex M4
-2	*	Washer, flat M4
-3	*	Washer, flat M4
-4	*	Screw, cross head M4 X 20
-5	*	Nut, hex M5
-6	*	Washer, lock M5
-7	*	Washer, flat M5
-8	J200226	Noise filter cover
-9		Insulator, included with 10-8
-10	*	Washer, lock M5
-11	*	Screw, cross head M5 X 10
-12	J200120	Noise filter
-13	*	Nut, included with 10-12
-14	*	Washer, included with 10-12
-15	*	Washer, included with 10-12
-16	*	Nut, included with 10-12
-17	*	Screw, slotted M4 X 10
-18	J200230	Adjuster
-19	*	Nut, hex M12
-20		Bracket, included with 10-18
-21	*	Washer, star M5
-22	*	Washer, flat M5
-23	*	Washer, lock M5
-24	*	Screw, cross head M5 X 10
-25	J200133	Line terminal block
-26	*	Washer, flat M4
-27	*	Washer, lock M4
-28	*	Screw, cross head M4 X 20
-29		Shield, included with 10-25
-30	*	Washer, flat M5
-31	*	Washer, lock M5
-32	*	Screw, cross head M5 X 9.5
-33	*	Washer, star M5
-34	*	Washer, flat M5
-35	*	Nut, hex M5
-36	*	Washer, flat M4

* See Common Hardware Listing

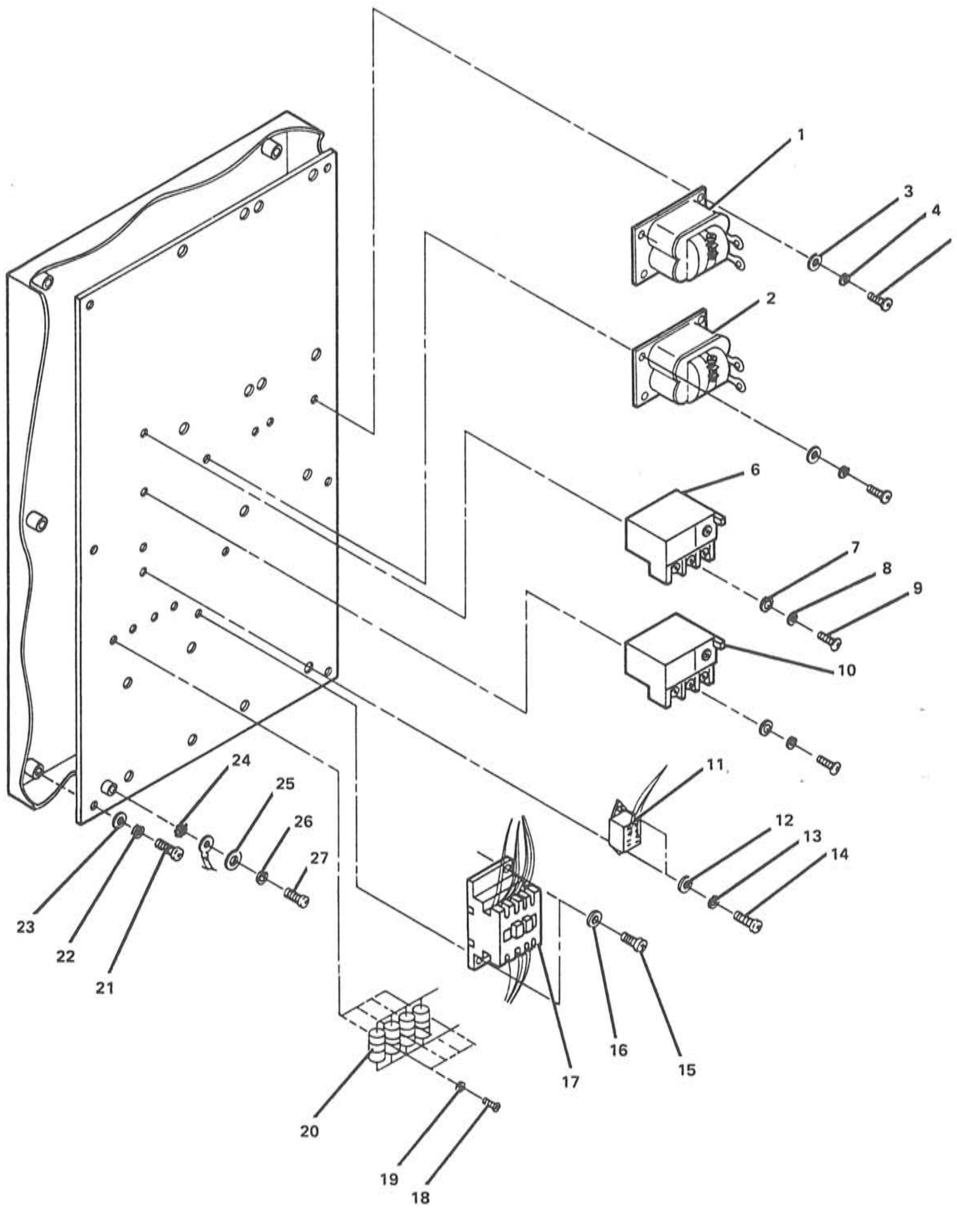


FIGURE 11. BACK PANEL. SHEET 1 OF 2. INDEX NOS. 1-27. SEE LIST 11.

BACK PANEL SHEET 1 OF 2

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
11-1	J200139	Inductor
-2	J200139	Inductor
-3	*	Washer, flat M4
-4	*	Washer, lock M4
-5	*	Screw cross head M4 X 7.5
-6	J200140	Theta 1 thermal relay
-7	*	Washer, flat M4
-8	*	Washer, lock M4
-9	*	Screw, cross head M4 X 19.5
-10	J200141	Theta 2 thermal relay
-11	J200124	Relay CR100
NR	J200130	Diode
-12	*	Washer, flat M3
-13	*	Washer, lock M3
-14	*	Screw, cross head M3 X 8.0
-15	*	Screw, cross head M4 X 16.0
-16	*	Washer, flat M4
-17	J200123	Contactor 110 Vac
-18	*	Screw, cross head M4 X 9.5
-19	*	Washer, lock M4
-20	J200134	Spark suppressor
-21	*	Screw cross head M6 X 12.0
-22	*	Washer, lock M6
-23	*	Washer, flat M6
-24	*	Washer, star M5
-25	*	Washer, flat M5
-26	*	Washer, lock M5
-27	*	Screw, cross head M5 X 9.5

* See Common Hardware Listing

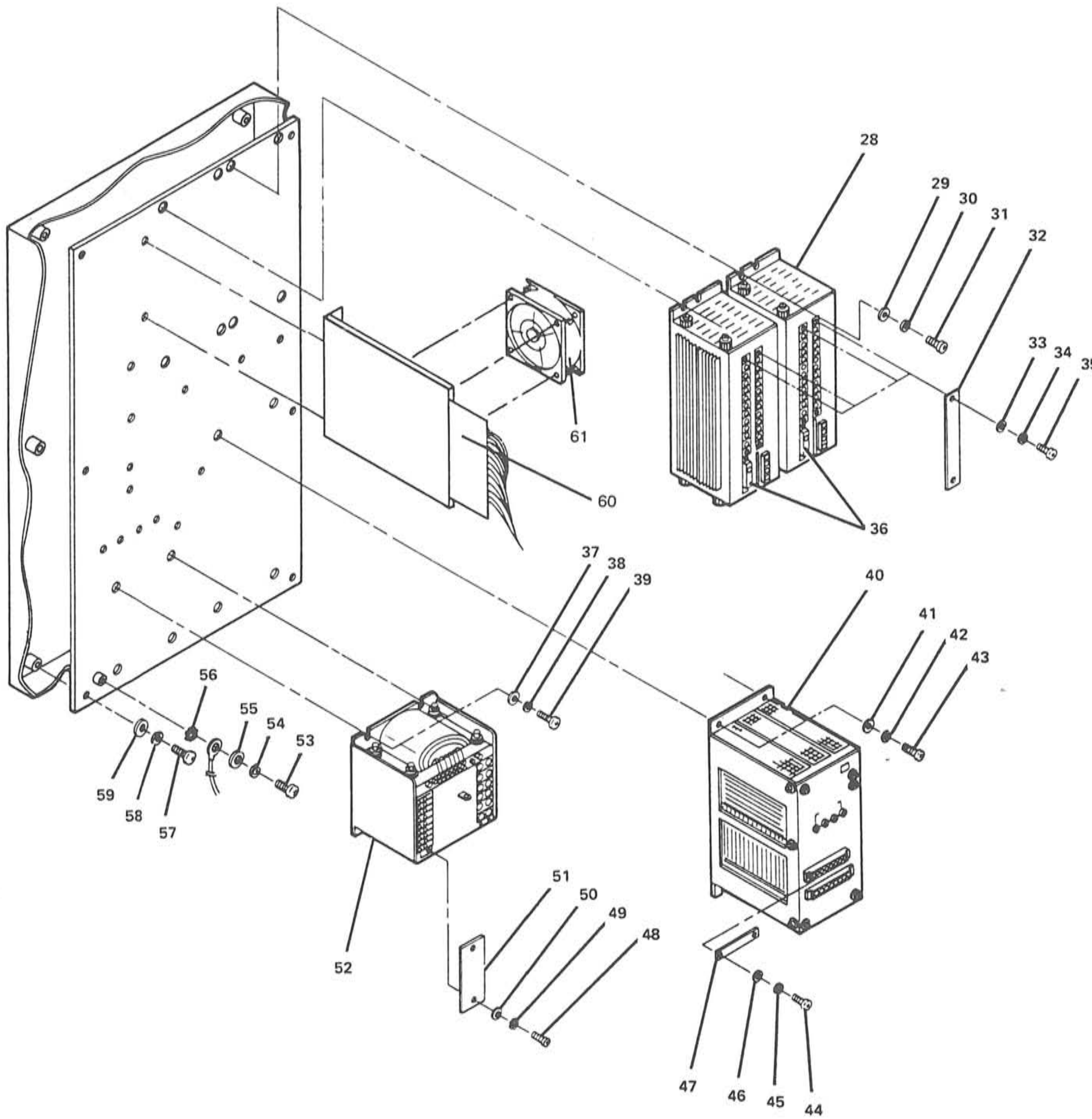


FIGURE 11. BACK PANEL. SHEET 2 OF 2. INDEX NOS. 28-59. SEE LIST 11.

BACK PANEL SHEET 2 OF 2

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
11-28	J200136	Theta 1 Servo Pack
-28	J200137	Theta 2 Servo Pack
-29	*	Washer, flat M4
-30	*	Washer, lock M4
-31	*	Screw, cross head M4 X 7.5
-32		Plastic shield
-33	*	Washer, flat M3
-34	*	Washer, lock M3
-35	*	Screw, cross head M3 X 5.5
-36	J200308	Servo pack fuse
-37	*	Washer, flat M6
-38	*	Washer, lock M6
-39	*	Screw, cross head M6 X 14.5
-40	J200125	DC power supply assembly, see figure 14
-41	*	Screw, cross head, M4 X 8.0
-42	*	Washer, lock M4
-43	*	Washer, flat M4
-44	*	Screw, cross head M3 X 5
-45	*	Washer, lock M3
-46	*	Washer, flat M3
-47		Shield, plastic
-48	*	Screw, cross head M3 X 7.5
-49	*	Washer, lock M3
-50	*	Washer, flat M3
-51		Shield, plastic
-52	J200138	Transformer
-53	*	Screw, cross head M5 X 9.5
-54	*	Washer, lock M5
-55	*	Washer, flat M5
-56	*	Washer, star M5
-57	*	Screw, cross head M6 X 12.0
-58	*	Washer, lock M6
-59	*	Washer, flat M6
-60	J400122	Driver card, roll motor
-61	J200376	Fan, roll motor driver 110 Vac

* See Common Hardware Listing

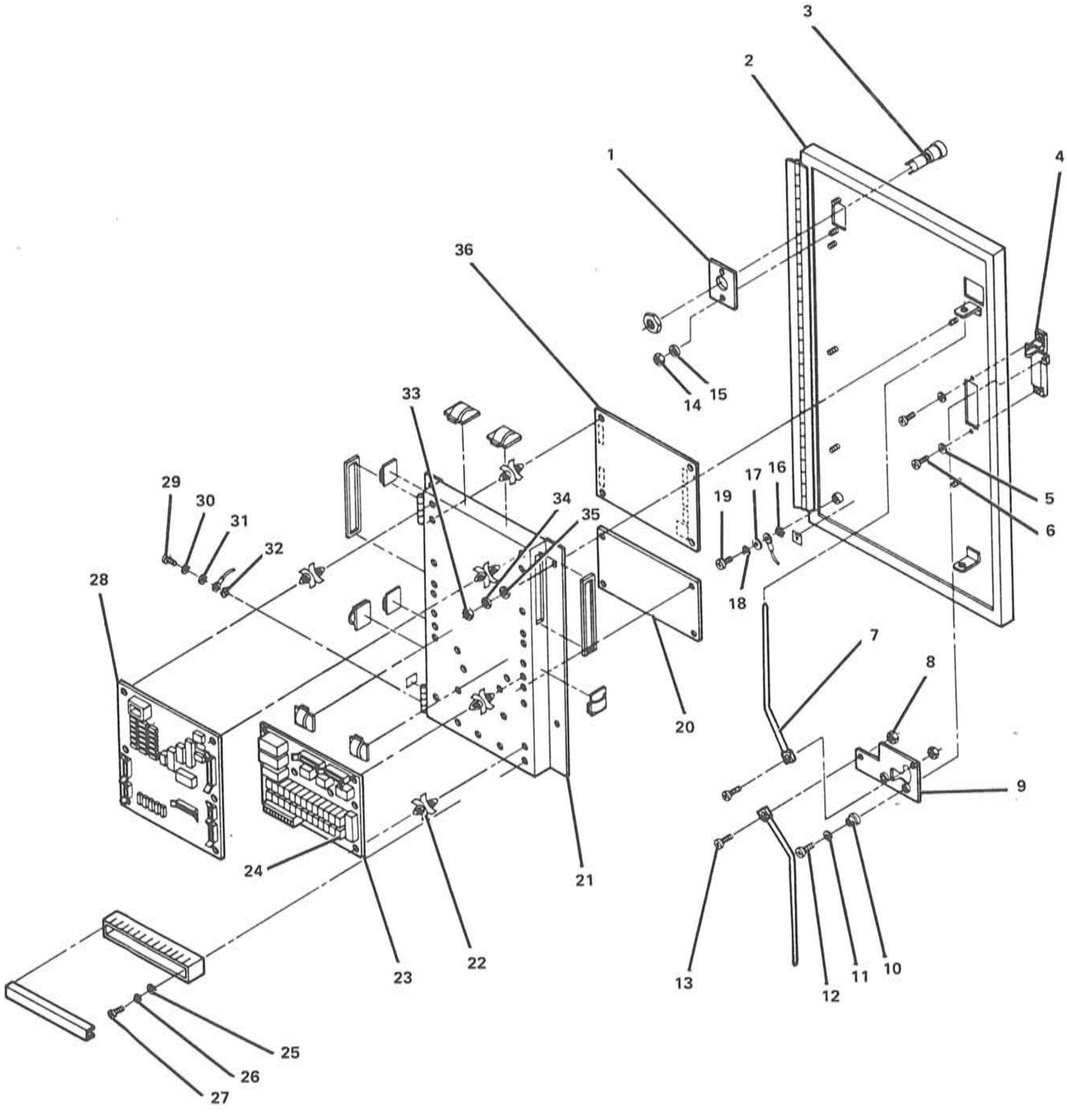


FIGURE 12. FRONT PANEL. SEE LIST 12.

FRONT PANEL

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
12-1	J200227	Plate, lamp mounting
-2	J200218	Front door
-3	J200132	Pilot lamp
NR	J200131	Pilot lamp holder
-4	J200231	Handle with keys
-5	*	Washer, lock M4
-6	*	Screw, cross head M4 X 5.5
-7		Latch rod
-8	*	Nut, hex M4
-9		Latch plate
-10		Spacer
-11	*	Washer, flat M5
-12	*	Screw, cross head, M5 X 9.0
-13	*	Screw, cross head, M4 X 9.5
-14	*	Nut, hex M3
-15	*	Washer, flat M3
-16	*	Washer, star M5
-17	*	Washer, flat M5
-18	*	Washer, lock M5
-19	*	Screw, cross head, M5 X 10
-20	J400147	Function enhancement card
-21		Bracket
-22		Stand off
-23	J200145	Relay board
-24	J200296	Relay, 1 contact
-24	J200295	Relay, 2 contact
-25	*	Washer, flat M4
-26	*	Washer, lock M4
-27	*	Screw, cross-head M4 X 10
-28	J200144	MTCB board
-29	*	Screw, cross head M5 X 9.5
-30	*	Washer, lock M5
-31	*	Washer, flat M5
-32	*	Washer, star M5
-33	*	Nut, hex M4
-34	*	Washer, lock M4
-35	*	Washer, flat M4
-36	J200372	CPU board

* See Common Hardware Listing

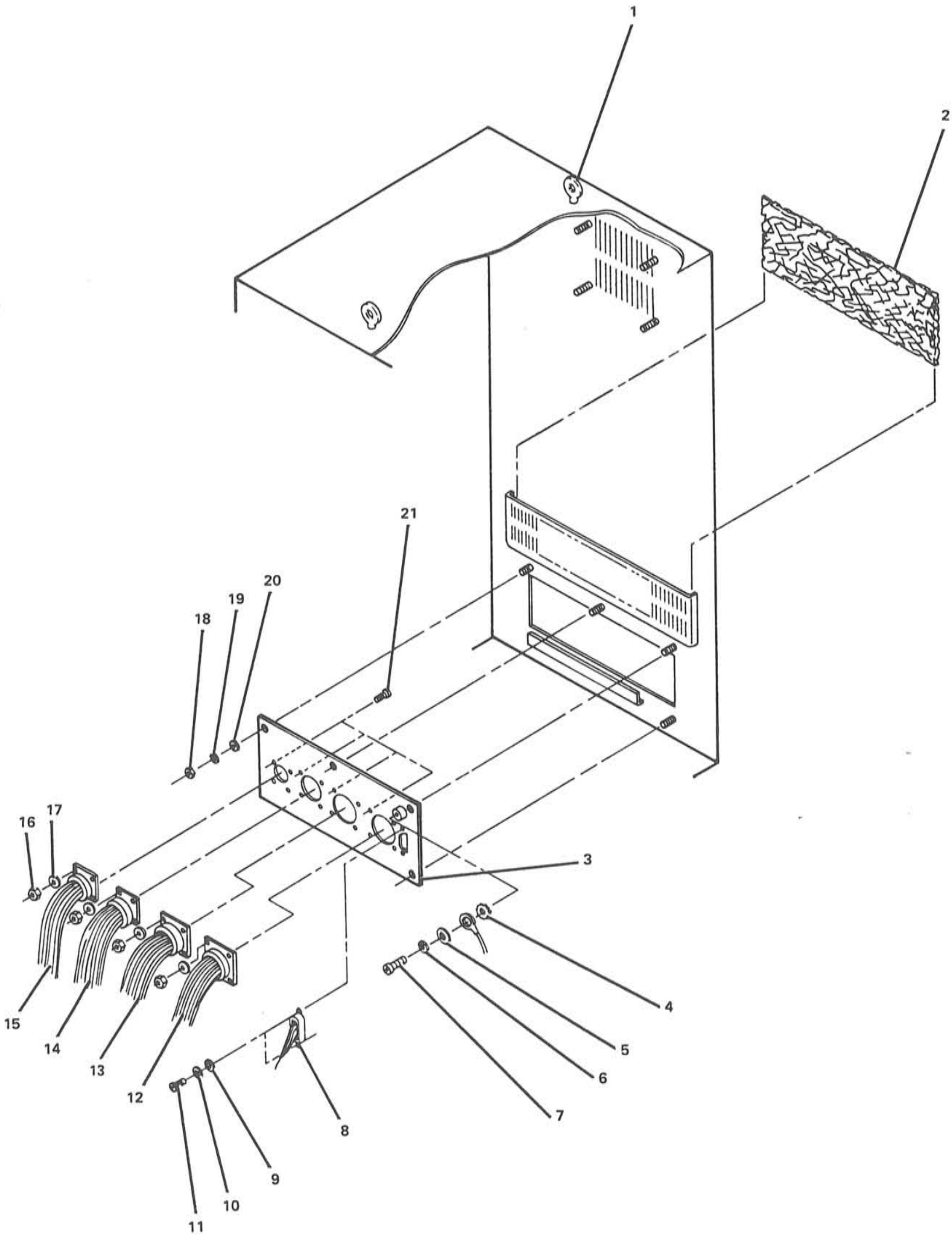


FIGURE 13. RIGHT OUTSIDE PANEL. SEE LIST 13.

RIGHT OUTSIDE PANEL

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
13-1	J200229	Eye bolt
-2	J200301	Filter
-3		Connector panel
-4	*	Washer, star M5
-5	*	Washer, flat M5
-6	*	Washer, lock M5
-7	*	Screw, cross head M5 X 9.5
-8	J200347	Cable, CB28
-9	*	Washer, flat M3
-10	*	Washer, lock M3
-11	*	Screw, cross head M3 X 5
-12	J200323	Cable, CB22, CB23
-13	J200325	Cable, CB24
-14	J200326	Cable, CB25, CB26
-15	J200321	Cable, CB19, CB20, CB27
-16	*	Nut, hex M3
-17	*	Washer, flat M3
-18	*	Nut, hex M4
-19	*	Washer, lock M4
-20	*	Washer, flat M4
-21	*	Screw, cross head M3 X 8
NR	J200345	Cable plug, DI/DO
NR	J200346	Cable clamp, DI/DO

* See Common Hardware Listing

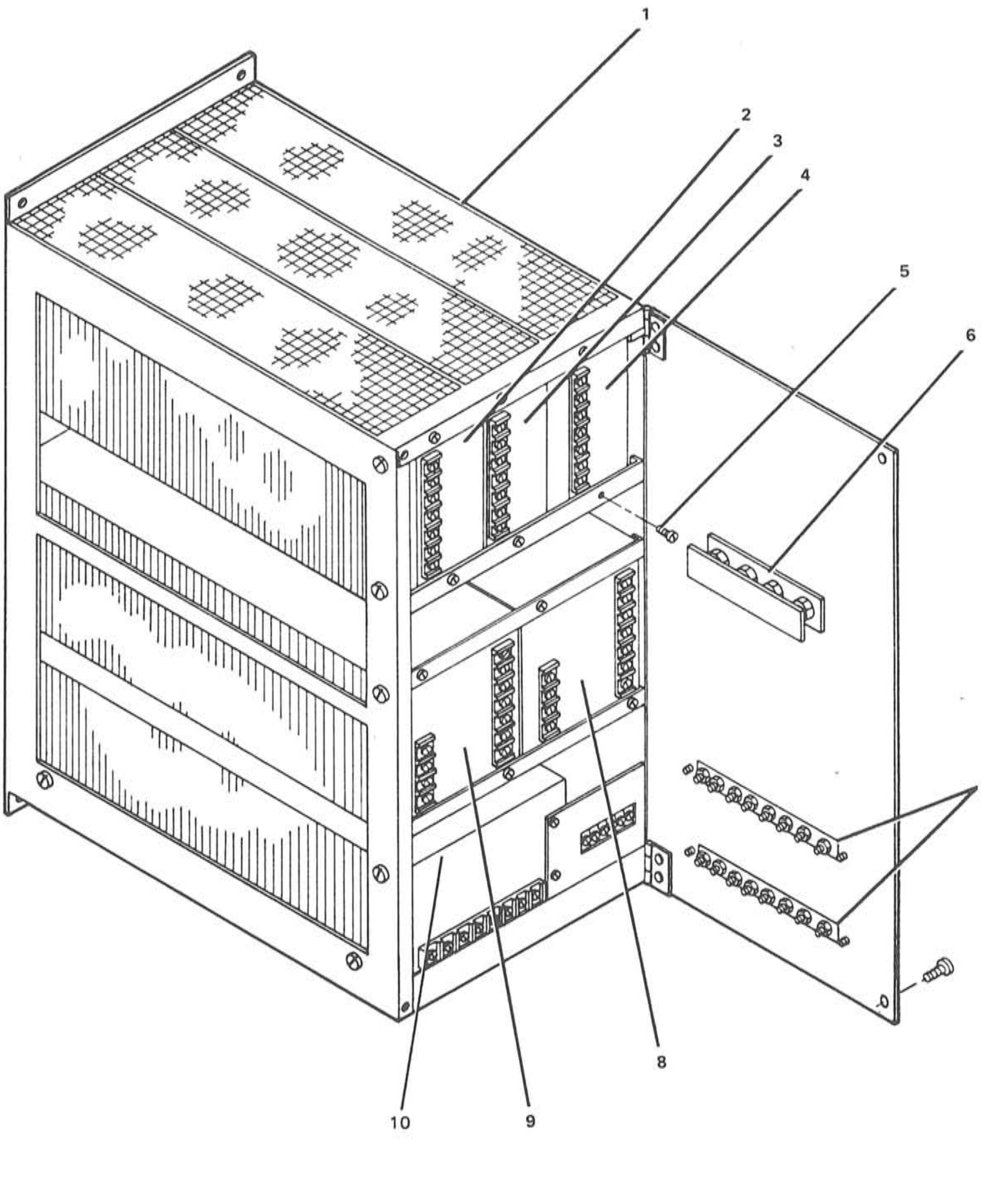


FIGURE 14. D.C. POWER SUPPLY ASSEMBLY. SEE LIST 14.

D. C. POWER SUPPLY ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
14-1	J200125	Power supply assembly
-2	J200127	12 Vdc, 2.5 ampere module
-3	J200127	12 Vdc, 2.5 ampere module
-4	J200126	5 Vdc, 10 ampere module
-5	*	Screw, cross head M3 X 4.5
-6	J200373	Indicator assembly
-7	J200374	Terminal strip
NR	*	Screw, cross head M3 X 8
-8	J200128	12 Vdc, 10 ampere module
-9	J200128	12 Vdc, 10 ampere module
-10	J200129	Power failure detector

* See Common Hardware Listing

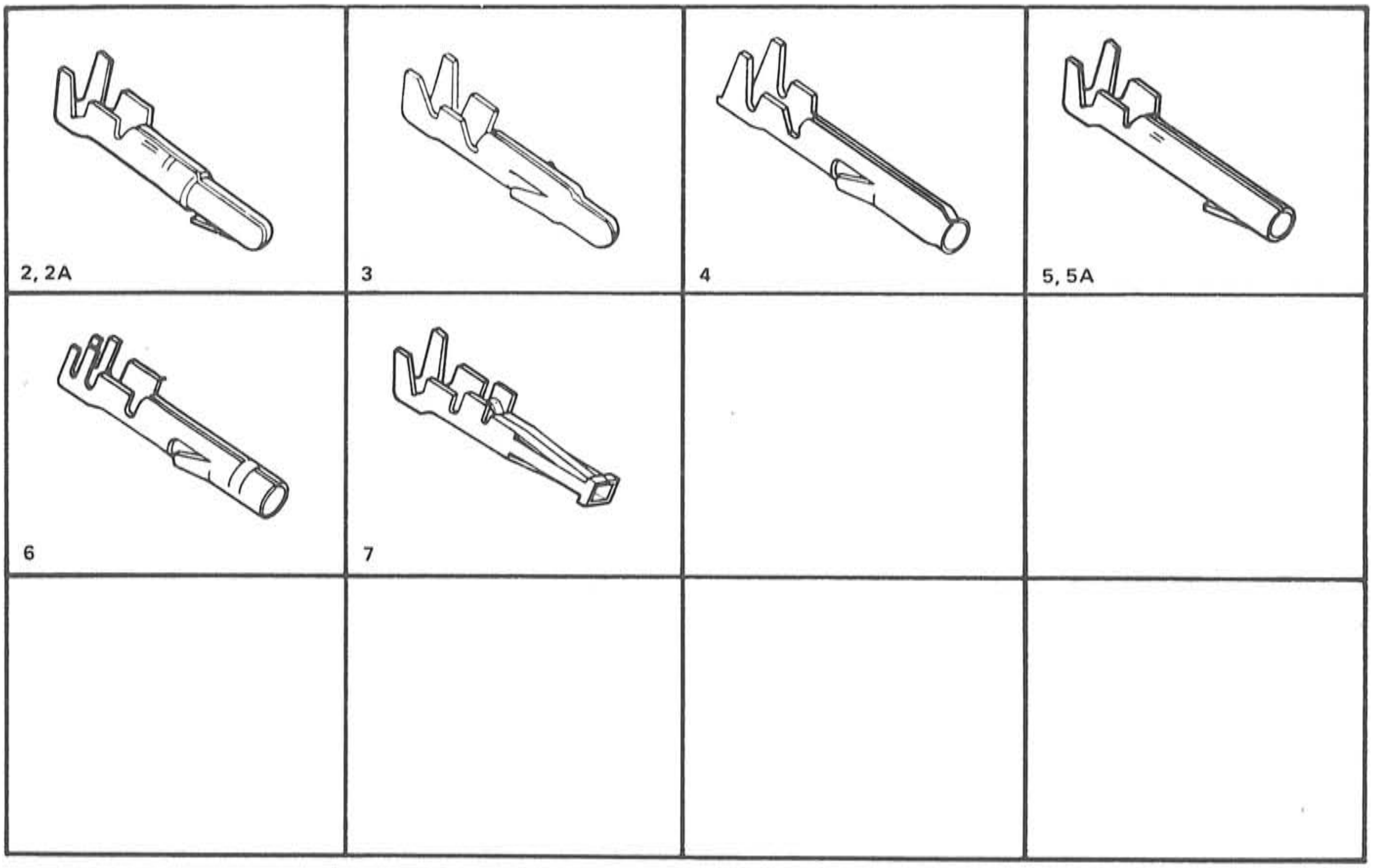
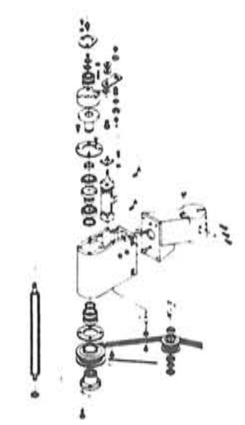


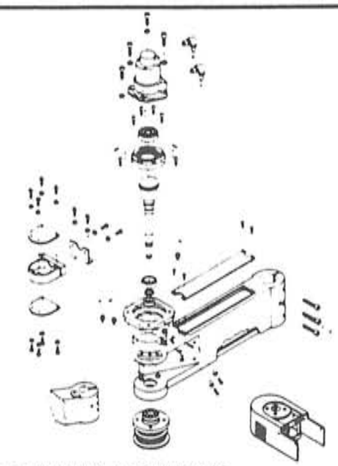
FIGURE 15. CABLE ASSEMBLIES WITH COMPONENT PARTS. INDEX NOS. 2-7. SEE LIST 15.

CABLE ASSEMBLIES

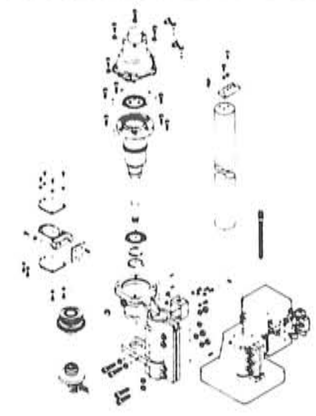
FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
15-2	AJ10059	Contact, 14-16 AWG
-2A	AJ10063	Contact, 18-22 AWG
-3	AJ10061	Contact
-4	AJ10062	Contact
-5	AJ10064	Contact, 18-22 AWG
-5A	AJ10066	Contact, 14-16 AWG
-6	AJ10067	Contact
-7	AJ10068	Contact
NR	J400134	CB8 Cable
NR	J200310	CB9 Cable
NR	J200311	CB10 Cable
NR	J200312	CB11 Cable
NR	J200313	CB12 Cable
NR	J200314	CB13 Cable
NR	J200315	CB14 Cable
NR	J200316	CB15 Cable
NR	J200317	CB16 Cable
NR	J400135	CB17 Cable
NR	J200288	CB31 Cable
NR	J200289	CB32 Cable
NR	J200286	CB33 Cable
NR	J200285	CB34 Cable
NR	J200290	CB35 Cable
NR	J200291	CB36 Cable
NR	J200287	CB37 Cable
NR	J400151	CB50 Cable
NR	J400152	CB51 Cable
NR	J400153	CB52 Cable
NR	J400154	CB53 Cable
NR	J400155	CB54 Cable



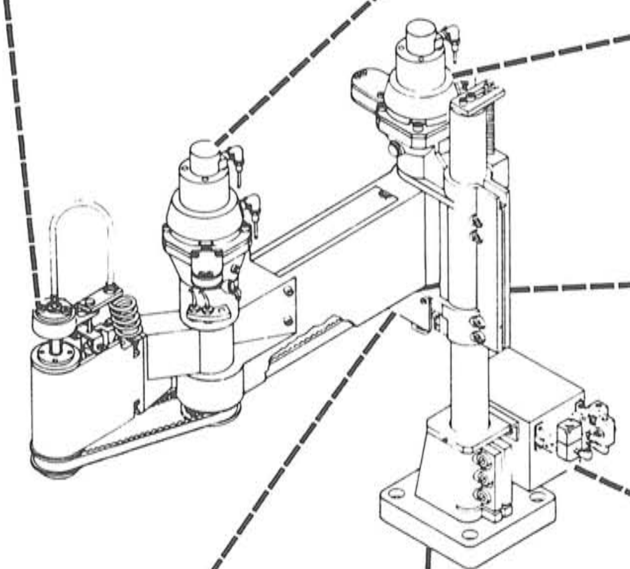
Z-AXIS ASSEMBLY
FIGURE 1 (SHEETS 1 & 2 OF 2)
PAGES 5-40 & 5-42

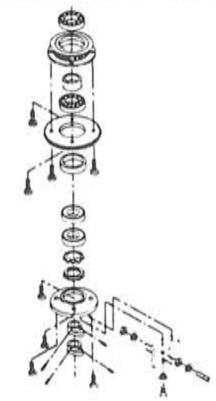


THETA TWO ASSEMBLY
FIGURE 2
PAGE 5-44

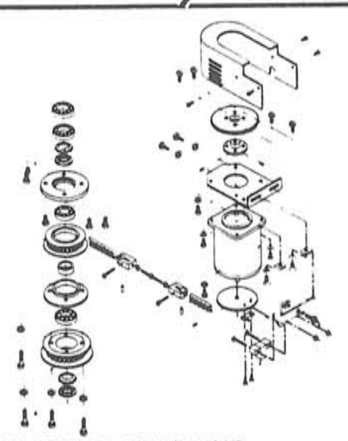


THETA ONE ASSEMBLY
FIGURE 3
PAGE 5-46

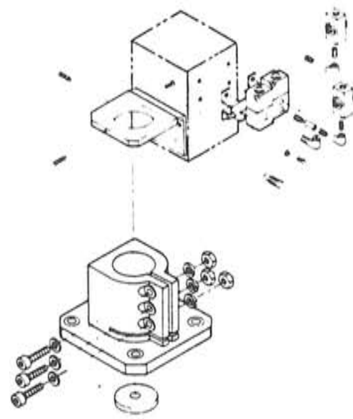




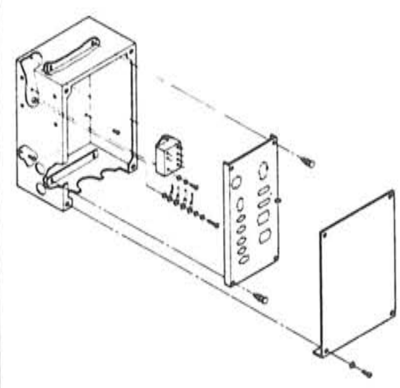
THETA ONE ASSEMBLY
FIGURE 4
PAGE 5-48



ROLL MOTOR AND DRIVE
ASSEMBLY
FIGURE 6
PAGE 5-52

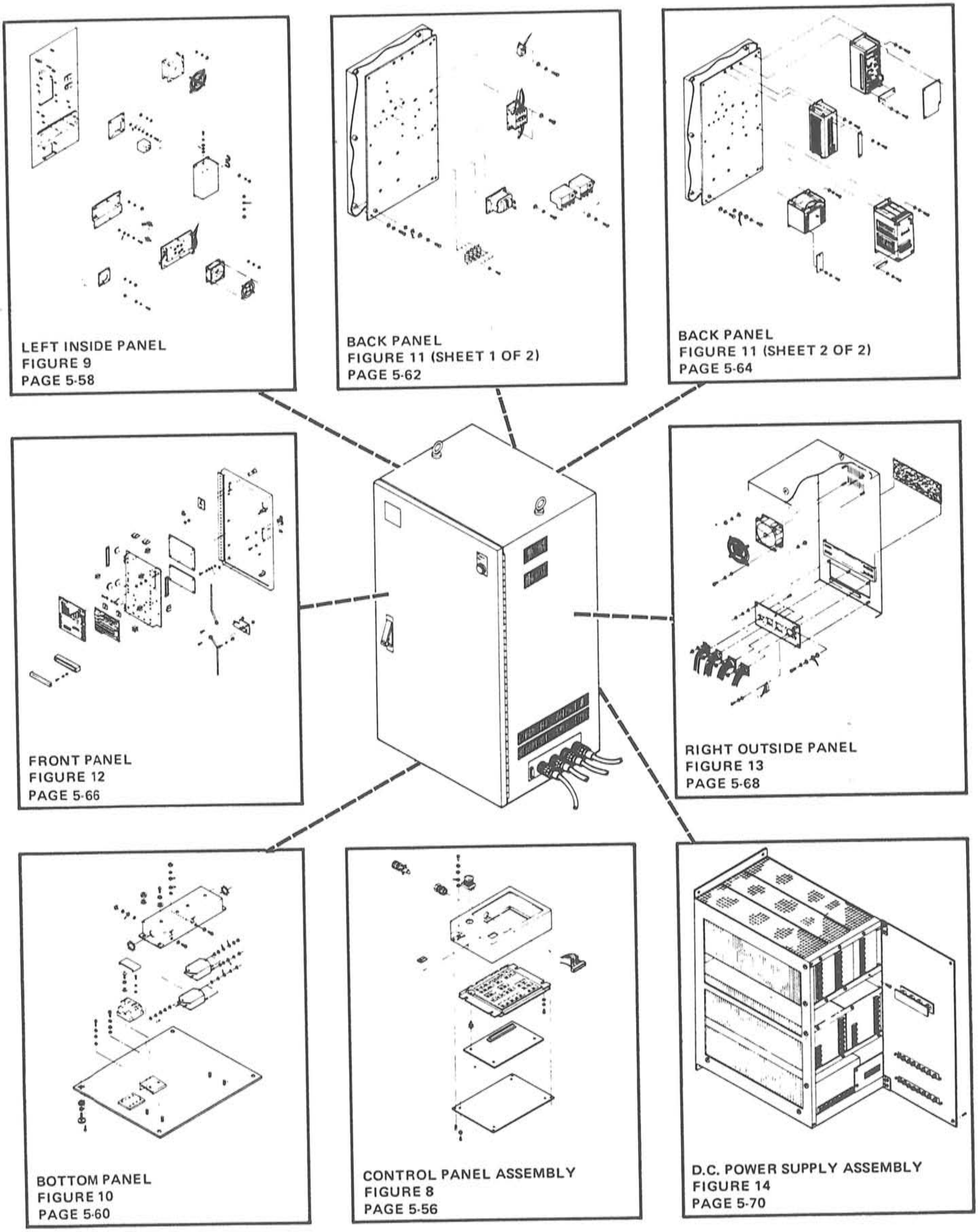


BASE ASSEMBLY
FIGURE 5
PAGE 5-50



OUTLET BOX ASSEMBLY
FIGURE 7
PAGE 5-54

VISUAL INDEX I



VISUAL INDEX II

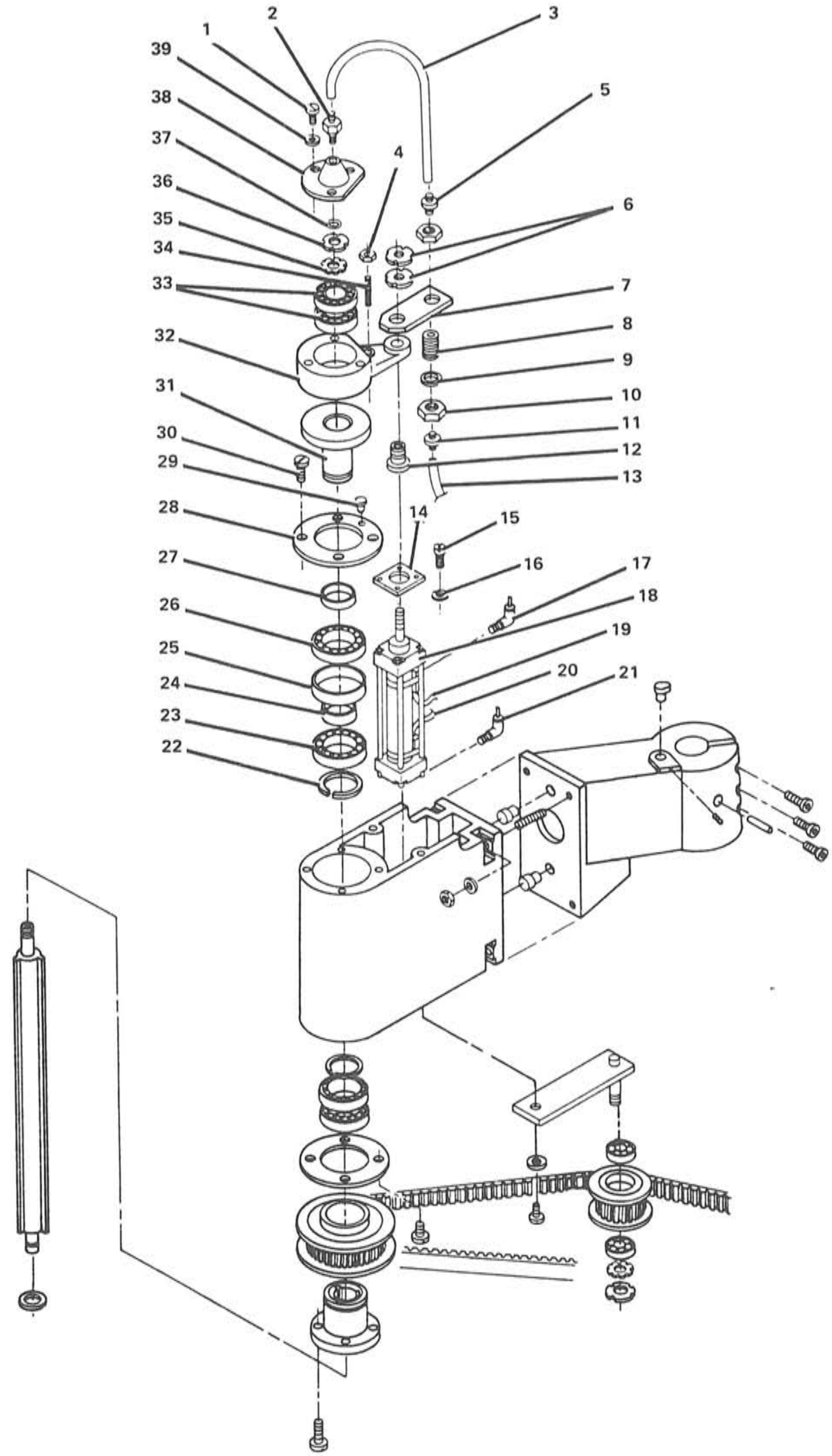


FIGURE 1. Z-AXIS ASSEMBLY. SHEET 1 OF 2. INDEX NOS. 1-39. SEE LIST 1.

Z-AXIS ASSEMBLY SHEET 1 OF 2

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
1-1	*	Screw, socket head cap M5 X 15
-2	J400110	Nipple
-3	J400114	Air line, straight
-4	*	Nut, hex M6
-5	J400110	Nipple
-6	J400097	Nut, circular
-7	J400091	Bracket, air
-8	J400112	Connector
-9	*	Washer, flat M20
-10	J400098	Nut, circular
-11	J400110	Nipple
-12	J400092	Bushing
-13	J400027	Triple curl hose, Theta two
-14	J400089	Plate, air cylinder mounting
-15	*	Screw, socket head cap M6 X 15
-16	*	Washer, lock M6
-17	J400111	Elbow, air
-18	J400104	Air cylinder assembly
-19	J200302	Proximity switch with cable
-20	J200302	Proximity switch with cable
-21	J400111	Elbow, air
-22	J400100	Retainer
-23	J400096	Bearing
-24	J400085	Spacer
-25	J400084	Spacer
-26	J400028	Bearing
-27	J400094	Spacer
-28	J400086	Bearing cap
-29	J400087	Stop, end pin
-30	*	Screw, cross head countersunk M5 X 12
-31		Ball spline, see 1-68
-32	J400081	Bracket, air cylinder
-33	J400095	Bearing
-34	J400090	Set screw, socket head M6 X 54
-35	J400099	Washer, lock tab
-36	J400097	Nut, circular
-37	J400101	"O" ring
-38	J400088	Cap, air intake and bearing
-39	*	Washer, lock M5

* See Common Hardware Listing

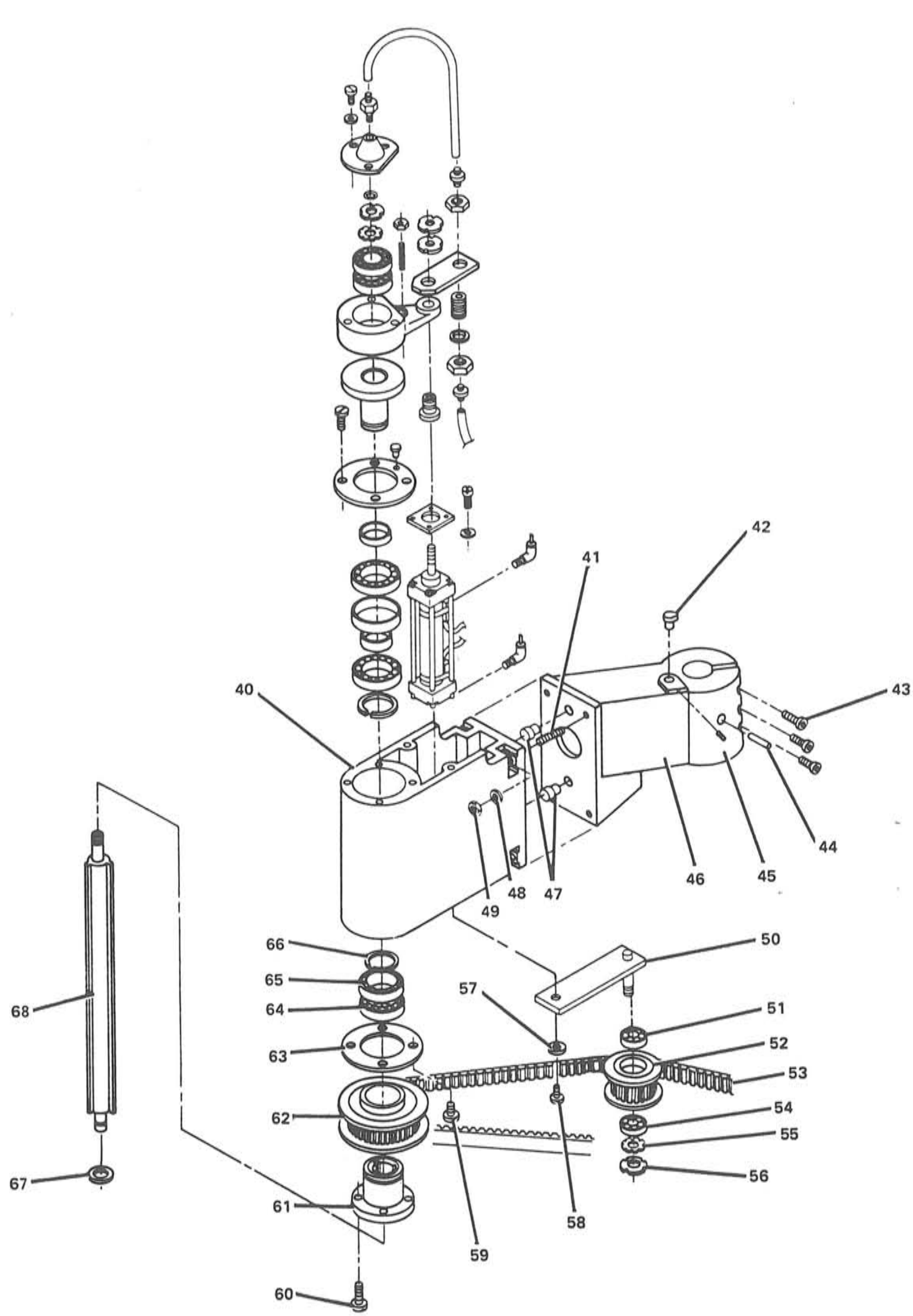


FIGURE 1. Z-AXIS ASSEMBLY. SHEET 2 OF 2. INDEX NOS. 40-68. SEE LIST 1.

Z-AXIS ASSEMBLY SHEET 2 OF 2

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
1-40	J400079	Head, pickup
-41	*	Set screw, socket head M8 X 40
-42	J400068	Eccentric, home/overrun
-43	*	Screw, socket head cap M8 X 40
-44	J400002	Pin, taper (J15 B 1354) M6 X 40
-45	*	Set screw, socket head M4 X 5
-46	J400062	Theta 2 Arm
-47	J400067	Pin, locating
-48	*	Washer M8
-49	*	Nut, hex M8
-50	J400066	Plate, belt tension
-51	J400069	Bearing
NR	J400064	Spacer, tension plate bearing
-52	J400063	Pulley, idler
-53	J400103	Belt, driven
-54	J400069	Bearing
-55	J400071	Washer, lock tab
-56	J400070	Nut, circular
-57	*	Washer, lock M6
-58	*	Screw, socket head cap M6 X 15
-59	*	Screw, cross head countersunk M5 X 12
-60	*	Screw, socket head cap M5 X 25
-61		Ball spline, see 1-68
-62	J400082	Pulley, finger
-63	J400083	Bearing cap
-64	J400028	Bearing set
NR	J400084	Spacer, large
NR	J400085	Spacer, small - between bearings
-65	J400028	Bearing set, same as 1-64
-66	J400100	Retainer
-67	J400102	"O" ring
-68	J400080	Z-shaft with ball splines

* See Common Hardware Listing

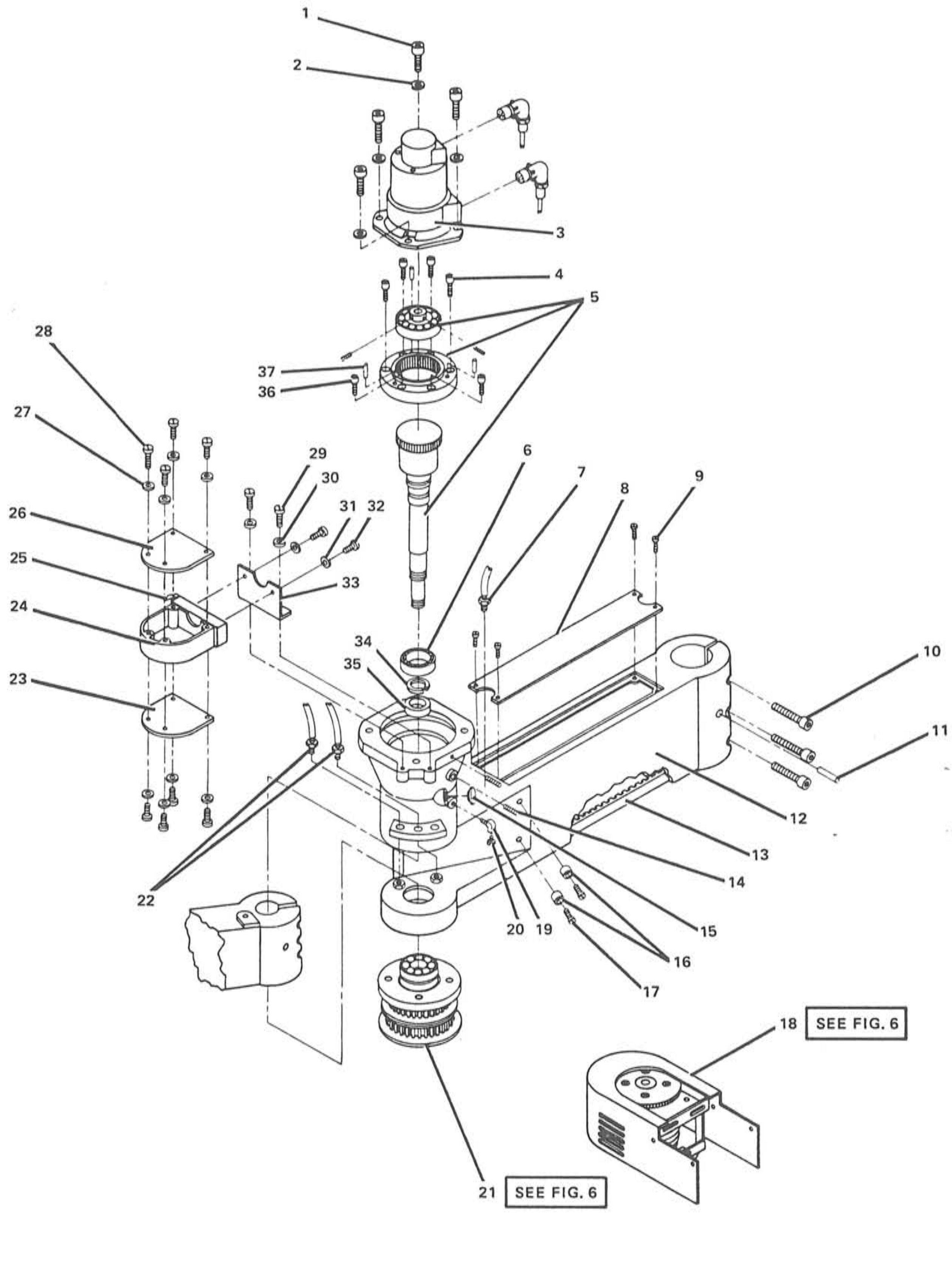


FIGURE 2. THETA TWO ASSEMBLY. SEE LIST 2.

THETA TWO ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
2-1	*	Screw, socket head cap M5 X 15
-2	*	Washer, lock M5
-3	J400008	Motor, Theta 2
NR	J200341	Brushes, Theta 2 motor
-4	*	Screw, socket head cap M5 X 30
-5	J400006	Harmonic drive assembly, includes: wave generator, circular spline and shaft
NR	*	Set screw, wave generator M4 X 15
-6	J200047	Bearing
-7	J200076	Proximity switch with hardware
-8	J400020	Duct cover
-9	*	Screw, cross head countersunk 4 X 10
10	*	Screw, socket head cap M12 X 50
-11	J400002	Pin, taper (J15 B 1354)
-12	J400001	Theta 1 arm
-13	J400061	Belt, drive
-14	*	Set screw, socket head M6 X 10
-15	J200049	Oil level port
-16	J400021	Bumper, stop
-17	*	Screw, socket head cap M6 X 15
-18		Roll motor and drive assembly, see figure 6
-19	J200343	Elbow, drain
-20	J200344	Plug, drain
NR	J400036	Pipe plug
-21		Roll motor and drive assembly, see figure 6
-22	J200076	Proximity switch with hardware
-23	J400076	Cover, lower
-24	J400075	Box, junction
-25	J400093	Manifold, air
-26	J400078	Cover, upper
-27	*	Washer, lock M3
-28	*	Screw, cross head M3 X 5
-29	*	Screw, socket head cap M5 X 12
-30	*	Washer, lock M5
-31	*	Washer, lock M5
-32	*	Screw, socket head cap M5 X 12
-33	J400074	Bracket
-34	J200046	Retainer
-35	J200045	Seal, oil
-36	*	Screw, socket head cap M5 X 30
-37	J400025	Pin, straight (J15 B 1354) M4 X 16

* See Common Hardware Listing

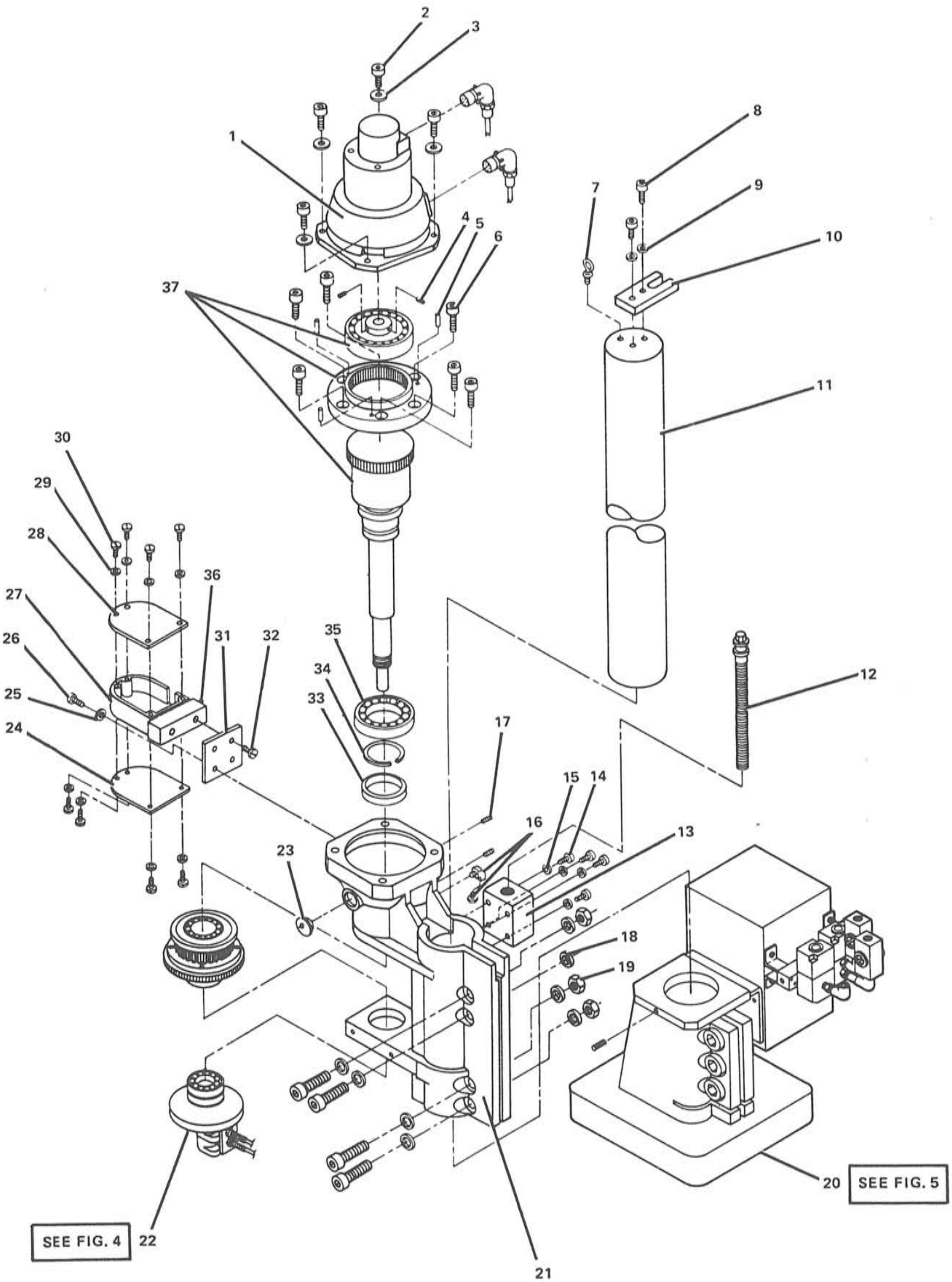


FIGURE 3. THETA ONE ASSEMBLY. SEE LIST 3.

THETA ONE ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
3-1	J400009	Motor, DC, Theta 1
NR	J400150	Brushes, Theta 1 motor
-2	*	Screw, socket head cap M8 X
-3	*	Washer, lock M8
-4	*	Set screw, socket head M4 X 15
-5	J400024	Pin, straight (J15 B 1354) M4 X 16
-6	*	Screw, socket head cap M4 X 25
-7	J200229	Eye bolt
-8	*	Screw, socket head cap M10 X 30
-9	*	Washer, lock M10
-10	J400013	Plate, height adjust
-11	J400011	Column
-12	J400014	Bolt, height adjust
-13	J400015	Block, height adjust
-14	*	Screw, socket head cap M8 X 55
-15	*	Washer, lock M8
-16	J400034	Elbow, drain
NR	J400035	Plug, drain
NR	J400037	Pipe plug
-17	*	Set screw, socket head M6 X 10
-18	*	Washer, flat M16
-19	*	Nut, hex M16
NR	*	Screw, socket head cap M16 X 80
-20		Base assembly, see figure 5
-21	J400003	Arm support
-22		Theta 1 assembly, see figure 4
-23	J400033	Oil level port
-24	J400077	Lower duct cover
-25	*	Washer, lock M5
NR	J400035	Plug, drain
-26	*	Screw, socket head cap M5 X 12
-27	J400075	Duct
-28	J400076	Upper duct cover
-29	*	Washer lock M3
-30	*	Screw, cross head M3 X 5
-31	J400073	Bracket
NR	J400026	Curl hose Theta one
-32	*	Screw, socket head cap M5 X 12
-33	J400145	Oil seal
-34	J400032	Retainer
-35	J400029	Bearing set (2 bearings included)
-36	J400093	Manifold, air
-37	J400005	Harmonic drive assembly, includes: wave generator, circular spline, and shaft

* See Common Hardware Listing

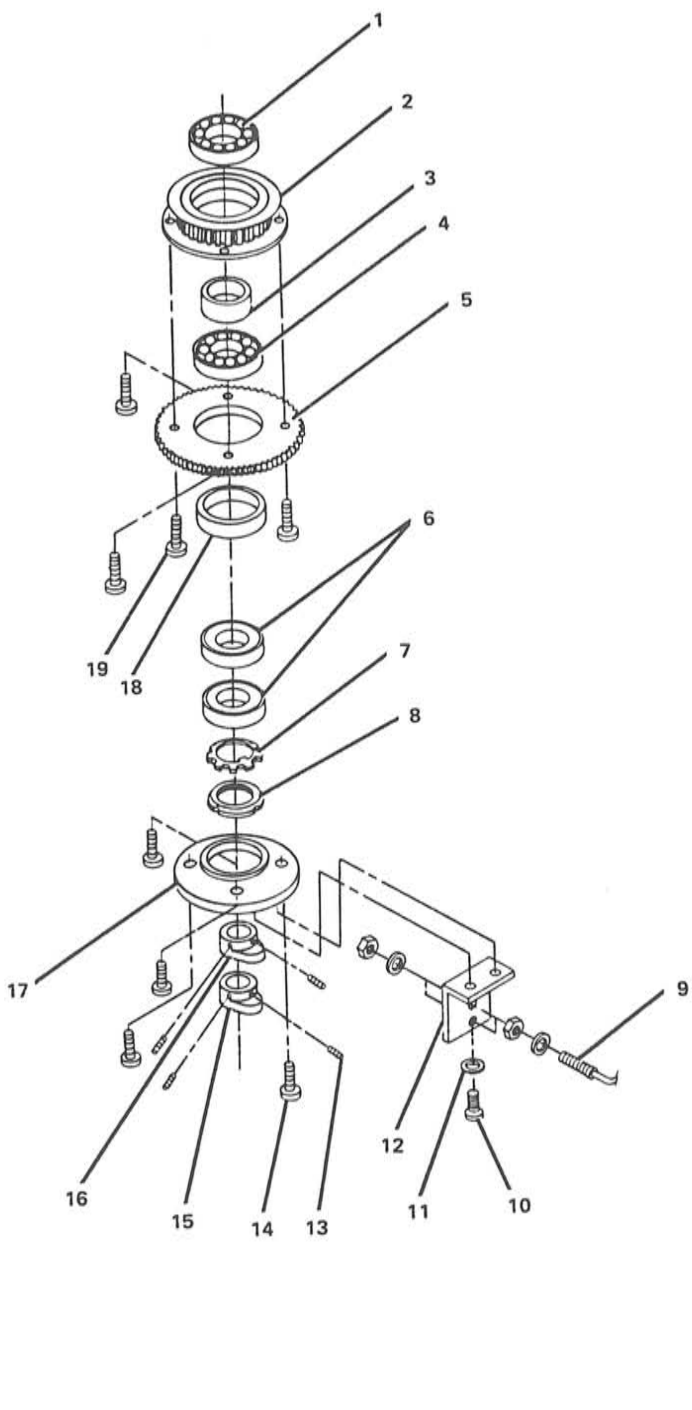


FIGURE 4. THETA ONE ASSEMBLY. SEE LIST 4.

THETA ONE ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
4-1	J400055	Bearing
-2	J400045	Pulley, roll drive
NR	J400046	Spacer, pulley to gear
-3	J400044	Spacer
-4	J400055	Bearing
-5	J400040	Gear, driven
-6	J400028	Bearing set
-7	J400031	Washer, lock tab
-8	J400030	Nut, circular
-9	J200076	Proximity switch with hardware
-10	*	Screw, socket head cap M5 X 10
-11	*	Washer, lock M5
12	J400017	Bracket, switch
-13	*	Set screw, socket head M4 X 5
-14	*	Screw, socket head cap M8 X 15
-15	J400018	Cam, overrun
-16	J400018	Cam, home
-17	J400016	Bearing cap
-18	J400043	Spacer
-19	*	Screw, socket head cap M5 X 12

* See Common Hardware Listing

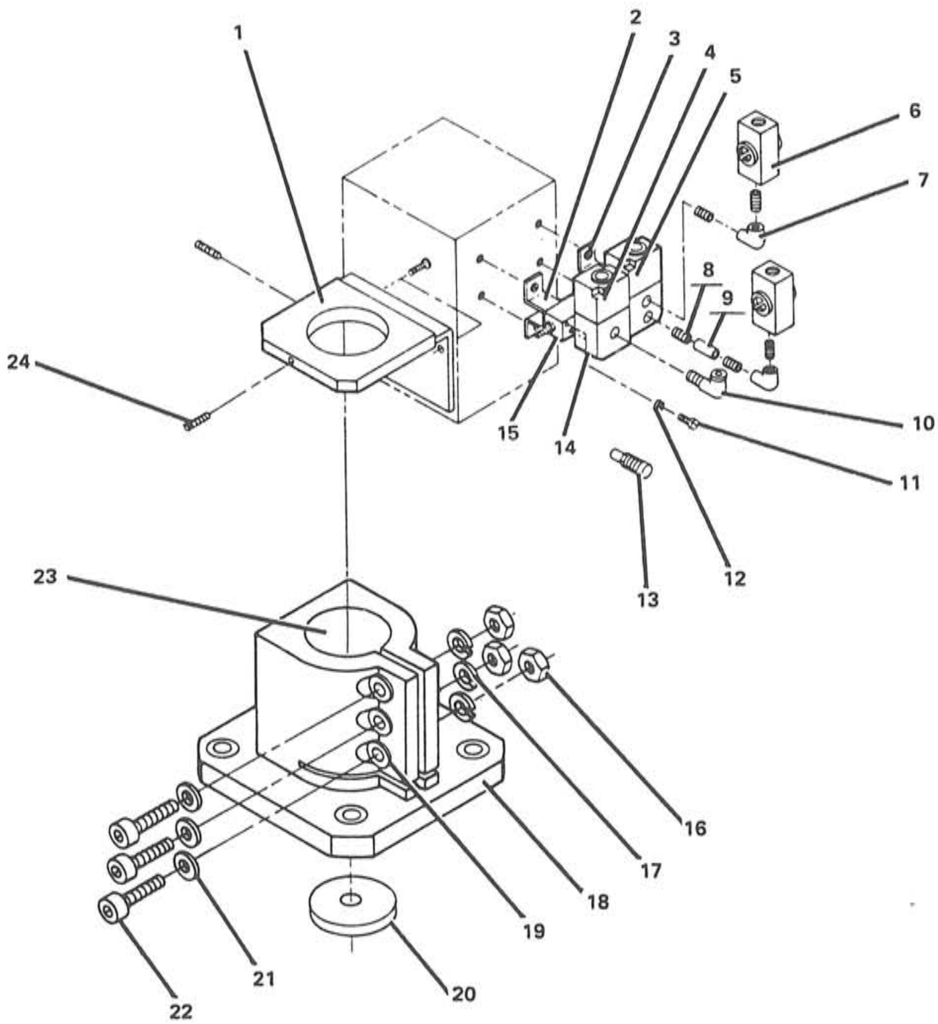


FIGURE 5. BASE ASSEMBLY. SEE LIST 5.

BASE ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
5-1	J400072	Bracket, J-box mounting
-2		Bracket, see 5-15
-3		Screw, see 5-15
-4	J400106	Solenoid valve SOL1
-5	J400105	Solenoid valve SOL2
-6	J400108	Air regulator
-7	J400117	Elbow, pipe
-8	J400110	Nipple, pipe
-9	J400113	Coupler, pipe
-10	J200111	Elbow, air line
-11	*	Screw, socket head cap M5 X 36
-12	*	Washer, lock M5
-13	J400109	Muffler
-14	J400106	Solenoid valve SOL1
-15	J400107	Manifold, air with mounting hardware
-16	*	Nut, hex M16
-17	*	Washer, lock M16
-18	J400004	Base, column
-19	J400004	Base, column
-20	J400012	Collar, positioning
-21	*	Washer, flat M16
-22	*	Screw, socket head cap M16 X 80
-23	J400004	Base, column
-24	*	Set screw, socket head M6 X 10

* See Common Hardware Listing

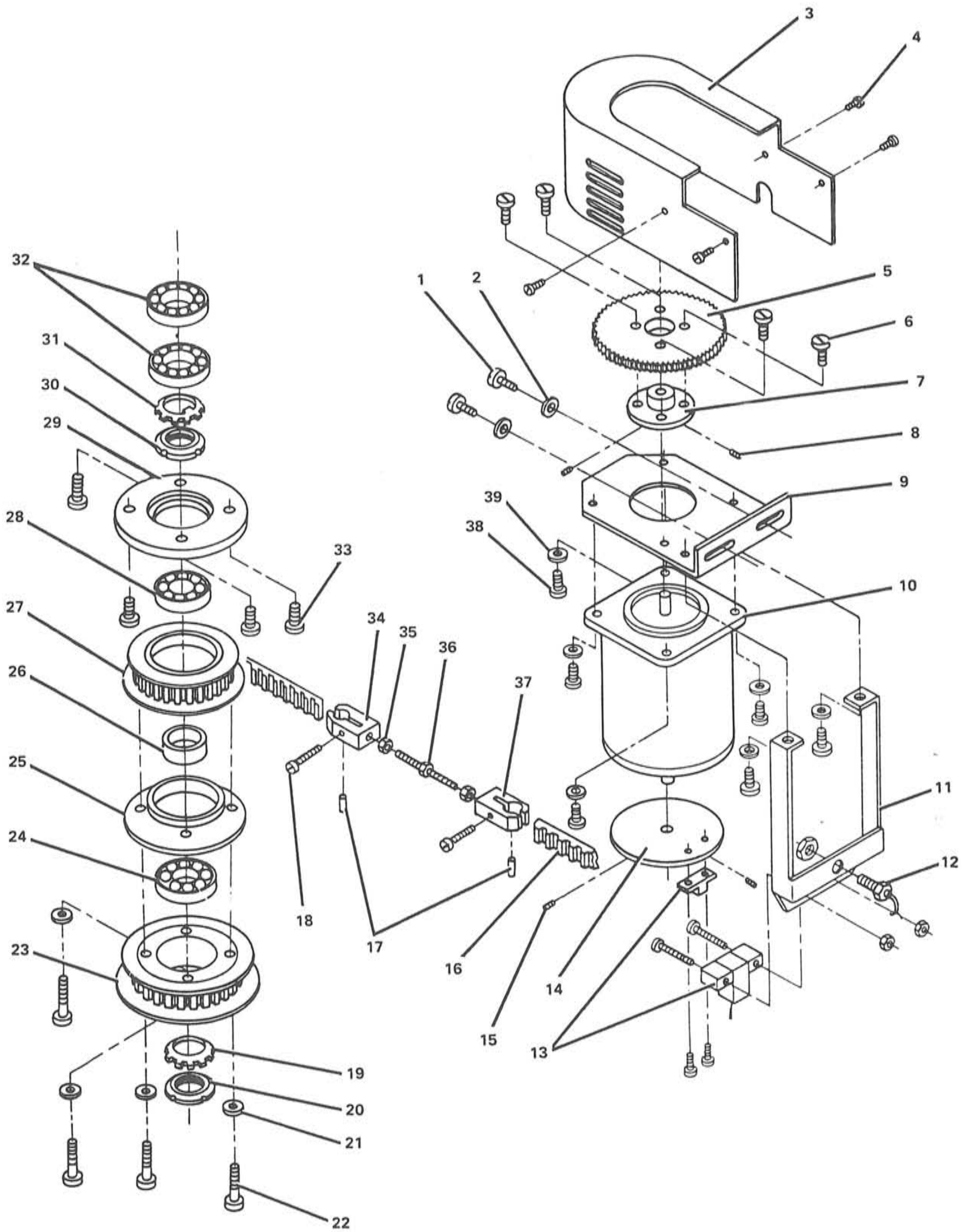


FIGURE 6. ROLL MOTOR AND DRIVE ASSEMBLY. SEE LIST 6.

ROLL MOTOR AND DRIVE ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
6-1	*	Screw, socket head cap M6 X 15
-2	*	Washer, lock M6
NR	*	Washer, flat M6
-3	J400007	Cover, roll motor
-4	*	Screw, cross head M6 X 10
-5	J400041	Gear, roll drive
-6	*	Screw, socket head cap M5 X 12
-7	J400042	Hub, roll drive gear
-8	*	Set screw, socket head M5 X 5
-9	J400038	Bracket, motor
-10	J400059	Motor
-11	J400039	Bracket, sensor
-12	J200076	Proximity sensor
-13	J200078	Home sensor assembly with detector module and hardware
-14	J400054	Cam, roll motor home
-15	*	Set screw, socket head M4 X 5
-16	J400061	Belt, drive
-17	J400053	Roll pin
-18	*	Screw, socket head cap M6 X 15
-19	J400058	Washer, lock tab
-20	J400057	Nut, circular
-21	*	Washer, lock M6
-22	*	Screw, socket head cap M6 X 30
-23	J400047	Pulley
-24	J400056	Bearing
-25	J400049	Spacer
-26	J400050	Spacer
-27	J400048	Pulley
-28	J400056	Bearing
-29	J400019	Bearing cap
-30	J200069	Nut, circular
-31	J200070	Washer, lock tab
-32	J200068	Bearing set
-33	*	Screw, socket head cap M6 X 12
-34	J400160	Nut, special L. H.
-35	J400060	Nut, left hand thread M5
NR	*	Nut, hex M5
-36	J400051	Bolt, tension
-37	J400052	Nut, special R. H.
-38	*	Screw, socket head cap M5 X 15
-39	*	Washer, lock M5

* See Common Hardware Listing

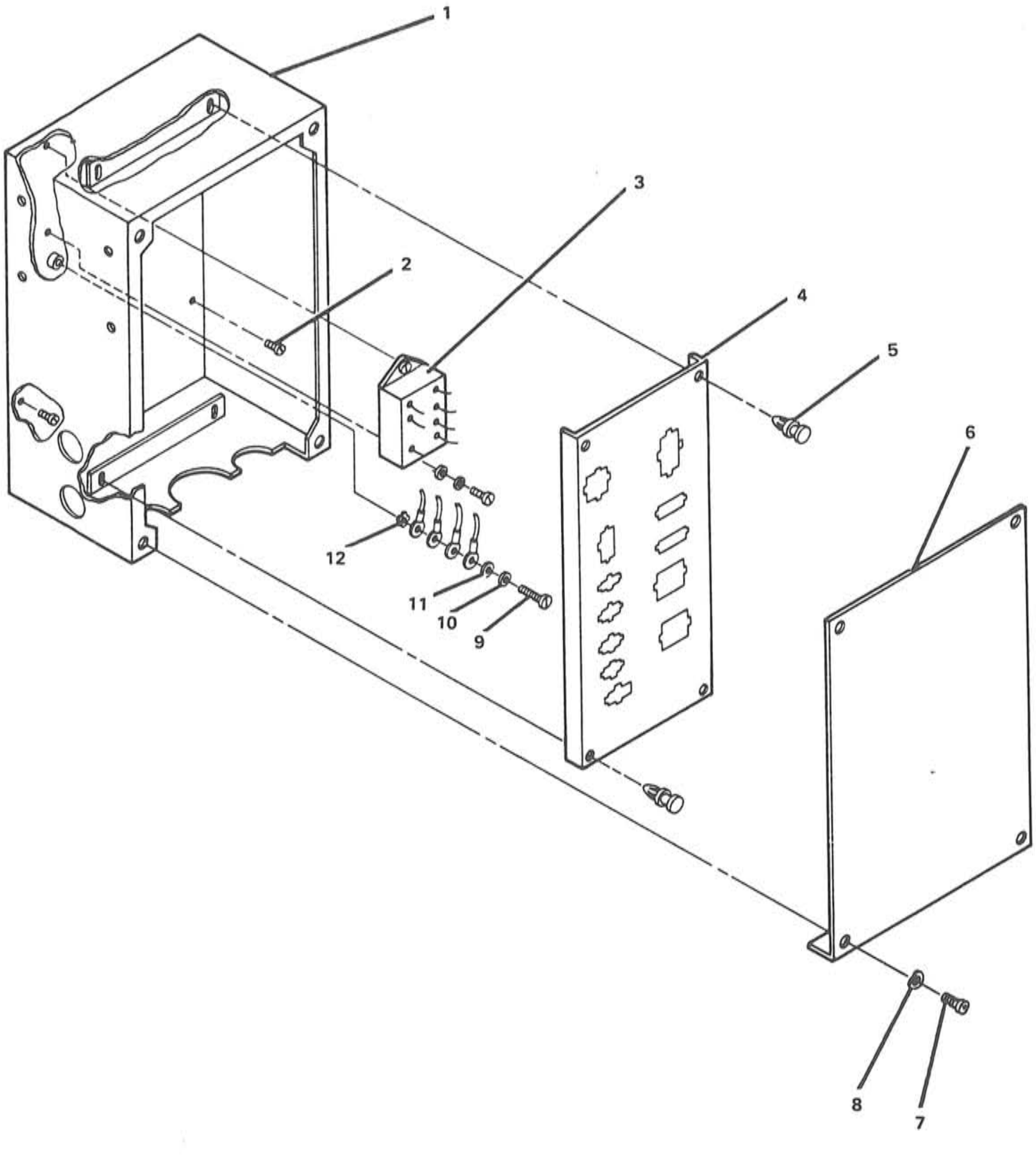


FIGURE 7. OUTLET BOX ASSEMBLY. SEE LIST 7.

OUTLET BOX ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
7-1		Box
-2	*	Screw, cross head M5 X 5
-3		Detector, included with 6-13
-4		Plate, receptacle mounting
-5		Fastener
-6		Plate, cover
-7	*	Screw, oval head M3 X 10
-8	*	Washer, cup M3
-9	*	Screw, cross head M5 X 9.5
-10	*	Washer, lock M5
-11	*	Washer, flat M5
-12	*	Washer, star M5

* See Common Hardware Listing

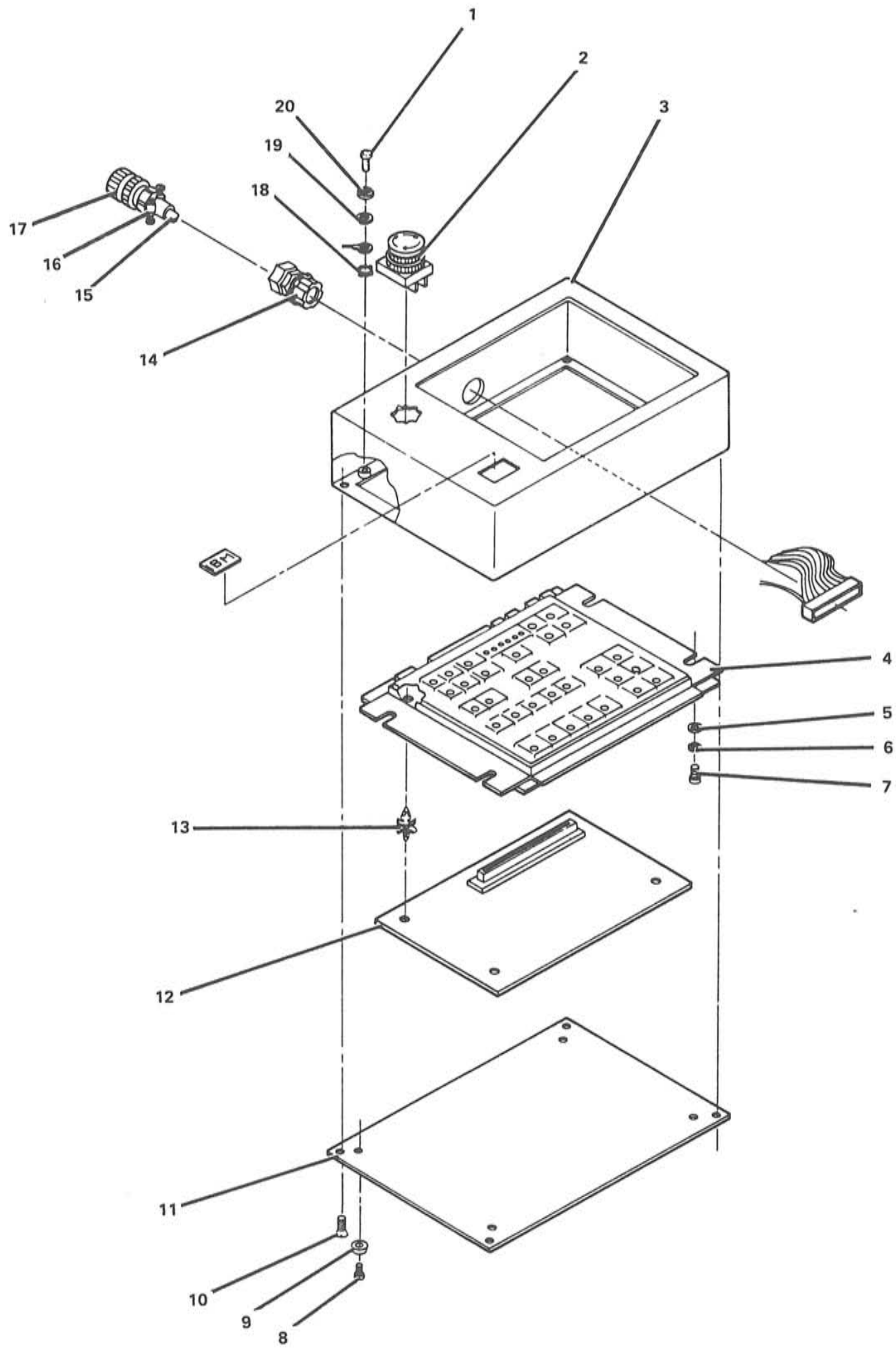


FIGURE 8. CONTROL PANEL ASSEMBLY. SEE LIST 8.

CONTROL PANEL ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
8-1	*	Screw, cross head M5 X 10
-2	J200148	Pushbutton assembly
-3	J200154	Box, control panel
-4	J200147	Keyboard, with plastic standoff
-5	*	Washer, flat M3
-6	*	Washer, lock M3
-7	*	Screw, cross head M3 X 8
-8	*	Screw, cross head M3 X 10
-9	J200150	Foot, rubber
-10	*	Screw, flat head countersunk M3 X 5
-11	J200155	Cover, bottom
-12	J200146	Board, key interface
-13		Standoff, plastic
-14	J200149	Connector assembly
-15	J200151	Cable
-16	J200153	Clamp
-17	J200152	Plug
-18	*	Washer, star M5
-19	*	Washer, flat M5
-20	*	Washer, lock M5

* See Common Hardware Listing

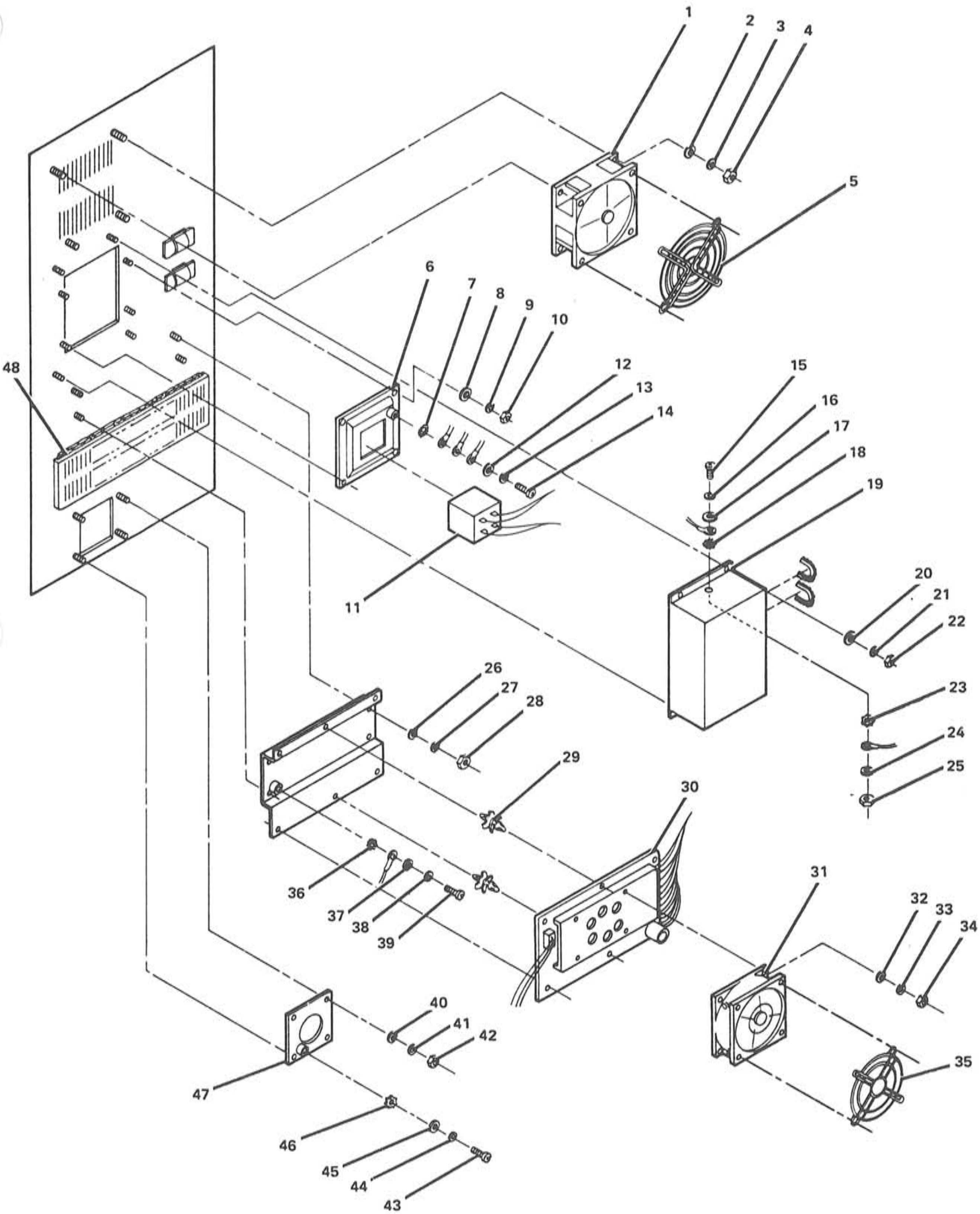


FIGURE 9. LEFT INSIDE PANEL. SEE LIST 9.

LEFT INSIDE PANEL

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
9-1	J200348	Fan, cabinet
-2	*	Washer, flat M3
-3	*	Washer, lock M3
-4	*	Nut, hex M3
-5		Guard, fan
-6		Bezel, included with 9-11
-7	*	Washer, star M4
-8	*	Washer, flat M4
-9	*	Washer, lock M4
-10	*	Nut, hex M4
-11	J200119	Circuit breaker
-12	*	Washer, flat M4
-13	*	Washer, lock M4
-14	*	Screw, cross head M4 x 10
-15	*	Screw, cross head M5 x 14.5
-16	*	Washer, lock M5
-17	*	Washer, flat M5
-18	*	Washer, star M5
-19	J200224	Cover, circuit breaker
-20	*	Washer, flat M4
-21	*	Washer, lock M4
-22	*	Nut, M4
-23	*	Washer, star M5
-24	*	Washer, flat M5
-25	*	Nut, M5
-26	*	Washer, flat M4
-27	*	Washer, lock M4
-28	*	Nut, M4
-29		Standoff
-30	J400122	Driver board, roll motor
NR	J400126	Panel, driver board mounting
-31	J400118	Fan, roll motor driver
-32	*	Washer
-33	*	Washer
-34	*	Nut, hex
-35		Guard, roll motor fan
-36	*	Washer, star M5
-37	*	Washer, flat M5
-38	*	Washer, lock M5
-39	*	Screw, cross head M5 x 12
-40	*	Washer, flat M4
-41	*	Washer, lock M4
-42	*	Nut, M4
-43	*	Screw, cross head M4 x 9.5
-44	*	Washer, lock M4
-45	*	Washer, flat M4
-46	*	Washer, star M4
-47		Plate, strain relief
-48	J200301	Filter

* See Common Hardware Listing

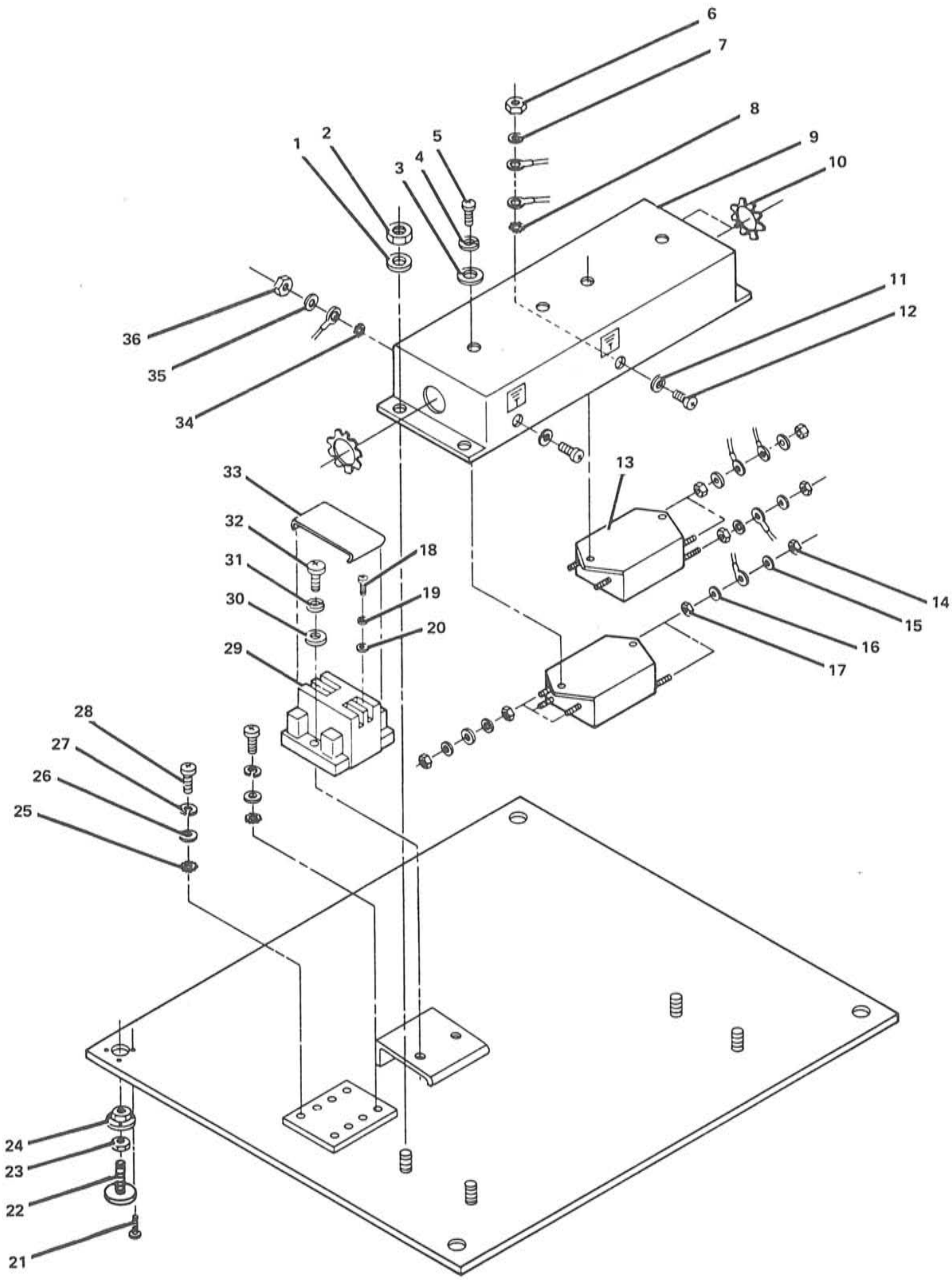


FIGURE 10. BOTTOM PANEL. SEE LIST 10.

BOTTOM PANEL

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
10-1	*	Washer, lock M4
-2	*	Nut, hex M4
-3	*	Washer, flat M4
-4	*	Washer, lock M4
-5	*	Screw, cross head M4 x 17.5
-6	*	Nut, hex M4
-7	*	Washer, lock M4
-8	*	Washer, star M4
-9	J200226	Cover, line filter
-10		Insulator
-11	*	Washer, star M5
-12	*	Screw, cross head M5 x 12
-13	J200120	Noise filter
-14		Nut, included with 10-13
-15		Washer, included with 10-13
-16		Washer, included with 10-13
-17		Nut, included with 10-13
-18	*	Screw, cross head M5 x 9.5
-19	*	Washer, lock M5
-20	*	Washer, flat M5
-21	*	Screw, flat head M3 x 8.5
-22	J200230	Foot, leveling pad
-23	*	Nut, hex M12
-24		Mounting plate, included with 10-22
-25	*	Washer, star M5
-26	*	Washer, flat M5
-27	*	Washer, lock M5
-28	*	Screw, cross head M5 x 9.5
-29	J200133	Terminal block
-30	*	Washer, flat M4
-31	*	Washer, lock M4
-32	*	Screw, hex head M5 x 11.5
-33	*	Terminal cover, included with 10-29
-34	*	Washer, star M5
-35	*	Washer, flat M5
-36	*	Nut, hex M5

* See Common Hardware Listing

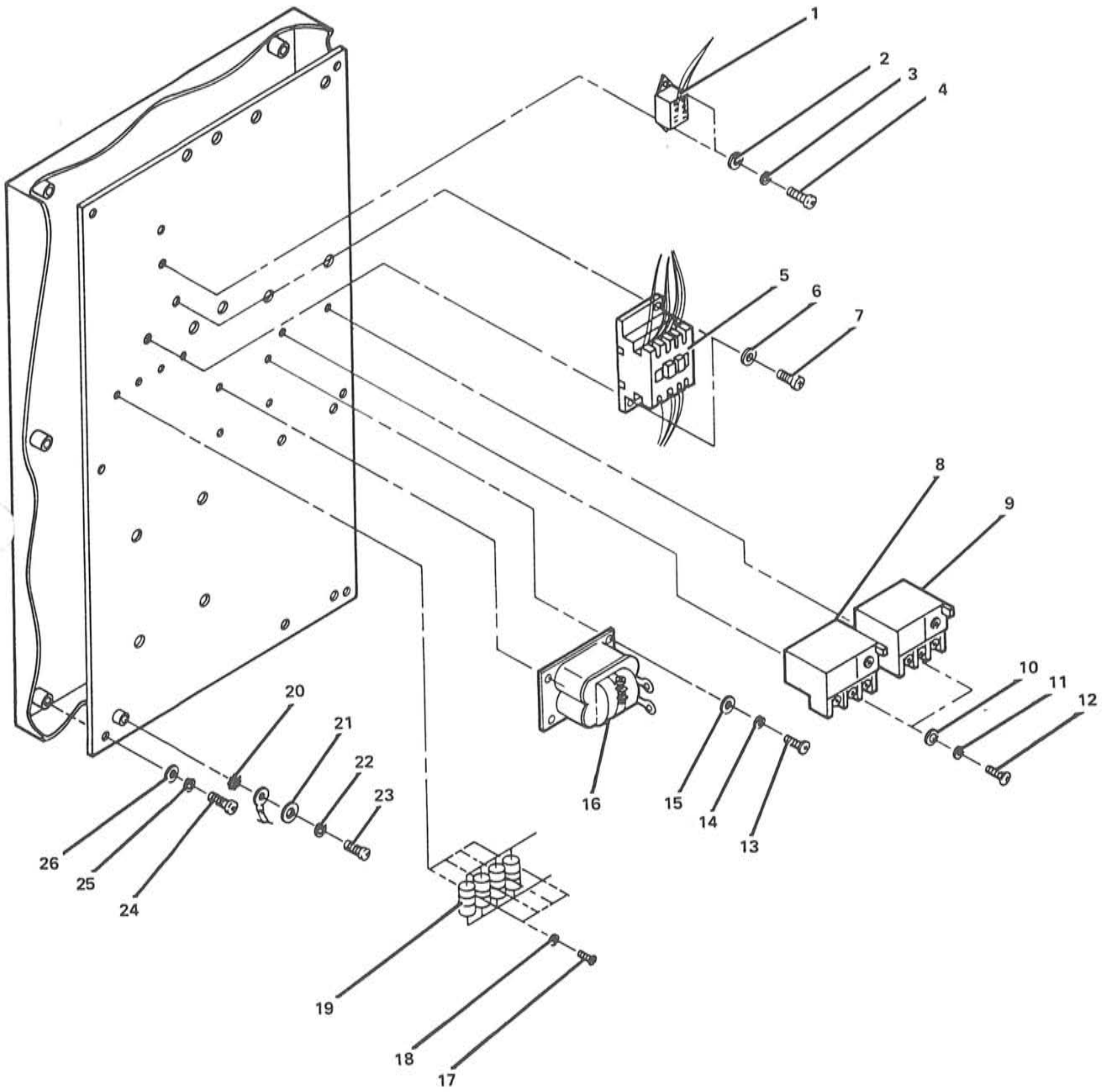


FIGURE 11. BACK PANEL. SHEET 1 OF 2. INDEX NOS. 1-26. SEE LIST 11.

BACK PANEL SHEET 1 OF 2

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
11-1	J200124	Relay, CR100
NR	J200130	Diode
-2	*	Washer, flat M3
-3	*	Washer, lock M3
-4	*	Screw, cross head M3 x 8
-5	J200349	Contactor, 220V
-6	*	Washer, flat M4
-7	*	Screw cross head M4 x 16
-8	J200140	Thermal relay OL2
-9	J400121	Thermal relay OL1
-10	*	Washer, flat M4
-11	*	Washer, lock M4
-12	*	Screw, cross head M4 x 19.5
-13	*	Screw, cross head M4 x 7.5
-14	*	Washer, lock M4
-15	*	Washer, flat M4
-16	J200139	Inductor, Theta 2 servo pack
-17	*	Screw, cross head M4 x 9.5
-18	*	Washer, lock M4
-19	J200134	Spark suppressor
-20	*	Washer, star
-21	*	Washer, flat M5
-22	*	Washer, lock M5
-23	*	Screw, cross head M5 x 9.5
-24	*	Screw, cross head M6 x 12
-25	*	Washer, lock M6
-26	*	Washer, flat M6

* See Common Hardware Listing

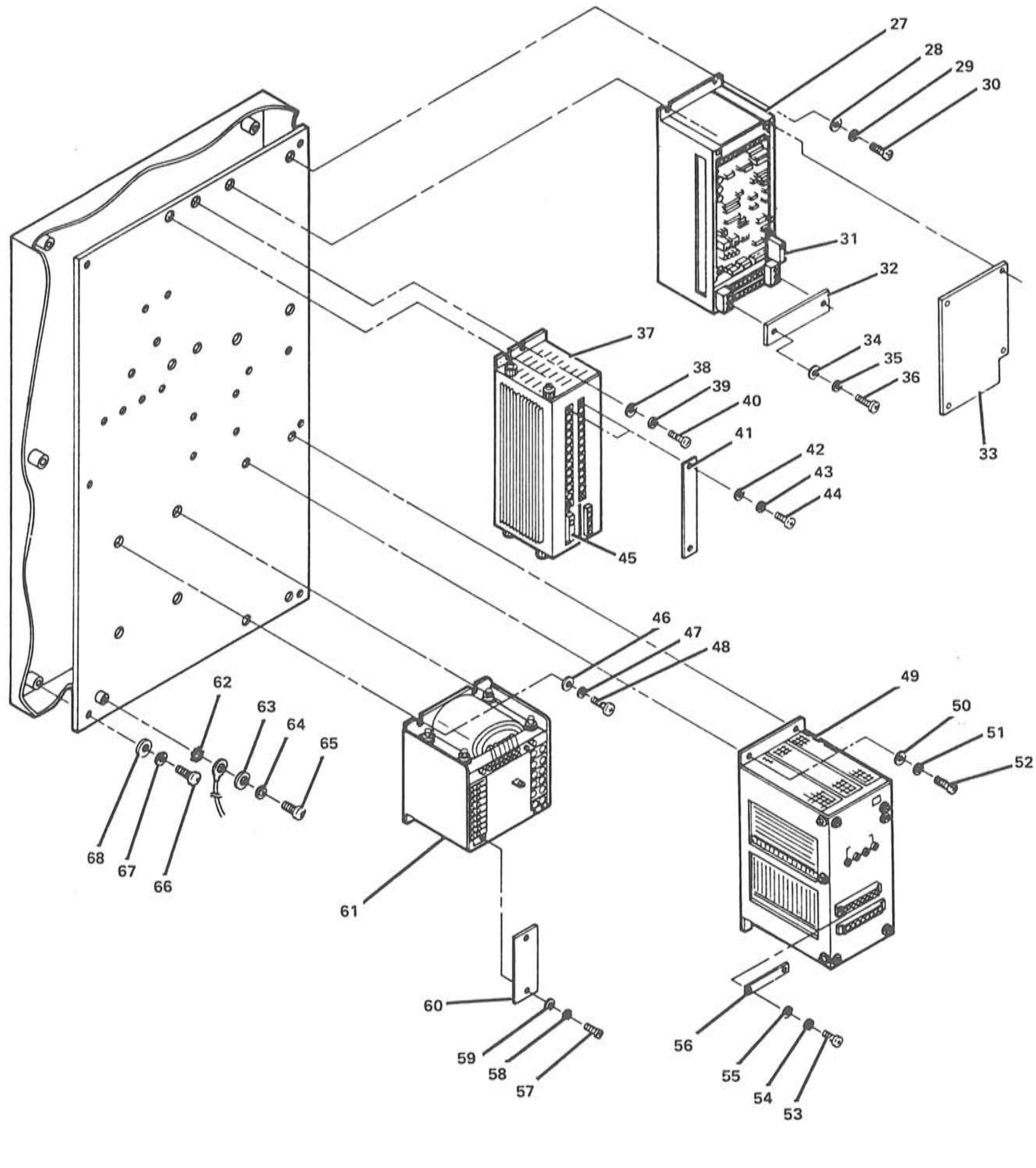


FIGURE 11. BACK PANEL. SHEET 2 OF 2. INDEX NOS. 27-68. SEE LIST 11.

BACK PANEL SHEET 2 OF 2

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
11-27	J400119	Theta 1 servo pack
-28	*	Washer, flat M4
-29	*	Washer, lock M4
-30	*	Screw, cross head M4 x 7.5
-31	J200308	Fuse
-32		Cover, plastic
-33		Cover, plastic
-34	*	Washer, flat
-35	*	Washer, lock
-36	*	Screw, cross head
-37	J200136	Theta 2 servo pack
-38	*	Washer, flat M4
-39	*	Washer, lock M4
-40	*	Screw, cross head M4 x 7.5
-41		Cover, plastic
-42	*	Washer, flat
-43	*	Washer, lock
-44	*	Screw, cross head
-45	J200308	Fuse
-46	*	Washer, flat M6
-47	*	Washer, lock M6
-48	*	Screw, cross head M6 x 14.5
-49	J200125	Power supply assembly, see figure 14
-50	*	Washer, flat M4
-51	*	Washer, lock M4
-52	*	Screw, cross head M4 x 8
-53	*	Screw, cross head
-54	*	Washer, lock
-55	*	Washer, flat
-56		Cover, plastic
-57	*	Screw, cross head M3 x 7.5
-58	*	Washer, lock M3
-59	*	Washer, flat M3
-60		Cover, plastic
-61	J400120	Transformer (TF1)
-62	*	Washer, star M5
-63	*	Washer, flat M5
-64	*	Washer, lock M5
-65	*	Screw, cross head M5 x 9.5
-66	*	Screw, cross head M6 x 12
-67	*	Washer, lock M6
-68	*	Washer, flat M6

* See Common Hardware Listing

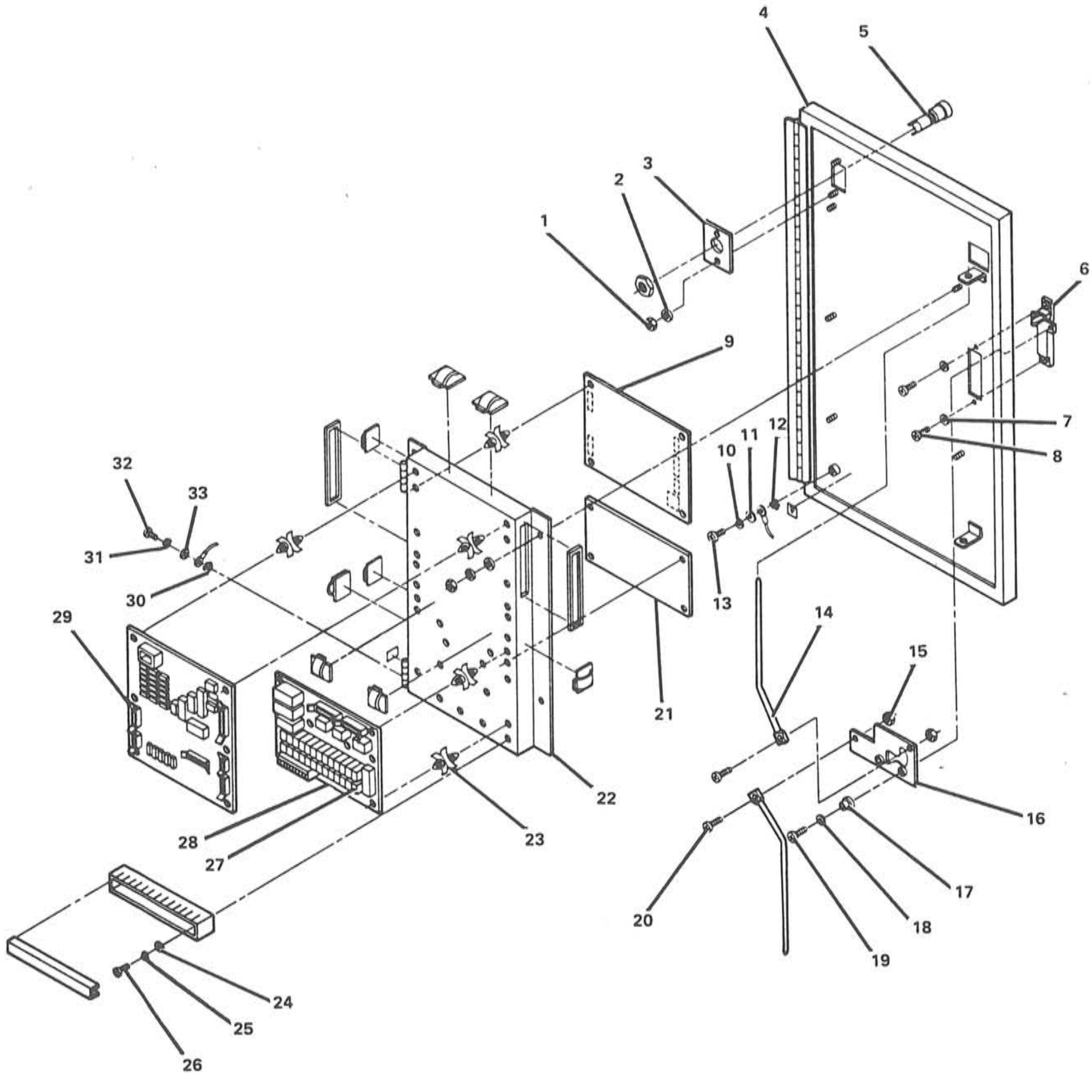


FIGURE 12. FRONT PANEL. SEE LIST 12.

FRONT PANEL

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
12-1	*	Nut, hex M3
-2	*	Washer, flat M3
-3	J200227	Plate, lamp mounting
-4	J400124	Front door
-5	J200132	Pilot lamp assembly
NR	J200131	Pilot lamp
-6	J200231	Latch asm w/keys
-7	*	Washer, lock M4
-8	*	Screw, cross head M4 x 5.5
-9	J400146	CPU oard complete asm.
-10	*	Washer, lock M5
-11	*	Washer, flat M5
-12	*	Washer, star M5
-13	*	Screw, cross head M5 x 9.5
-14		Latch rod
-15	*	Nut, hex M4
-16		Plate
-17		Bushing
-18	*	Washer, flat M5
-19	*	Screw, cross head M5 x 9
-20	*	Screw, cross head M4 x 9.5
-21	J400147	Function enhancement card
-22	J400125	Main panel
-23		Standoff
-24	*	Washer
-25	*	Washer
-26	*	Screw
-27	J200296	Relay, 1 contact
-27	J200295	Relay, 2 contact
-28	J200145	Relay board
-29	J200144	MTCB board
-30	*	Washer, star M5
-31	*	Washer, flat M5
-32	*	Screw, cross head M5 x 12
-33	*	Washer, flat M5

* See Common Hardware Listing

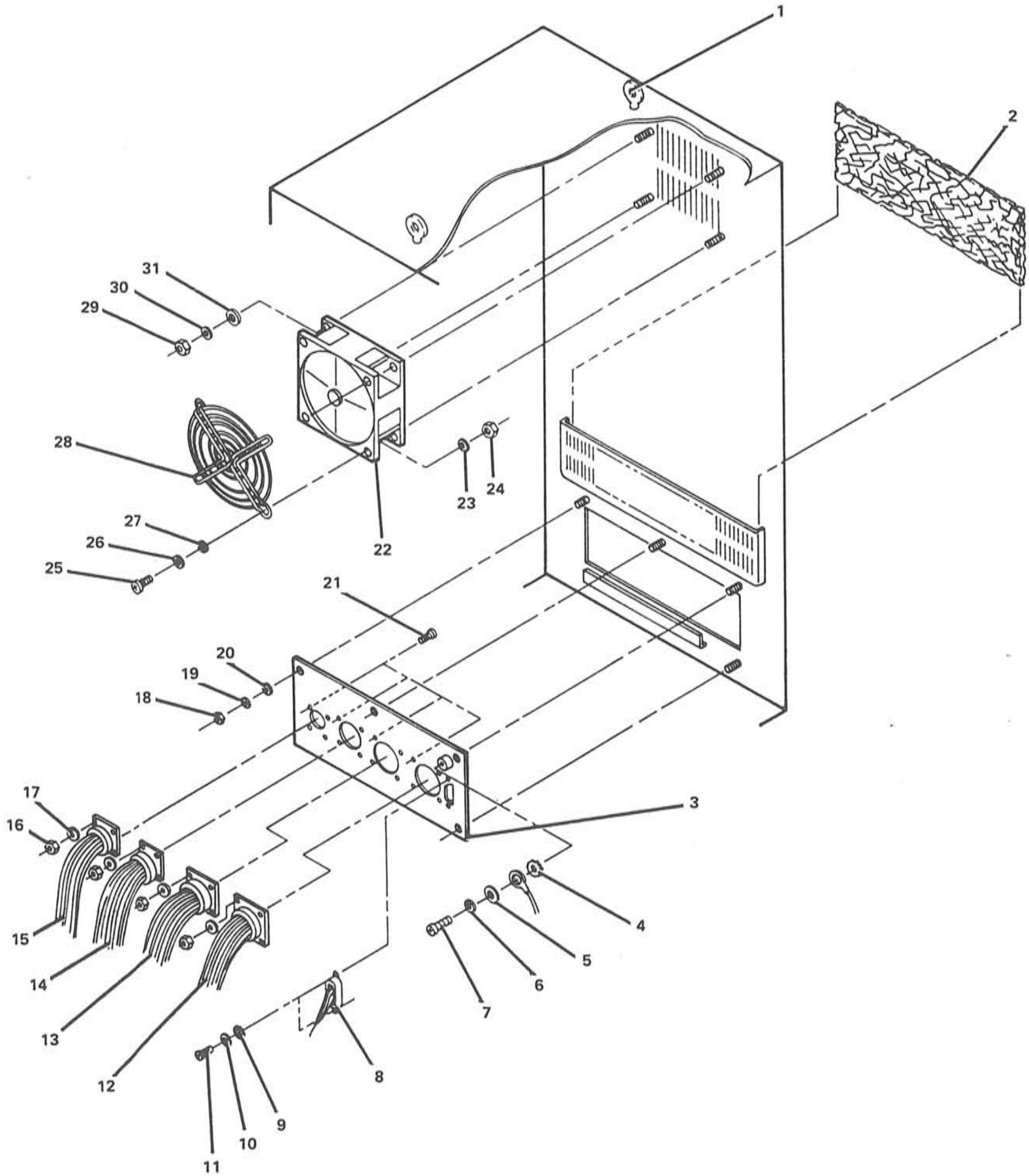


FIGURE 13. RIGHT OUTSIDE PANEL. SEE LIST 13.

RIGHT OUTSIDE PANEL

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
13-1	J200229	Eye bolt
-2	J200301	Filter
-3		Connector panel
-4	*	Washer, star
-5	*	Washer, flat
-6	*	Washer, lock
-7	*	Screw, cross head
-8	J400141	Cable, CB28
-9	*	Washer, flat M3
-10	*	Washer, lock M3
-11	*	Screw, cross head M3 x 5
-12	J400138	Cable, CB22, CB23
-13	J400139	Cable, CB24
-14	J400140	Cable, CB25, CB26
-15	J400137	Cable, CB19, CB20, CB27
-16	*	Nut, hex M3
-17	*	Washer, star M3
-18	*	Nut, hex M4
-19	*	Washer, lock M4
-20	*	Washer, flat M4
-21	*	Screw, cross head M3 x 8
-22	J200348	Fan
-23	*	Washer, flat M3
-24	*	Nut, hex M3
-25	*	Screw, cross head M3 x 14.5
-26	*	Washer, lock M3
-27	*	Washer, flat M3
-28		Guard, fan
-29	*	Nut, hex M3
-30	*	Washer, lock M3
-31	*	Washer, flat M3
NR	J200345	Cable plug, DI/DO
NR	J200346	Cable clamp, DI/DO

* See Common Hardware Listing

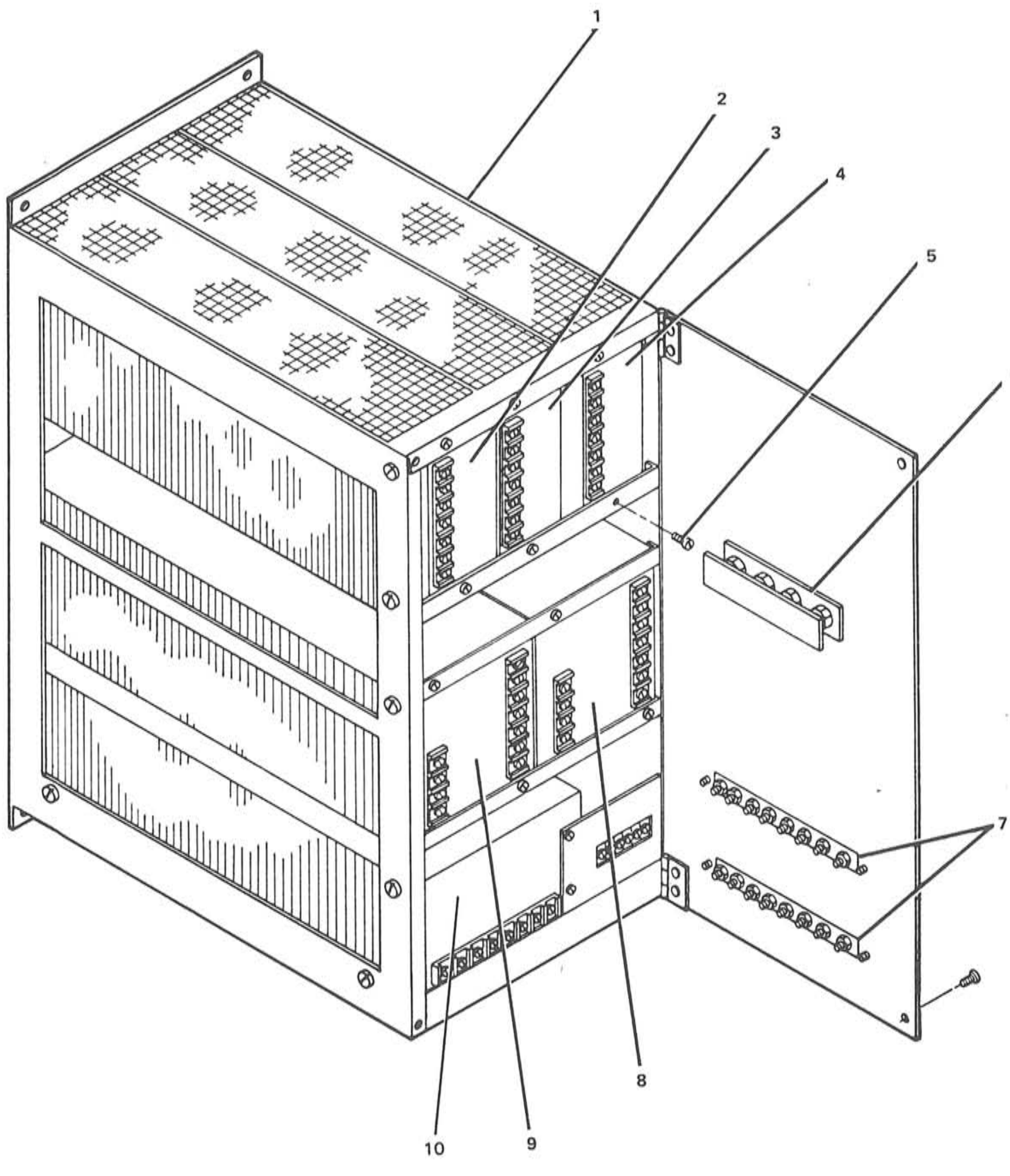


FIGURE 14. D.C. POWER SUPPLY ASSEMBLY. SEE LIST 14.

D. C. POWER SUPPLY ASSEMBLY

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
14-1	J200125	Power supply assembly
-2	J200127	12 Vdc, 2.5 ampere module
-3	J200127	12 Vdc, 2.5 ampere module
-4	J200126	5 Vdc, 10 ampere module
-5	*	Screw, round head M3 X 4.5
-6	J200373	Indicator assembly
-7	J200374	Terminal strip
NR	*	Screw, round head M3 X 8
-8	J200128	12 Vdc, 10 ampere module
-9	J200128	12 Vdc, 10 ampere module
-10	J200129	Power failure detector

* See Common Hardware Listing

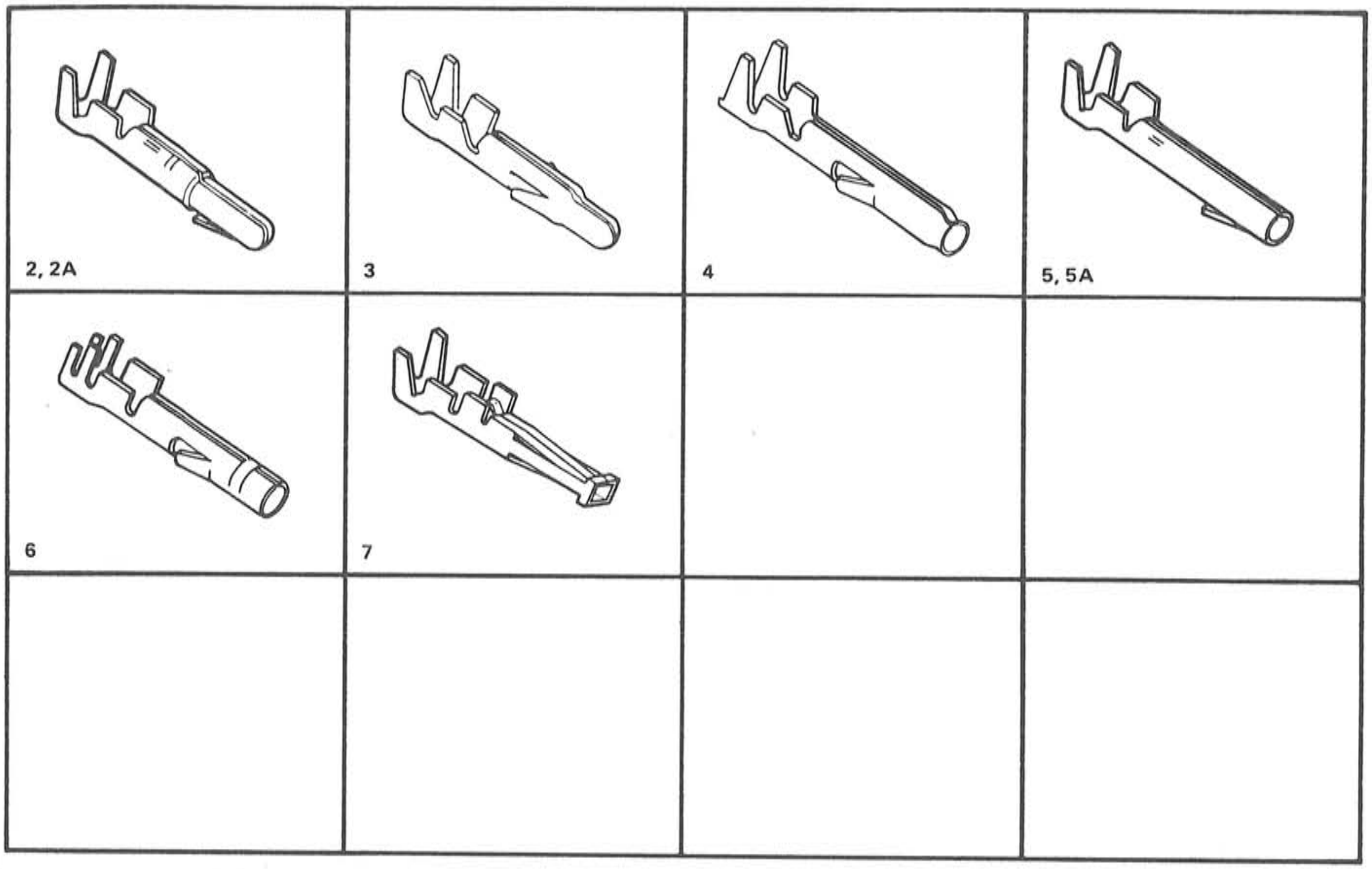


FIGURE 15. CABLE ASSEMBLIES WITH COMPONENT PARTS. INDEX NOS. 2-7. SEE LIST 15.

CABLE ASSEMBLIES

FIGURE INDEX NUMBER	PART NUMBER	DESCRIPTION
15-2	AJ10059	Contact, 14-16 AWG
-2A	AJ10063	Contact, 18-22 AWG
-3	AJ10061	Contact
-4	AJ10062	Contact
-5	AJ10064	Contact, 18-22 AWG
-5A	AJ10066	Contact, 14-16 AWG
-6	AJ10067	Contact
-7	AJ10068	Contact
NR	J400134	CB8 Cable
NR	J200310	CB9 Cable
NR	J200311	CB10 Cable
NR	J200312	CB11 Cable
NR	J200313	CB12 Cable
NR	J200314	CB13 Cable
NR	J200315	CB14 Cable
NR	J200316	CB15 Cable
NR	J200317	CB16 Cable
NR	J400135	CB17 Cable
NR	J400130	CB31 Cable
NR	J400131	CB32 Cable
NR	J400128	CB33 Cable
NR	J400127	CB34 Cable
NR	J400132	CB35 Cable
NR	J400133	CB36 Cable
NR	J400129	CB37 Cable
NR	J400151	CB50 Cable
NR	J400152	CB51 Cable
NR	J400153	CB52 Cable
NR	J400154	CB53 Cable
NR	J400155	CB54 Cable

COMMON HARDWARE LISTING

Note: The following metric sized common hardware is stocked by the IBM parts distribution center in Boca Raton. This stock does not include all fasteners for the 7535/7540 systems.

Socket Head Cap Screws

Size	Part Number
M3 X 5	AJ10017
M4 X 10	AJ10016
M4 X 20	AJ10015
M5 X 10	AJ10014
M5 X 15	AJ10013
M5 X 20	AJ10012
M5 X 25	AJ10011
M6 X 10	AJ10010
M6 X 15	AJ10009
M6 X 20	AJ10008
M6 X 30	AJ10007
M6 X 40	AJ10006
M6 X 55	AJ10005
M8 X 20	AJ10004
M8 X 40	AJ10003
M12 X 50	AJ10002
M14 X 70	AJ10001
M16 X 70	AJ10000

Socket Head Set Screws

Size	Part Number
M4 X 5	AJ10022
M5 X 6	AJ10021
M6 X 10	AJ10020
M6 X 30	AJ10019

Cross Recessed Pan Head Screws

Size	Part Number
M2.5 X 5	AJ10053
M2.5 X 10	AJ10052
M3 X 5	AJ10041
M3 X 8	AJ10047
M3 X 10	AJ10040
M3 X 15	AJ10039
M4 X 8	AJ10027
M4 X 10	AJ10045
M4 X 10 BLACK	AJ10026
M4 X 12	AJ10056
M4 X 20	AJ10044
M4 X 45	AJ10051
M5 X 10	AJ10038
M5 X 15	AJ10025
M6 X 10	AJ10043
M6 X 15	AJ10042

Cross Recessed Countersunk Screws

Size	Part Number
M3 X 10	AJ10058
M4 X 10	AJ10024
M5 X 8	AJ10023
M5 X 10	AJ10057

Hex Head Cap Screws

Size	Part Number
M4 X 10	AJ10018

Hex Nuts

Size	Part Number
M3	AJ10050
M4	AJ10054
M5	AJ10037
M12	AJ10036
M14	AJ10035

Flat Washers

Size	Part Number
M2.5	AJ10055
M3	AJ10054
M12	AJ10037
M14	AJ10036
M16	AJ10035

Lock Washers, Spring

Size	Part Number
M3	AJ10034
M4	AJ10033
M5	AJ10032
M6	AJ10031
M8	AJ10030

Adapters

BPS to USP 1/8"	AJ10069
BPS to USP 1/4"	AJ10070

Paint

Yellow 100ml	J200330
Black 100ml	J200331
Gray 100ml	J200332
Dkgray 100ml	J200333
Yellow 1000ml	J200334
Black 1000ml	J200335
Gray 1000ml	J200336
Dkgray 1000ml	J200337
Applicator	J200338

INSTALLATION REQUIREMENTS

The Site Preparation Guide for the IBM Manufacturing System should be used for all the physical planning requirements before installing the system. The following is a brief overview of these requirements.

Power

- One 115 ± 10% Vac, 20-ampere, single-phase, 60-Hertz circuit for the 7535 controller or one 220 ± 10%, 20-ampere, single-phase, 50/60-Hertz circuit for the 7540 controller.
- One 115 ± 10% Vac, 15-ampere, single-phase, 60-Hertz circuit for the Personal Computer.
- One 3-wire (2 conductor plus ground), 14-AWG or larger gauge power cable is required from your power source to the controller. The cable can have a length of up to 4.6 m (15 feet).
- One convenience outlet within 1.83 m (6 feet) of the controller for service and test equipment.

Compressed Air

A source of filtered, compressed shop air at a pressure of not greater than 6 kg/cm^2 (85 psig) is needed for the Z-axis on the manipulator. Providing lubricated air can increase the life of the valves in the solenoids, but this is not a requirement.

A pressure regulator is needed for adjusting air pressure.

A 1/8-in. (7535) or 1/4-in. (7540) air line is required to attach the air supply to the manipulator.

The 7540 is equipped with mufflers however piping the exhaust air from the Z-axis can result in a quieter application. An exhaust pipe can be connected to the Z-axis by using a BSP 1/8-in.(7535) or BSP 1/4-in.(7540) fitting.

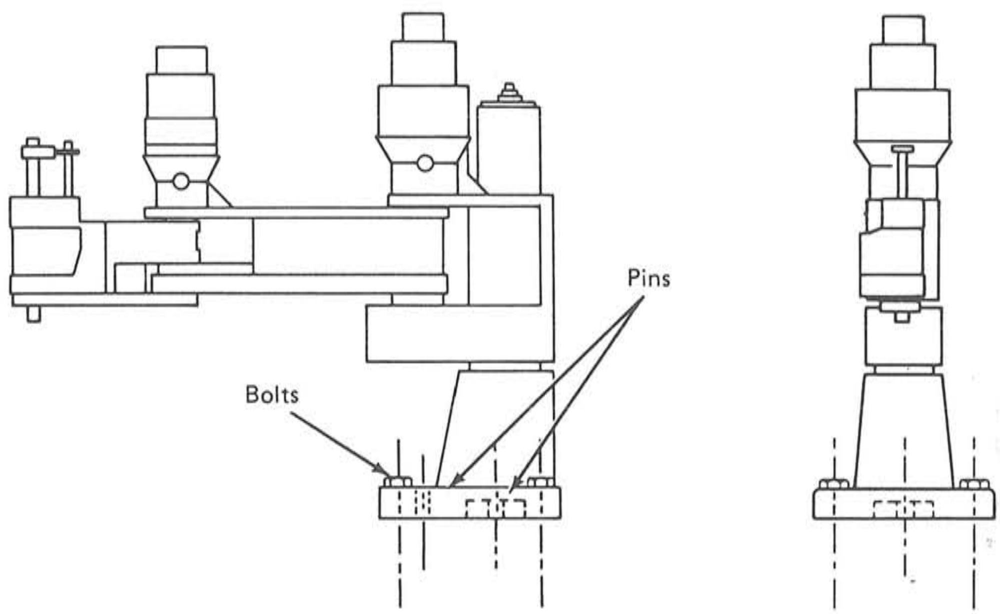
Cable Interfacing

Cable ramps, troughs, or other access for installing cables and compressed air hosing/tubing between units may be required for your installation.

Note: If you are not familiar with the safety notices located in the front of this manual, you should review them before proceeding.

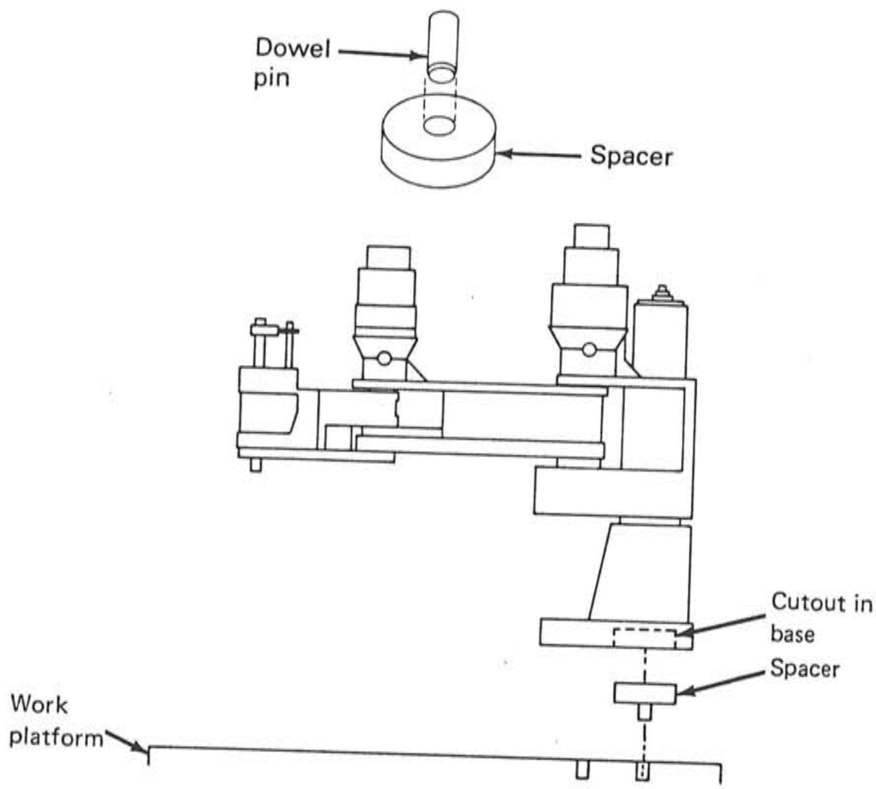
Mounting the Manipulator

After unpacking the system, mount the manipulator to its work platform. Four mounting bolts for the system are supplied. If accurate placement is a requirement, two 20 mm (0.78 in.) dowel pins (not supplied) for the 7535 or two 30 mm (1.181 in.) dowel pins (not supplied) for the 7540 and one spacer (supplied) are needed to pin the manipulator to the work platform.



Manipulator Base Mounting

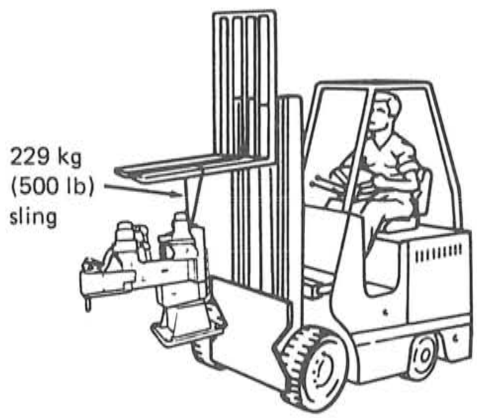
A spacer for mounting the manipulator is supplied in the packaging material. The spacer fits into the cutout in the underside of the manipulator base. The spacer has a hole in its center to accommodate one of the user-supplied dowel pins. First drive the dowel pin into the spacer; then drive the pin and spacer into the hole in the work platform, as shown here:



Spacer Installation

A lift truck capable of lifting at least 229 kg (500 lb) should be used to lift the manipulator to its work platform. To accomplish this, place a wire sling through the eye bolt on top of the manipulator. Use care when moving the manipulator to prevent it from contacting the lift truck while in motion.

Caution: Do not place the sling around the manipulator arm. Lift only by the eye bolt.

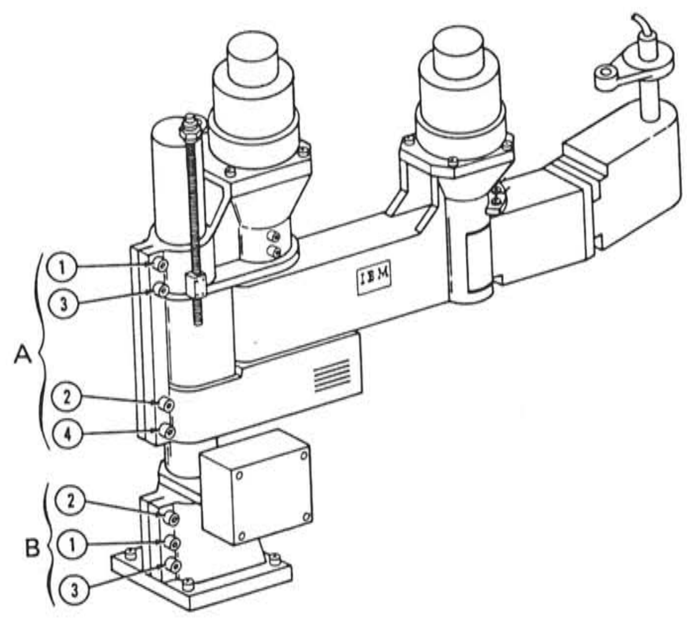


Lifting the Manipulator

After mounting the manipulator to its work platform, check the torque on the clamping nuts. If the manipulator is adjusted to the desired height for the intended application, use the following procedure to tighten the clamping nuts before applying power to the manipulator.

To properly tighten the nuts to the required torque, the nuts should be step-tightened in the sequences shown in the figure below. Tighten the top four nuts (A) first; then tighten the bottom three (B) second. Begin by tightening all nuts to 2 kg/m (14 ft/lbs), and then to 4-6 kg/m (29-43 ft/lbs) for 7535 or 6-8 kg/m (43-57 ft/lbs) for 7540, in the correct sequences.

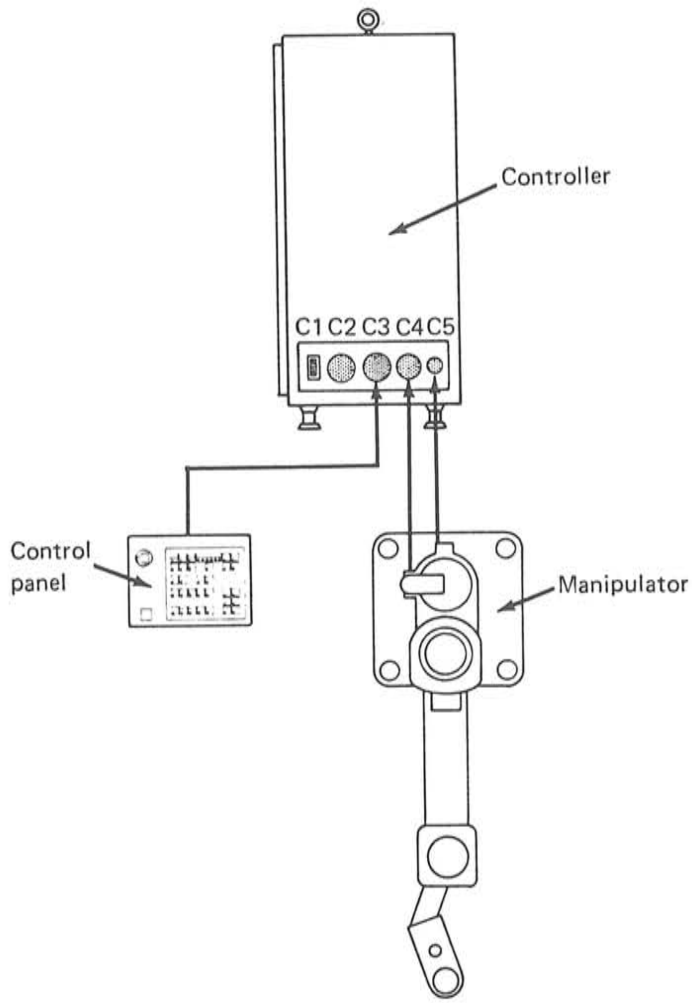
If the manipulator height needs to be changed, tighten only the lower three nuts (B); then refer to the manipulator height adjustment (4002) in "Section 4 - Adjustments" before tightening the four upper nuts (A).



Nut Tightening Sequence

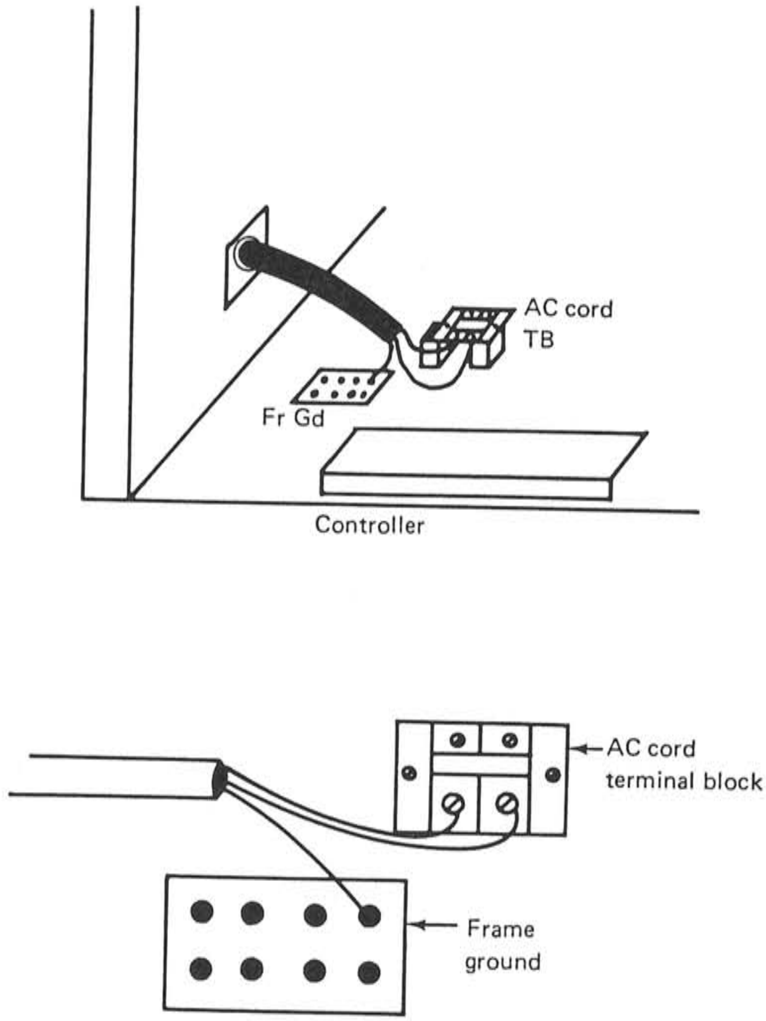
Connect the two cables from the manipulator to connectors C4 and C5 on the controller as shown in the figure below. Connect the cable from the control panel to connector C3 on the controller. Remove the clear plastic wrap from these cables.

Note: For proper installation of connectors C3, C4, and C5, the cable end of the connector must be fully seated into the controller connector receptacle. This can be accomplished by inserting the connector pins into the holes and tightening the outer cap finger-tight. Next, push the pins further into the holes and tighten the cap again. Continue this procedure until the pins cannot be pushed any further into the holes and the outer cap is tightened securely.



Cable Connections

Connect the power cable to the inside of the controller, providing a strain-relief for the cable, as shown in the figure below.

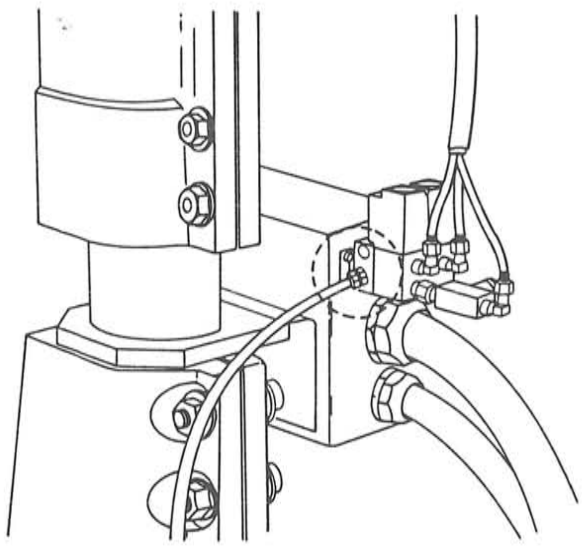


Power Cable Connection

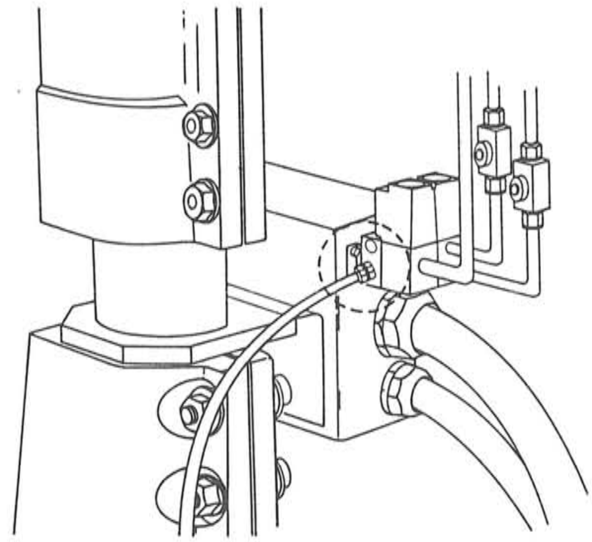
DANGER:

Use a wrench to check for loose air fittings on the manipulator before connecting the supplied air.

Connect the supplied air to the manifold mounted on the side of the manipulator as shown in the figure below.



7535

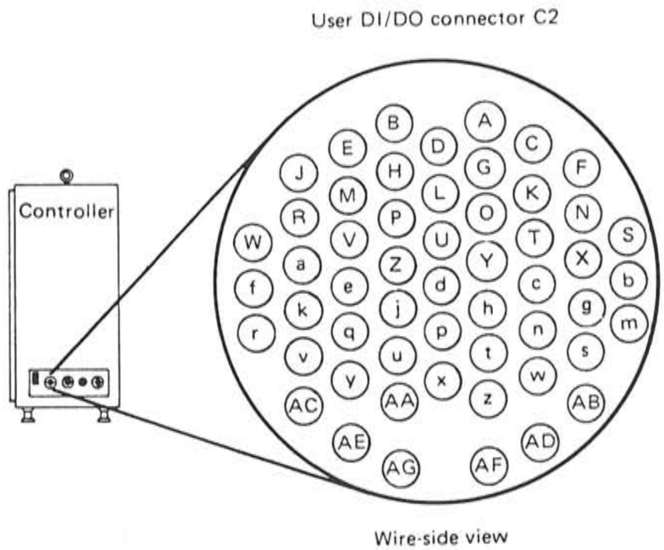


7540

Air Supply Connection

DI/DO Cable

The following chart shows the pin assignment of the DI/DO cable:



Pin	Name	Pin	Name
A	DI01 (Note 1)	e	(Note 6)
B	DI02 (Note 2)	f	(Note 7)
C	DI03	g	(Note 8)
D	DI04	h	(Note 9)
E	DI05	j	Common for e, f, g, and h
F	DI06	k	Common for DO01 thru DO04
G	DI07	m	Common for DO09 thru DO12
H	DI08	n	Common for DO13 thru DO16
J	DI09	p	Common for DO05 thru DO08
K	DI10	q	DO01 (Note 10)
L	DI11	r	DO02 (Note 11)
M	DI12	s	DO03
N	DI13	t	DO04
O	DI14	u	DO05
P	DI15	v	DO06
R	DI16	w	DO07
S	DI Ground	x	DO08
T	DI Ground	y	DO09
U	DI Ground	z	DO10
V	DI Ground	AA	DO11
W	(Note 3)	AB	DO12
X	(Note 4)	AC	DO13
Y	(Note 5)	AD	DO14
Z	(Note 5)	AE	DO15
a	Not used	AF	DO16
b	Not used	AG	(Note 12)
c	Not used		
d	Not used		

Notes:

1. Can only be used for Z-axis down.
2. Can only be used for Z-axis up.
3. Connecting this point to DI ground will inhibit movement to home position. (See Note 9.)
4. Connecting this point to DI ground will provide an emergency stop function.
5. Connecting points Y and Z together will provide a manipulator power on function.
6. DO point is on during Auto mode.
7. DO point is on during an error condition.
8. DO point is on when arms are at Home position.
9. DO point is on when Return Home key is pressed and point W is connected to ground.
10. Can only be used for moving Z-axis.
11. For gripper, if installed.
12. Controller frame ground.

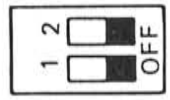
Control Switches

There are several switches within the controller that should be checked for the proper setting prior to using the manipulator for an application. A brief discussion of these switches and their use is provided in "Section 7 - Switch Settings".

System Checkout

Refer to the Symptom Identification procedure in "Section 10 - Symptom/Fix" to verify correct machine operation.

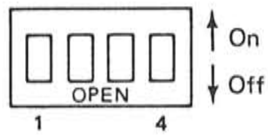
WRITE PROTECT



WR PROT switches

There are two switches on the CPU board labeled WR PROT (Write Protect). These switches are for factory use only and must be left in the OFF position.

MODE



Mode Switches

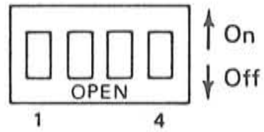
The Mode switches control the baud rate and character format for communications. The tables below show the settings of the Mode switches.

	On	Off
Switch 1	Odd parity	Even parity
Switch 2	Non-parity 1 Stop Bit	Parity 2 Stop Bits

Baud rate	Switch 3	Switch 4
4800	Off	Off
2400	On	Off
1200	Off	On
300	On	On

The Mode switches must be positioned in the off (down) position for communication to the Personal Computer.

TYPE

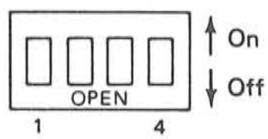


Type Switches

The Type switch selects the operational modes as described below.

- If switch 1 is on and manipulator power is energized, the last program to run is selected.
- If switch 2 is on and manipulator power is energized, a return to home (RTH) is done automatically.
- If switch 3 is on and manipulator power is energized, auto mode is chosen as the default instead of manual mode.
- Switch 4 has no current function and must be in the off position.

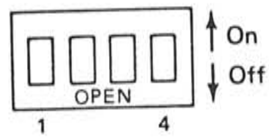
CURVE



Curve Switches

Curve switches 1, 2, 3, and 4 have no currrent function and must be in the off position.

POSITION ZONE



Position Zone Switches

The Position Zone switches reduce the settle time of each move. Settle time is the time between the arm reaching its goal and the next command being read from storage.

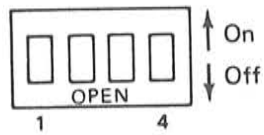
To increase system throughput, the position zone switches can decrease the time the microprocessor waits before reading the next command. Each of the Position Zone switches, 1 through 4, has a specific pulse value assigned to it as shown below. The switches are used in any combination to provide values from 256 to 3840 pulses.

- SW1 = 256 1
- SW2 = 512 2
- SW3 = 1024 4
- SW4 = ~~2048~~ 8

The position zone value can also be set by the application program. If a position zone value is not specified by the application program, the switch value is assumed.

The position zone switches can be set in the off position for an initial setting.

SPEED



Speed Switches

The speed at which the arm moves can be controlled by the setting of the four speed switches as shown in the table below.

Speed	Switch 1	Switch 2	Switch 3	Switch 4
High	On	On	Off	Off
Med	Off	On	Off	Off
Low	On	Off	Off	Off

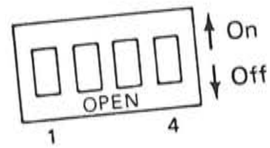
Speed Switch Settings

Note that switches number 3 and 4 are always in the off (down) position. These switches are not used at this time and must remain off.

The speed value can also be set by the application program. If a speed value is not specified by the application program, the switch value is assumed.

A consideration for the speed switch settings is the weight of the payload on the manipulator.

INTERLOCK



Interlock Switches

The interlock switches are used with the control panel ± Theta 1 and ± Theta 2 keys and user digital input (DI) points, 1 through 15, when the system is in manual mode. Switch values from 1 through 15 correspond to user digital input points 1 through 15.

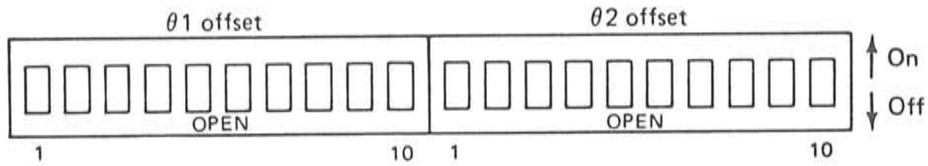
With all interlock switches off (down), pressing the ± Theta 1 or ± Theta 2 keys on the control panel causes those arms to move. However, if any of the switches are on (up), and the ± Theta 1 or ± Theta 2 keys are pressed, movement does not occur until the digital input point, represented by the switch combination, becomes inactive.

For example, if interlock switches 1 and 2 are on and DI point 3 is active when the ± Theta 1 key is pressed, movement does not occur until DI point 3 becomes inactive.

The interlock switches can be set in combinations for values of 1 through 15. The value of each switch is:

- SW1 = 1
- SW2 = 2
- SW3 = 4
- SW4 = 8

THETA 1 AND THETA 2 OFFSET



Theta 1 and Theta 2 Offset Switches

These switches are used only when making the Theta 1 and Theta 2 home position adjustments. There are 10 switch positions for the Theta 1 arm and 10 switch positions for the Theta 2 arm.

For further information on the settings of these switches, refer to the Theta 1 (4005) and Theta 2 (4006) home position adjustments in "Section 4 - Adjustments".

The value of each switch (Theta 1 or Theta 2) in pulses is shown below.

- SW1 = 1
- SW2 = 2
- SW3 = 4
- SW4 = 8
- SW5 = 16
- SW6 = 32
- SW7 = 64
- SW8 = 128
- SW9 = 256
- SW10 = 512

To aid in problem determination, several exerciser programs are provided on one of the AML/Entry diskettes. The programs let you check the operation of the manipulator to isolate any failures. There are eight individual function exercisers and a comprehensive system exerciser. To use the exerciser programs, load the AML/Entry diskette into the IBM Personal Computer, select the program desired, and send it to the controller. For more information on loading AML/Entry and sending programs to the controller, see the User's Guide. Each exerciser program runs continuously when it is selected in the automatic mode from the control panel. If you choose, each program can be stepped through in the manual mode.

Use the exercisers that are labeled 7535EX for 7535, and 7540EX for 7540.

7535EX1, 7540EX1 This exerciser moves the Theta 1 arm through its full range of motion. In the automatic mode, the arm moves from home to approximately 200 degrees and then returns to home. This cycle continues until you interrupt it.

7535EX2, 7540EX2 This exerciser moves the Theta 2 arm through its full range of motion. In the automatic mode, the arm moves from its home position to approximately 160 degrees and then returns to home. This cycle continues until you interrupt it.

7535EX3, 7540EX3 This exerciser rotates the R-axis 180 degrees in the positive direction and then 180 degrees in the negative direction. This cycle continues until you interrupt it.

7535EX4, 7540EX4 This exerciser moves the Z-axis down and then up. This cycle continues until you interrupt it.

7535EX5, 7540EX5 This exerciser opens and closes the gripper when it is attached. It operates the solenoid valve that controls the gripper or any other pneumatic device attached to the manipulator, and continues until you interrupt it.

7535EX6, 7540EX6 This exerciser turns each DO port on and off sequentially. This provides a way of exercising peripheral equipment attached to the manufacturing system. Each port is turned on and, then after a brief delay, is turned off. The cycle continues until you interrupt it.

7535EX7, 7540EX7 This exerciser checks each DI port to verify that it is open. If a port is not open, the manipulator arm will move to the error position at approximately 90 degrees. This cycle continues until you interrupt it.

7535EX8, 7540EX8 This exerciser checks DI ports 1 and 2 to verify that they are closed. If either one is open, the manipulator arm will move to the error position at approximately 90 degrees. This cycle continues until you interrupt it.

7535EX9, 7540EX9 This exerciser integrates straight line motion, slow speed moves, and parts of the other exercisers into one comprehensive system exerciser. This cycle continues until you interrupt it.

Preventive maintenance should be performed according to the chart in the figure below.

Unit	Action	Interval	Lubrication
Manipulator	Clean Check Oil Level Check for Air Leaks	Daily Daily Daily	– – –
Controller	Check Air Filters	Monthly	–
Roll Axis Belts	Check Tension	Monthly	–
Roll Axis Gears	Lubricate	Monthly	Light Coat - Molycoat G or Equivalent (PN 357830)
Theta 1 and Theta 2 Axes	Change Oil	Semi-Annually	IBM No. 10 Oil or Equivalent* (PN 1280444)
Bearings	Pack Bearing	Every Replacement	IBM No. 23 Grease or Equivalent (PN 1280442)
*Equivalent oil must have a viscosity ranking of JIS Class 2, Number 2.			

Preventive maintenance may need to be performed more often under dirty and dusty conditions or during periods of extended use.

HOW TO USE THIS SECTION

This section contains a "Symptom Identification Procedure", on page 10-2 that systematically checks each function of the system and identifies the failing function. These failing functions are listed in the "Symptom List", on page 10-4. Under each symptom is a list of possible fixes along with a brief service check. The fixes are sequenced so that the quickest service check or most likely cause is first. Apply the fixes until the reported problem is found. If the reported problem is not found and all of the fixes for that symptom have been applied, then find another symptom that resembles the reported problem.

The "Symptom Identification Procedure" is recommended as a starting place when trying to solve a reported problem.

Obvious problems, such as leaking oil and broken parts, are not listed in this section.

Note: Wiring diagrams referenced WD00 through WD15, are in "Section 11 - Wiring Diagrams".

SYMPTOM IDENTIFICATION PROCEDURE

1. Set the controller power switch to 0 (off).

2. Disconnect the DI/DO cable at the C2 connector.

3. Manually move both the Theta 1 and Theta 2 arms away from the overrun areas. Check for any mechanical binds.

4. Make sure all cable connectors are seated correctly.

5. Set the controller power switch to | (on). If the fans are not running, there is a problem with the AC power. See WD09.

6. Check the LEDs on the front of the power supply assembly. If any LED is not lit, there is a power supply problem. See WD10.

7. Check the error LEDs on the operator panel. If any error LED is lit, go to the appropriate symptom for that LED.

8. If more than one error LED lit, go to the "Control Panel Failures" symptom.

   DANGER

   The next step causes the manipulator to power on. Stand clear of the work space.

9. Make sure that the Stop pushbutton is unlatched; then press the Manip Power key. If the Manip Power LED does not light, go to the "Manipulator Power Switch Does Not Work" symptom.

10. Check the Power On LEDs on the servo packs. If any LED is not lit, suspect the servo pack or the power to the servo pack. See WD12 and WD13.

11. Press the Stop pushbutton. If the Manip Power LED did not turn off, check the Stop pushbutton switch and wiring. See WD06.

    DANGER

    The next step requires you to push on the end of the arm with manipulator power on. Do not allow your body to enter the work space.

12. Unlatch the Stop pushbutton and press the Manip Power key. Carefully push on the end of the arm. If either arm moves, go to the appropriate "Theta Arm Does Not Move" symptom.

13. Press the Theta 1 and Theta 2, plus (+) and minus (-) keys, to move the axes in the plus and minus directions. Check for any of the following error conditions:

   - An axis moves in the positive direction only. There is a shorted home switch or cabling. See WD08 or go to the "Does Not Home" symptom.

   - An axis runs away or has erratic movement. Go to the appropriate "Theta Arm Moves Erratically" symptom.

   - An axis does not move at all. Go to the appropriate "Theta Axis Does Not Move" symptom.

14. Using the operator panel keys, move both Theta arms to the full negative extreme. If an overrun condition occurs, the appropriate home switch is defective or out of adjustment. Go to the "OR LED On" symptom.

15. Press the Roll + and Roll - keys to move the roll axis clockwise and counterclockwise. If the roll motor does not move correctly, go to the "Roll Motor Does Not Move" symptom.

16. Using the control panel keys, open and close the gripper and move the Z-arm up and down. If any failures occur, go to the appropriate symptom.

17. Set the controller power switch to 0 (off). Move the Theta arms away from the home position. Set the controller power to | (on). Press the Manip Power key. Press the Return Home key. Check for one of the following error symptoms:

   - If an overrun condition occurs. Go to the "Overrun LED On" symptom.

   - If the arm is not homed at the correct position go to the "Repeatability Varies" symptom.

This completes the symptom identification procedure. For further testing, load the exercisers and check the system operation.

Note: Intermittent errors may be caused by electrical noise. Arc suppression is needed for inductive loads connected to the C2 interface. See the Site Preparation Guide.

SYMPTOM LIST

Note: If any other symptoms apply, use that symptom first.

If there is another system close by, a quick way to isolate control panel failures is to swap the control panel with a known good control panel.

Defective Keyboard

If only one switch or indicator is failing and all the other indicators and switches work correctly, suspect the keyboard.

Missing +24 Vdc To The Control Panel

Disconnect the C3 connector and check for +24 Vdc at C3-J and C3-K. If +24 Vdc is missing, refer to WD07 and isolate the missing voltage.

Missing +5 Vdc To The Control Panel

Disconnect the C3 connector and check for +5 Vdc at C3-A, C3-B, C3-C, and C3-D. If +5 Vdc is missing, refer to WD07 and isolate the missing voltage.

Loose C3 Connector

Reseat the C3 connector. Shake the cable and connector as you tighten the retaining ring.

Defective Control Panel Cable

Disconnect the C3 connector. Refer to WD06 and WD07 and check for continuity from the C3 connector to the CN1T connector. If there are any broken wires, replace the cable.

Continued on the next page.

Defective Control Panel Interface Board

Check the STB line at CN7R-22 for a drop from +24 Vdc to 0 Vdc when a key is pressed. If there is 0 Vdc all the time, suspect a defective cable. See WD06. If the voltage never drops, suspect the control panel interface board. Press and release the failing key. Check for +24 Vdc (active) at the CN7R connector for each line associated with that key (see the figure below). Use CN7R-31 for ground. If the lines are incorrect, suspect the control panel interface board or the cable. Use "Section 1 - Locations" for the "pin-out" of the CN7R connector.

Key Pressed	Lines Active (24 Vdc)
Gripper Open	33,18
Gripper Close	18
Return Home	34,30,29,17
Recall Memory	33,30,29,17
Reset Error	30,29,17
Z-Up	33,29,17
Z-Down	29,17
On Line	33,34,30,17
Off Line	34,30,17
Auto	33,30,17
Manual	30,17
Start Cycle	33,34,30,29
Stop Cycle	34,30,29
Stop and Mem	33,30,29
Step	30,29
Theta 1 +	33,34,29
Theta 1 -	34,29
Theta 2 +	33,29
Theta 2 -	29
Appl 1	33,34,30
Appl 2	34,30
Appl 3	33,30
Appl 4	30
Appl 5	33,34
Roll +	33
Roll -	None

DATA ERROR (DE) LED ON

Tried To Move The Arm To An Invalid Point

The compiler allows points that are outside the valid workspace (linear or normal) to be defined. However, when the controller attempts to go to that point, a data error occurs. To check for an invalid point, run the application in step mode. If the data error occurs at the same point every time, suspect an invalid point.

The Data In A Partition Has Been Altered

Reload the application program.

Defective Battery On The CPU Board

With the system powered off, check the voltage across the battery. The voltage should be between +3.2 and +3.6 Vdc. If the voltage is low, replace the battery.

Defective CPU Board

If the battery is good and there is not an invalid point, replace the CPU board.

Low Power Supply Voltages

Check for 24 Vdc, -12 Vdc, 12 Vdc, 5 Vdc at PSTB1 and PSTB2 on the front of the power supply enclosure. See WD10. If any of the voltages differ by more than 5% adjust or replace the appropriate power supply.

Defective Encoder

Defective MTCB Board

1. Set the controller power switch to | (on). Do not bring up manipulator power.

2. Check for +12 Vdc at CN32H-E for Theta 1 or CN34H-E for Theta 2. If the voltage is missing, suspect the MTCB board or the wiring from the MTCB board to the encoder. See WD12 and WD13.

3. With an analog voltmeter, monitor TP1 for Theta 1 or TP3 for Theta 2 on the MTCB board. These are the timing pulses.

4. Remove the plug from the access hole in the encoder housing and use your finger to slowly turn the encoder coupling. You should see the voltage vary from about +0.5 Vdc to +6 Vdc as the encoder disk turns.

5. Monitor TP2 for Theta 1 and TP4 for Theta 2. Repeat step 4. These are the timing pulses.

6. Monitor TP5 for Theta 1 and TP6 for Theta 2. Repeat step 4.

   Note: Turn the encoder coupling slowly. There is only one pulse per revolution of the encoder. This is the index pulse.

7. If any voltage is missing, suspect the encoder or the wiring from the encoder to the MTCB board. See WD12 and WD13.

Defective Or Misaligned Home Switches

Caution: Do not change the home switch adjustments unless you are certain it is necessary.

1. Set the controller power switch to | (on). Make sure that both the Theta 1 and Theta 2 arms are away from their home positions.

2. Check for 24 Vdc at:
   CN6R-6 Theta 1
   CN6R-5 Theta 2

   If there is 0 Vdc refer to WD08 and check the appropriate circuit and home switch.

3. Monitor the voltage at the same two points and manually push the appropriate arm to the home position. The voltage should change from +24 Vdc to 0 Vdc when the arm goes to the home position. If the voltage never goes to 0 Vdc, check the home switch adjustments , home switch, or the circuitry for the appropriate home switch.

Defective Motor/Encoder Assembly

If the motor does not move at all, go to the "Theta 1 Motor Does Not Move Symptom" or the"Theta 2 Motor Does Not Move Symptom."

MANIP POWER DOES NOT WORK (NO OTHER INDICATIONS)

Defective MS1 Relay or Circuitry

Refer to "Manipulator Power On" in Section 2 for more information.

1. If the fans are not running with the power on, check the circuit breaker, line filter, and input power.

2. If any indicator on the power supply front panel is not lit, check the powe supply assembly. See WD10.

3. Observe the MS1 relay when pressing the Manip Power key on the contro panel. You should see and hear the MS1 relay energize. If the relay doe not energize, check the CR100 relay and the MS1 relay.

4. Check the voltage at TB1R-1. If it is 0 Vdc, the CR100 relay is defectiv If there is +24 Vdc at TB1R-1, the CR1 relay is not energized or defective.

5. The CR1 relay is energized by the following conditions:

   - Stop switch not pressed.
   - +5 Vdc,+12 Vdc, and -12 Vdc present.
   - CREM relay not energized.

   If these conditions are correct and the CR1 relay is not energized, rep the relay board.

UP

Defective Stop Switch

Set the controller power switch to 0 (off). With the Stop pushbutton in t position, check for continuity from CN7R-31 to CN7R-35. If you read inf either the Stop switch or the wiring is defective.

Defective CR1X Relay

If the manipulator power LED stays on only when the Manip Power key is p the CR1X-2 point or wiring is defective.

Defective Or Misaligned Home Switch

1. Power up the system and ensure that both the Theta 1 and Theta 2 arms are away from their home positions.

2. Check for 24 Vdc at:
   CN6R-6 Theta 1
   CN6R-5 Theta 2

   If 0 Vdc is present, the switch is closed. Refer to WD08 and check the appropriate circuit and switch.

3. Monitor the voltage at the same two points and manually push the appropriate arm to the home position. If the voltage does not go from +24 Vdc to 0 Vdc, check the home switch adjustments, the home switch, or the circuitry for the home switch.

Defective Or Out Of Adjustment Overrun Switch

Caution: Do not adjust the overrun switches unless you are certain that they need adjustment.

1. Check the voltage at CN6R-7. If the voltage is 0 Vdc, the Theta 1 or the Theta 2 overrun switch is closed or defective, or the +24 Vdc power for the overrun switches is missing.

2. Check the voltage at CN2H-9. If the voltage is 0 Vdc, check the wiring from the +24 Vdc supply to the home and overrun switches (WD08-D5).

3. To isolate the defective switch, disconnect the overrun switches one at a time until the voltage at CN6R-7 measures +24 Vdc. The switch that causes the change in voltage is the defective switch. See the following table:

Theta 1 overrun	CN8H
Theta 2 plus overrun	CN16H
Theta 2 minus overrun	CN17H

An Axis Is In An Overrun Position

Move both the Theta 1 and Theta 2 axes away from their overrun areas.

Continued on the next page.

Defective Encoder

Defective MTCB Board

1. Set the controller power switch to | (on). Do not bring up manipulat
   power.
2. Check for +12 Vdc at CN32H-E for Theta 1 or CN34H-E for Theta 2. If the vo
   tage is missing, suspect the MTCB board or the wiring from the MTCB board
   the encoder. See WD12 and WD13.
3. With an analog voltmeter, monitor TP1 for Theta 1 or TP3 for Theta 2 on t
   MTCB board. These are timing pulses.
4. Remove the plug from the access hole in the encoder housing and use y
   finger to slowly turn the encoder coupling. You should see the voltage v
   from about +0.5 Vdc to +6 Vdc as the encoder disk turns.
5. Monitor TP2 for Theta 1 and TP4 for Theta 2. Repeat step 4. These are tim
   pulses.
6. Monitor TP5 for Theta 1 and TP6 for Theta 2. Repeat step 4.

   Note: Turn the encoder coupling slowly. There is only one pulse per r
   lution of the encoder. This is the index pulse.
7. If any voltage is missing, suspect the encoder or the wiring from the en
   er to the MTCB board. See WD12 and WD13.

OVERTIME ERROR (OT) LED ON

Improper Input From External Hardware

Defective Relay Board

Disconnect the C2 connector from the controller. Load and run the exerciser 7535EX7 for 7535 or 7540EX7 for 7540. If the arm goes to the error position at 90 degrees, suspect the relay board. If the exerciser shows no error, suspect the external hardware.

Defective Or Out Of Adjustment Z-Axis Switches

Load and run the exerciser 7535EX7 for 7535 or 7540EX7 for 7540. If exerciser gives an overtime error, the Z-axis is the cause of the failure. Remove the air pressure from the system. Move the Z-axis to the top and bottom of its motion; check the indicators on the Z-axis sensing switches. If the indicators do not light, check the sensing switch adjustment. If the switches are transferring, suspect the cabling from the switches to the MTCB board. See WD14.

Defective Control Panel

If the system exercisers run correctly and the only failure is the LED, suspect the control panel.

POWER FAILURE (PF) LED ON

Defective Power Failure Detector

defective pf detector

With the manipulator running, check the line
comes on with no drop in power, suspect a de
WD10.

Low Input Power

Check the AC input voltage. If the voltage
in-house wiring.

Is below specs, check

Too Much Mass For The Roll Motor

Make sure that the load is within the specifications for your system.

Loose Roll Motor Drive/Driven Belt

Check the drive/driven belt tension. (4011,4012)

Defective Harmonic Drive

With Manip Power on, **carefully** check for play in the manipulator by pushing on the end of the arms. The arms have some compliance built in; do not confuse compliance with play in the harmonic drive. If any play is felt, isolate the play to either the joint mounts or the harmonic drive. If the play is inside the harmonic drive housing, suspect the harmonic drive. If the play is at the end of the arm, reseat or tighten the pin and tighten the arm mounting screws. It may also be necessary to reseat or tighten the pin between the harmonic drive shaft and the arm.

Defective Encoder

Defective MTCB Board

1. Set the controller power switch to | (on). Do not bring up manipulator power.

2. Check for +12 Vdc at CN32H-E for Theta 1 or CN34H-E for Theta 2. If the voltage is missing, suspect the MTCB board or the wiring from the MTCB board to the encoder. See WD12 and WD13.

3. With an analog voltmeter, monitor TP1 for Theta 1 or TP3 for Theta 2 on the MTCB board. These are the timing pulses.

4. Remove the plug from the access hole in the encoder housing and use your finger to slowly turn the encoder coupling. You should see the voltage vary from about +0.5 Vdc to +6 Vdc as the encoder disk turns.

5. Monitor TP2 for Theta 1 and TP4 for Theta 2. Repeat step 4. These are timing pulses.

6. Monitor TP5 for Theta 1 and TP6 for Theta 2. Repeat step 4.

   Note: Turn the encoder coupling slowly. There is only one pulse per revolution of the encoder. This is the index pulse.

7. If any voltage is missing, suspect the encoder or the wiring from the encoder to the MTCB board. See WD12 and WD13.

Continued on the next page.

Loose Encoder Wheel

Remove the access plug and check for a loose c
Clamp on encoder shaft

Low Power Supply Voltages

Check for 24 Vdc, -12 Vdc, 12 Vdc, 5 Vdc at
power supply enclosure. See WD10. If any of
adjust or replace the appropriate power suppl

if differ more than 5%

10-15

ROLL MOTOR DOES NOT TURN

Defective Roll Motor Driver Card Fuse

Check the fuse on the roll driver card.

Defective MS1 Relay

With manipulator power on, check for +24 Vdc at the Vh pin on the roll driver card. If +24 Vdc is not present, suspect a dirty or defective MS1-3 N/O point.

Missing +5 Vdc To The Driver Card

Check for +5 Vdc at the Vc pin on the roll driver card. If +5 Vdc is not present, repair the system as necessary. See WD11.

Defective Roll Motor Driver Card

1. Unplug the CN5M connector.
2. Attach a jumper from MTCB TP2 to CN5M-1 (plug side).
3. Attach another jumper from MTCB TP3 to CN5M-2 (plug side).
4. Press the Theta 1 +key. The roll motor should turn counterclockwise as the Theta 1 arm moves. Press the Theta 2 +key. The roll motor should turn clockwise as the Theta 2 arm moves. The roll motor may drive erratically. If the roll motor does not drive with the jumpers attached, remove the jumpers and go to the next step.

Defective Roll Motor

Monitor the voltages on the outputs to the roll motor while attempting to turn the roll motor by pressing the Roll+ and Roll- keys. Each output should be varying between about +2.5 Vdc to +20 Vdc as the phases change. If the voltages go above +23 Vdc or below +2.3 Vdc, suspect the cabling. If all outputs vary, suspect the roll motor or cabling to the roll motor. If all the outputs do not vary between +2.5 Vdc and +20 Vdc, suspect the roll motor driver card.

Defective MTCB Board

If the roll motor, roll motor driver card, and cabling are good, suspect the MTCB board.

The Arm May Have Hit An Obstruction

Remove the obstruction and reset the OL relay for the axis.

Servo Pack Fuse FR1 Or FR2 Is Blown

Replace the fuse. If the fuse blows again, make sure that the payload is within the specifications for the system and the application program. If the payload is within limits, suspect the servo pack or motor/encoder.

Motor Running Too Fast

Check the adjustment of the IN-B potentiometer on the servo pack, using the appropriate speed adjustment procedure (4019, 4020).

Payload Too Large

Make sure that the load is within the specifications for your system and the PAYLOAD parameter is set in the application program.

Defective OL1 Or OL2

Push the reset on the OL relay that is suspected. If the Servo error does not reset. Set the controller power to 0 (off) and check the OL normally open contact. If there is 0 ohms, replace the OL relay.

If the CREM relay is energized, check for the OL relay point shorted or a defective servo pack fuse. If the internal servo pack thermal switch is shorted, there will be continuity between terminals C3 and C4 with external circuits disconnected.

THETA 1 ARM MOVES ERRATICALLY OR RUNS AWAY

Defective Encoder

Defective MTCB Board

1. Set the controller power switch to | (on). Do not bring up manipulator power.

2. Check for +12 Vdc at CN32H-E for Theta 1. If the voltage is missing, suspect the MTCB board or the wiring from the MTCB board to the encoder. See WD12 and WD13.

3. With an analog voltmeter, monitor TP1 for Theta 1 on the MTCB board. These are the timing pulses.

4. Remove the plug from the access hole in the encoder housing and use your finger to slowly turn the encoder coupling. You should see the voltage vary from about +0.5 Vdc to +6 Vdc as the encoder disk turns.

5. Monitor TP2 for Theta 1. Repeat step 4. These are timing pulses.

6. Monitor TP5 for Theta 1 . Repeat step 4.

   Note: Turn the encoder coupling slowly. There is only one pulse per revolution of the encoder. This is the index pulse.

7. If any voltage is missing, suspect the encoder or the wiring from the encoder to the MTCB board. See WD12.

Loose Encoder Wheel

Remove the access plug and check for a loose clamp on the encoder shaft.

Defective Tach Generator

1. Set the power switch on the controller to 0.

2. With a voltmeter set on the +12 Vdc scale, monitor the voltage at T11 and T12 on the servo pack. Manually move the arm. A voltage should be shown on the meter when the arm is moving. The faster the arm moves, the higher the voltage should be.

3. If the voltage does not change, check the voltage at CN32H-G and CN32H-H (motor side), while you move the arm. If there is no voltage, the tach generator is defective. If there is voltage at the motor, check the cabling from the motor to the controller. See WD12.

Servo Pack Out Of Adjustment

Perform the "Theta 1 Speed Adjustment" (4019).

THETA 1 ARM DOES NOT MOVE

Defective Servo Pack Fuse

Check the servo pack fuse. If the indicator shows in the window, the fuse is blown and should be replaced.

Defective Theta 1 Servo Pack

Defective MTCB Board

Defective Motor

Defective CPU Board

1. With the system powered off, move both arms to check for binds. If an arm cannot be moved, isolate the bind.

2. Set the controller power switch to |. Press the Manip Power key on the control panel.

3. Connect an analog ohm meter between TP12 (positive lead) and TP11 (negative lead). Set the meter to the R X 10000 scale. Step down to a lower resistance scale until the arm moves. Reverse the meter leads and the arm should drive in the other direction. If the arm drives in only one direction, suspect the servo pack. If the arm does not move at all, go to the next step. If the arm drives correctly, go to step 6.

   DANGER

   The next step requires you to push on the arm with manipulator power on. Do not allow your body to enter the work space.

   Caution: Before doing the next step, ensure that your voltmeter negative meter lead is not connected to frame ground.

4. Attempt to move the manipulator arm. If the arm does not move, check the cable between CN6M and the servo pack. See WD12. If the cable checks out good, suspect the motor control board.

   Caution: Do not allow the meter leads to short together when you are checking the voltage at the motor.

5. Check the voltage between pins A and B on the servo pack while moving the arm. If the voltage goes abnormally high, the circuit or the motor is open. If the voltage does not change, suspect the servo pack. If the voltage changes between these points, turn controller power to 0 (off) then | (on) and press the Manip Power key. Check the voltage between CN31H-A and CN31H-B at the Theta 1 motor connector when you push the arm. See WD12.

   If the voltage changes, suspect the motor. If the voltage does not change, check the cabling between the servo pack and the motor.

   Continued on the next page.

6. Set the meter to read +0.5 Vdc and monitor between CN6M-1 and CN6M-3 at the MTCB board while pushing the arm. The voltage should vary from about 0 Vdc to +0.5 Vdc. If the voltage does not vary, suspect the MTCB board. See WD12.

7. If all the previous checks are good and the arm does not move under program control, suspect the CPU board.

Out Of Adjustment Zero

Perform the "Theta 1 Servo Pack Zero Adjustment" (4017).

THETA 2 ARM MOVES ERRATICALLY OR RUNS AWAY

Defective Encoder

Defective MTCB Board

1. Set the controller power switch to | (on). Do not bring up manipulator power.

2. Check for +12 Vdc at CN34H-E for Theta 2. If the voltage is missing, suspect the MTCB board or the wiring from the MTCB board to the encoder. See WD13.

3. With an analog voltmeter, monitor TP3 for Theta 2 on the MTCB board. This are the timing pulses.

4. Remove the plug from the access hole in the encoder housing and use your finger to slowly turn the encoder coupling. You should see the voltage vary from about +0.5 Vdc to +6 Vdc as the encoder disk turns.

5. Monitor TP4 for Theta 2. Repeat step 4. These are the timing pulses.

6. Monitor and TP6 for Theta 2. Repeat step 4.

   Note: Turn the encoder coupling slowly. There is only one pulse per revolution of the encoder. This is the index pulse.

7. If any voltage is missing, suspect the encoder or the wiring from the encoder to the MTCB board. See WD13.

Defective Tach Generator

1. Power off the system and set up a meter to read 12 Vdc.

2. Monitor the voltage at the T21 and T22 connectors on the servo pack. Manually move the arm. A voltage should be shown on the meter when the arm is moving. The faster the arm moves, the higher the voltage should be.

3. If the voltage does not change, check the voltage at CN34H-G and CN34H-H (motor side) while you move the motor. If there is 0 Vdc, the tach generator is defective. If there is voltage at the motor, check the cabling from the motor to the controller. See WD13.

Servo Pack Out Of Adjustment

Perform the "Theta 2 Speed Adjustment" (4020).

THETA 2 ARM DOES NOT MOVE

Defective Theta 2 Servo Pack

Defective MTCB Board

Defective Motor

Defective CPU Board

1. With the system powered off, move both arms to check for binds. If an arm cannot be moved, isolate the bind.

2. Set the controller power switch to | (on). Press the Manip Power key on the control panel.

3. Connect an analog ohm meter between TP13 (positive lead) and TP11 (negative lead). Set the meter to the R X 10000 scale. Step down to a lower resistance scale until the arm moves. Reverse the meter leads and the arm should drive in the other direction. If the arm drives in only one direction, suspect the servo pack. If the arm does not move at all, go to the next step. If the arm drives correctly, go to step 6.

   DANGER

   The next step requires you to push on the arm with manipulator power on. Do not allow your body to enter the work space.

   Caution: Before doing the next step, ensure that your voltmeter negative meter lead is not connected to frame ground.

4. Attempt to move the manipulator arm. If the arm does not move, check the cable between CN6M and the servo pack. See WD13. If the cable checks out good, suspect the motor control board.

   Caution: Do not allow the meter leads to short together when you are checking the voltage at the motor.

5. Set the voltmeter to read +12 Vdc. Check the voltage between pins A and B on the servo pack while moving the arm. If the voltage does not change, suspect the servo pack. If the voltage changes between these points. Set the controller power to 0 (off) then | (on) and press the Manip Power button. Check the voltage between CN33H-A and CN33H-B at the Theta 2 motor connector when you push the arm. See WD13.

   If the voltage changes, suspect the motor. If the voltage does not change, check the cabling between the servo pack and the motor.

   Continued on the next page.

6. Set the meter to read +0.5 Vdc and monitor between CN6M-2 and CN6M-4 at the MTCB board while pushing the arm. The voltage should vary from about 0 Vdc to +0.5 Vdc. If the voltage does not vary, suspect the MTCB board. See WD13.

7. If all the previous checks are good and the arm does not move under program control, suspect the CPU board.

Defective Servo Pack Fuse

Check the servo pack fuse. If the indicator shows in the window, the fuse is blown and should be replaced.

Out Of Adjustment Zero

Perform the "Theta 2 Servo Pack Zero Adjustment" (4018).

TRANSMISSION ERROR (TE) LED ON OR COMMUNICATION ERROR

Incorrect Communications Cable Being Used

The communications cable supplied with the system is blue. If the cable is not blue, replace it with the correct cable for this system.

Defective Communications Cable From The Personal Computer (PC) To The Controller

1. Check for continuity between pins 4 and 5, and pins 6 and 8, on both ends of the cable.

2. Check for continuity between the following points:

PC end	Controller end
pin 2	pin 3
pin 3	pin 2
pin 7	pin 7
pin 8	pin 20
pin 20	pin 8

   If any point is open, repair or replace the cable.

Personal Computer

Run the Personal Computer diagnostics to check out the communications card and also the system configuration.

Defective Function Enhancement Card

Disconnect the CN1F connector from the Function Enhancement Card (FEC) and plug it into the CN5 connector on the CPU board. Load an application program. If the program loads, suspect the FEC.

Defective CPU Board

If the Personal Computer is good and the communications cable and FEC are good, replace the CPU board.

Problems With The Host Communications

1. Connect the Personal Computer and use the editor to teach a few points. If the Personal Computer communications are good, go to the next step. If the Personal Computer does not communicate, check the Personal Computer communications. If the Personal Computer is good, replace the CPU board.

2. Check for continuity between pins 7 and 18 on the cable from the host. If the cable has continuity from pin 7 to pin 18, and the Personal Computer communications are good, and the controller communications are good, check the host.

Z-ARM DOES NOT GO UP/DOWN

Bent Z-Shaft

Turn off the air pressure to the manipulator and try to move the Z-shaft up and down. If the Z-shaft binds, suspect a bent Z-shaft.

Bad Air Solenoid Or Wiring

Defective Relay Board

Defective MTCB Board

1. Manually activate the solenoid by pushing the red button on top of the solenoid valve. If the Z-arm moves, the air supply and hoses are good. If the Z-arm does not move, check the air supply, hoses, and cylinder.

2. Check the voltage at CN3H-4. If 0 Vdc is present, the +24 Vdc supply to the solenoid is missing. See WD14.

3. Check the voltage at CN3H-1. See WD14. If 0 Vdc is present, the solenoid may be bad. Check the solenoid.

4. Visually observe the CRL1 relay while alternately pressing the Z-Up and Z-Down keys. If the relay is picking and dropping, monitor the voltage at CN3H-1 for a change from 0 to +24 Vdc when the keys are pressed. If the voltage does not change, the cabling from the relay board to the CN3H connector is bad, or the CRL1-2 point is defective.

5. If the CRL1 relay does not pick, monitor the left side of D7 (located underneath the CRL1 relay). Press the Z-Down key. If the voltage drops to 0 Vdc, the relay board is defective. If the voltage stays at +24 Vdc, the MTCB board is defective.

Defective Z-Arm Sensing Switches

Misaligned Z-Arm Switches

Defective Relay Board

1. Visually check to see that the proper indicator on the Z-arm sense switch is lit. The top should be lit for up and the bottom for down.

2. Monitor the voltage at CN6R10 while moving the Z-arm up and down. The voltage should be 0 with the Z-arm down and +24 Vdc with the Z-arm up. If the voltage does not vary, the switch is out of adjustment or defective, or the associated wiring is defective.

Continued on the next page.

3. Monitor the voltage at CN6R9 while moving the Z-arm up and down. The voltage should be 0 with the Z-arm up and +24 Vdc with the Z-arm down. If the voltage does not vary, the switch is out of adjustment or defective, or the associated wiring is defective.

4. Monitor the voltage at C2-A while you move the Z-arm up and down. If the voltage is not 0 Vdc with the Z-arm down and +24 Vdc with the Z-arm up, the relay board is defective.

Pinched Air Lines

Clogged Air Lines

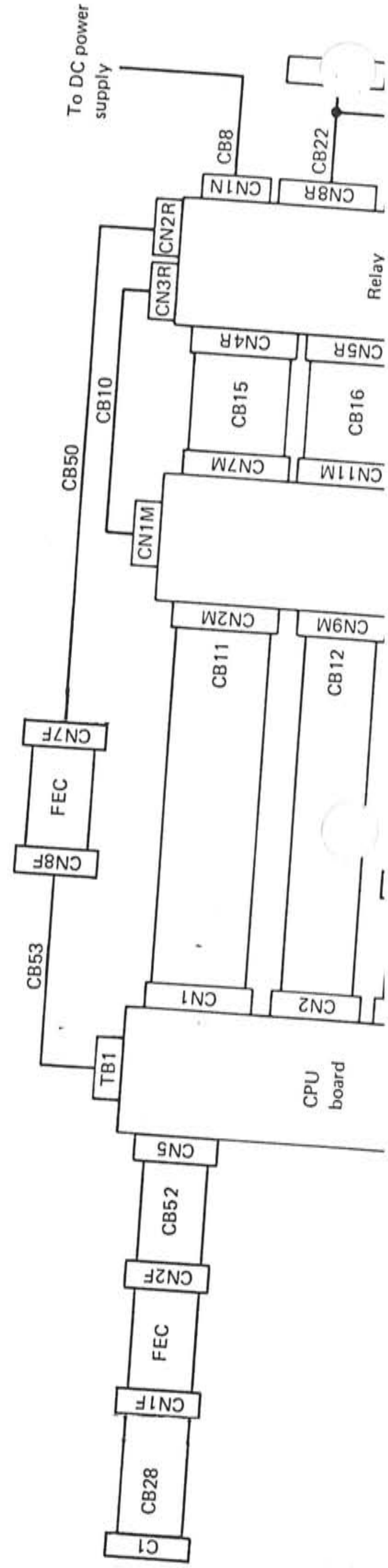
Manually activate the air solenoid by pushing the red button on top of the solenoid valve. If the air solenoid does not work, check the air supply to the system. If the air supply to the system is good, disconnect the air supply to the Z-shaft and press the red button on the solenoid. If the air does not reach the Z-shaft, check each air hose until the pinched or clogged hose is found.

Also, check for pinched air lines inside the junction boxes.

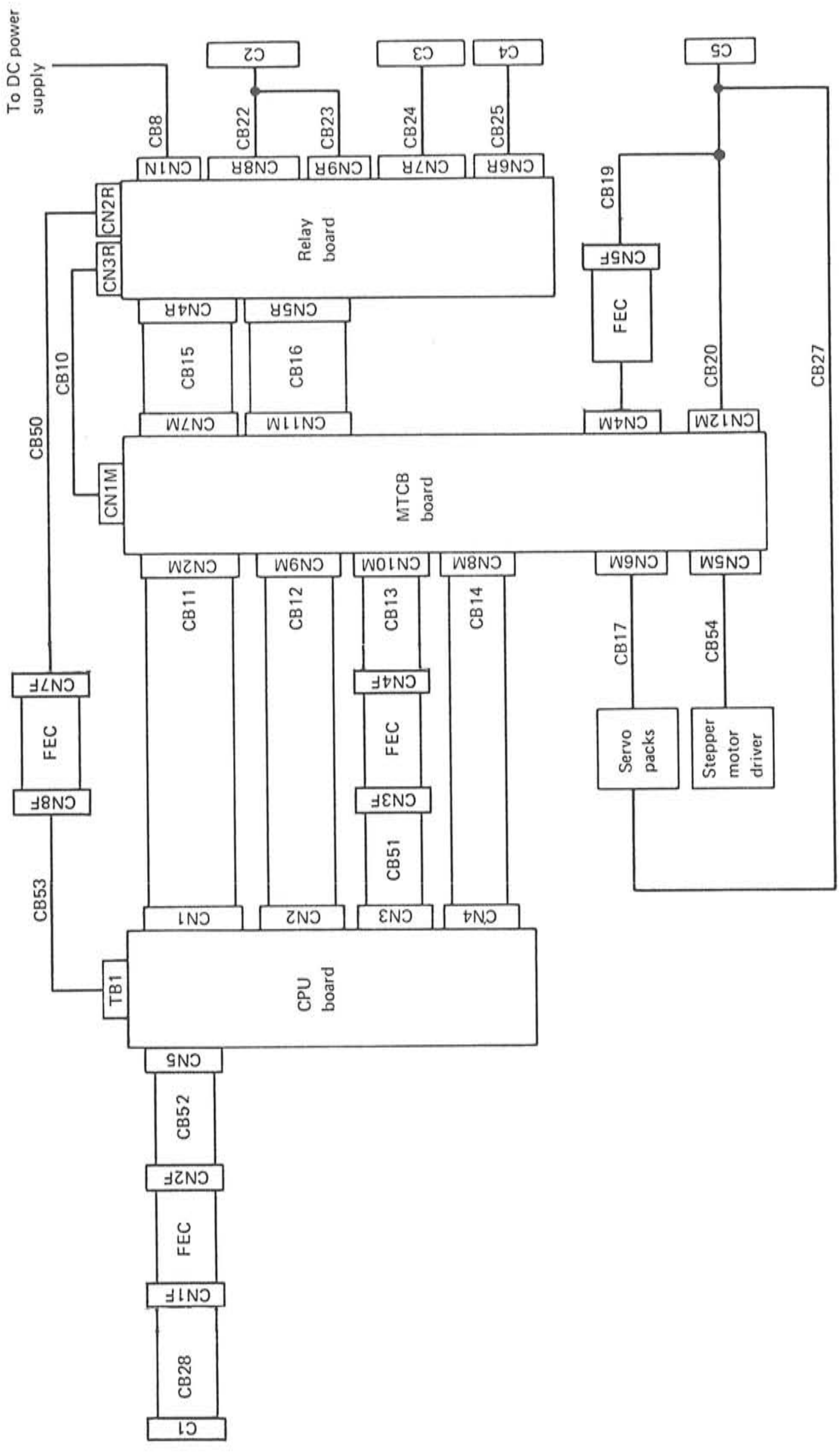
Defective Or Out Of Adjustment Flow Control Valve

Adjust the flow control valve to give more flow. If the Z shaft still fails remove the ouput line from the flow control valve and manually activate the air solenoid. If the air flow from the valve is not correct suspect the valve.

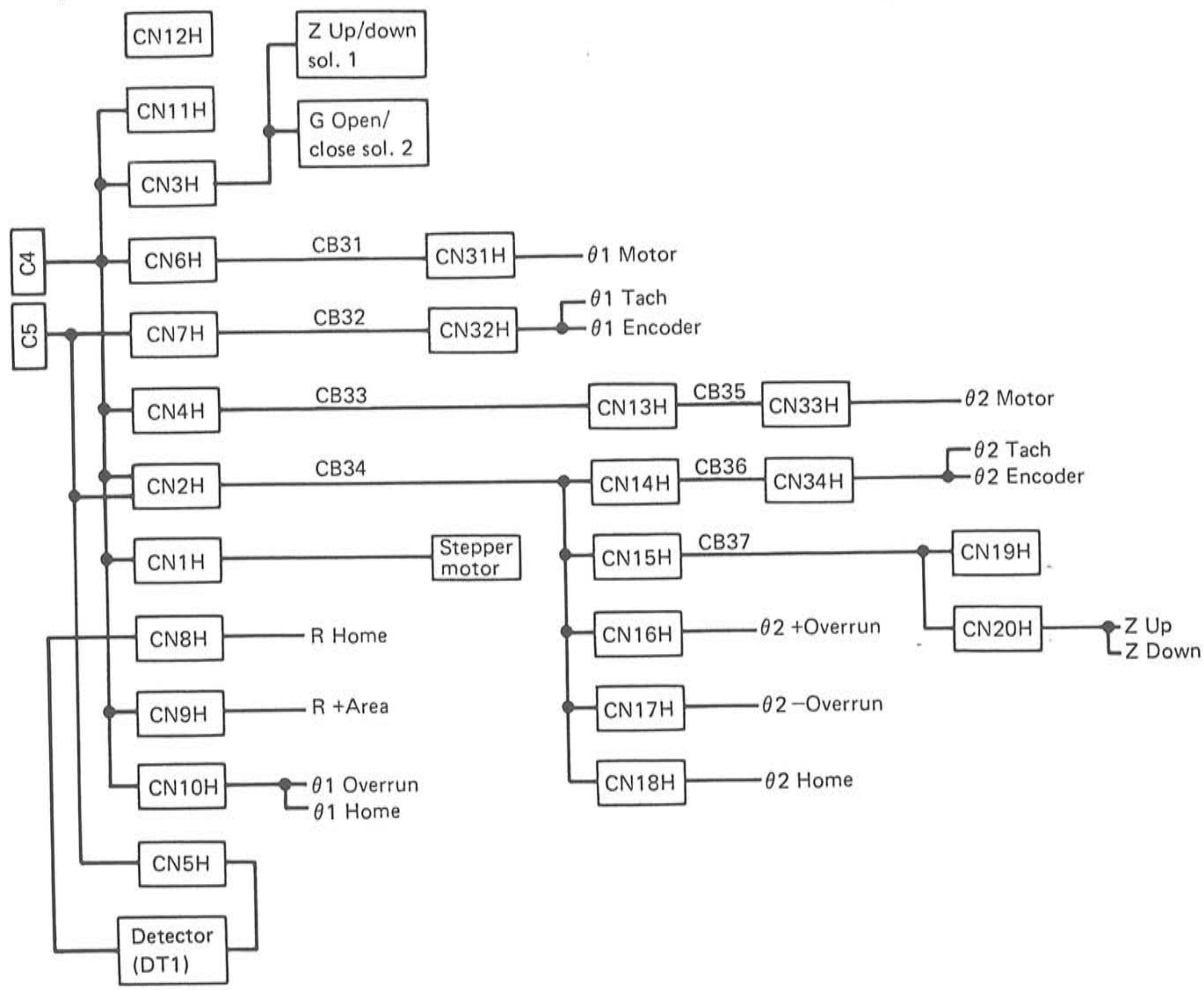
SECTION 11 - WIRING DIAGRAMS


To DC power supply
CB8
CB22
CN1N
CN8R
CN2R
CN3R
Relay
CN4R
CN5R
CB15
CB16
CB10
CB50
CN7M
CN11M
CN1M
CN2M
CN9M
CB11
CB12
CN7F
FEC
CN8F
CB53
CN1
CN2
TB1
CPU board
CN5
CB52
CN2F
FEC
CN1F
CB28
C1

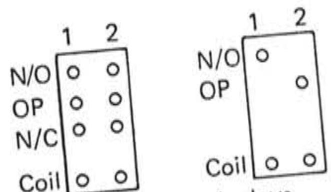
Controller Cable Diagram



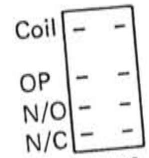
Manipulator Cable Diagram



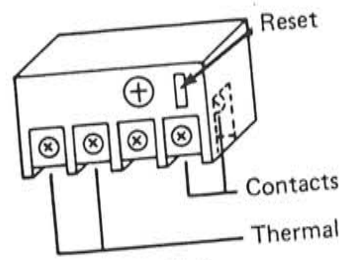
Connectors



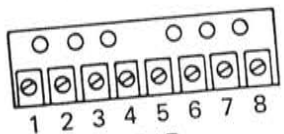
Relay board relays



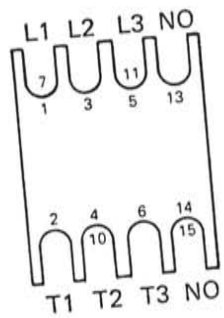
CR100



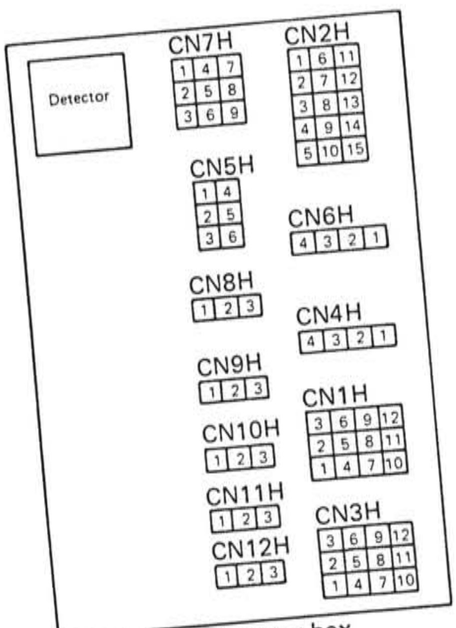
OL1 and OL2



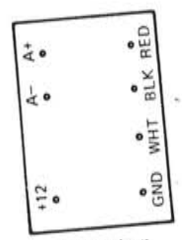
TB1R



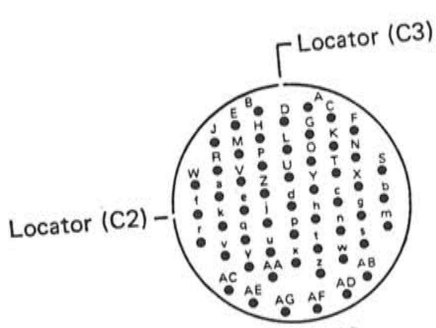
MS1 (Contactor)



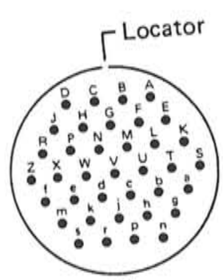
Manipulator connector box



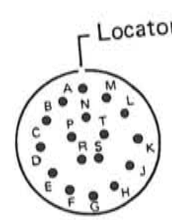
Detector



C2 and C3



C4



C5

C1

Note: All connectors shown female pin-side.

THE FOLLOWING VOLTAGES ARE PRESENT WITH THE SYSTEM POWERED ON AND THE MANIPULATOR AT HOME:

An = +5VDC

Bn = -12VDC

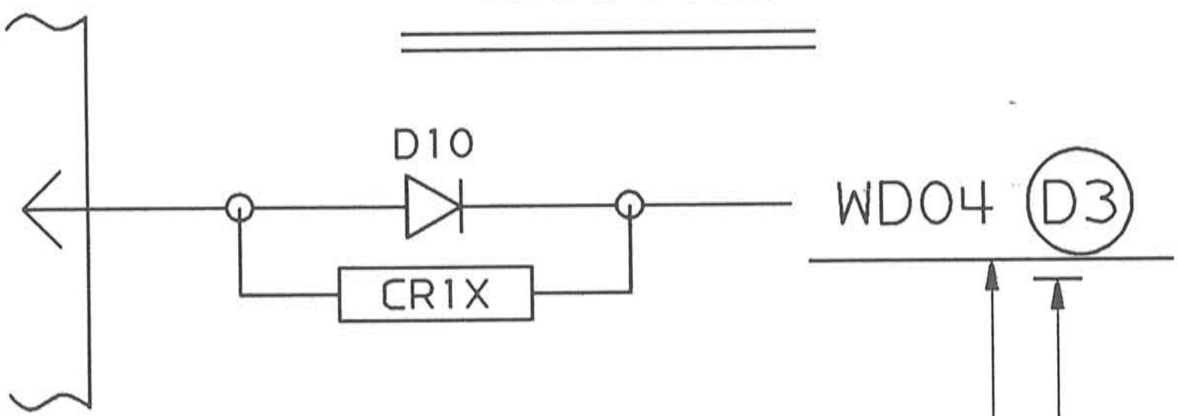
Cn = +12VDC

Dn = +24VDC

En = MISC VOLTAGE

Gn = ±0VDC

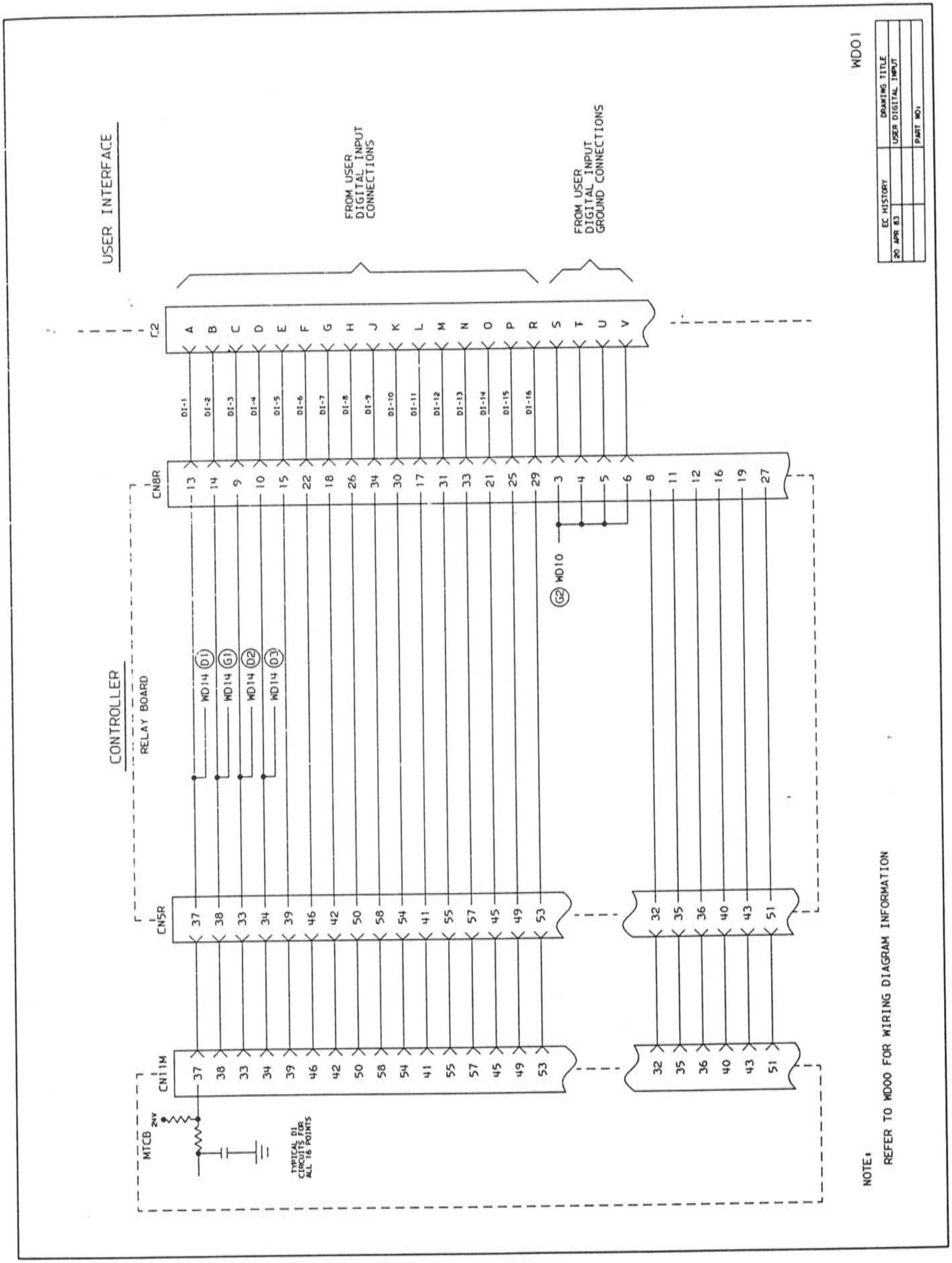
EXAMPLE



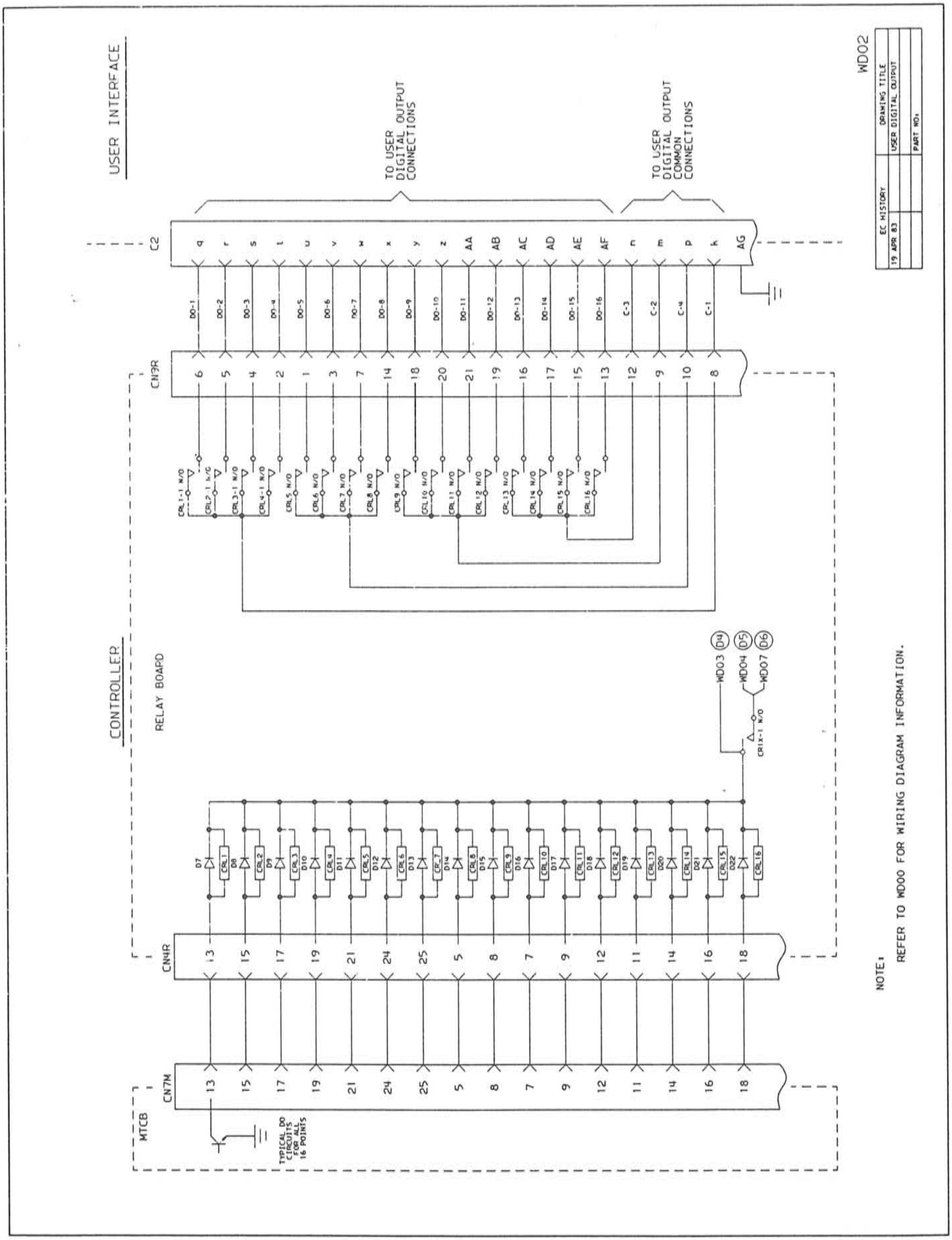
WIRE IS CONNECTED TO D3 ON WD04

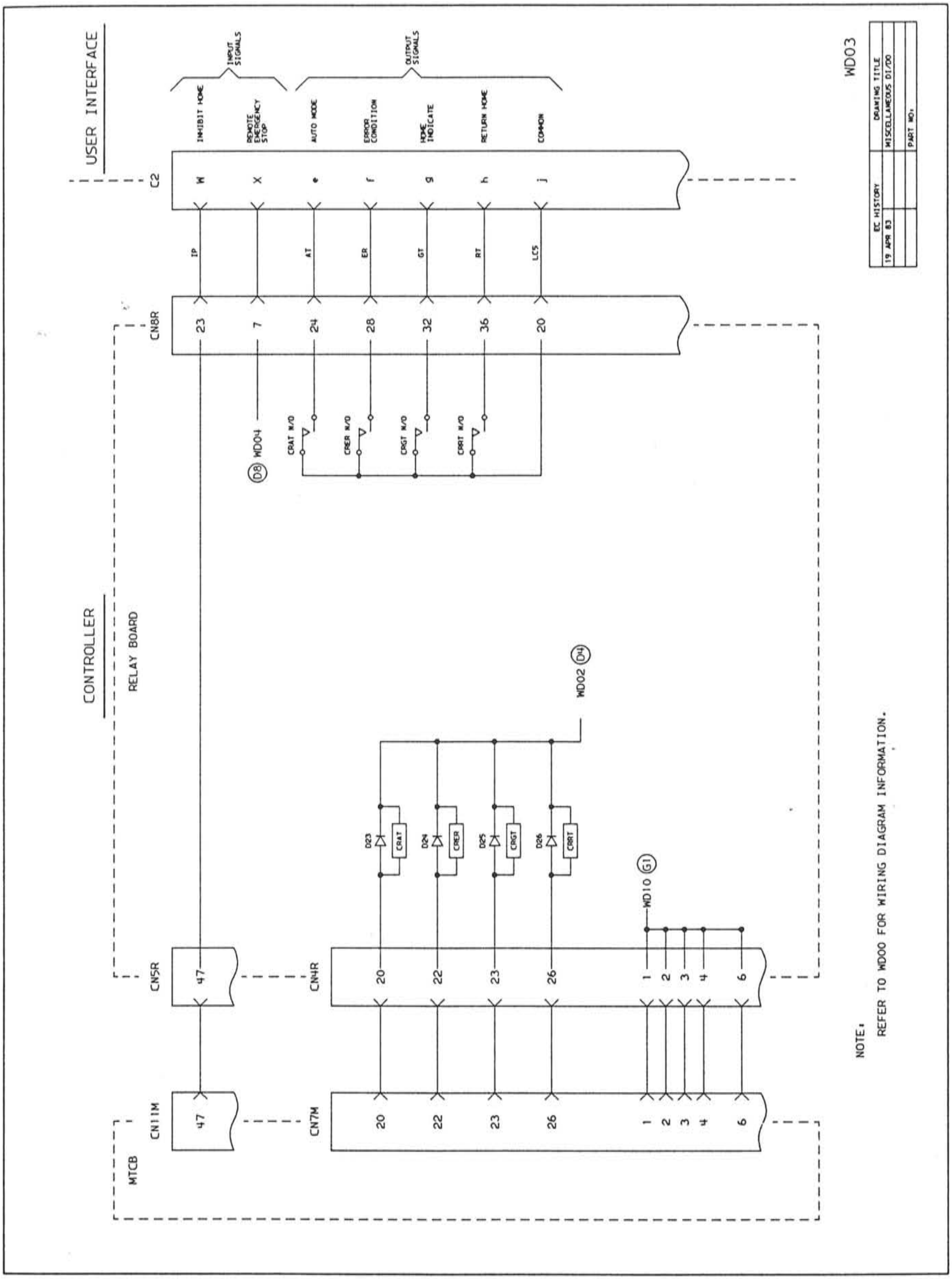
+24VDC IS ON THIS POINT

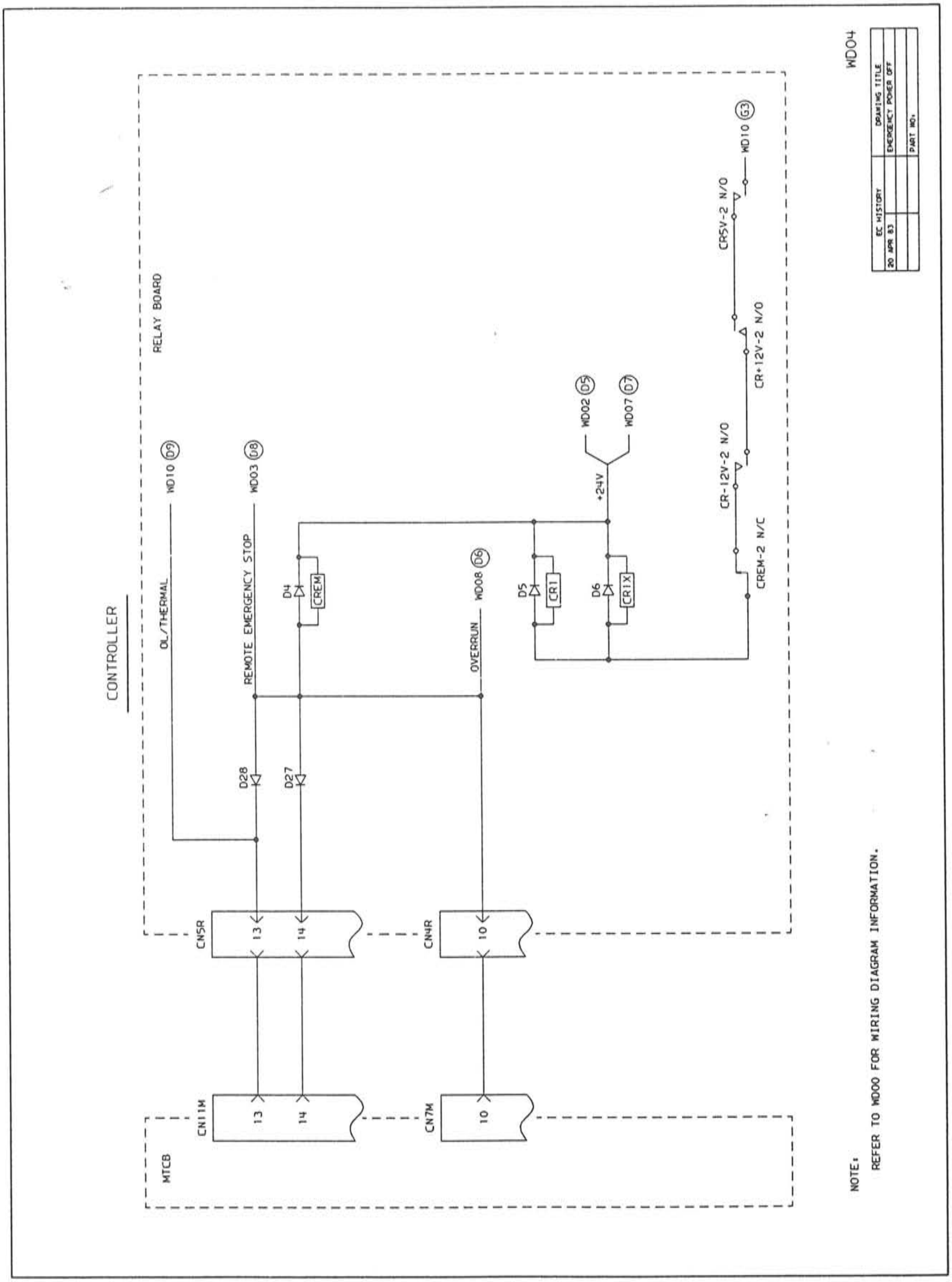
	EC HISTORY	DRAWING TITLE
WD00	25 APR 83	WIRING DIAGRAM LEGEN

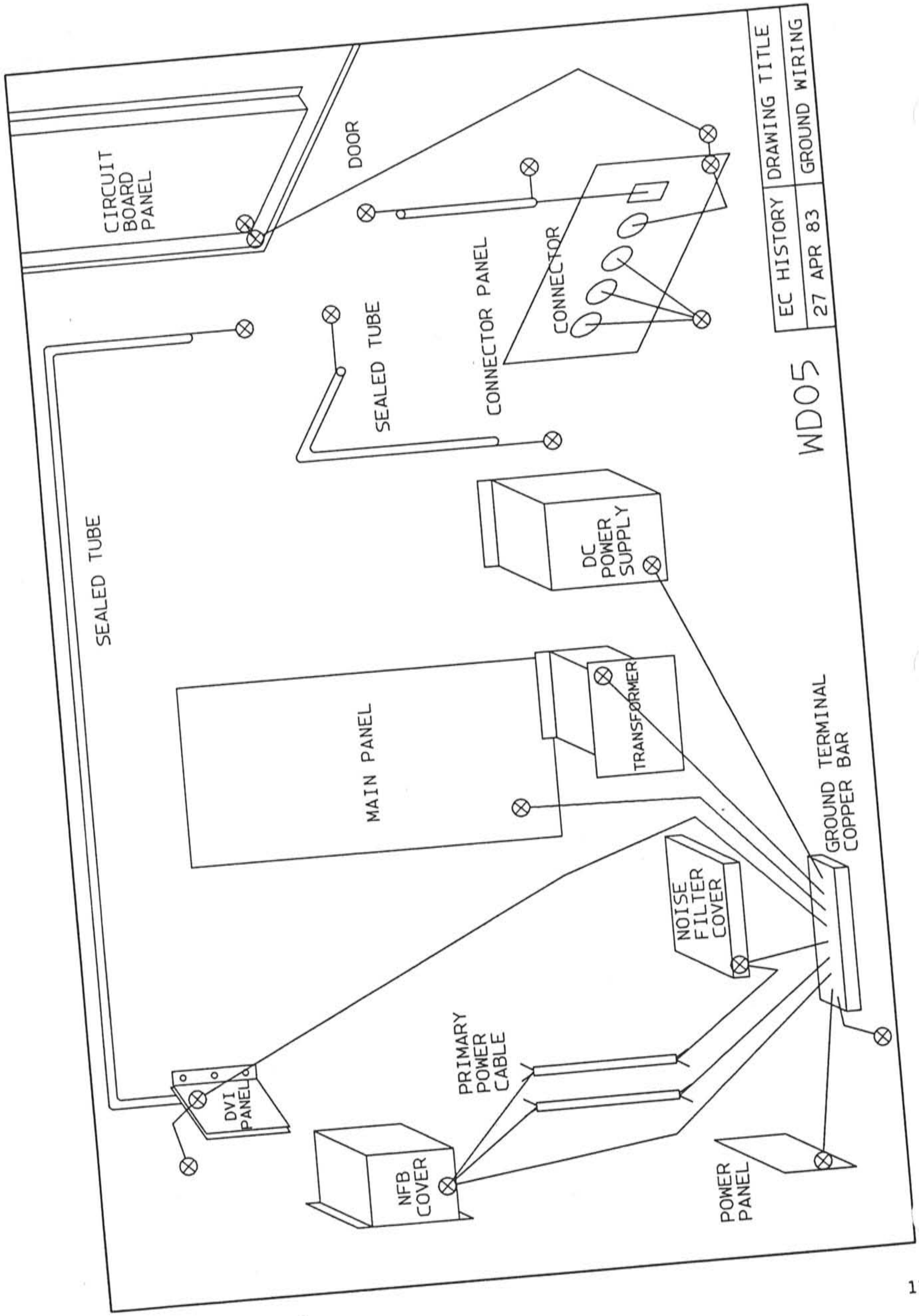


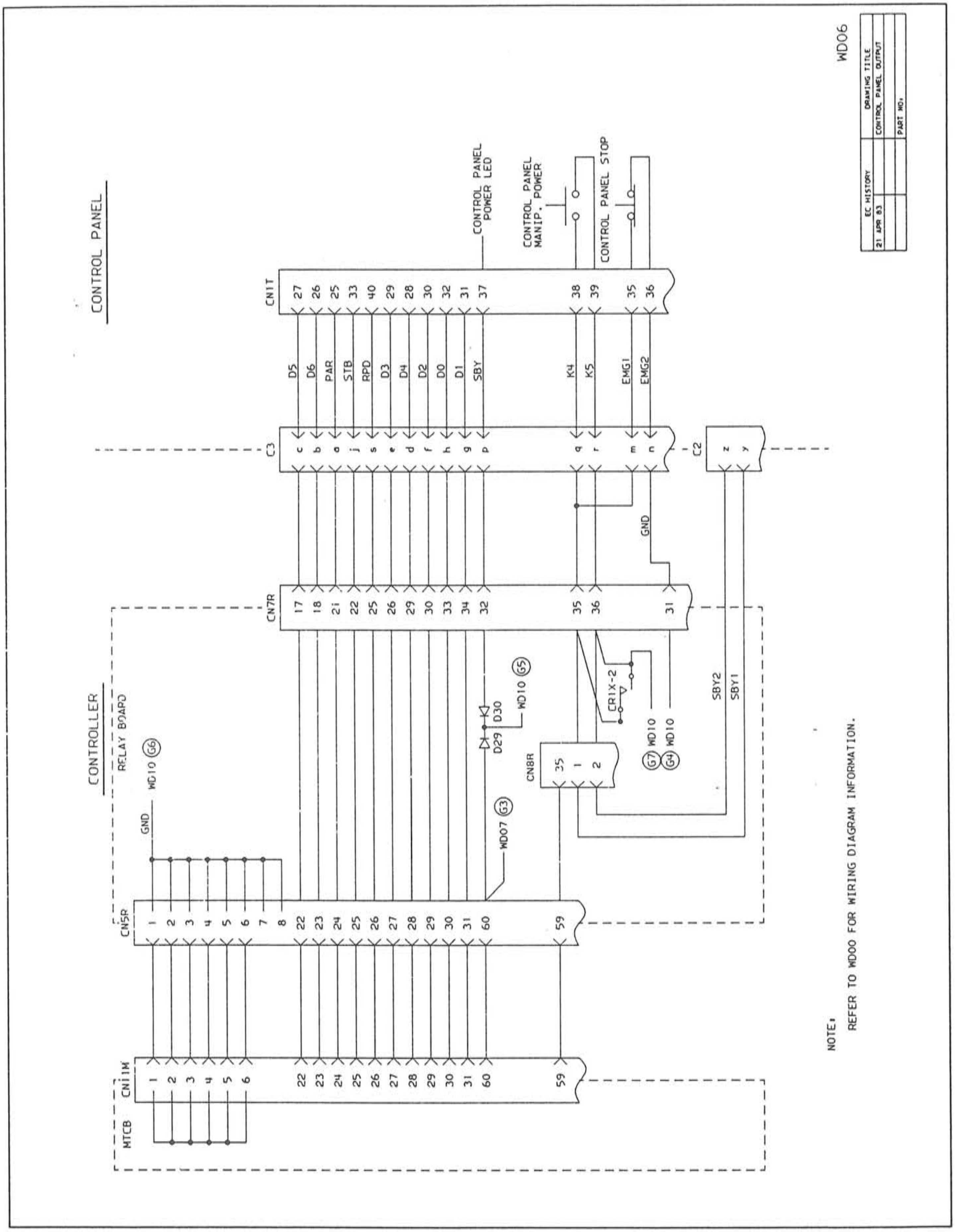
WD01
USER INTERFACE
FROM USER DIGITAL INPUT CONNECTIONS
FROM USER DIGITAL INPUT GROUND CONNECTIONS
C2
A B C D E F G H J K L M N O P R S T U V
DI-1 DI-2 DI-3 DI-4 DI-5 DI-6 DI-7 DI-8 DI-9 DI-10 DI-11 DI-12 DI-13 DI-14 DI-15 DI-16
CN8R
13 14 9 10 15 22 18 26 34 30 17 31 33 21 25 29 3 4 5 6 8 11 12 16 19 27
G2 WD10
CONTROLLER
RELAY BOARD
WD14 D1
WD14 G1
WD14 D2
WD14 D3
CN5R
37 38 33 34 39 46 42 50 58 54 41 55 57 45 49 53
32 35 36 40 43 51
CN11M
37 38 33 34 39 46 42 50 58 54 41 55 57 45 49 53
32 35 36 40 43 51
MTCB
24V
TYPICAL DI CIRCUITS FOR ALL 16 POINTS
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION
EC HISTORY
20 APR 83
DRAWING TITLE
USER DIGITAL INPUT
PART NO:

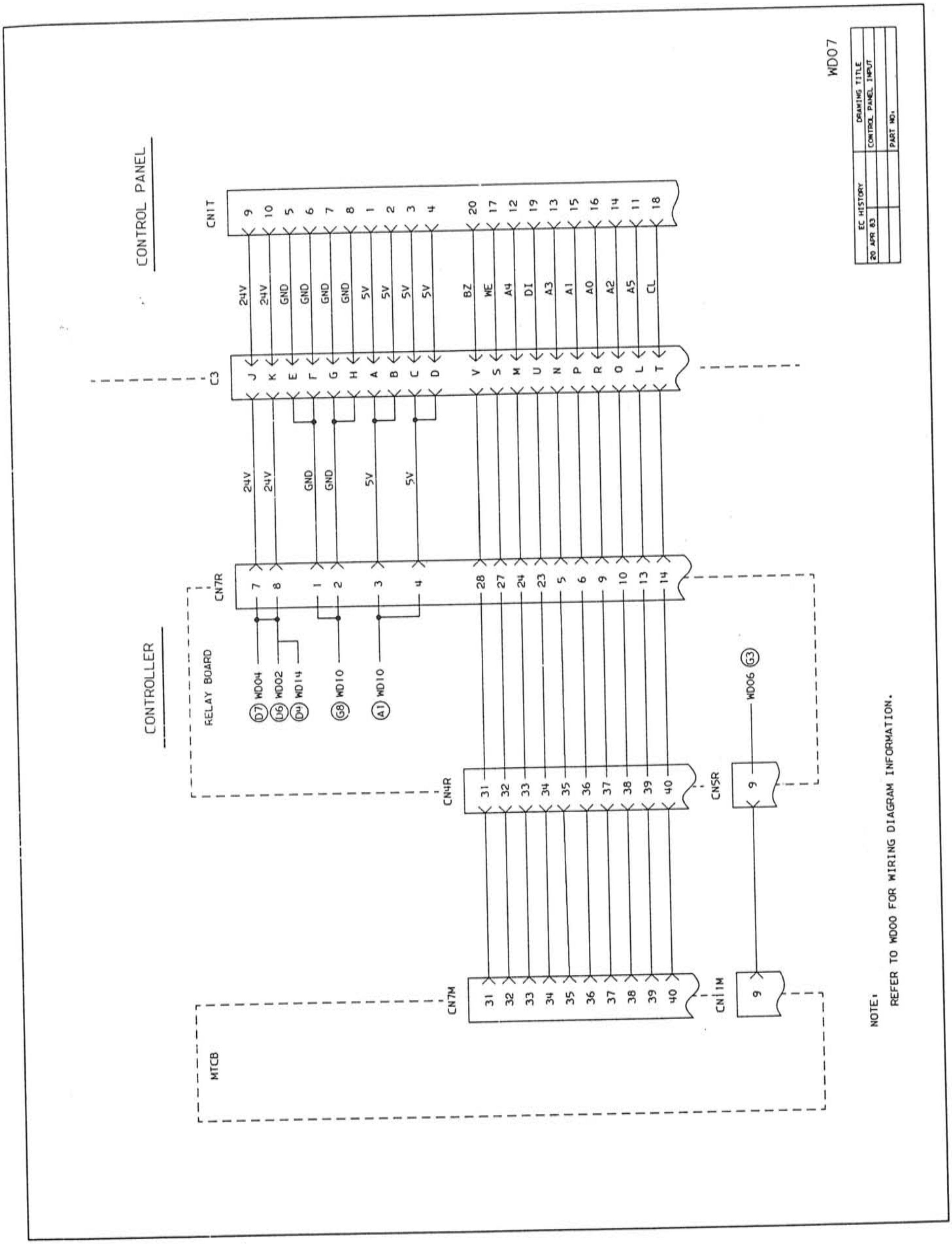

USER INTERFACE
TO USER DIGITAL OUTPUT CONNECTIONS
TO USER DIGITAL OUTPUT COMMON CONNECTIONS
C2
CN9R
CONTROLLER
RELAY BOARD
CN4R
CN7M
MTCB
TYPICAL DO CIRCUITS FOR ALL 16 POINTS
WD03 D4
WD04 D5
WD07 D6
CRIX-1 N/O
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION.
WD02
EC HISTORY
19 APR 83
DRAWING TITLE
USER DIGITAL OUTPUT
PART NO.

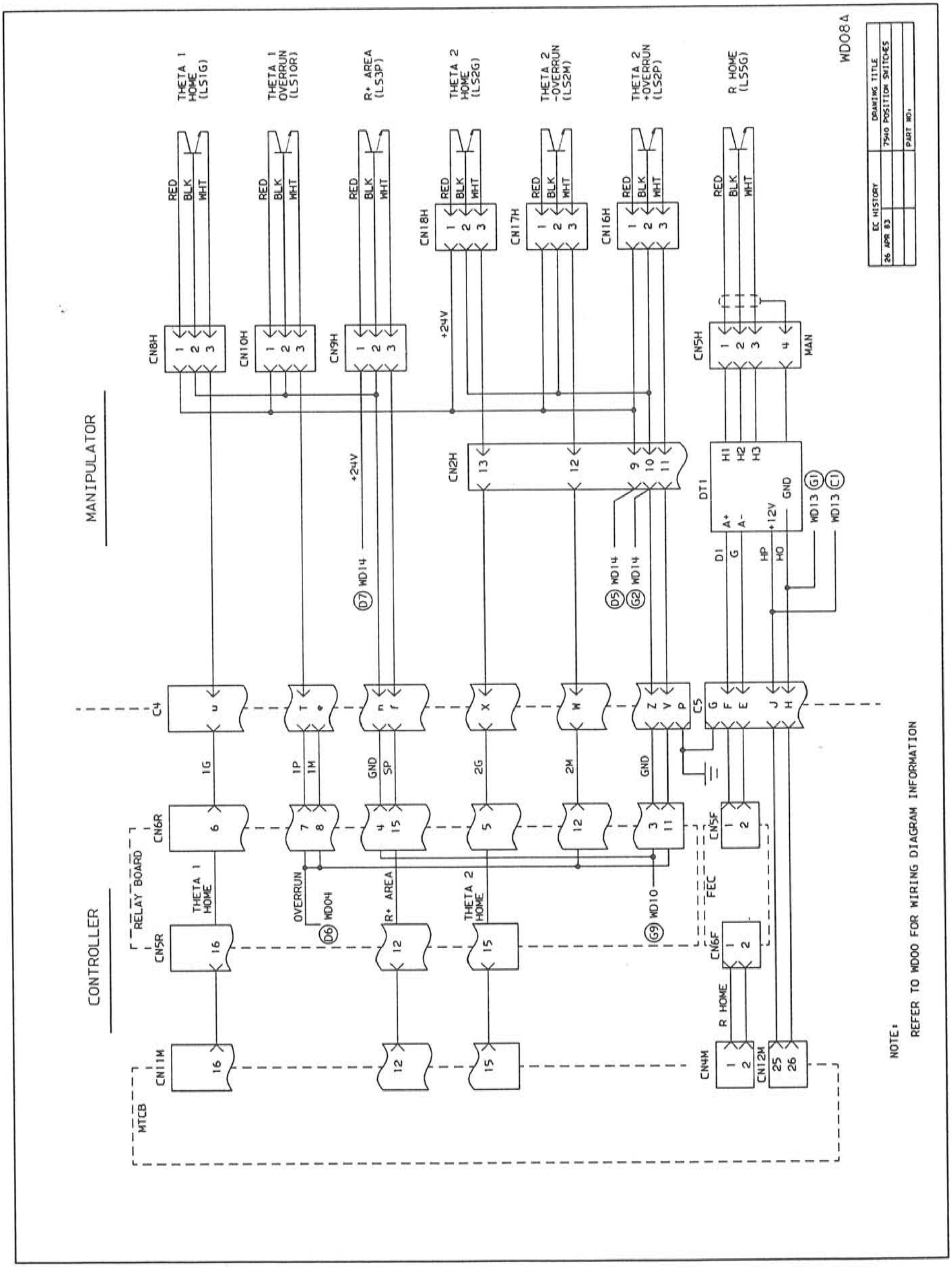

USER INTERFACE
INPUT SIGNALS
OUTPUT SIGNALS
INHIBIT HOME
REMOTE EMERGENCY STOP
AUTO MODE
ERROR CONDITION
HOME INDICATE
RETURN HOME
COMMON
C2
W
X
e
f
g
h
j
IP
AT
ER
GT
RT
LCS
CN8R
23
7
24
28
32
36
20
CRAT N/O
CRER N/O
CRGT N/O
CRRT N/O
D8 WD04
CONTROLLER
RELAY BOARD
WD02 D4
D23
CRAT
D24
CRER
D25
CRGT
D26
CRRT
WD10 G1
CN5R
47
CN4R
20
22
23
26
1
2
3
4
6
CN11M
47
CN7M
20
22
23
26
1
2
3
4
6
MTCB
WD03
EC HISTORY
19 APR 83
DRAWING TITLE
MISCELLANEOUS DI/DO
PART NO.
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION.

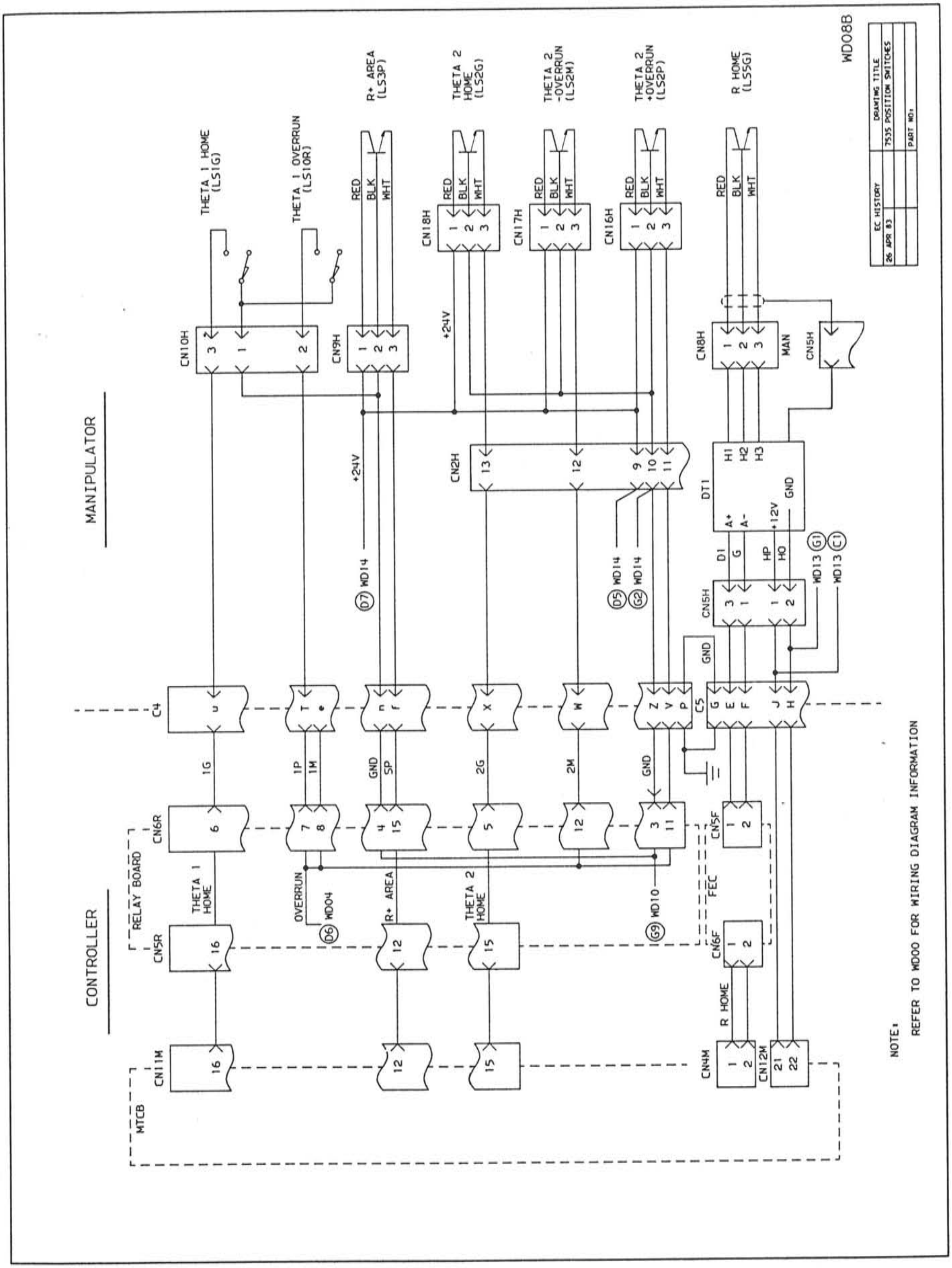

CONTROLLER
RELAY BOARD
OL/THERMAL
WD10 D9
REMOTE EMERGENCY STOP
WD03 D8
OVERRUN
WD08 D6
+24V
WD02 D5
WD07 D7
D4
CREM
D5
CR1
D6
CR1X
D28
D27
CREM-2 N/C
CR-12V-2 N/O
CR+12V-2 N/O
CR5V-2 N/O
WD10 G3
CN5R
CN4R
CN11M
CN7M
MTCB
13
14
10
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION.
EC HISTORY
20 APR 83
DRAWING TITLE
EMERGENCY POWER OFF
PART NO.
WD04

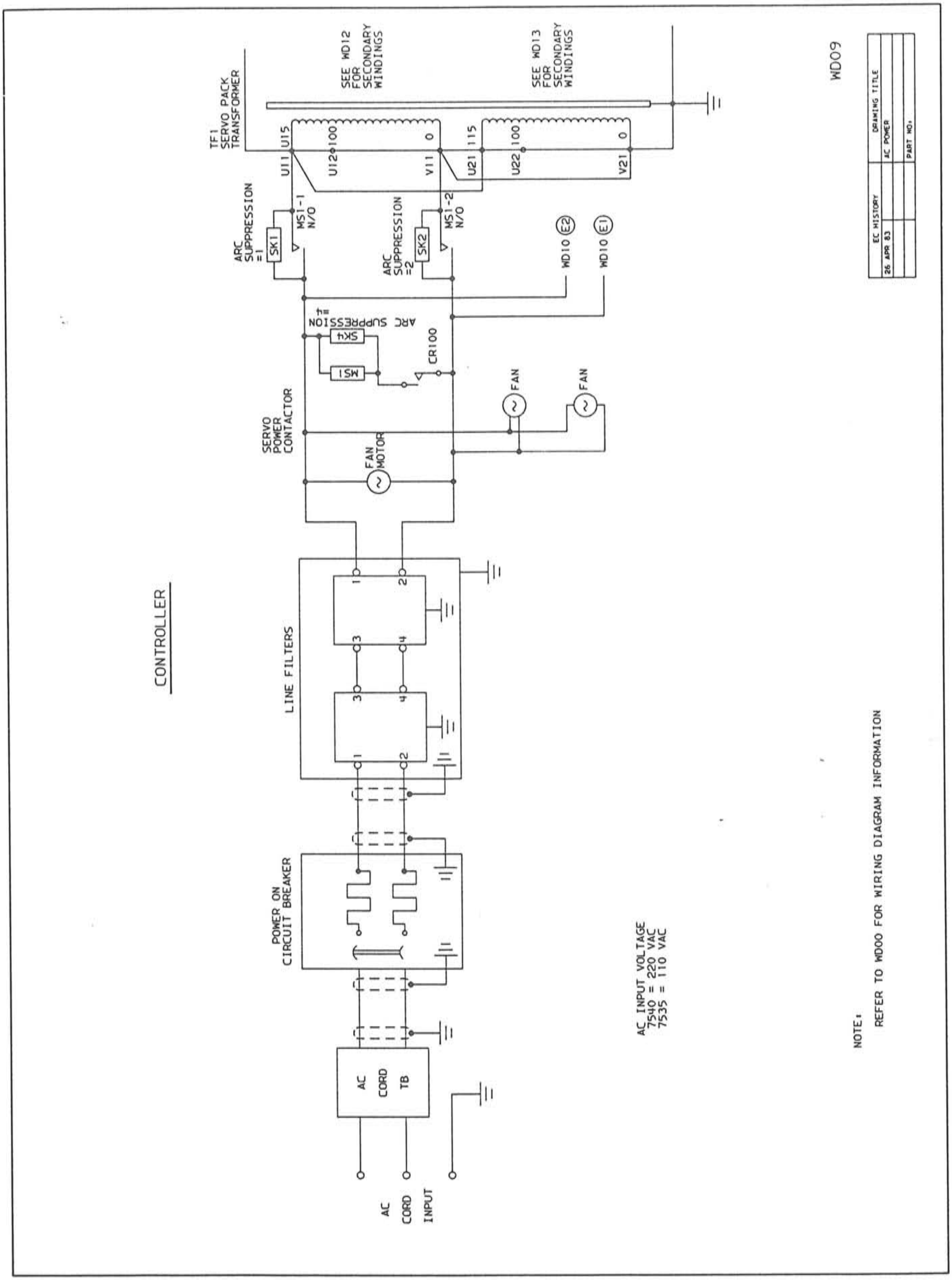

CIRCUIT BOARD PANEL
DOOR
SEALED TUBE
SEALED TUBE
CONNECTOR PANEL
CONNECTOR
EC HISTORY
27 APR 83
DRAWING TITLE
GROUND WIRING
WD05
DC POWER SUPPLY
MAIN PANEL
TRANSFORMER
GROUND TERMINAL COPPER BAR
NOISE FILTER COVER
PRIMARY POWER CABLE
DVI PANEL
NFB COVER
POWER PANEL


WD06
EC HISTORY
21 APR 83
DRAWING TITLE
CONTROL PANEL OUTPUT
PART NO.
CONTROL PANEL
CONTROL PANEL POWER LED
CONTROL PANEL MANIP. POWER
CONTROL PANEL STOP
CN1T
C3
C2
CN7R
CN8R
CN5R
CN11M
MTCB
CONTROLLER
RELAY BOARD
WD10 (G6)
GND
WD07 (G3)
WD10 (G5)
D29
D30
CR1X-2
(G7) WD10
(G4) WD10
SBY2
SBY1
D5
D6
PAR
STB
RPD
D3
D4
D2
D0
D1
SBY
K4
K5
EMG1
EMG2
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION.

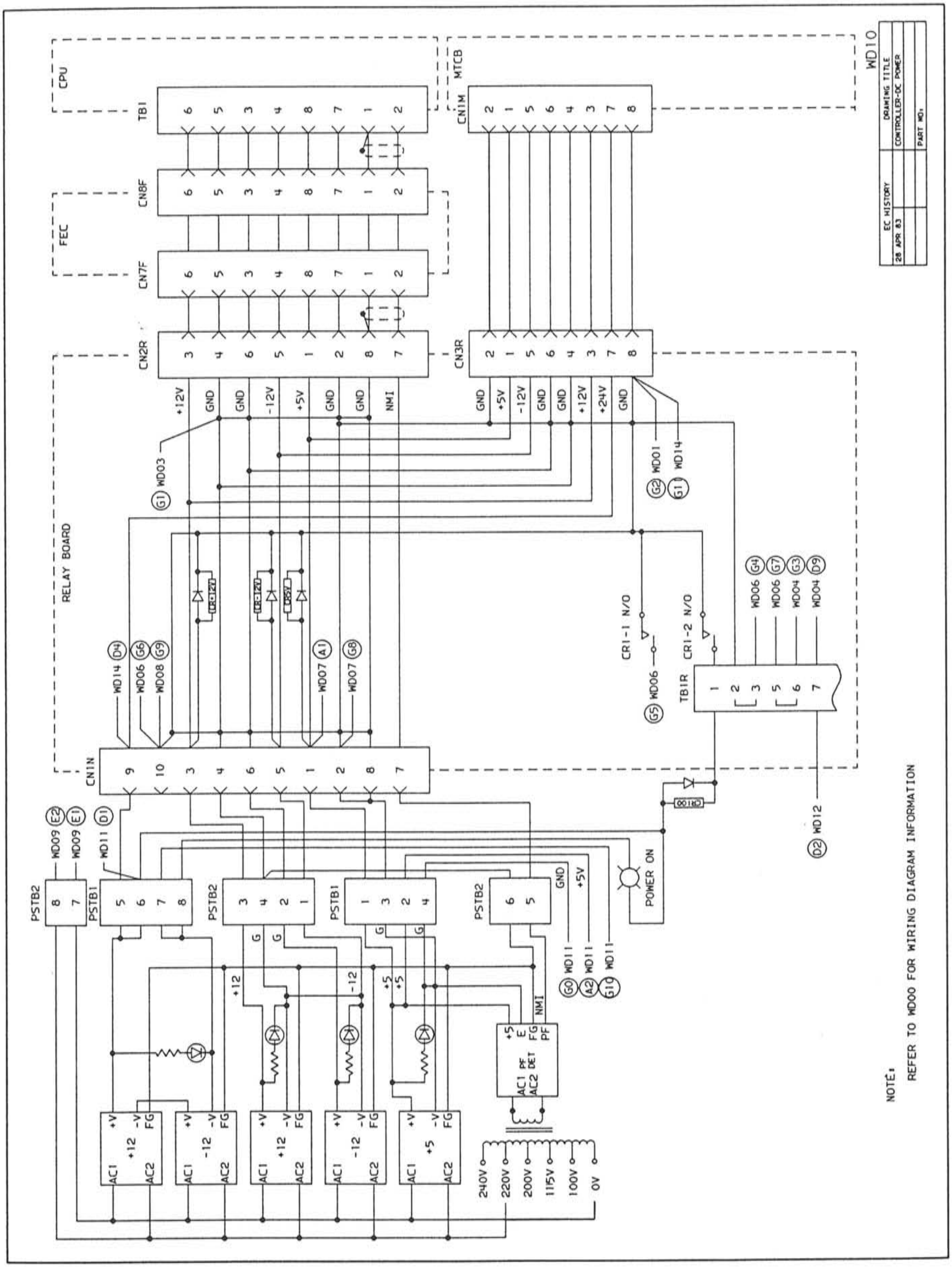

WD07
EC HISTORY
20 APR 83
DRAWING TITLE
CONTROL PANEL INPUT
PART NO.
CONTROL PANEL
CN1T
C3
CONTROLLER
RELAY BOARD
CN7R
CN4R
CN5R
CN7M
CN11M
MTCB
24V
GND
5V
BZ
WE
A4
DI
A3
A1
A0
A2
A5
CL
D7 WD04
U6 WD02
D4 WD14
G8 WD10
A1 WD10
WD06 G3
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION.


WD08A
EC HISTORY
26 APR 83
DRAWING TITLE
7540 POSITION SWITCHES
PART NO.
MANIPULATOR
CONTROLLER
THETA 1 HOME (LS1G)
THETA 1 OVERRUN (LS1OR)
R+ AREA (LS3P)
THETA 2 HOME (LS2G)
THETA 2 -OVERRUN (LS2M)
THETA 2 +OVERRUN (LS2P)
R HOME (LS5G)
RED
BLK
WHT
CN8H
CN10H
CN9H
CN18H
CN17H
CN16H
CN5H
MAN
CN2H
DT1
+24V
WD14
WD13
WD10
WD04
OVERRUN
RELAY BOARD
FEC
MTCB
C4
C5
CN6R
CN5R
CN11M
CN5F
CN6F
CN4M
CN12M
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION

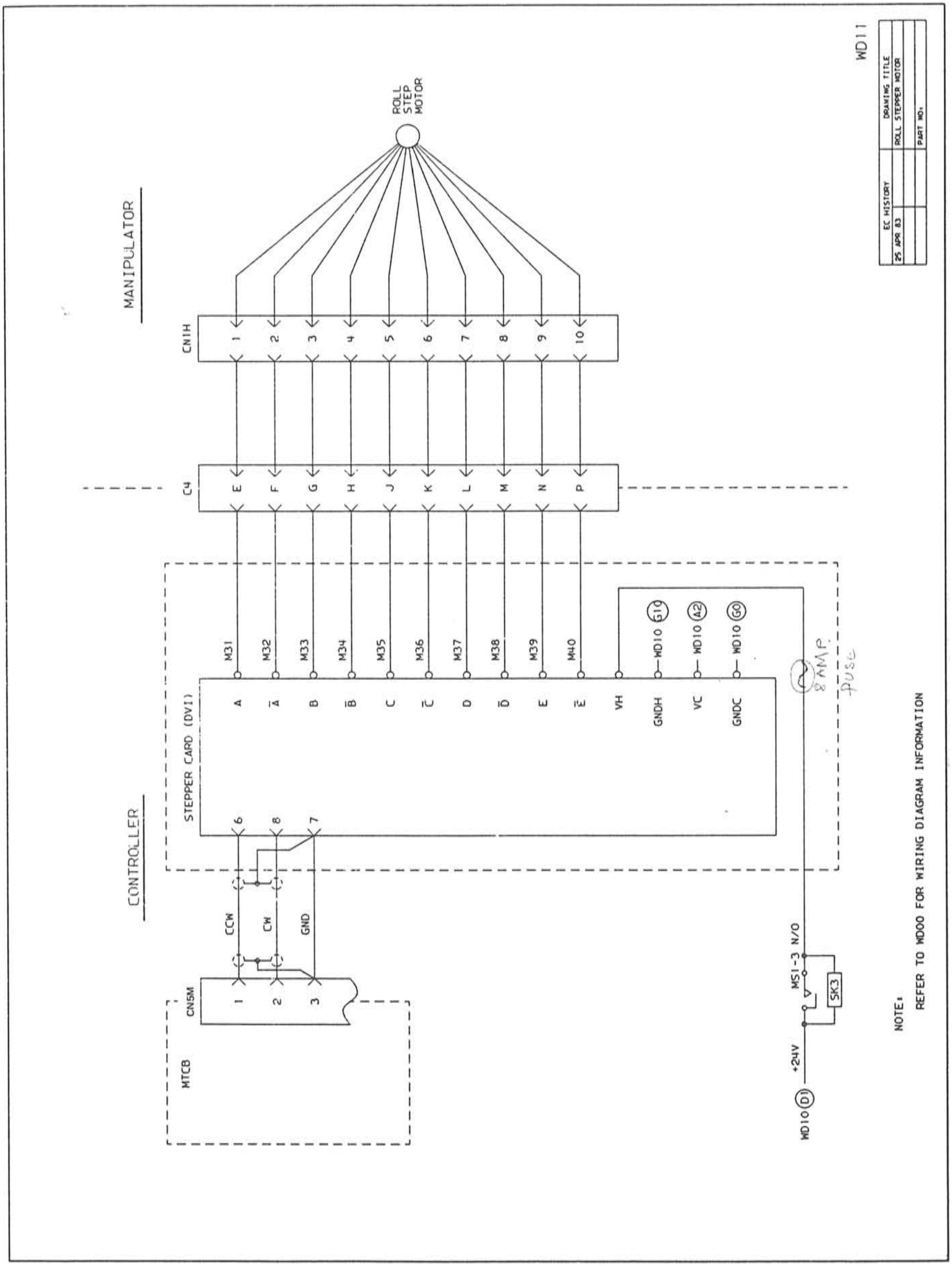

WD08B
MANIPULATOR
CONTROLLER
THETA 1 HOME (LS1G)
THETA 1 OVERRUN (LS10R)
R+ AREA (LS3P)
THETA 2 HOME (LS2G)
THETA 2 -OVERRUN (LS2M)
THETA 2 +OVERRUN (LS2P)
R HOME (LS5G)
RED
BLK
WHT
CN10H
CN9H
CN18H
CN17H
CN16H
CN8H
CN5H
CN2H
MAN
DT1
+24V
+12V
GND
C4
C5
CN6R
CN5R
CN11M
CN5F
CN6F
CN4M
CN12M
RELAY BOARD
FEC
MTCB
THETA 1 HOME
OVERRUN
R+ AREA
THETA 2 HOME
R HOME
WD14
WD13
WD10
WD04
EC HISTORY
26 APR 83
DRAWING TITLE
7535 POSITION SWITCHES
PART NO.
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION

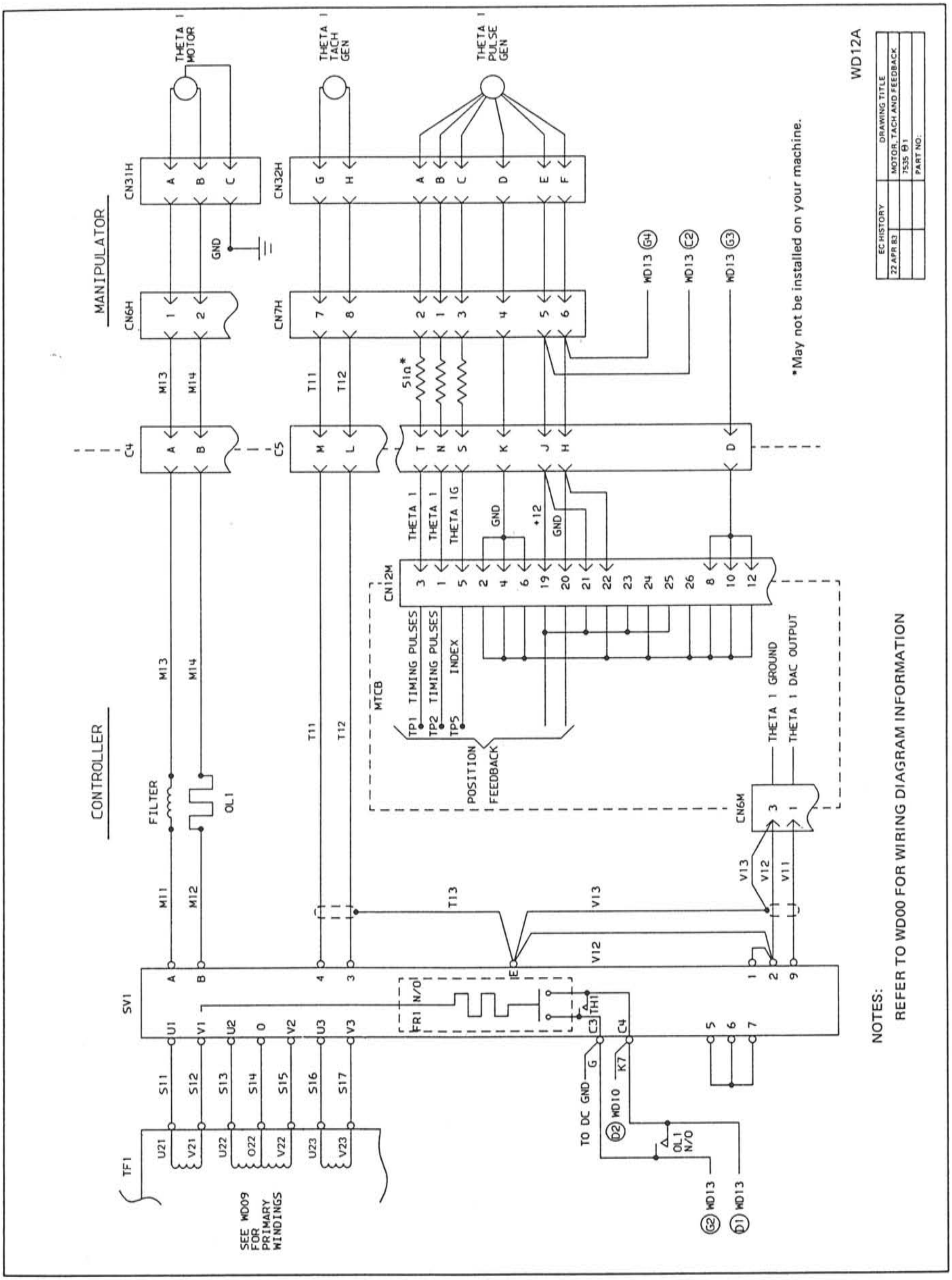


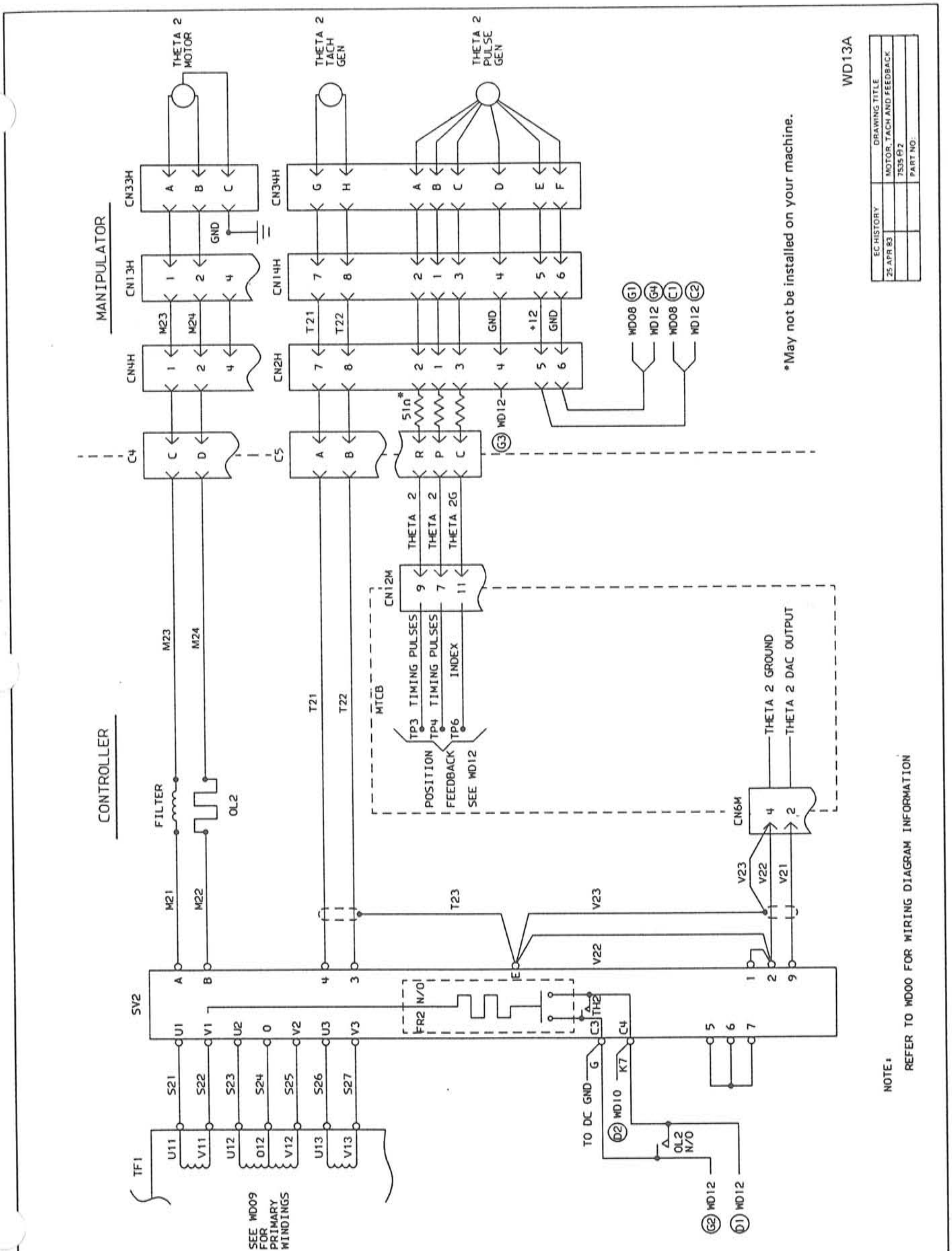
CONTROLLER
TF1 SERVO PACK TRANSFORMER
SEE WD12 FOR SECONDARY WINDINGS
SEE WD13 FOR SECONDARY WINDINGS
U15
100
0
115
U11
U12
V11
U21
U22
V21
ARC SUPPRESSION =1
SK1
MS1-1 N/O
ARC SUPPRESSION =2
SK2
MS1-2 N/O
WD10 E2
WD10 E1
ARC SUPPRESSION =4
SK4
MS1
CR100
FAN
FAN
SERVO POWER CONTACTOR
FAN MOTOR
LINE FILTERS
POWER ON CIRCUIT BREAKER
AC CORD TB
AC CORD INPUT
AC INPUT VOLTAGE
7540 = 220 VAC
7535 = 110 VAC
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION
WD09
EC HISTORY
26 APR 83
DRAWING TITLE
AC POWER
PART NO.

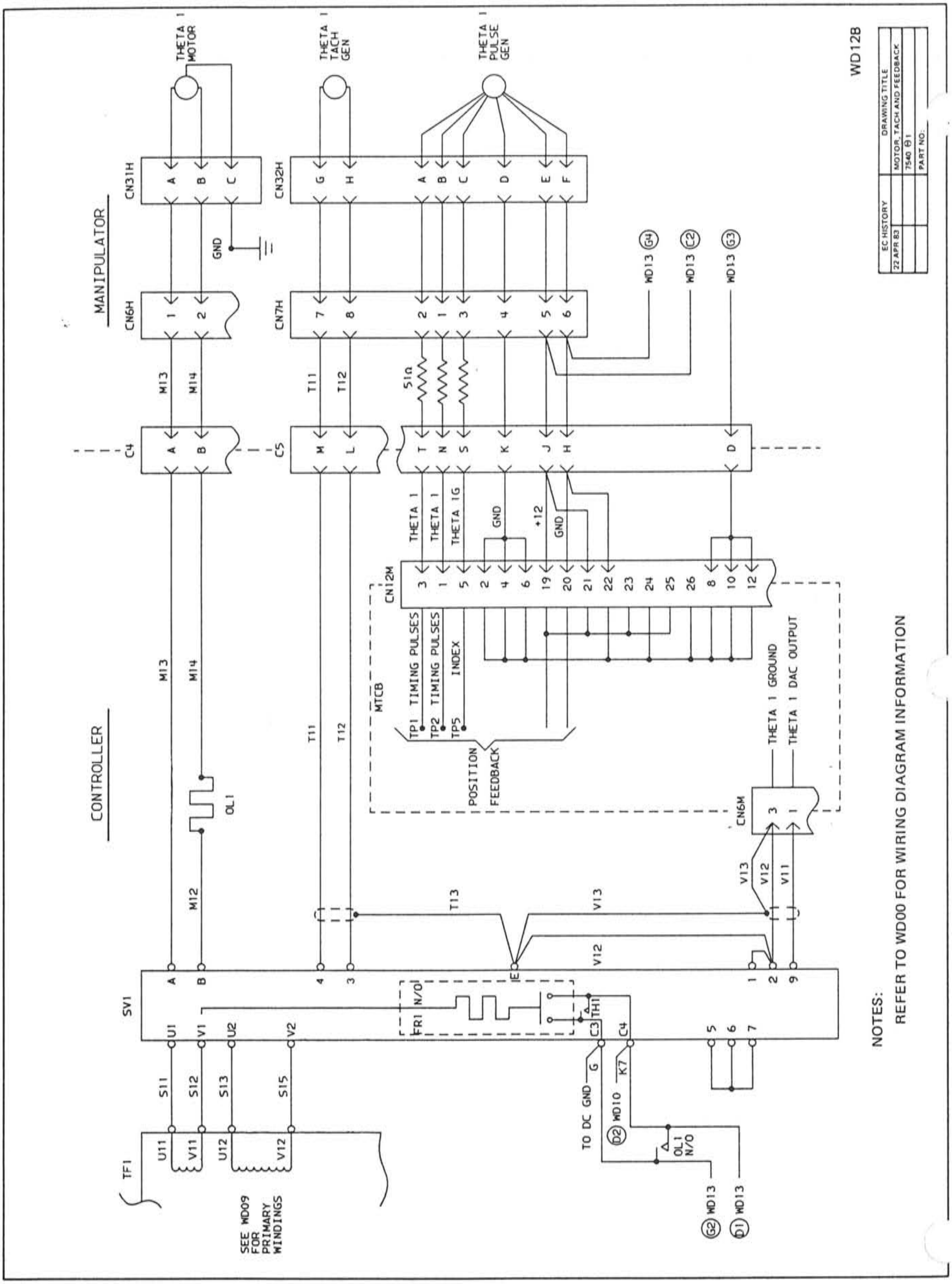


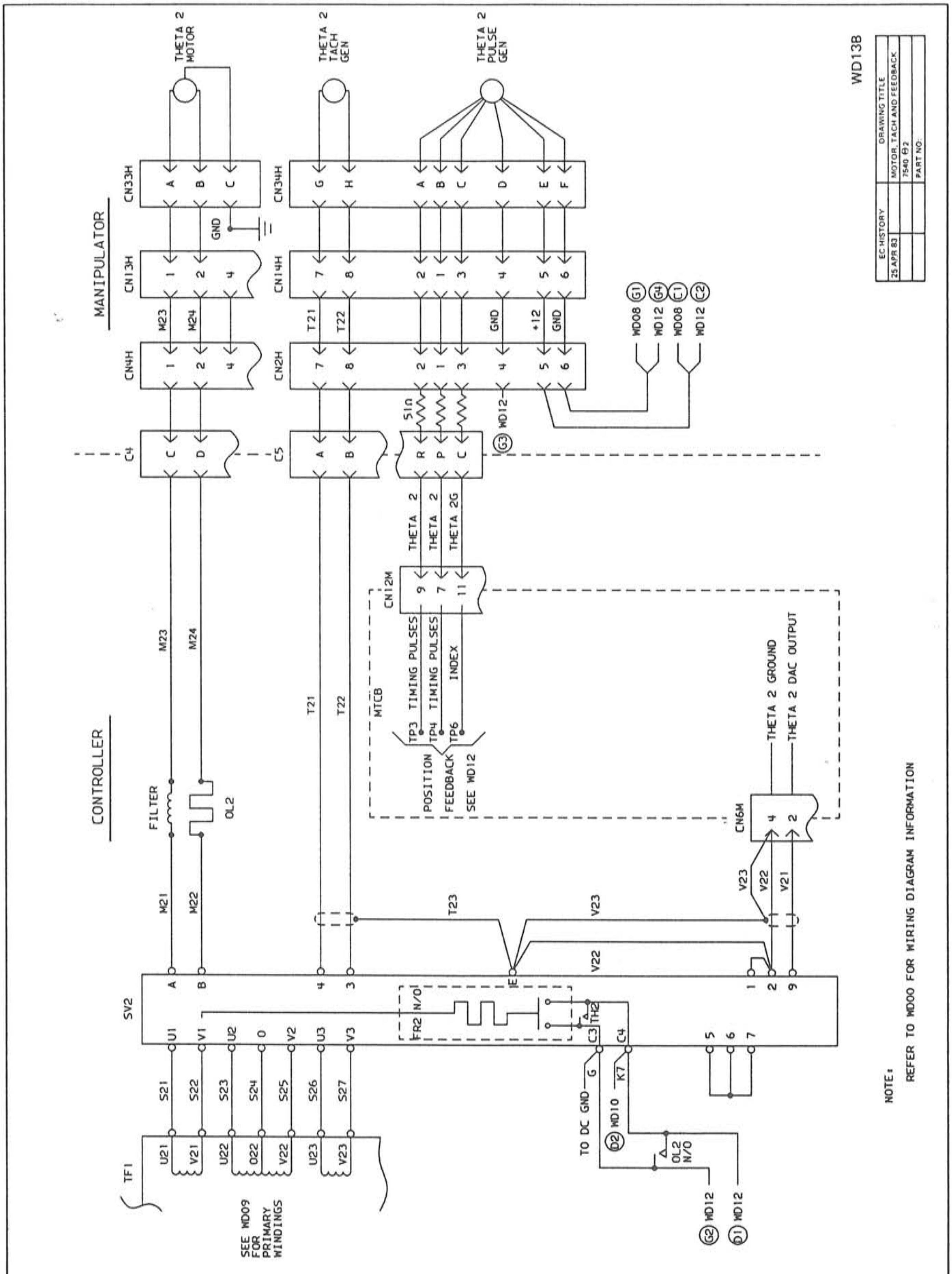
CPU
FEC
MTCB
RELAY BOARD
TB1
CN8F
CN7F
CN2R
CN3R
CN1M
CN1N
TB1R
PSTB1
PSTB2
POWER ON
CR1-1 N/O
CR1-2 N/O
WD10
EC HISTORY
28 APR 83
DRAWING TITLE
CONTROLLER-DC POWER
PART NO:
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION

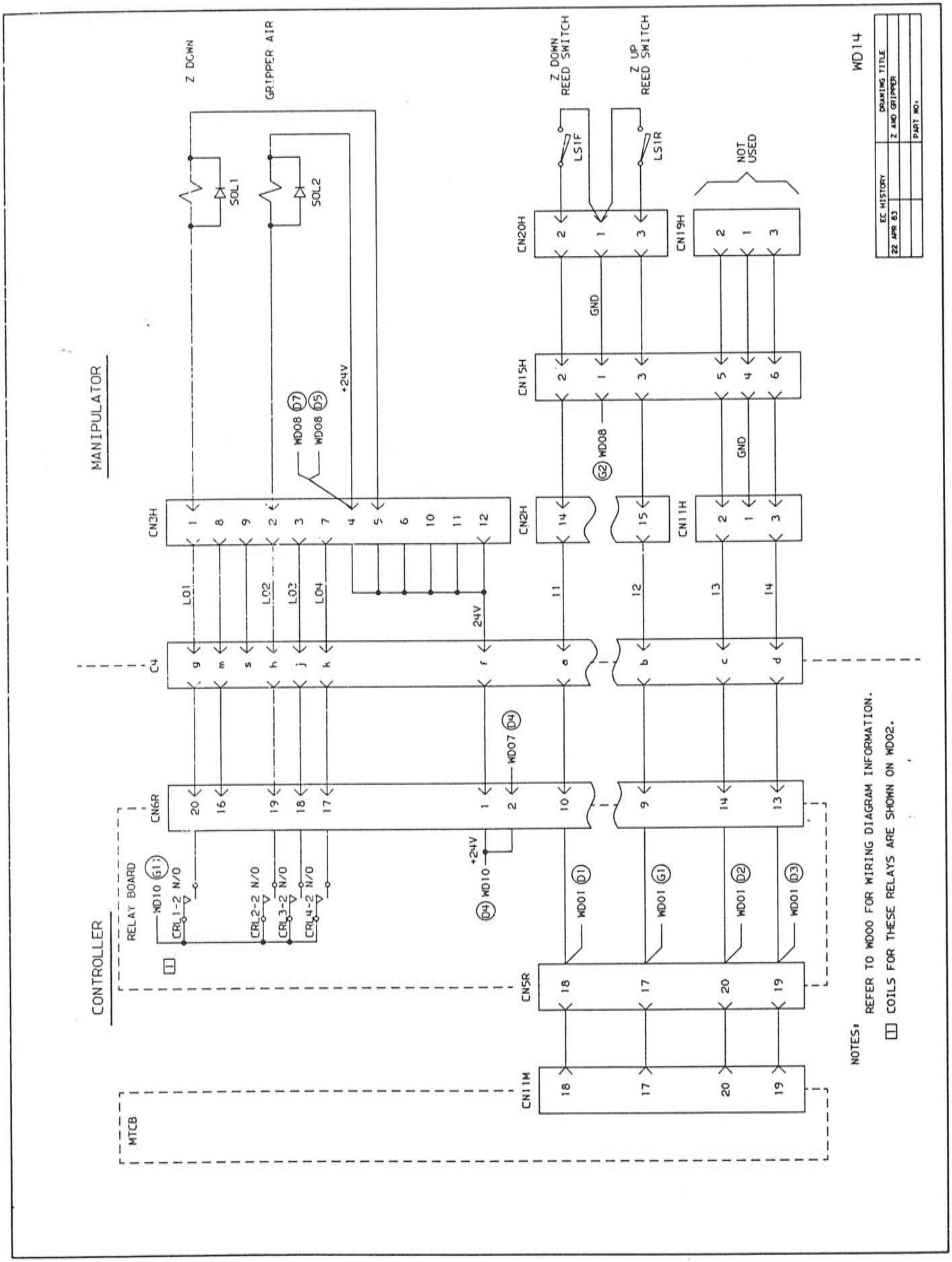

WD11
EC HISTORY
25 APR 83
DRAWING TITLE
ROLL STEPPER MOTOR
PART NO.
ROLL STEP MOTOR
MANIPULATOR
CN1H
C4
CONTROLLER
STEPPER CARD (DV1)
M31
M32
M33
M34
M35
M36
M37
M38
M39
M40
VH
GNDH
VC
GNDC
WD10 G10
WD10 A2
WD10 G0
8 AMP FUSE
CCW
CW
GND
CN5M
MTCB
+24V
WD10 D1
MS1-3 N/O
SK3
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION

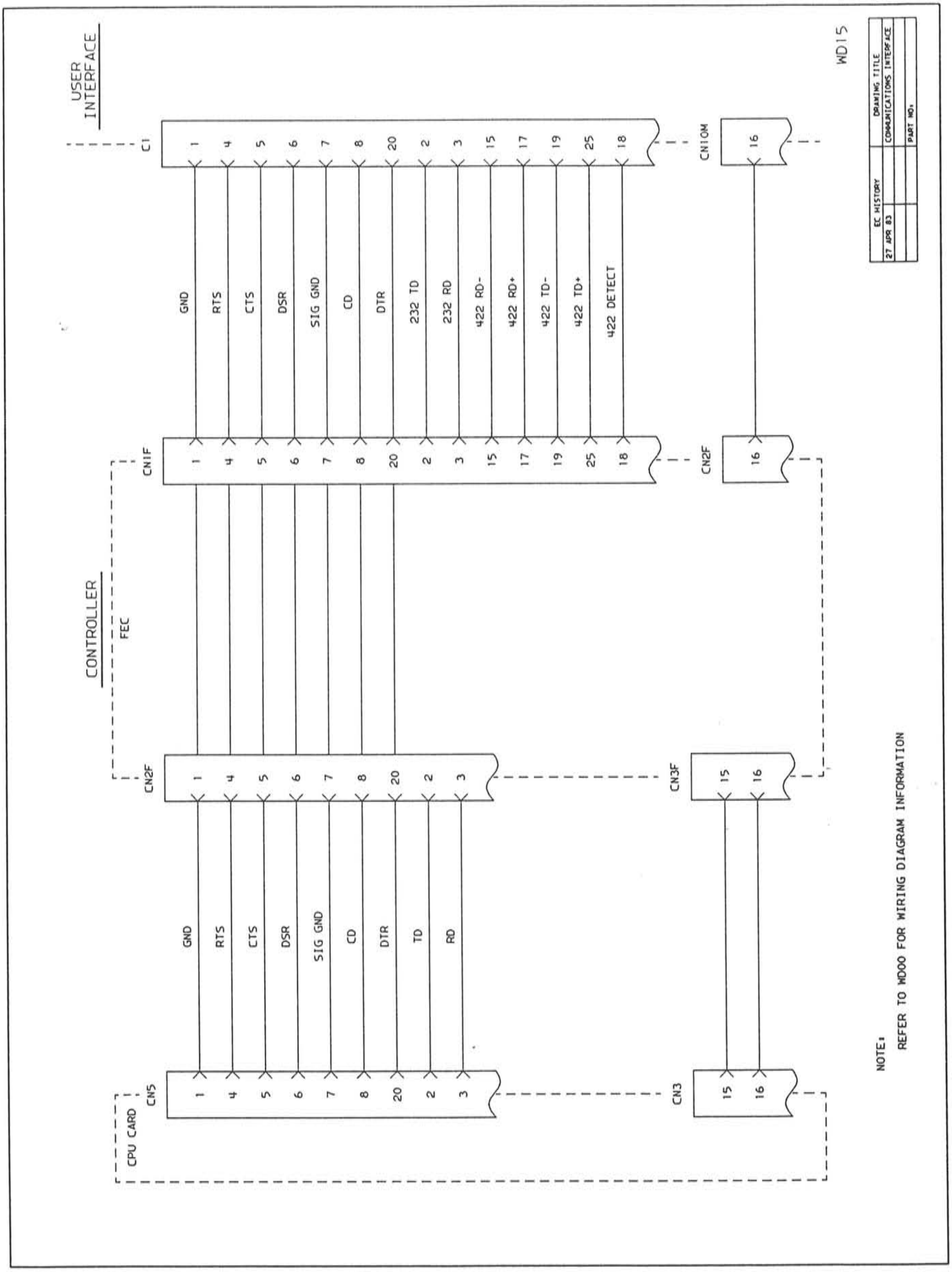

WD12A
DRAWING TITLE
MOTOR, TACH AND FEEDBACK
7535 θ1
PART NO:
EC HISTORY
22 APR 83
*May not be installed on your machine.
NOTES:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION
MANIPULATOR
CONTROLLER
THETA 1 MOTOR
THETA 1 TACH GEN
THETA 1 PULSE GEN
CN31H
CN32H
CN6H
CN7H
C4
C5
CN12M
CN6M
MTCB
SV1
TF1
GND
51Ω*
FILTER
OL1
THETA 1 TIMING PULSES
THETA 1 TIMING PULSES
THETA 1G INDEX
+12
POSITION FEEDBACK
THETA 1 GROUND
THETA 1 DAC OUTPUT
FR1 N/O
TH1
TO DC GND
OL1 N/O
SEE WD09 FOR PRIMARY WINDINGS
WD13 G4
WD13 C2
WD13 G3
WD13 G2
WD13 D1
WD10 D2


WD13A
MANIPULATOR
CONTROLLER
THETA 2 MOTOR
THETA 2 TACH GEN
THETA 2 PULSE GEN
CN33H
CN13H
CN4H
CN34H
CN14H
CN2H
C4
C5
CN12M
CN6M
MTCB
SV2
TF1
FILTER
OL2
GND
51Ω*
THETA 2 TIMING PULSES
THETA 2 TIMING PULSES
THETA 2G INDEX
POSITION FEEDBACK SEE WD12
THETA 2 GROUND
THETA 2 DAC OUTPUT
TO DC GND
SEE WD09 FOR PRIMARY WINDINGS
*May not be installed on your machine.
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION
EC HISTORY
25 APR 83
DRAWING TITLE
MOTOR, TACH AND FEEDBACK
PART NO:


MANIPULATOR
CONTROLLER
THETA 1 MOTOR
THETA 1 TACH GEN
THETA 1 PULSE GEN
CN31H
CN32H
CN6H
CN7H
C4
C5
GND
51Ω
M13
M14
M12
T11
T12
T13
V11
V12
V13
OL1
WD13 (G4)
WD13 (C2)
WD13 (G3)
THETA 1
THETA 1
THETA 1G
+12
CN12M
MTCB
TP1 TIMING PULSES
TP2 TIMING PULSES
TP5 INDEX
POSITION FEEDBACK
THETA 1 GROUND
THETA 1 DAC OUTPUT
CN6M
SV1
FR1 N/O
TH1
TO DC GND
(D2) WD10
OL1 N/O
(G2) WD13
(D1) WD13
TF1
SEE WD09 FOR PRIMARY WINDINGS
NOTES:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION
EC HISTORY
22 APR 83
DRAWING TITLE
MOTOR, TACH AND FEEDBACK
7540 θ1
PART NO:
WD12B


MANIPULATOR
CONTROLLER
THETA 2 MOTOR
THETA 2 TACH GEN
THETA 2 PULSE GEN
CN33H
CN34H
CN13H
CN14H
CN4H
CN2H
C4
C5
GND
M23
M24
M21
M22
T21
T22
T23
+12
51Ω
WD12
G3
WD08 G1
WD12 G4
WD08 C1
WD12 C2
THETA 2 TIMING 2
THETA 2 TIMING 2
THETA 2G INDEX
CN12M
TIMING PULSES
TIMING PULSES
INDEX
MTCB
TP3
TP4
TP6
POSITION
FEEDBACK
SEE WD12
FILTER
OL2
THETA 2 GROUND
THETA 2 DAC OUTPUT
CN6M
V21
V22
V23
SV2
FR2 N/O
TH2
TF1
S21
S22
S23
S24
S25
S26
S27
U21
V21
U22
O22
V22
U23
V23
SEE WD09 FOR PRIMARY WINDINGS
TO DC GND
D2 WD10
K7
OL2 N/O
G2 WD12
D1 WD12
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION
WD13B
EC HISTORY
25 APR 83
DRAWING TITLE
MOTOR, TACH AND FEEDBACK
7540 θ2
PART NO:


WD14
DRAWING TITLE
Z AND GRIPPER
PART NO.
EC HISTORY
22 APR 83
MANIPULATOR
CONTROLLER
RELAY BOARD
MTCB
Z DOWN
GRIPPER AIR
SOL1
SOL2
Z DOWN REED SWITCH
Z UP REED SWITCH
LS1F
LS1R
NOT USED
CN20H
CN19H
CN15H
CN3H
CN2H
CN11H
C4
CN6R
CN5R
CN11M
GND
+24V
24V
L01
L02
L03
L04
WD08
WD07
WD10
WD01
CRL1-2 N/O
CRL2-2 N/O
CRL3-2 N/O
CRL4-2 N/O
NOTES:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION.
1 COILS FOR THESE RELAYS ARE SHOWN ON WD02.


USER INTERFACE
C1
1 4 5 6 7 8 20 2 3 15 17 19 25 18
GND
RTS
CTS
DSR
SIG GND
CD
DTR
232 TD
232 RD
422 RD-
422 RD+
422 TD-
422 TD+
422 DETECT
CN10M
16
CONTROLLER
FEC
CN1F
1 4 5 6 7 8 20 2 3 15 17 19 25 18
CN2F
16
CN2F
1 4 5 6 7 8 20 2 3
CN3F
15 16
GND
RTS
CTS
DSR
SIG GND
CD
DTR
TD
RD
CPU CARD
CN5
1 4 5 6 7 8 20 2 3
CN3
15 16
NOTE:
REFER TO WD00 FOR WIRING DIAGRAM INFORMATION
WD15
EC HISTORY
27 APR 83
DRAWING TITLE
COMMUNICATIONS INTERFACE
PART NO:

RELAY	COIL	CONTACTS 1	CONTACTS 2	CONTACTS 3	DESCRIPTION
CR5V	WD10		WD04		CLOSES PART OF A SERIES LINK FOR POWER ON WHEN +5 VDC IS PRESENT.
CR+12V	WD10		WD04		CLOSES PART OF A SERIES LINK FOR POWER ON WHEN +12 VDC IS PRESENT.
CR-12V	WD10		WD04		CLOSES PART OF A SERIES LINK FOR POWER ON WHEN -12 VDC IS PRESENT.
CR1	WD04	WD10	WD10		PROVIDES POWER TO CR100.
CR1X	WD04	WD02	WD06		PROVIDES A CIRCUIT HOLD UP FOR POWER ON AND +24 VDC TO THE DO RELAYS.
CR100	WD10	WD09			PROVIDES POWER TO MS1.
CRAT	WD03	WD03			CLOSES DO POINT DURING AUTO MODE.
CRER	WD03	WD03			CLOSES DO POINT DURING AN ERROR CONDITION.
CREM	WD04		WD04		DROPS POWER TO THE MANIPULATOR.
CRGT	WD03	WD03			CLOSES DO POINT WHEN ARMS ARE AT HOME.
CRL1	WD02	WD02	WD14		CLOSES DO POINT 1.
CRL2	WD02	WD02	WD14		CLOSES DO POINT 2.
CRL3	WD02	WD02	WD14		CLOSES DO POINT 3.
CRL4	WD02	WD02	WD14		CLOSES DO POINT 4.
CRL5	WD02	WD02			CLOSES DO POINT 5.
CRL6	WD02	WD02			CLOSES DO POINT 6.
CRL7	WD02	WD02			CLOSES DO POINT 7.
CRL8	WD02	WD02			CLOSES DO POINT 8.
CRL9	WD02	WD02			CLOSES DO POINT 9.
CRL10	WD02	WD02			CLOSES DO POINT 10.
CRL11	WD02	WD02			CLOSES DO POINT 11.
CRL12	WD02	WD02			CLOSES DO POINT 12.
CRL13	WD02	WD02			CLOSES DO POINT 13.
CRL14	WD02	WD02			CLOSES DO POINT 14.
CRL15	WD02	WD02			CLOSES DO POINT 15.
CRL16	WD02	WD02			CLOSES DO POINT 16.
CRRT	WD03	WD03			CLOSES DO POINT WHEN RETURN TO HOME KEY IS PRESSED AND DI POINT W IS GROUNDED.
MS1	WD09	WD09	WD09	WD11	SUPPLIES AC VOLTAGE TO THE SERVO PACKS AND DC TO THE STEPPER MOTOR.
OL1	WD12	WD12			DROPS POWER TO THE THETA 1 SERVO PACK DURING AN OVER-CURRENT CONDITION.
OL2	WD13	WD13			DROPS POWER TO THE THETA 2 SERVO PACK DURING AN OVER-CURRENT CONDITION.

STARTUP SEQUENCE

X - Relay activated

< > - Relay point used

Circuit breaker turned on

Power to the +5,+12,-12 power supplies

X- CR-12

X- CR+12

X- CR5V

<CREM - 2N/C>

<CR-12 - 2N/O>

<CR+12 - 2N/O>

<CR5V N/O>

Manip Power button pressed

<Manip Power N/O>

<Stop N/C>

X-CR1X

<CR1X - 2N/O>

X-CR1

<CR1 - 2N/O>

X-CR100

<CR100 N/O>

X-MS1

<MS1 - 1N/O>

<MS1 - 2N/O>

Servo pack power on

<MS1 - 3N/O>

Roll motor power on