

3348 Roll Drive Pulley Removal

Note: Consider that roll home position and payload position will be lost.

1. Perform steps 1 through 10 of the "Roll Axis Harmonic Drive Removal" procedure (3344).

3349 Roll Drive Pulley Replacement

1. Perform steps 6 through 15 of the "Roll Axis Harmonic Drive Replacement" procedure.



CHAPTER 4. CHECKS AND ADJUSTMENTS

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

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CONTROLLER CHECKS AND ADJUSTMENTS

4001 Controller Power Supply Checks

1. Set the controller power switch to **O** (Off).
2. Remove the mounting screws and pull the controller forward from the rack. Remove the top cover (3101).
3. Set the voltmeter to the 15 Vdc scale, and set the controller power switch to **I** (On).
4. Using the figure on the facing page as a reference, measure the voltages in the controller in the sequence presented.

Note: Do not disconnect any connectors to check voltages.

5. Reverse the above procedure to restore the controller to operation.
6. If any voltage except P10, P11, or P12 is incorrect, go to "Controller Power Supply Failure (Incorrect Voltage Reading)," in Chapter 8, "Symptom Fix."
7. If the voltage on P10, P11, or P12 is incorrect, go to "6XX - Diskette Error, Defective Power Supply/Cable."

P23/P27 Power Supply Voltage Chart			
min Vdc	max Vdc	- lead	+ lead
2.4	5.2	P23 - 5	P23 - 1
4.8	5.2	P23 - 5	P27 - 4
4.5	5.4	P27 - 3	P23 - 6
11.5	12.6	P27 - 1	P23 - 3
10.8	12.9	P23 - 4	P27 - 2

P8/P9 Power Adapter Card Voltage Chart			
min Vdc	max Vdc	- lead	+ lead
2.4	5.2	P8 - 5	P8 - 1
-4.8	-5.2	P8 - 5	P9 - 4
-4.5	-5.4	P9 - 3	P8 - 6
11.5	12.6	P9 - 1	P8 - 3
10.8	12.9	P8 - 4	P9 - 2

P10/P11/P12 Disk/Diskette Voltage Chart			
min Vdc	max Vdc	- lead	+ lead
4.8	5.2	2	4
11.5	12.6	3	1

Controller

4002 Controller Fan Check

1. Set the Controller power switch to **O** (Off).
2. Remove the mounting screws and pull the controller forward from the rack. Remove the top cover (3101).
3. Disconnect P24 from the power adapter card.
4. Set the voltmeter to the 12 Vdc scale.
5. Set the controller power switch to **|** (On).
6. Check for a voltage of 5 Vdc or 12 Vdc.
7. Reverse the above procedure to restore the controller to operation.

4003 Controller Speaker Check

1. Set the Controller power switch to **O** (Off).
2. Remove the mounting screws and pull the controller forward from the rack. Remove the top cover (3101).
3. Disconnect J19 from the system board.
4. Set the ohmmeter to the RX1 scale.
5. Check for a continuity of about 8 ohms at the connector.
6. Reverse the above procedure to restore the controller to operation.

4004 Controller Reset Switch Check

1. Set the Controller power switch to **O** (Off).
2. Remove the mounting screws and pull the controller forward from the rack. Remove the top cover (3101).
3. Disconnect P25 from the power adapter card.
4. Set the ohmmeter to the RX1 scale.
5. Check for a continuity of infinity at the connector.
6. Press and hold the reset button and check for a continuity of 0 ohms at the connector.
7. Reverse the above procedure to restore the controller to operation.

4005 Diskette Drive Motor Speed

1. Set the Controller power switch to **O** (Off).
2. Remove the mounting screws and pull the controller forward from the rack. Remove the top cover (3101).
3. Refer to "Diskette Drive Removal" (3106) and perform all steps except cable removals.
4. Place the diskette drive in the controller to gain access to the variable resistor.
5. Place the controller diagnostic diskette in the IPL drive.
6. Set the Controller power switch to **|** (On).
7. Using the pendant, select the diskette drive diagnostics speed test. Refer to "Extended Diagnostic Tests" in Chapter 5.
8. Place a known good formatted diskette in the failing diskette drive.
9. With an insulated screwdriver, adjust the variable resistor on the diskette drive unit until the pendant displays a number within specifications (1640 to 1695 for 1.2Mb drive; 1970 to 2030 for 360Kb drive).
10. Reverse the above procedure to restore the controller to operation.

4006 Variable Capacitor Adjustment (Color Display)

Note: This adjustment is for non-direct drive displays and should only be performed if your display has incorrect or an absence of color.

1. Set the Controller power switch to **O** (Off).
2. Remove the mounting screws and pull the controller forward from the rack. Remove the top cover (3101).
3. Remove any adapter cards necessary to access the variable capacitor. (Refer to "System Board" in Chapter 1, "Locations.")
4. With a nonmetallic screwdriver, adjust the variable capacitor in small increments until the color is correct.
5. If this is not possible, refer to the operator's guide for your display.
6. Reverse the above procedure to restore the controller to operation.

SERVO POWER MODULE CHECKS

4007 Power Supply Checks

There are two transformers in the Servo Power Module; one is a low voltage transformer for the power supply and the other is an 80-volt transformer for the servo systems. Check the power supply and transformers as follows.

Low Voltage Power Supply

1. Check the fuses on the power supply board.
2. Measure the voltages on the manipulator interface board at the voltage test points for $\pm 3\%$. Refer to wiring diagram SP01.
3. Measure for 220 Vac $\pm 10\%$ at the input terminals of the low voltage transformer. Refer to wiring diagram WD05.

80 Vdc Power

For the following tests, manipulator power must be on.

1. Measure for 70 Vdc ($\pm 10\%$) at the + and - terminals of the rectifier (silicon power cube) when manipulator power is on. Refer to wiring diagram WD07.
2. Measure for 60 Vac ($\pm 10\%$) at the output of the 80-Vac transformer. Refer to wiring diagram WD07.
3. Measure for 220 Vac ($\pm 10\%$) at the input of the 80-Vac transformer. Refer to wiring diagram WD07.

MANIPULATOR CHECKS AND ADJUSTMENTS

4008 Home Flag Adjustment Program

RIGHT HOME!

CAUTION

The purpose of this program is to verify and adjust any home position on the manipulator, after a loss of home FRU has been removed and replaced. Do not perform procedures 4010, 4011, 4012, or 4013 without first executing this procedure.

CONTROL

1. Install the AML/2 diskette in the diskette drive and power on the controller and the Servo Power Module.
2. Attach a pendant to the remote stop cable.
3. When the Manip Power LED flashes, press that button.
4. Remove the AML/2 diskette and install the diagnostic diskette in the diskette drive.
5. Select program level 6, and press the Load button. (The name of the program is Appl6.aml.)
6. When the diskette drive LED turns off, press Start.
7. If an individual axis requires adjustment, go to:

Theta 1 = 4010
Theta 2 = 4011

Z Axis = 4012
Roll = 4013

Home Flag
Adjustment
Program

Display screen 1

The Home Flag Adjustment Program will run and the pendant display as shown at the left will appear. A return to home will be initiated by the program.

Axes within
Adjustment
1 2. 4
A: to Continue

Display screen 2

This display shows the axes that are within adjustment by displaying that axis number. In the example at the left, axis 3 (Z) will require an adjustment. Press the A button.

Do you wish
to make the
adjustment ?

Display screen 3

If all axes are adjusted correctly, press the No button and display screen 2 will appear after a return to home sequence. If the Yes button is pressed, continue with display screen 4.

Theta 1 = X
Theta 2 = X
Z = X Roll = X
A: to Continue

Display screen 4

If X = 1, the axis home sensor is covered. If X = 0, the axis home sensor is exposed. For any axis adjustment, this screen will tell you when the home sensor is properly adjusted.

Press
Manip Power
to continue

Display screen 5

If you wish to once again verify the home position, press Manip Power and you will be returned to display screen 2.

8. If an adjustment is required, see step 7 and go to that procedure.
9. If no adjustment is required, you are finished with this procedure. Go to "4020 Offset Program" to verify the integrity of the points in the application program. (You may wish to test the application program first.)

4009 Overrun Sensors

CAUTION

Moving any axis home/overrun flag will cause the loss of home for that axis. If moving a home/overrun flag becomes necessary, you must verify or adjust the home position.

(Refer to "4008 Axis Home Adjustment Program.")

1. Remove the front cover of the Servo Power Module so that the Overrun LEDs (on the manipulator interface board) may be observed.
2. Move the axis to be checked in one direction to the Overrun condition by observing the LED in the Servo Power Module.
3. If the condition is not noted, move the axis to the other Overrun condition.
4. Note the amount of travel to the axis stop.
5. Try to equalize each Overrun condition for the axis by adjusting the Overrun sensor.
6. If that is not possible, you must adjust the home/overrun flag. Review the **CAUTION** note above.

4010 Theta 1 Home Adjustment

CAUTION

You should only perform this procedure if directed here from the "4008 Home Flag Adjustment Program" procedure. If not, go to that procedure before continuing.

1. Remove the necessary covers to access the home/overrun flag.
2. With the AML/2 diskette installed in diskette drive A, power off, then on, the controller and Servo Power Module.
3. Press the stop button on the remote stop cable and carry it into the workspace while making adjustments to the manipulator. This will insure that no one can power up the manipulator.
4. Loosen both set screws of the home/overrun flag just enough to allow a manual adjustment (movement) of the flag.

Note: In the following step, it is easier to make the adjustment with two people — one to move the axis, and one to observe the overrun LED on the manipulator interface board in the Servo Power Module.

5. Adjust the flag so that the overrun sensor is made at the end of travel in both directions of the axis. Try to make each direction even with respect to movement of the axis to the mechanical stop.
6. If necessary, snug the home/overrun flag setscrews enough to keep the flag from moving on its own, but so that it can still be moved manually. (Another adjustment may be necessary later with the home sensor.)
7. Twist and release the stop button on the remote stop cable.
8. By now the Manip Power LED on the Servo Power Module should be flashing. If not, press the reset button to IPL the AML/2 software. When the Manip Power LED flashes, press that button.
9. Install the diagnostic diskette. Select program level 6, then press the Load button. When the diskette LED turns off, press Start.
10. A return to home sequence will be initiated.
11. At the "Axes within adjustment" display, press A: to continue.
12. At the next display, answer yes to the question, "Do you wish to make the adjustment?"
13. The program will perform a shutdown when it is time to adjust the home/overrun flag. Be sure to press the Manip Stop button on the remote stop cable and carry it into the workspace with you, so that no one can power up the manipulator.

14. Without moving the axis, adjust the home/overrun flag so that the home sensor is just covered. Observe the pendant: When the "Theta 1 = 0" changes to "Theta 1 = 1" the home sensor is covered. (0 = exposed; 1 = covered.)
15. After the adjustment is completed, slowly move the axis so that the set screws in the flag can be tightened. Do not over tighten.
16. Press the A button on the pendant to continue.
17. Follow the instruction "Press Manip Power to continue", and the adjustment just completed can be verified.
18. If the verification fails, go through the adjustments again.
19. If an application exists on this manufacturing system, and the verification is correct, go to "4020 Offset Program", to finalize the home position for the manipulator.
20. If an application does not exist on this manufacturing system, you are finished with this procedure.
21. Replace all removed covers.

4011 Theta 2 Home Adjustment

CAUTION

You should only perform this procedure if directed here from the "4008 Home Flag Adjustment Program" procedure. If not, go to that procedure before continuing.

1. Remove the necessary covers to access the home/overrun flag.
2. With the AML/2 diskette installed in diskette drive A, power off, then on, the controller and Servo Power Module.
3. Press the stop button on the remote stop cable and carry it into the workspace while making adjustments to the manipulator. This will insure that no one can power up the manipulator.
4. Loosen both set screws of the home/overrun flag just enough to allow a manual adjustment (movement) of the flag.

Note: In the following step, it is easier to make the adjustment with two people — one to move the axis, and one to observe the overrun LED on the manipulator interface board in the Servo Power Module.

5. Adjust the flag so that the overrun sensor is made at the end of travel in both directions of the axis. Try to make each direction even with respect to movement of the axis to the mechanical stop.
6. If necessary, snug the home/overrun flag setscrews enough to keep the flag from moving on its own, but so that it can still be moved manually. (Another adjustment may be necessary later with the home sensor.)
7. Twist and release the stop button on the remote stop cable.
8. By now the Manip Power LED on the Servo Power Module should be flashing. If not, press the reset button to IPL the AML/2 software. When the Manip Power LED flashes, press that button.
9. Install the diagnostic diskette. Select program level 6, then press the Load button. When the diskette LED turns off, press Start.
10. A return to home sequence will be initiated.
11. At the "Axes within adjustment" display, press A: to continue.
12. At the next display, answer yes to the question, "Do you wish to make the adjustment?"
13. The program will perform a shutdown when it is time to adjust the home/overrun flag. Be sure to press the Manip Stop button on the remote stop cable and carry it into the workspace with you, so that no one can power up the manipulator.

14. Without moving the axis, adjust the home/overrun flag so that the home sensor is just covered. Observe the pendant: When the "Theta 2 = 0" changes to "Theta 2 = 1" the home sensor is covered. (0 = exposed; 1 = covered.)
15. After the adjustment is completed, slowly move the axis so that the set screws in the flag can be tightened. Do not over tighten.
16. Press the A button on the pendant to continue.
17. Follow the instruction "Press Manip Power to continue", and the adjustment just completed can be verified.
18. If the verification fails, go through the adjustments again.
19. If an application exists on this manufacturing system, and the verification is correct, go to "4020 Offset Program", to finalize the home position for the manipulator.
20. If an application does not exist on this manufacturing system, go to "4022 Generating Theta 2 Offsets".
21. Replace all removed covers.

4012 Z Axis Home Adjustment

CAUTION

You should only perform this procedure if directed here from the "4008 Home Flag Adjustment Program" procedure. If not, go to that procedure before continuing.

1. Remove the necessary covers to access the home/overrun flag.
2. Remove the payload if one exists on your system. (A payload could allow some movement in the Z axis at shutdown.)
3. With the AML/2 diskette installed in diskette drive A, power off, then on, the controller and Servo Power Module.
4. Press the stop button on the remote stop cable and carry it into the workspace while making adjustments to the manipulator. This will insure that no one can power up the manipulator.
5. Loosen both set screws of the home/overrun flag just enough to allow a manual adjustment (movement) of the flag.
6. Adjust the flag to the center of its travel.
7. If necessary, snug the home/overrun flag setscrews enough to keep the flag from moving on its own, but so that it can still be moved manually. (Another adjustment may be necessary later with the home sensor.)
8. Twist and release the stop button on the remote stop cable.
9. By now the Manip Power LED on the Servo Power Module should be flashing. If not, press the reset button to IPL the AML/2 software. When the Manip Power LED flashes, press that button.
10. Install the diagnostic diskette. Select program level 6, then press the Load button. When the diskette LED turns off, press Start.
11. A return to home sequence will be initiated.
12. At the "Axes within adjustment" display, press A: to continue.
13. At the next display, answer yes to the question, "Do you wish to make the adjustment?"
14. The program will perform a shutdown when it is time to adjust the home/overrun flag. Be sure to press the Manip Stop button on the remote stop cable and carry it into the workspace with you, so that no one can power up the manipulator.
15. Without moving the axis, adjust the home/overrun flag so that the home sensor is just covered. Observe the pendant: When the "Z = 0" changes to "Z = 1" the home sensor is covered. (0 = exposed; 1 = covered.)

16. After the adjustment is completed, tighten the set screws in the flag.
17. Press the A button on the pendant to continue.
18. Follow the instruction "Press Manip Power to continue", and the adjustment just completed can be verified.
19. If the verification fails, go through the adjustments again.
20. If an application exists on this manufacturing system, and the verification is correct, go to "4020 Offset Program", to finalize the home position for the manipulator.
21. If an application does not exist on this manufacturing system, you are finished with this procedure.
22. Replace all removed covers.

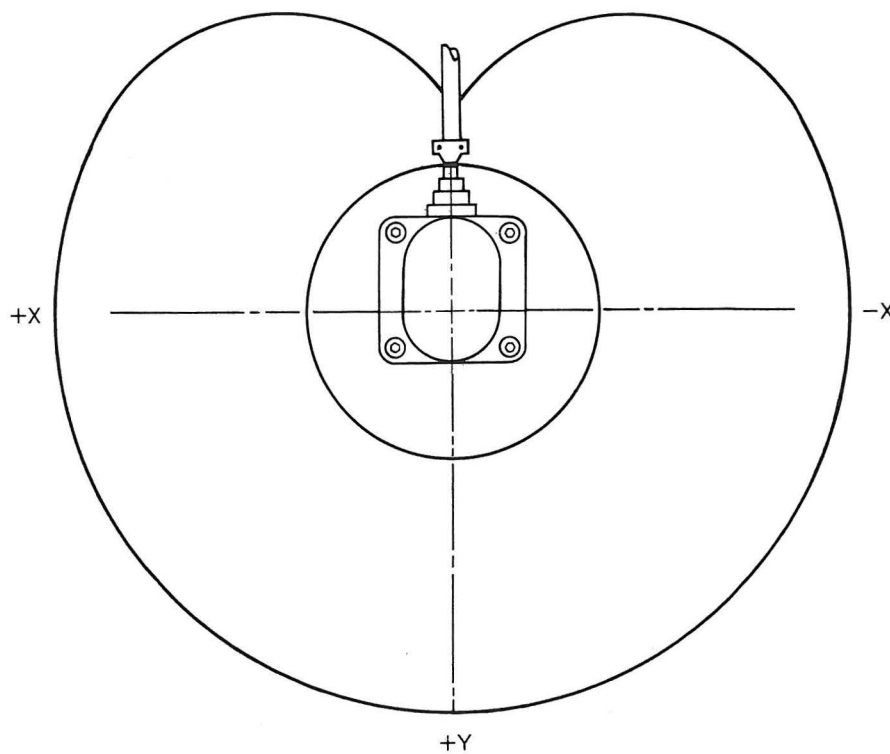
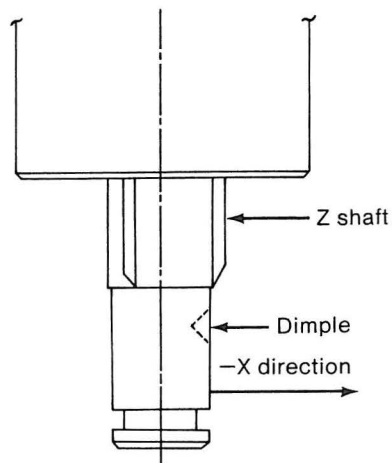
4013 Roll Home Adjustment

CAUTION

You should only perform this procedure if directed here from the "4008 Home Flag Adjustment Program" procedure. If not, go to that procedure before continuing.

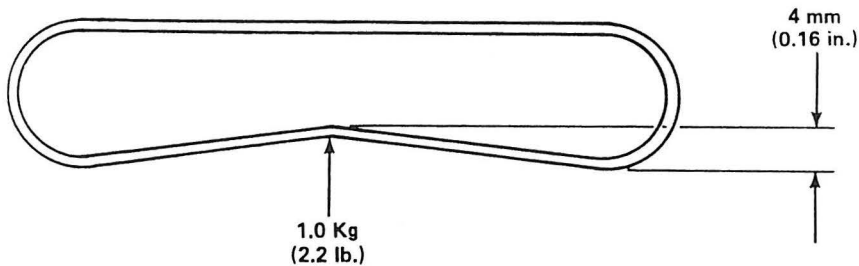
1. Remove the necessary covers to access the home flag.
2. With the AML/2 diskette installed in diskette drive A, power off, then on, the controller and Servo Power Module.
3. Press the stop button on the remote stop cable and carry it into the workspace while making adjustments to the manipulator. This will insure that no one can power up the manipulator.
4. Refer to the figure on the facing page.
5. Try to place the arm as close as possible along the +X coordinate line, then place the Z shaft so that the dimple (recess) at the base of the Z shaft is in the -X position. The dimple is used for the set screw for the tool tip flange which may or may not be installed on your manipulator.
6. Twist and release the stop button on the remote stop cable.
7. By now the Manip Power LED on the Servo Power Module should be flashing. If not, press the reset button to IPL the AML/2 software. When the Manip Power LED flashes, press that button.
8. Install the diagnostic diskette. Select program level 6, then press the Load button. When the diskette LED turns off, press Start.
9. A return to home sequence will be initiated.
10. At the "Axes within adjustment" display, press A to continue.
11. At the next display, answer yes to the question, "Do you wish to make the adjustment?"
12. The program will perform a shutdown when it is time to adjust the home/overrun flag. Be sure to press the Manip Stop button on the remote stop cable and carry it into the workspace with you, so that no one can power up the manipulator.
13. Without moving the axis, adjust the home/overrun flag so that the home sensor is just covered. Observe the pendant: When the "Roll = 0" changes to "Roll = 1" the home sensor is covered. (0 = exposed; 1 = covered.)
14. After the adjustment is completed, slowly move the axis so that the set screws in the flag can be tightened. Do not over tighten.
15. Press the A button on the pendant to continue.

16. Follow the instruction "Press Manip Power to continue", and the adjustment just completed can be verified.
17. If the verification fails, go through the adjustments again.
18. If an application exists on this manufacturing system, and the verification is correct, go to "4020 Offset Program", to finalize the home position for the manipulator.
19. If an application does not exist on this manufacturing system, you are finished with this procedure.
20. Replace all removed covers.



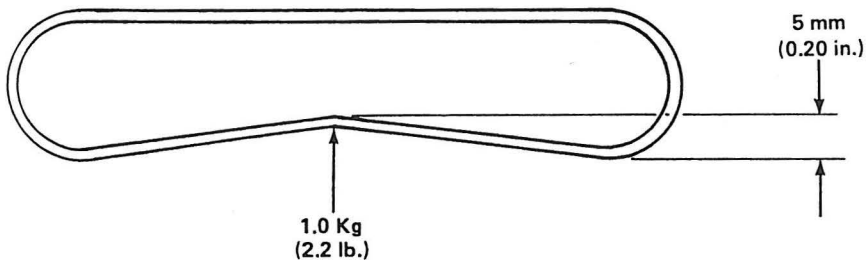
4014a Theta 2 Drive Belt (7575 only)

1. Press the Manip Stop switch.
2. Remove the Theta 2 motor cover.
3. Loosen the four Theta 2 motor bracket screws.
4. Tighten the belt by sliding the motor bracket away from the Theta 2 joint until the belt will only deflect 4 mm (0.16 in.) in the middle of the belt with a 1.0 kg (2.20 lb) force applied.
5. Tighten the four Theta 2 motor bracket screws.
6. Replace the Theta 2 motor cover.



4014b Theta 2 Drive Belt (7576 only)

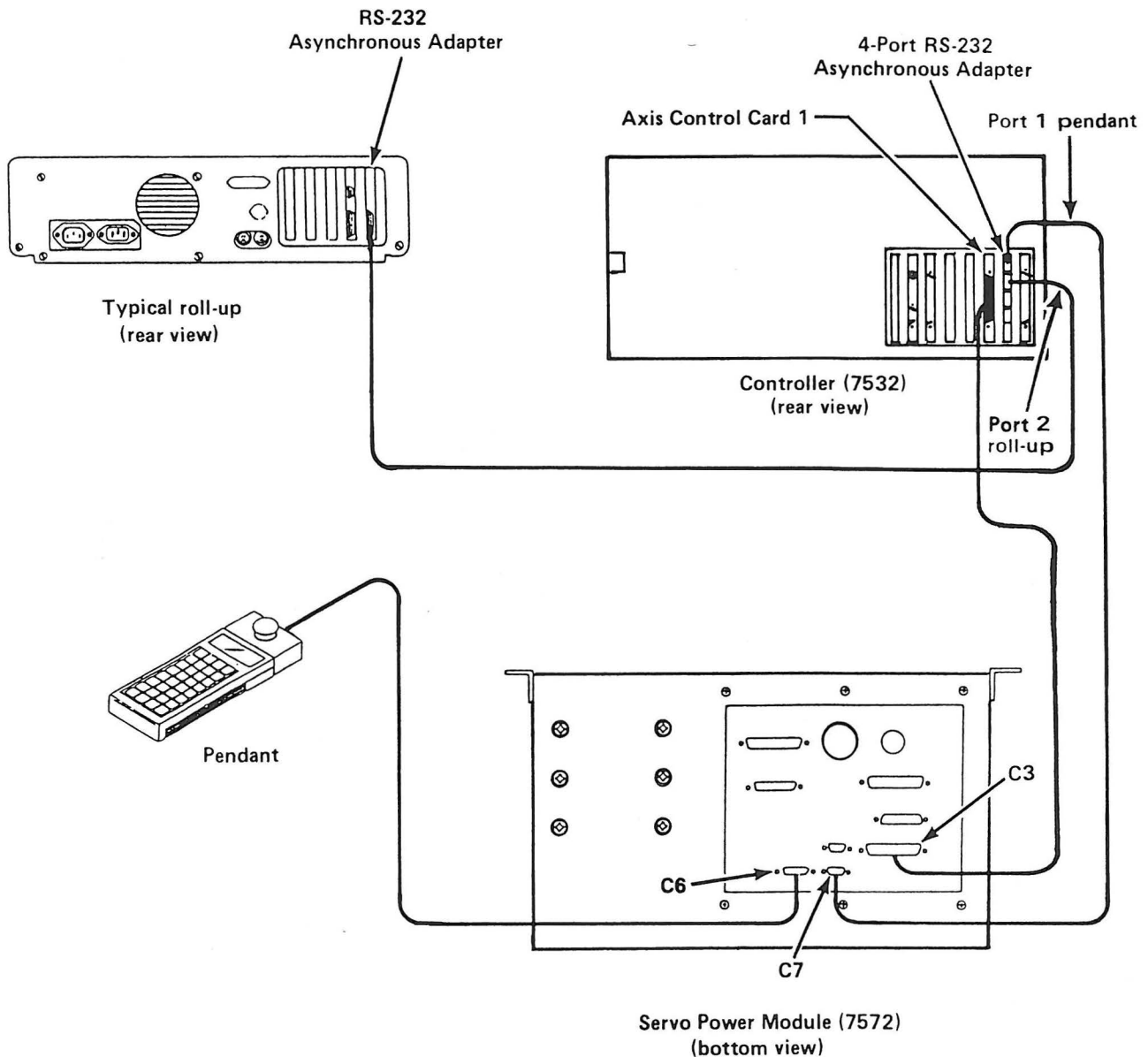
1. Press the Manip Stop switch.
2. Remove the Theta 2 motor cover.
3. Loosen the four Theta 2 motor bracket screws.
4. Tighten the belt by sliding the motor bracket away from the Theta 2 joint until the belt will only deflect 5 mm (0.20 in.) in the middle of the belt with a 1.0 kg (2.20 lb) force applied.
5. Tighten the four Theta 2 motor bracket screws.
6. Replace the roll belt cover.



Roll-Up Tool (IBM Industrial Computer)

An IBM Industrial Computer (or an IBM Personal Computer), when used as a "roll-up" tool, offers application flexibility by providing application program development for the manufacturing system. One roll-up tool can support multiple manufacturing systems. The roll-up tool must be connected to the controller when downloading or uploading programs to the controller memory or diskette. However, the roll-up tool may be disconnected from the controller and used for developing programs or other non-related applications, or it may remain connected to monitor system operation.

A powerful Debug program facility, the AML/2 Application Development Environment, is available for use with the roll-up tool.

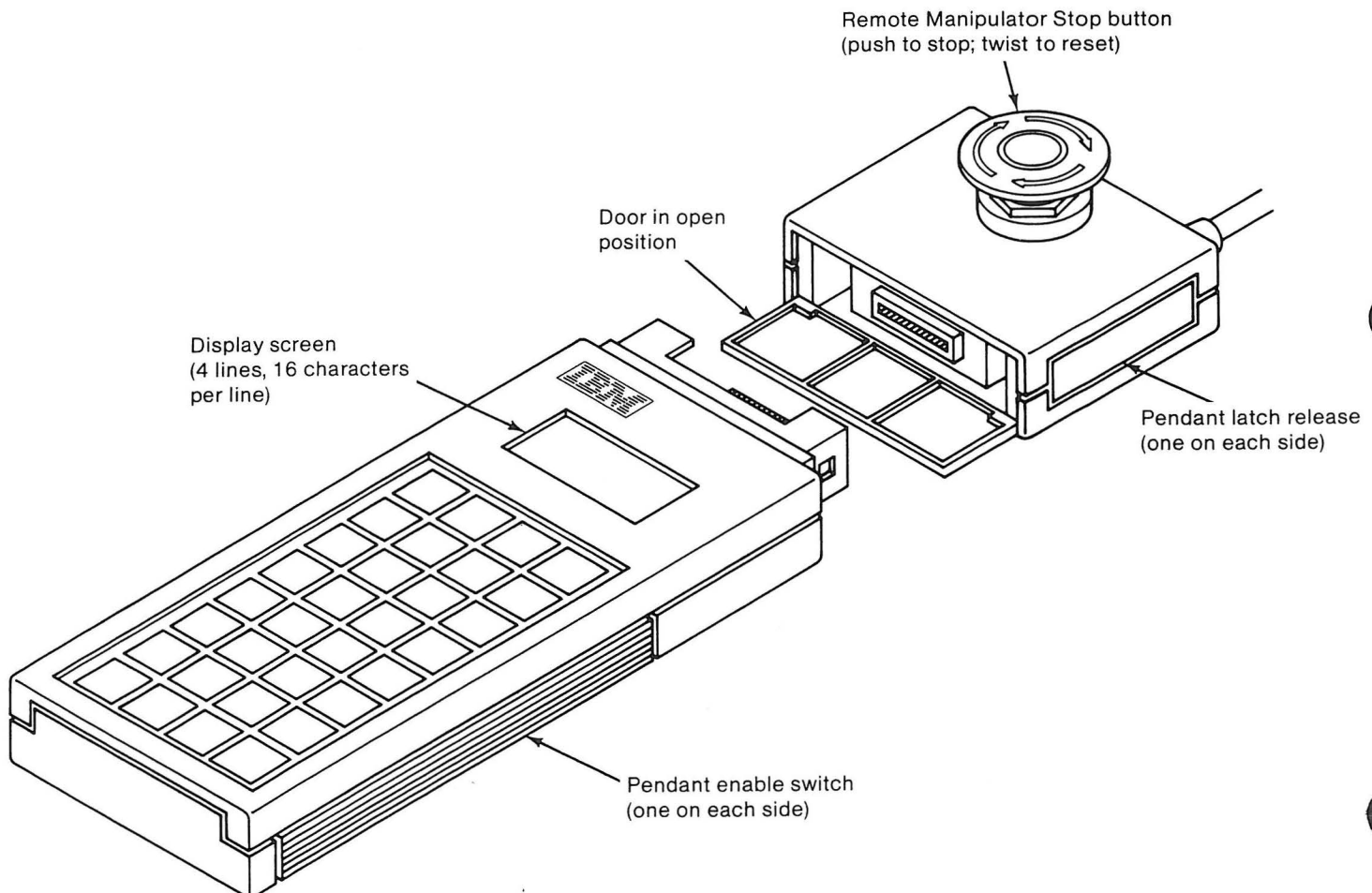


Pendant

The pendant is a hand-held key entry/display device designed for use in the shop floor environment. It is used primarily for the "teach" function, but it is also required for maintenance to retrieve error codes and select diagnostics. The pendant consists of:

- A 32-button keypad, each button having its associated LED — The keybuttons are programmable as digital input points. The LEDs are also programmable. Thus the operator is provided an easy means of interaction with the application: keybuttons for input and LEDs for visual output.
- A 64-character display — This LED display is four lines, with 16 characters per line. The display can be used to read out verbal or coded operator or system messages.
- A pendant enable switch — This switch (one on each side of the pendant) must be held closed with light pressure to enable any pendant keybutton.

Note: During "teach" mode, all manipulator movements are inhibited unless the pendant enable switch is held closed.

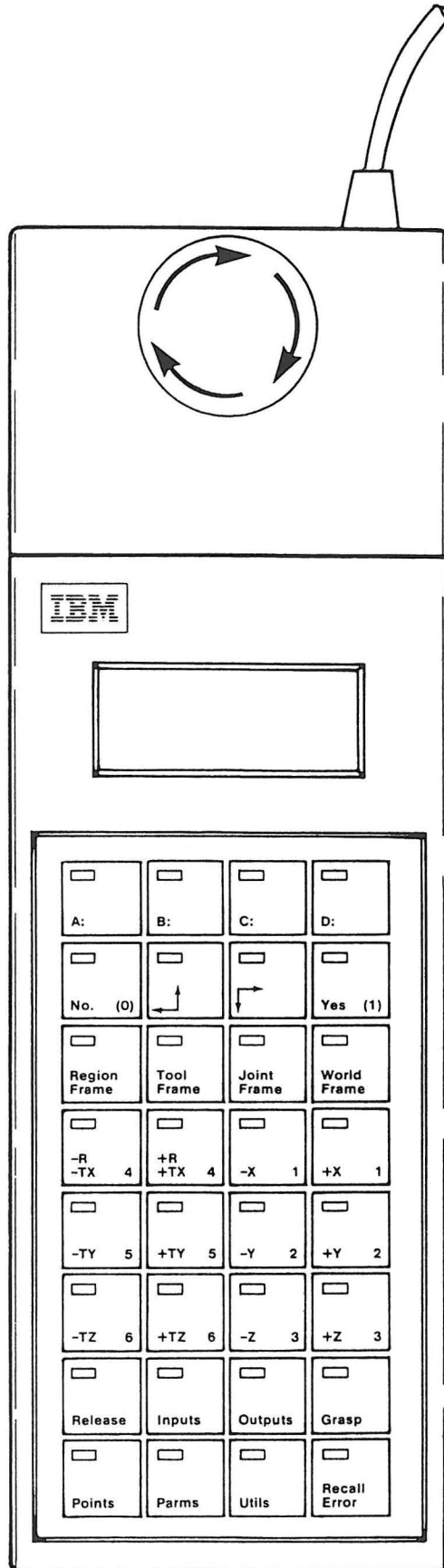


The standard pendant overlay defines the functions of the 32 pushbuttons as follows:

A:	General purpose
B:	General purpose
C:	General purpose
D:	General purpose
No (0)	General purpose; turns DO point off
←↑	Cursor Left/Scroll up
↓→	Cursor Right/Scroll down
Yes (1)	General purpose; turns DO point on
Region Frame	Select frame, points relate to region
Tool Frame	Select frame, points relate to roll axis orientation
Joint Frame	Select frame, points relate to individual axis
World Frame	Select frame, points relate to X-Y plane
-R/-TX, 4	Axis motion
+R/+TX, 4	Axis motion
-X, 1	Axis motion
+X, 1	Axis motion
-TY, 5	Axis motion
+TY, 5	Axis motion
-Y, 2	Axis motion
+Y, 2	Axis motion
-TZ, 6	Axis motion
+TZ, 6	Axis motion
-Z, 3	Axis motion
+Z, 3	Axis motion

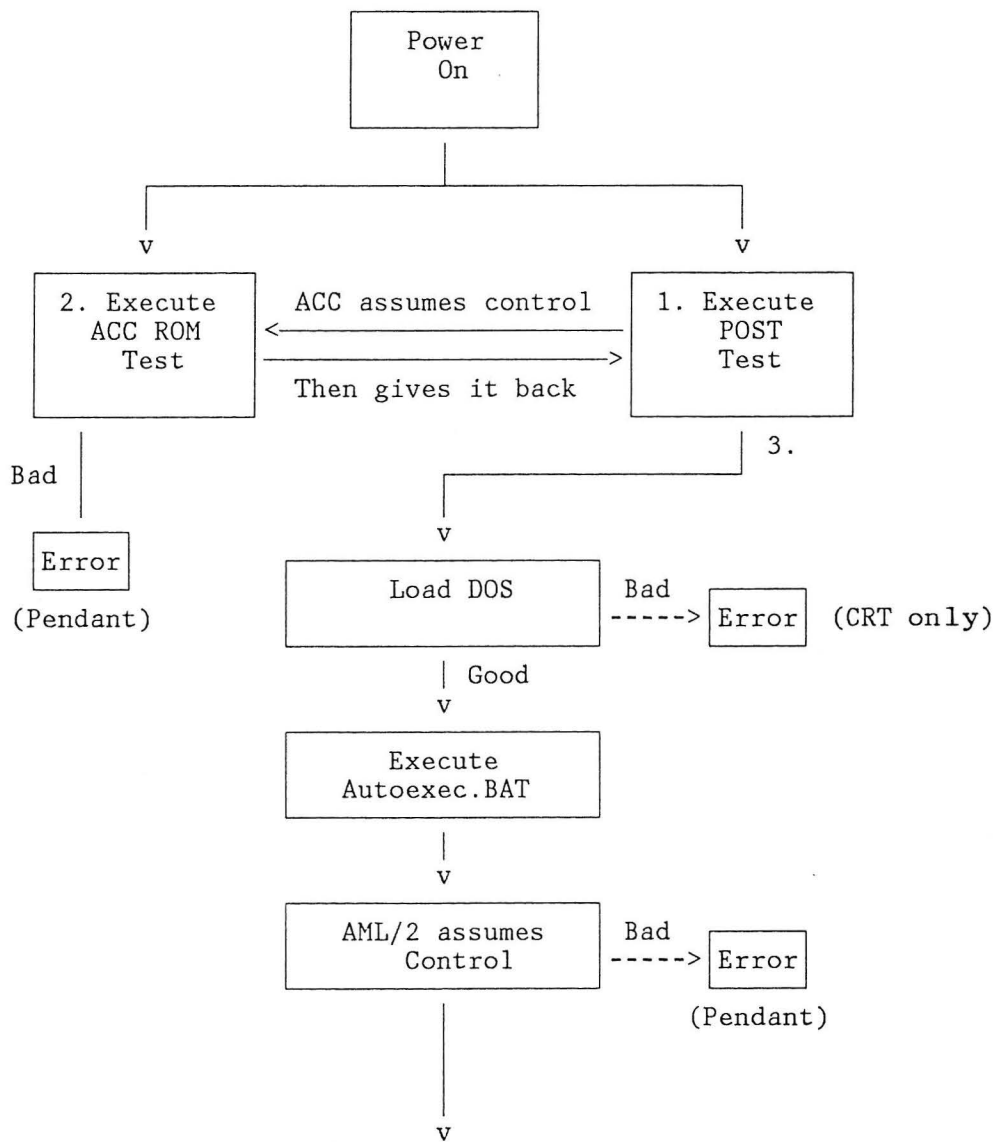
Manufacturing System Overview

Release	Open gripper
Inputs	DI/DO mode, selects DI
Outputs	DI/DO mode, selects DO
Grasp	Close gripper
Points	Select teach mode, displays global points
Parms	Motion parameters menu, allows modification
Utils	Utility programs menu, allows selection
Recall Error	Displays error code to the pendant



CONTROLLER POWER-ON SEQUENCE

1. The controller circuit breaker enables the ac circuit to the fans and dc power supply.
2. The Power-On Self-Test (POST) and the Axis Control Card ROM tests execute. The POST test completes first and the Axis Control Card ROM assumes control. Because the Axis Control Card is "intelligent" (and therefore unique to this manufacturing system), certain hardware and software functions must be checked to ensure the integrity of the system.
3. After the Axis Control Card ROM tests are completed, DOS is loaded. Errors and exceptions are presented to the Servo Power Module operator panel Error LED.
4. AUTOEXEC.BAT file is executed.
5. AML/2 assumes control and:
 - a. Installs DOS extensions
 - b. Initializes Motion Control System (MCS)
 - c. Executes RUNTIME.AML which allows a manipulator STARTUP.



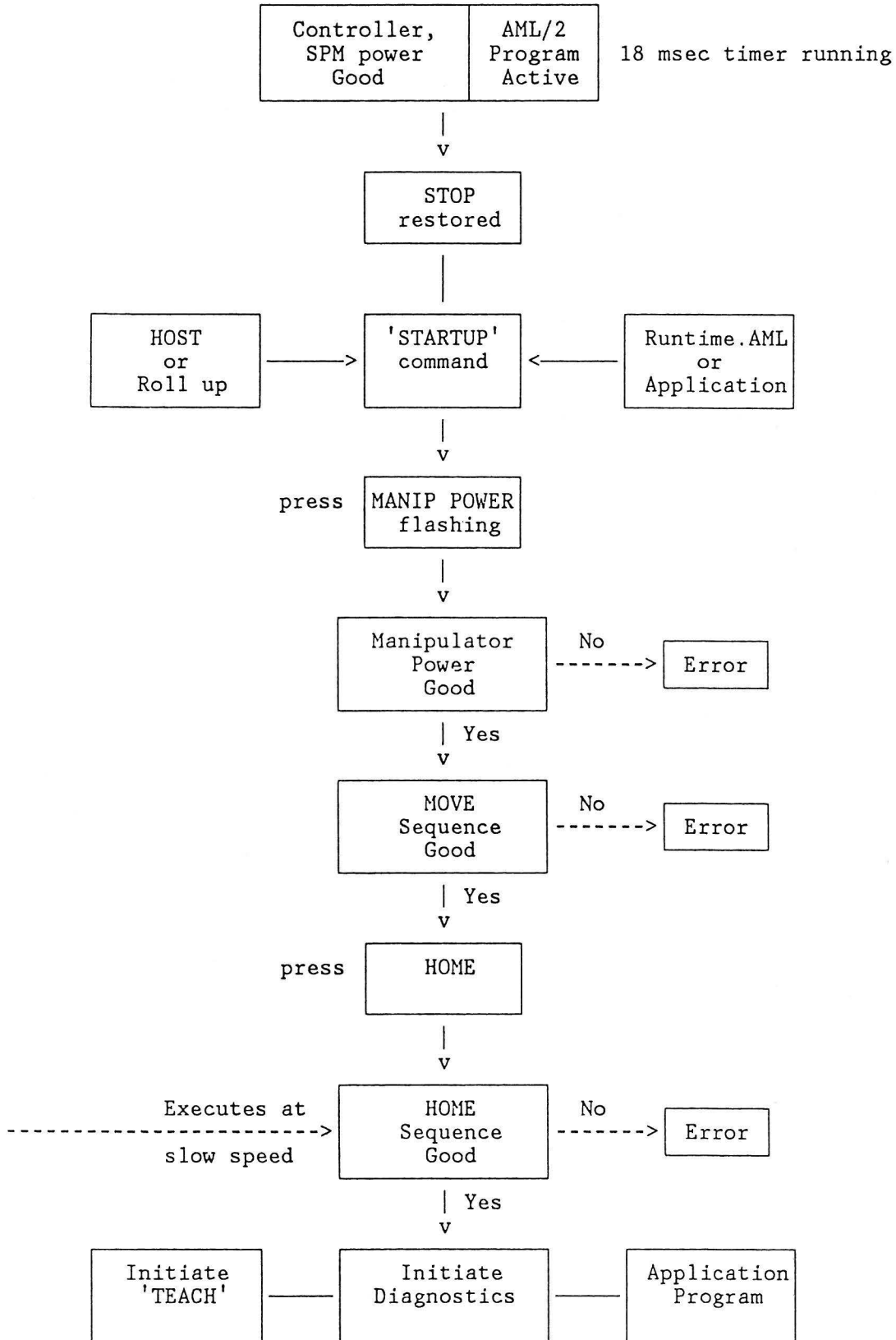
1. Install DOS Extensions
2. Initialize Motion Control System
3. Execute Runtime.AML
 - a. Issue a STARTUP
 - b. Wait for flashing Manip Power LED
 - c. Wait for SELECT, LOAD, then START

Note: CRT is optional.

Manipulator Power-On Sequence

MANIPULATOR POWER-ON SEQUENCE

1. With the AML/2 Manufacturing Control System in the diskette drive, switch on the controller and Servo Power Module Power.
2. This will load the manufacturing system control program (for example, AML/2). (The 18-msec watchdog timer is active. Thus every 18 msec, the entire system is scanned for interrupts, conditions, and errors.)
3. Reset the Manip Stop pushbutton if it has been latched.
4. The AML/2 system will issue a STARTUP.
5. Press the flashing Manip Power LED/pushbutton on the Servo Power Module operator panel.
6. Power is presented and a move sequence is executed on all axes. If the move sequence is successful, the Manip Power LED stays on; otherwise the Error LED illuminates.
7. Press the Home pushbutton on the Servo Power Module operator panel.
8. If the manipulator homes correctly, the Home LED stays on.
9. An application, teach, or diagnostic function can now be initiated.



MANIPULATOR MOVEMENT SEQUENCE

The dc servo motors are pulse driven by pulse-width modulation. There are 500 timing pulses (windows) per revolution and one index pulse (window) per revolution. The 500 timing pulses and one index pulse from the encoder provide position and speed information to the Axis Control Cards.

Each timing pulse (window) is read by two photocells (A and B), and they are only on together for 1/4 of each encoder pulse. These two signals are monitored by the Axis Control Cards under control of the AML/2 software, and provide a resolution just under .002 inch.

The index pulse allows the establishment of a "home" position. If the home sensor is covered, then the next index pulse will be the home position for that axis.

The index is also used to ensure a proper count of 500 timing pulses per revolution. The index pulse (I) is monitored by a single photocell.

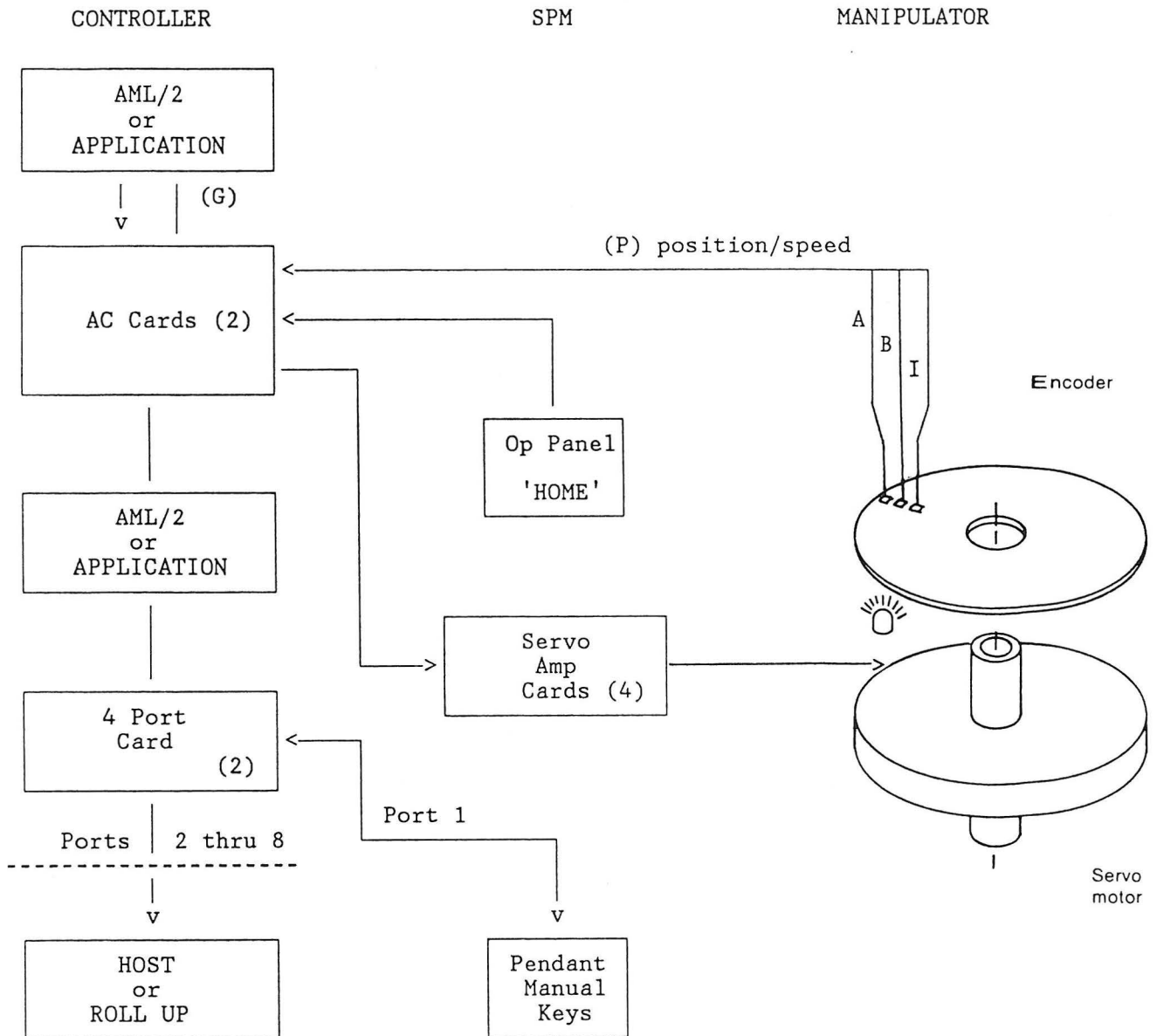
If the source of the move is one of the manual axis motion keys on the pendant, all joints are allowed to move only at a very slow speed.

If the move is under the control of the application program, the following sequence takes place:

1. The servo amplifier card receives input from the Axis Control Card and drives the servo motor at the proper speed and direction.
2. The Axis Control Card compares "position" (P) with "goal" (G) and sends the proper control voltage to the servo amplifier card.
3. The Axis Control Card receives instructions and calculates the "goal."

Manipulator Movement Sequence

The following figure shows a closed servo loop circuit.



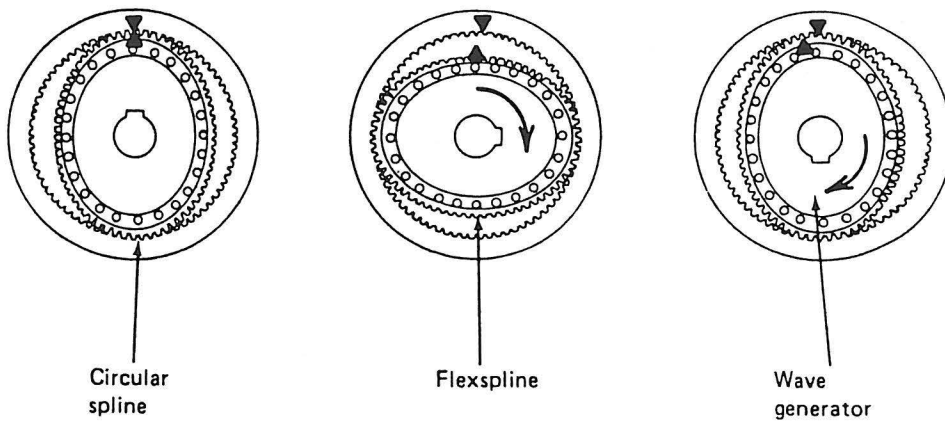
Manipulator Movement Sequence

Harmonic Drive

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.



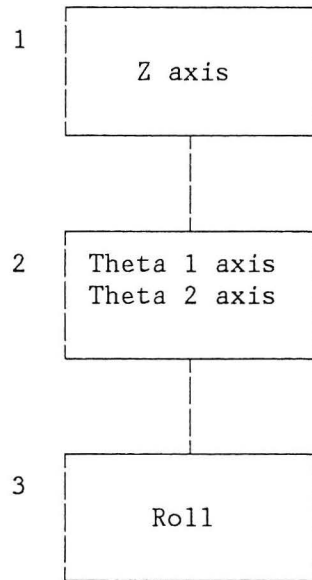
The reduction ratios of the harmonic axes are as follows:

	<u>7575</u>	<u>7576</u>
Theta 1	60:1	120:1
Theta 2	51:1	51:1
Roll	50:1	50:1

Return To Home Sequence

Home position is defined by the next index pulse after the home sensor is covered. Whether the manipulator returns to Left Home or to Right Home is determined by software. Unless altered in software, the default is Right Home.

The following figure shows a flow diagram of the default return-to-home sequence:



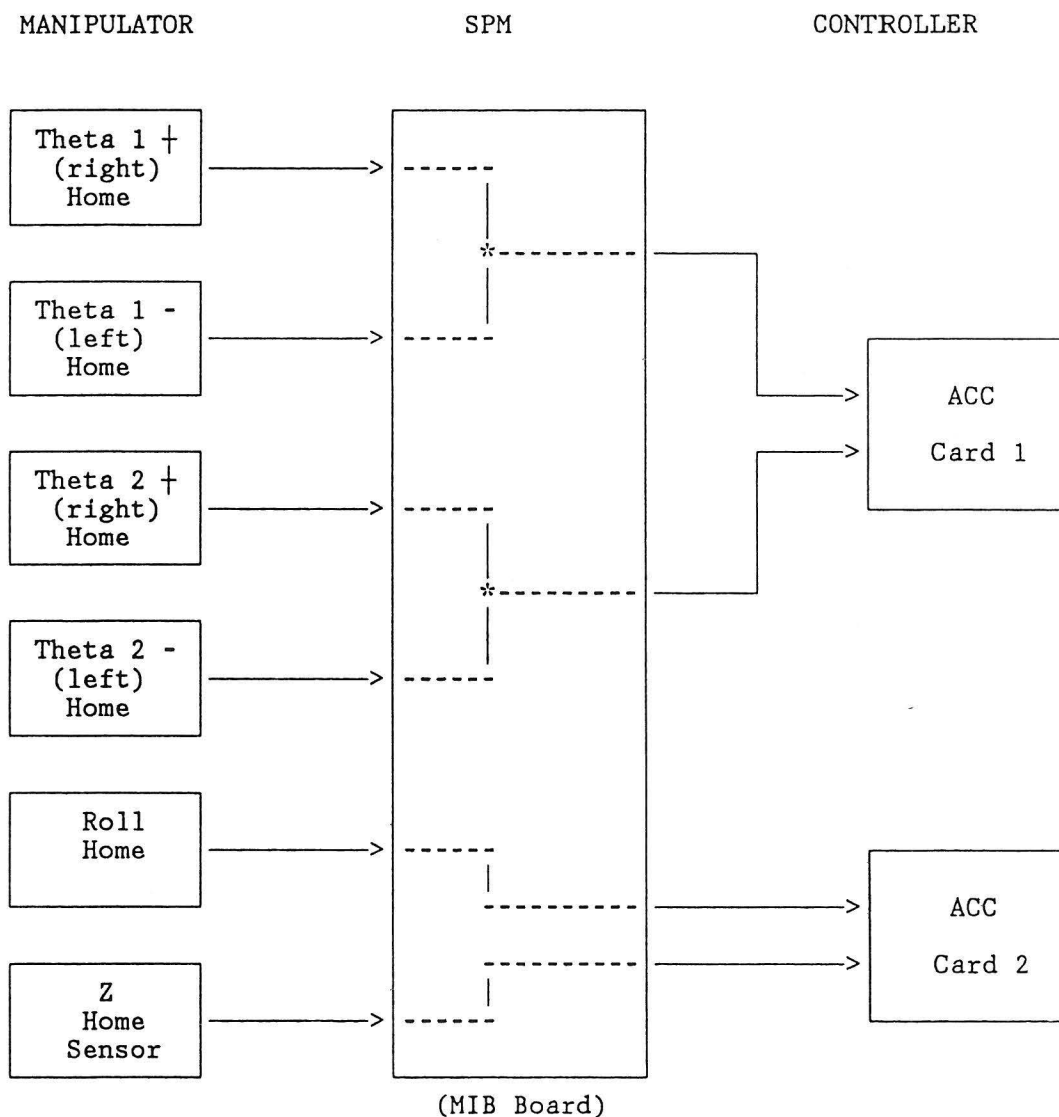
Manipulator Movement Sequence

Home Conditions

There are two Theta 1 and Theta 2 home positions on the 7575 and 7576 Manipulators: Left Home and Right Home. Whether the manipulator returns to Left Home or to Right Home is determined by software. Unless altered in software, the default is Right Home.

The Roll motion of the Z-shaft has only one home position. Likewise, the vertical travel of the Z-shaft has only one home position, the extreme up position.

When the Home LED on the Servo Power Module is illuminated, the manipulator has been homed. The figure below shows the home sensors.



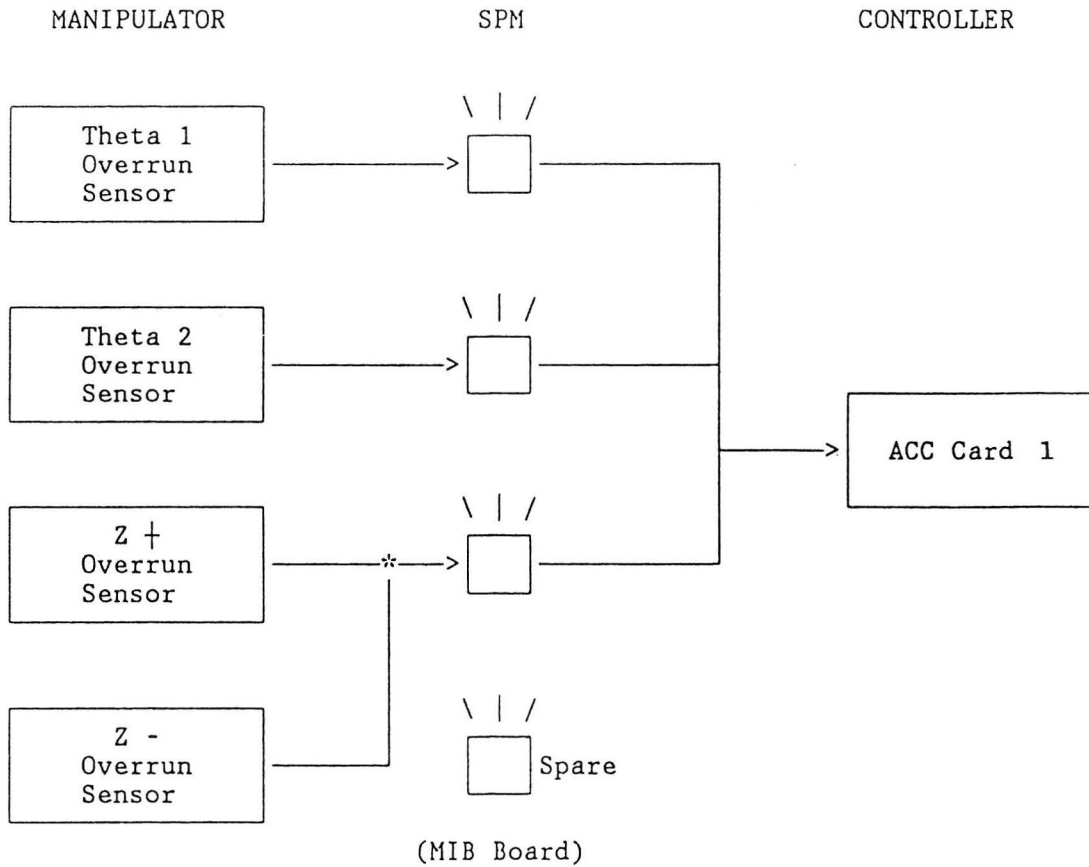
Overrun Condition

An overrun condition occurs when the sensors detect that the manipulator is trying to move outside its normal work area. The drive voltages to all the axis servo motors are immediately removed.

This condition may be corrected by manually placing the manipulator arm back in the workspace.

Note that each axis, except for roll, has its own overrun LED. These lines are combined to a single line that presents the overrun condition to the Axis Control Card.

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



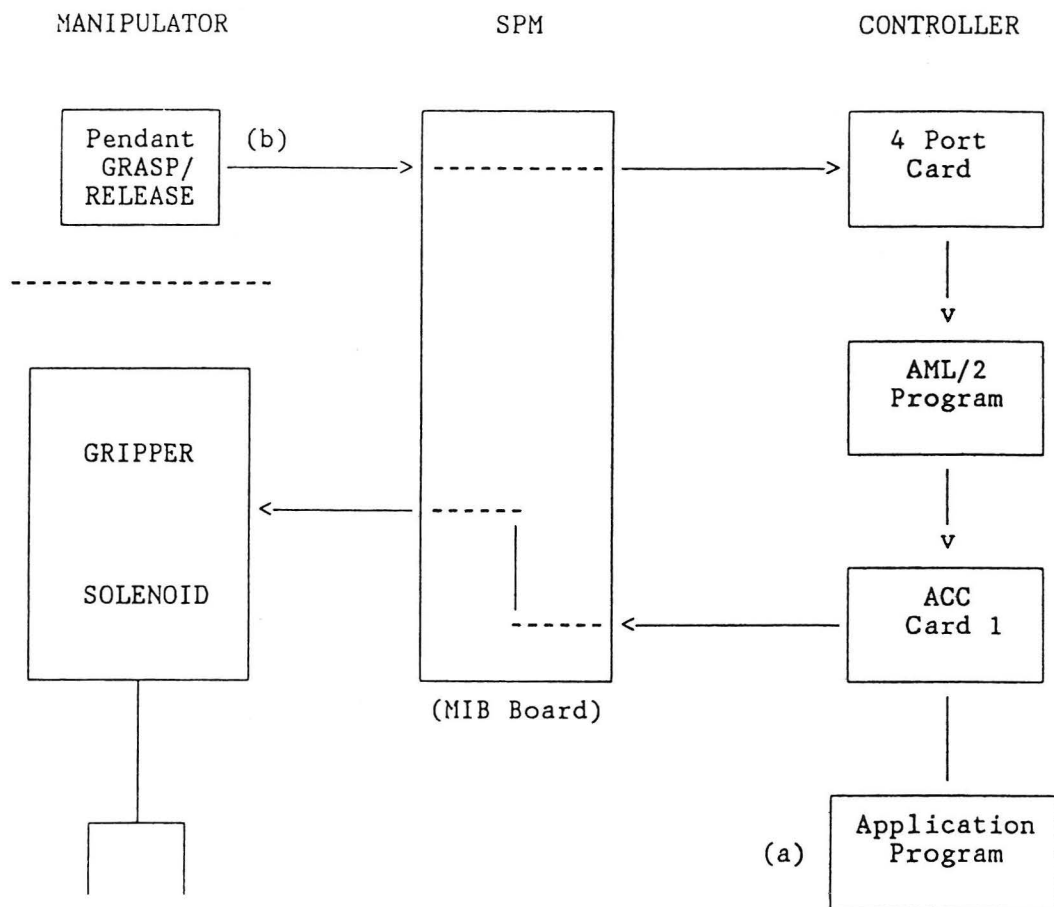
Manipulator Movement Sequence

Gripper Operation

Compressed air to operate the gripper is connected to a solenoid-operated flow control valve. The solenoid (and thus the flow control valve) is controlled by a circuit in the Servo Power Module on the manipulator interface board.

The gripper can be operated in two ways:

- By the GRASP and RELEASE commands in the application program.
- By the Grasp and Release buttons on the pendant.



CONTROLLER DIGITAL INPUT/DIGITAL OUTPUT (DI/DO)

The digital input/digital output (DI/DO) feature provides 48 non-isolated TTL level signals that are configurable in groups of eight as either inputs or outputs. A cable is provided to connect the DI/DO card to two industry standard 24-point optical isolation boards, such as those made by Opto 22, Potter-Brumfield, or Gordos-Arkansas. These manufacturers offer a variety of modules that plug into each of the 24 positions on the boards to provide input or output capability to ac or dc devices of various voltage ratings.

The user must supply a 5-volt dc power source to the two optical isolation boards. The 5-volt dc supply should meet international requirements for safety isolation transformers and provide safety extra-low voltages (SELV). All modules on the optical isolation boards must be designed for operation using the 5-volt dc voltage supplied by the user.

CAUTION

Any user wiring attached to the controller other than at the user interface connectors may cause:

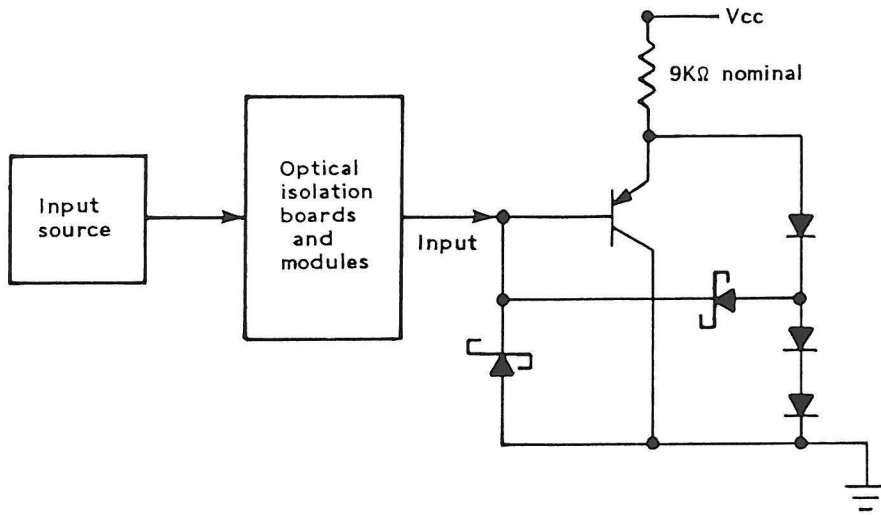
- a safety hazard
- warranty invalidation
- system errors
- unreliable operation.

The following tables and diagrams describe the DI/DO feature.

Digital Input (DI)

The following figure shows the digital input circuit from a 48-point DI/DO card and a representation of a typical optical isolation circuit interfacing to the input source.

The optical isolation circuit is based on an industry standard 24-point optical isolation board, such as those made by Opto 22, Potter-Brumfield, or Gordos-Arkansas. The user must provide dc voltage to power such a board.



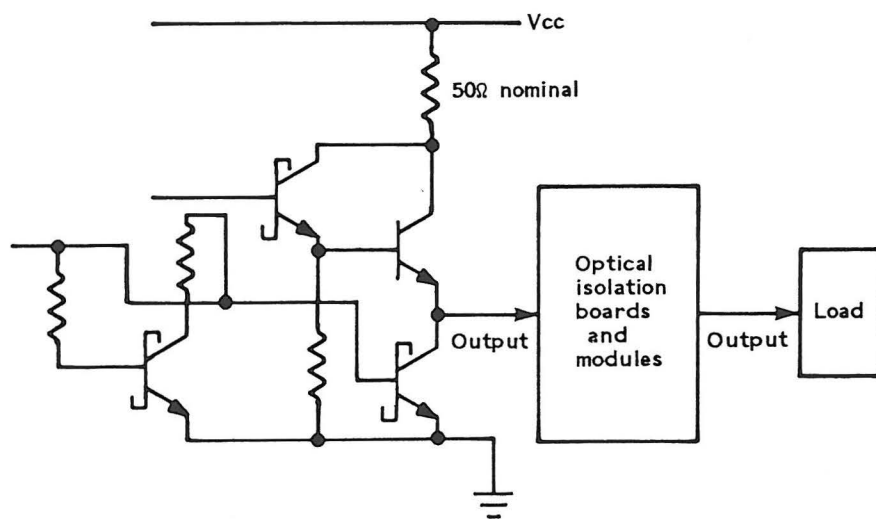
Characteristic	Voltage Sense Description
Circuit type	Solid state, nonisolated TTL
Input form:	
Low	Current sinking, 0.2 ma at 0.8 V maximum
High	20 μa at 2.0 V minimum
Voltage limits:	
	5.5 Vdc maximum, high level input
	0 Vdc minimum, low level input
Input impedance	TTL characteristic
Response time	20 ms

Digital Output (DO)

Output commands from the application program or the pendant energize DO circuits, providing a circuit closure for external devices.

External user devices must provide voltage (5 Vdc) and optical isolation. The following figure shows a digital output circuit from a 48 DI/DO card and a representation of a typical optical isolation circuit interfacing to the load.

The optical isolation circuit is based on an industry standard 24-point optical isolation board, such as those made by Opto 22, Potter-Brumfield, or Gordos-Arkansas.



Characteristic	Circuit Description
Circuit type	Solid state, nonisolated TTL 3-state outputs
Output form:	
High	(Source current) 15 ma at 2.0 V
Low	(Sink current) 24 ma at 0.5 V
Off-state	200 μa
Duration of output	Application controlled
Response time	20 ms

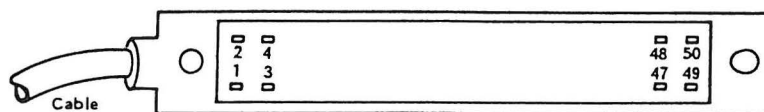
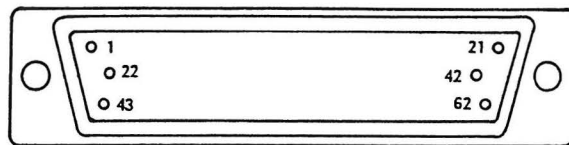
48-Point DI/DO Card User Cable Layout

Cable 1-24

62-pin conn.	Conn. 1-24	Signal name
1	50	--
2	48	Data 1
3	46	Data 2
4	44	Data 3
5	42	Data 4
6	49	Gnd
7	40	Data 5
8	38	Data 6
9	36	Data 7
10	34	Data 8
11	1	Gnd
12	32	Data 9
13	30	Data 10
14	28	Data 11
15	26	Data 12
16	13	Gnd
17	24	Data 13
18	22	Data 14
19	20	Data 15
20	18	Data 16
21	25	Gnd
22	NA	Not used
23	16	Data 17
24	14	Data 18
25	12	Data 19
26	10	Data 20
27	37	Gnd
28	8	Data 21
29	6	Data 22
30	4	Data 23
31	2	Data 24

Cable 25-48

62-pin conn.	Conn. 25-48	Signal name
32	na	Not used
33	48	Data 25
34	46	Data 26
35	44	Data 27
36	42	Data 28
37	49	Gnd
38	40	Data 29
39	38	Data 30
40	36	Data 31
41	34	Data 32
42	1	Gnd
43	50	--
44	32	Data 33
45	30	Data 34
46	28	Data 35
47	26	Data 36
48	13	Gnd
49	24	Data 37
50	22	Data 38
51	20	Data 39
52	18	Data 40
53	25	Gnd
54	16	Data 41
55	14	Data 42
56	12	Data 43
57	10	Data 44
58	37	Gnd
59	8	Data 45
60	6	Data 46
61	4	Data 47
62	2	Data 48



POWER SUPPLIES

Controller

The IBM 7532 Industrial Computer Model 310 contains a 192-watt power supply that furnishes ± 5 Vdc, and ± 12 Vdc. The power adapter board (which is placed between the power supply and the optional disk drive) allows for the distribution of the power supply output to the system board, fan, and connection of the Reset switch. Refer to Chapter 4, "Controller Power Supply Checks" (4001) for measuring of the power supply output.

Servo Power Module

The 7572 Servo Power Module contains two power supplies. The low voltage power supply is a pluggable unit and furnishes +5 Vdc, ± 15 Vdc, and +24 Vdc. The +80 Vdc power supply is a standalone power supply that furnishes +80 Vdc for the manipulator servo motors only.

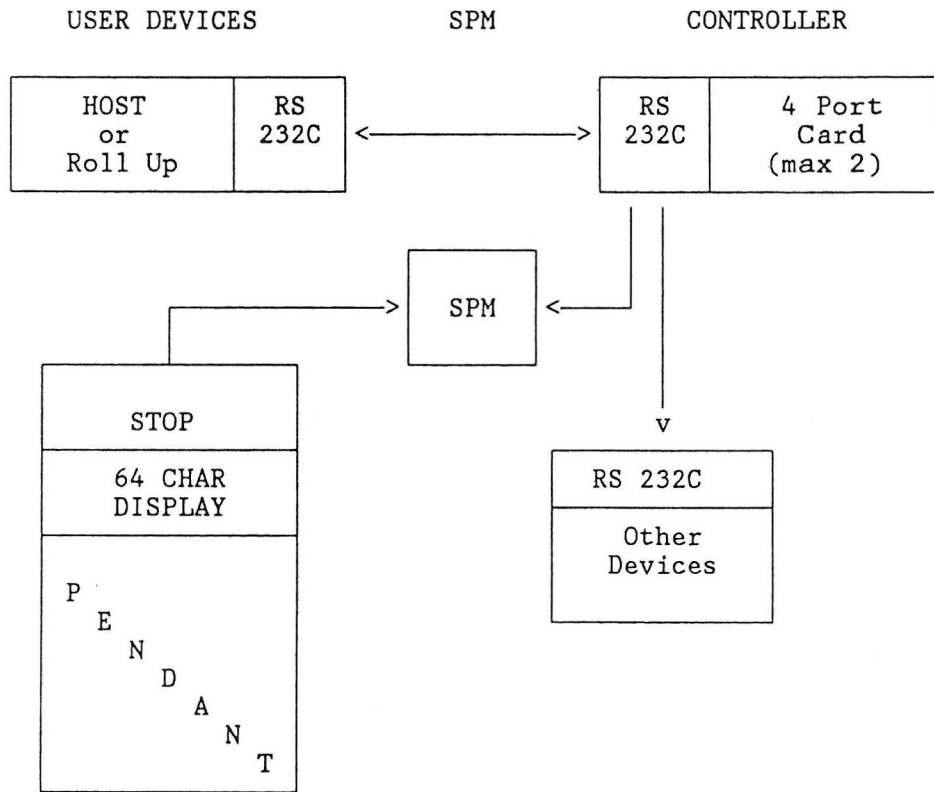
Refer to chapter 4, "Power Supply Checks" (4007) for measuring of the power supply output.

COMMUNICATIONS

Communication to the controller is established through the 4-Port RS-232 Asynchronous Communications Adapter. This card contains four separate communication ports and is fully programmable. Options, such as baud rate, start and stop bits, data bits, and parity are set by the user with the AML/2 programming facility. The roll-up/host computer cable adapts the 10-pin connector to a standard EIA RS-232-C communication connector.

One 4-Port card (ports 1 - 4) is standard on the Manufacturing System; a second 4-Port card (ports 5 - 8) may be installed. Port 1 is reserved for the pendant, and Port 2 is reserved for the roll-up tool. Ports 3 through 8 can be attached to any other RS-232-C communications line.

The following figures show a block diagram of the communications data flow, pin assignments, and typical hook-up.

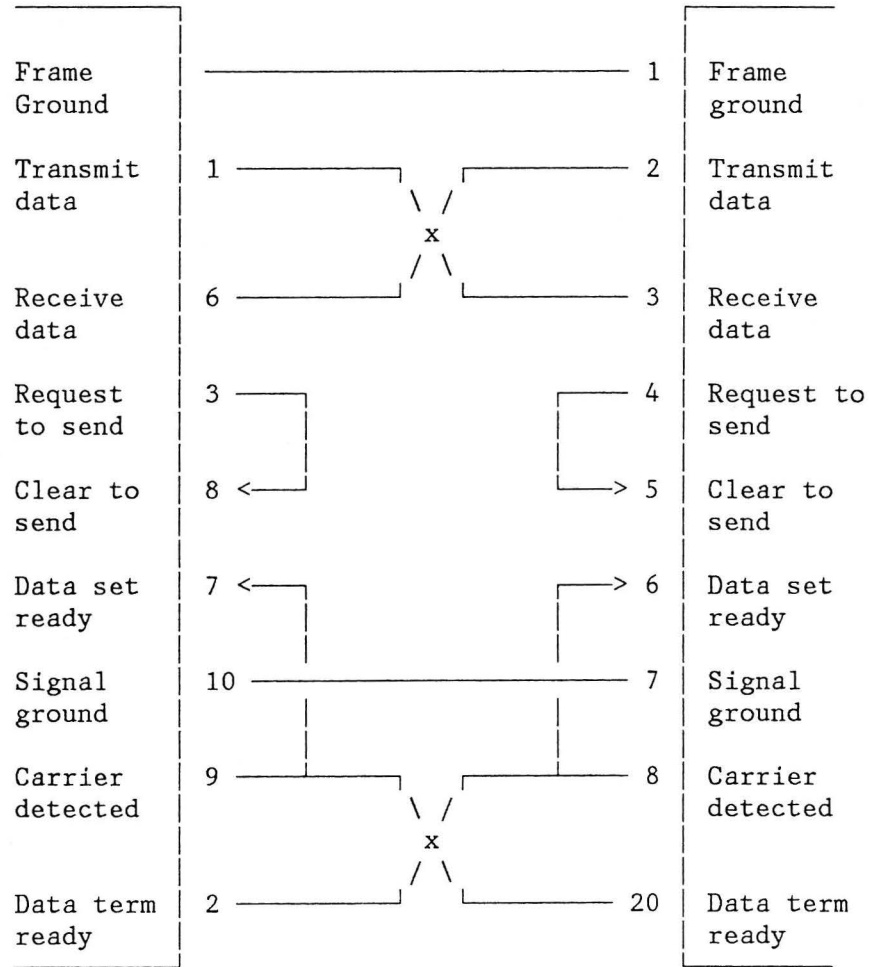


4-Port RS-232 Asynchronous
Communications Adapter

Roll-up tool or
host computer

10-Pin Connector

25-Pin Connector



Local RS-232-C Cable Wiring

5	10
4	9
3	8
2	7
1	6

4-Port Card Connector
(as viewed from rear of 7532)

CUSTOMER CONNECTOR (C5)

Customer connector C5 on the bottom of the Servo Power Module provides the electrical connection for optional safety and convenience functions.

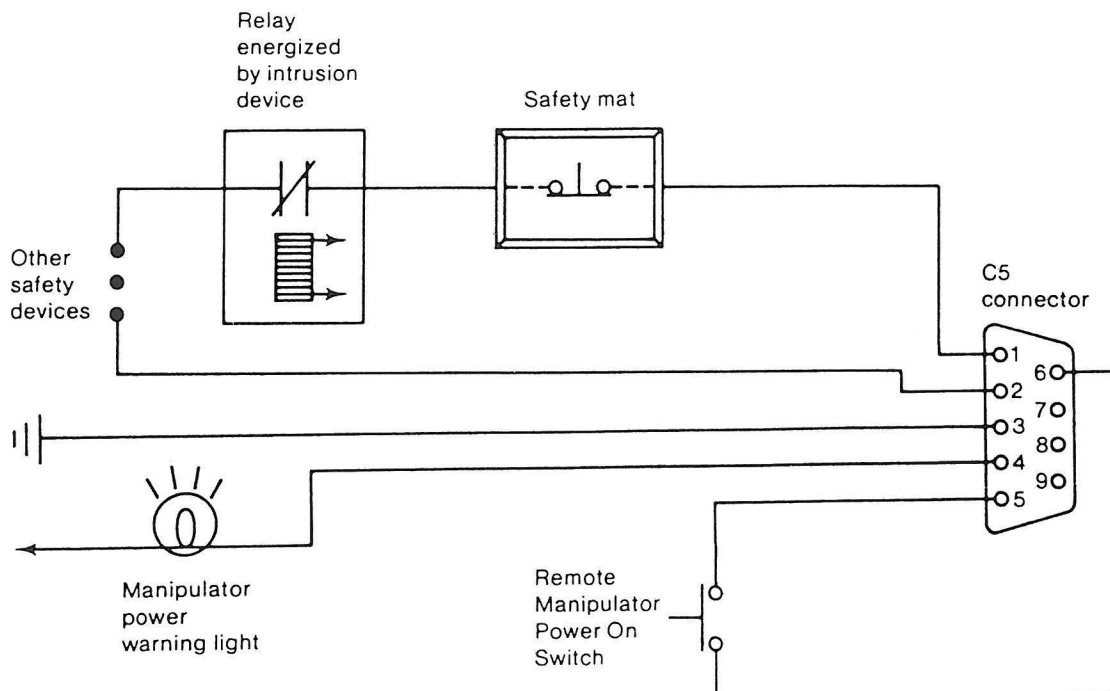
- Pins 1 and 2 on connector C5 allow an extension of the manipulator stop circuit. Thus a safety zone can be established around the manipulator by installing intrusion warning devices between pins 1 and 2. User contacts should be rated for 24 Vdc at 20 mA minimum.

Note: If no intrusion device is installed, pins 1 and 2 must be jumpered to power on the manipulator.

- Pins 3 and 4 on connector C5 allow a "Manipulator Power On" indicator to be installed near the workspace. A contact set on the power sequencing relay (CR1) completes the circuit between pins 3 and 4 when manipulator power is applied. Thus, warning signals can be installed between pins 3 and 4 to indicate when manipulator power is on, making manipulator movement possible at any time. This contact set is rated for 30 Vdc at 2 A maximum.
- Pins 5 and 6 on connector C5 may be used to connect a remote Manipulator Power switch. That remote switch would serve the same function as the Manipulator Power pushbutton on the Servo Power Module operator panel. User contacts should be rated for 24 Vdc at 30 mA minimum.

Note: The remote Manipulator Power feature is disabled when the Auto/Teach keyswitch is in the Teach position.

- Pins 7, 8, and 9 are not used.



CHAPTER 3. REMOVAL AND 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.

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CAUTION

Before performing any removal or replacement procedures, observe the following:

1. Set all power switches to off and unplug or otherwise disconnect all manufacturing system components, whenever possible.
2. Observe proper cable routing and handle all cables carefully to avoid damage to them.
3. Observe the safety instructions given in the front of this book.

3100 CONTROLLER REMOVALS AND REPLACEMENTS

3101 Top Cover

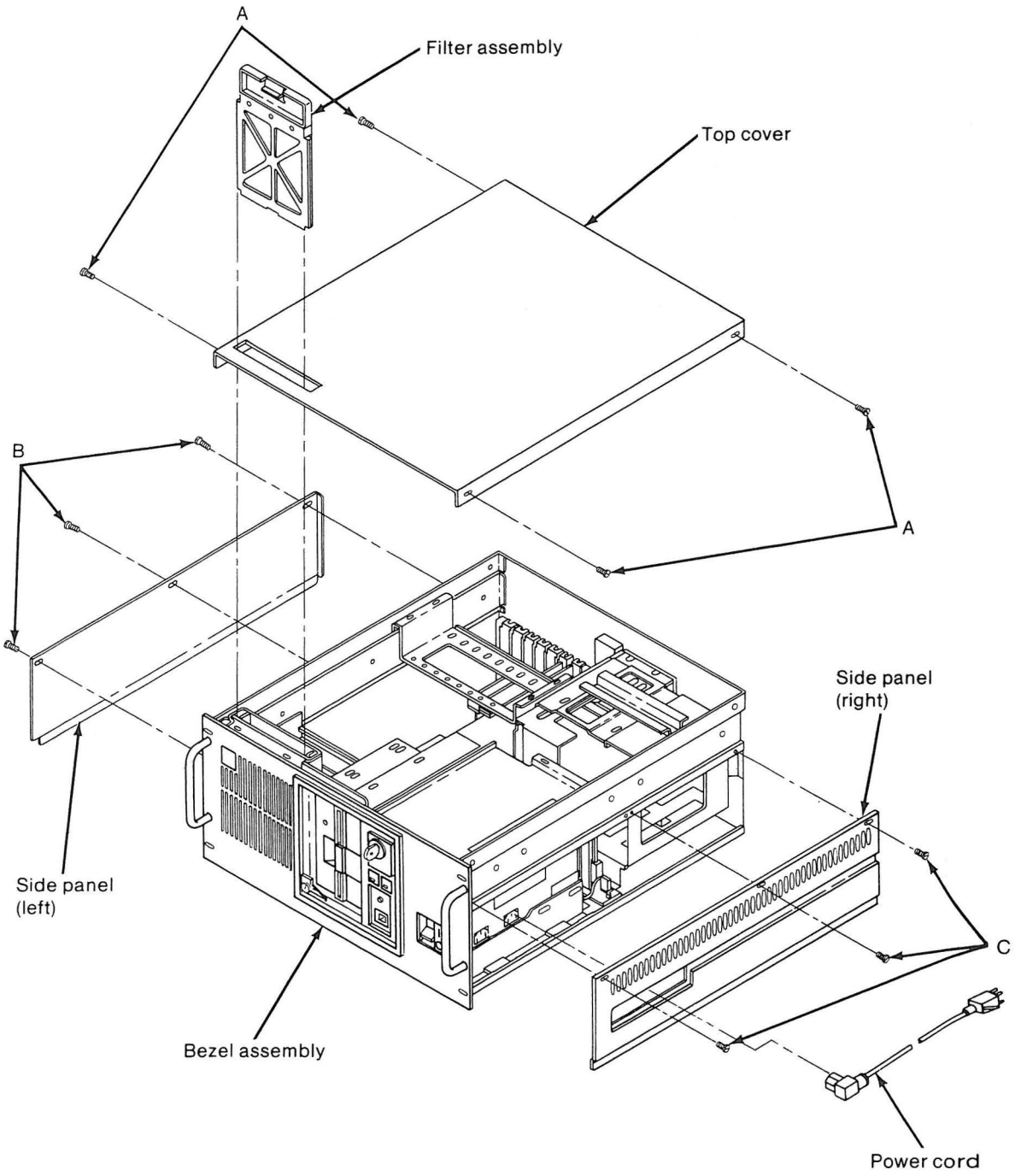
1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the four screws (A).
3. For replacement, reverse the above procedure.

3102 Left Cover

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the three screws (B).
3. For replacement, reverse the above procedure.

3103 Right Cover

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the power cord from the right side.
3. Remove the three screws (C).
4. For replacement, reverse the above procedure.

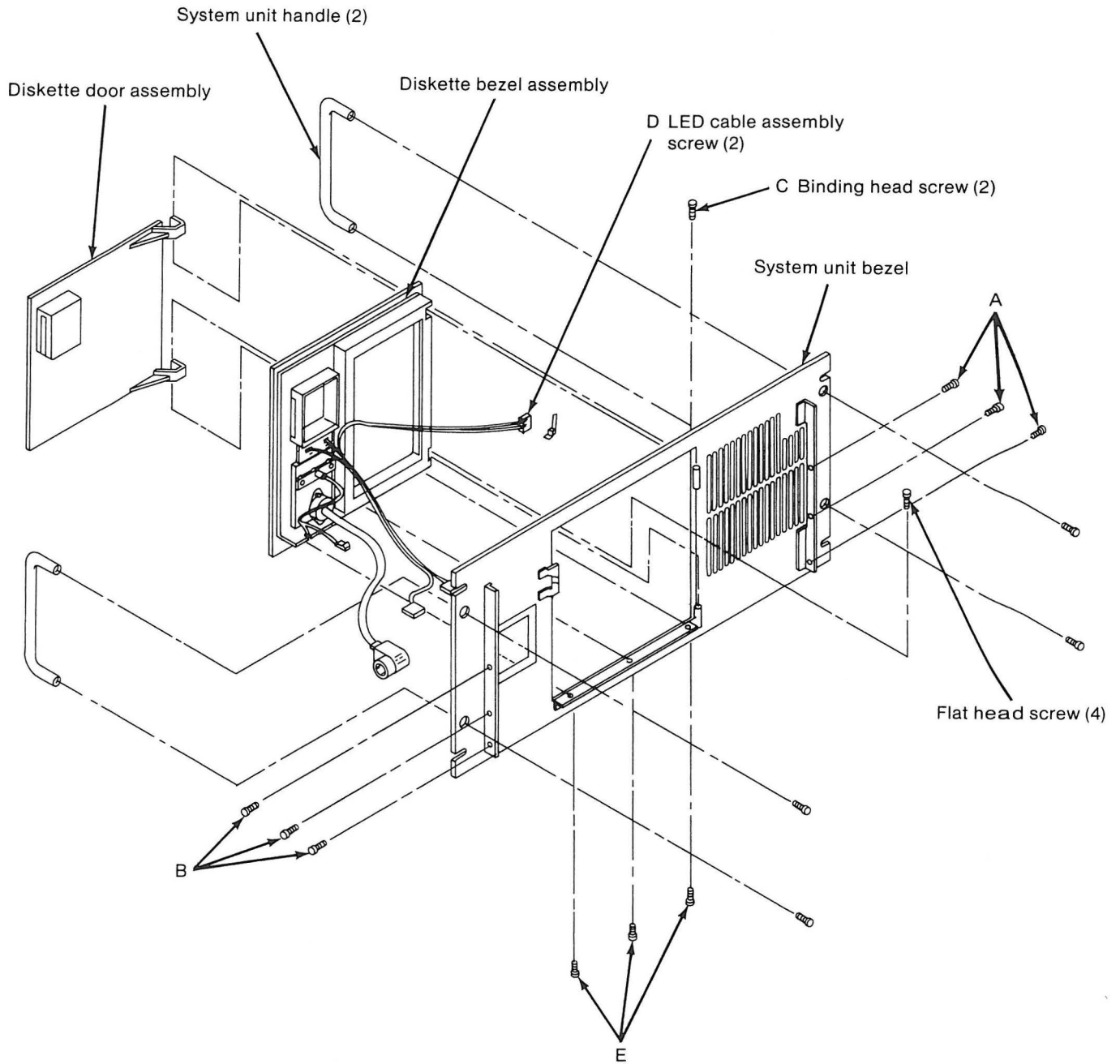


3104 Front Bezel

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the left and right side covers (3102 and 3103).
3. Remove the three screws (A).
4. Remove the three screws (B).
5. For replacement, reverse the above procedure.

3105 Diskette Bezel

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the controller front bezel (3104).
3. Remove the two door screws (C).
4. Remove the two switch screws (D).
5. Remove the three bottom screws (E).
6. For replacement, reverse the above procedure.

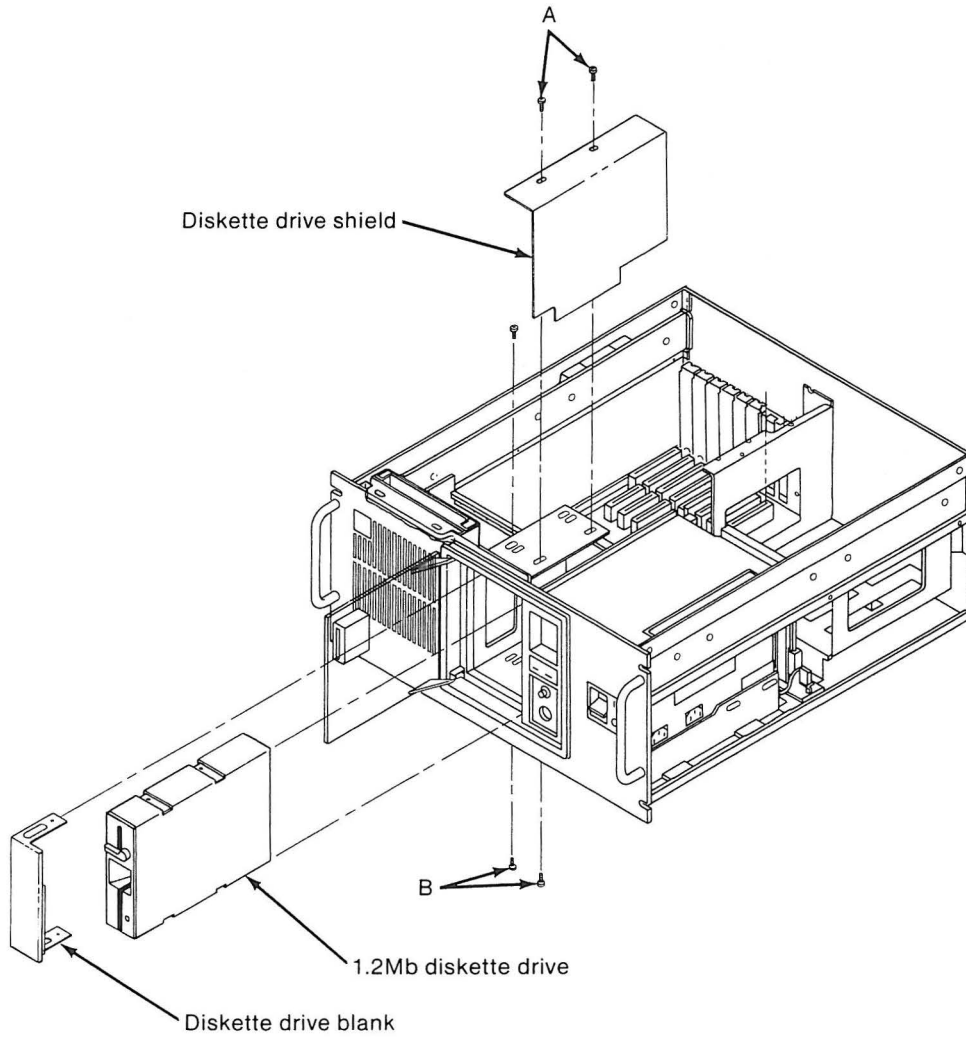


3106 1.2Mb Diskette Drive

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top cover (3101).
3. Disconnect the power cable and the signal cable.
4. Remove the two top mounting screws (A) and the bottom screw (B), for the appropriate drive.
5. Remove the diskette blank, if necessary.
6. Remove the drive through the front of the cabinet.
7. For replacement, reverse the above procedure.

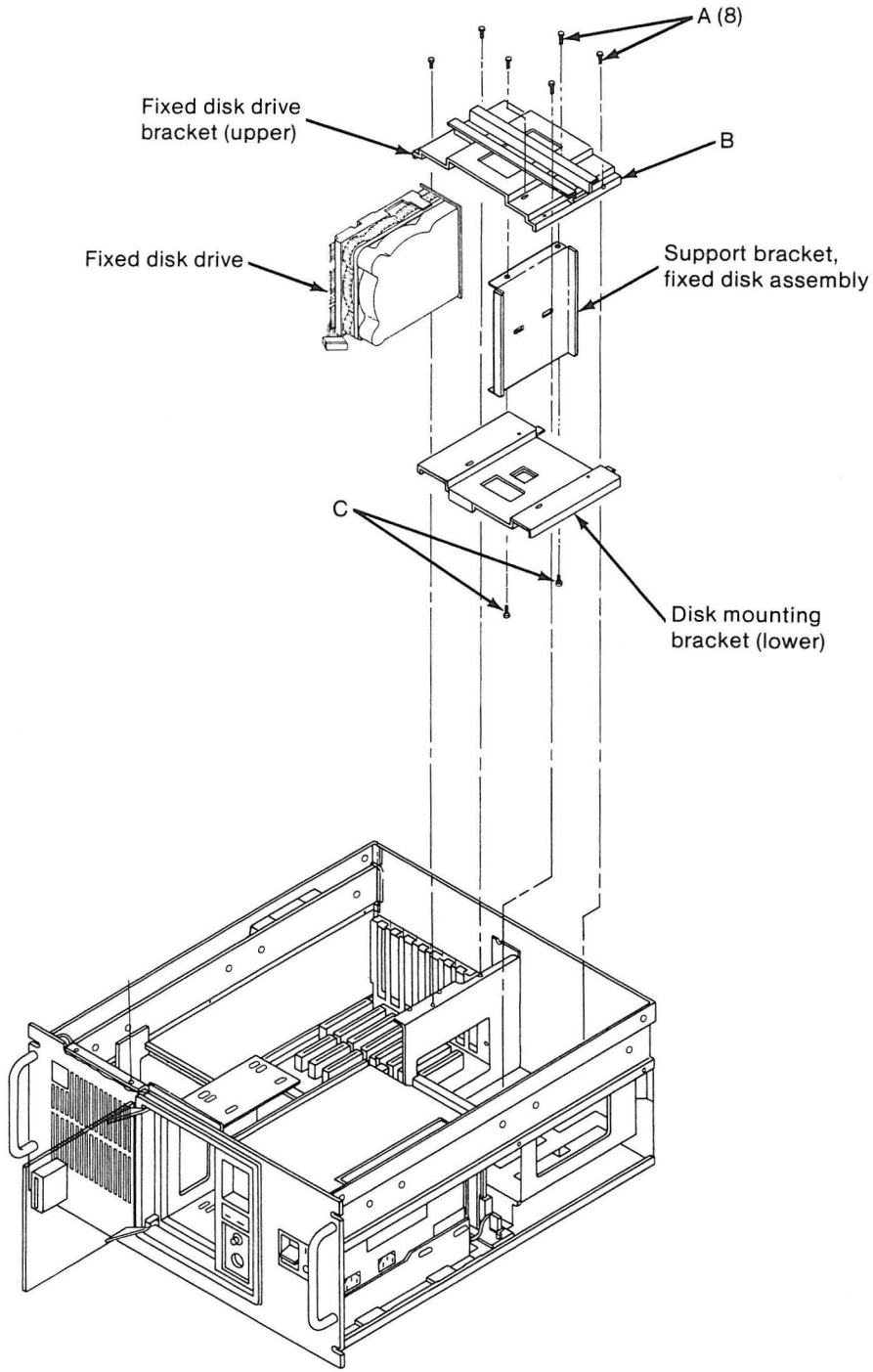
3107 360Kb Diskette Drive

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top cover (3101).
3. Disconnect the power cable and the signal cable.
4. Remove the two top mounting screws (A) and the bottom screw (B), for the appropriate drive.
5. Remove the diskette blank, if necessary.
6. Remove the drive through the front of the cabinet.
7. For replacement, reverse the above procedure.



3108 20Mb Fixed Disk

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top cover (3101).
3. Disconnect the power, signal, and data cables.
4. Remove the eight upper bracket screws (A), and remove the upper bracket (B).
5. Lift the fixed disk unit up from the controller base.
6. Remove the two lower bracket screws (C), allowing removal of the fixed disk unit.
7. For replacement, reverse the above procedure.



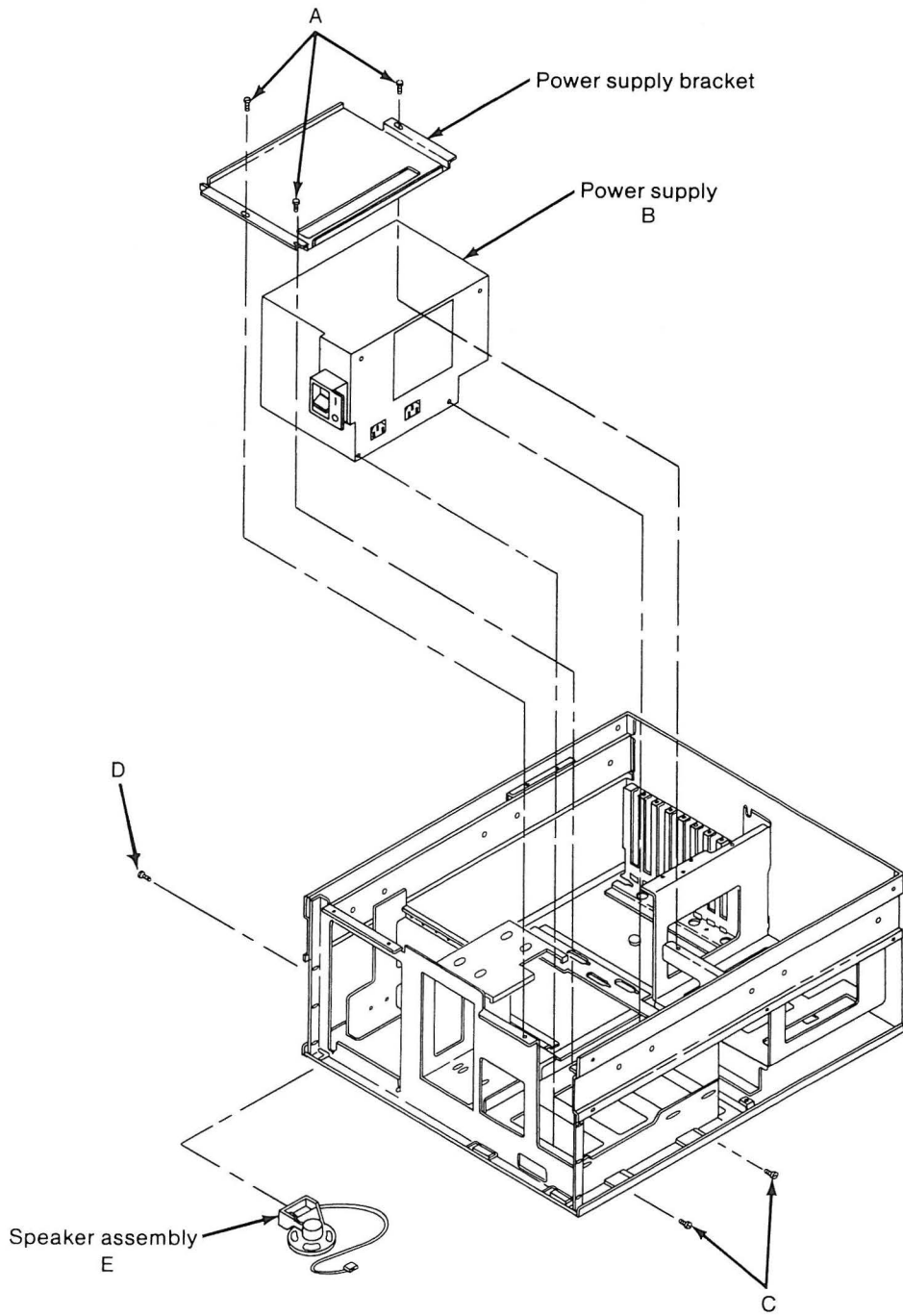
3100 Controller

3109 Power Supply

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top and right side covers (3101 and 3103).
3. Disconnect the power cord from the left side and the power supply cables.
4. Remove the three upper power supply bracket screws (A).
5. Remove the two right side power supply screws (C).
6. Lift the power supply (B) from the cabinet.
7. For replacement, reverse the above procedure.

3110 Speaker Assembly

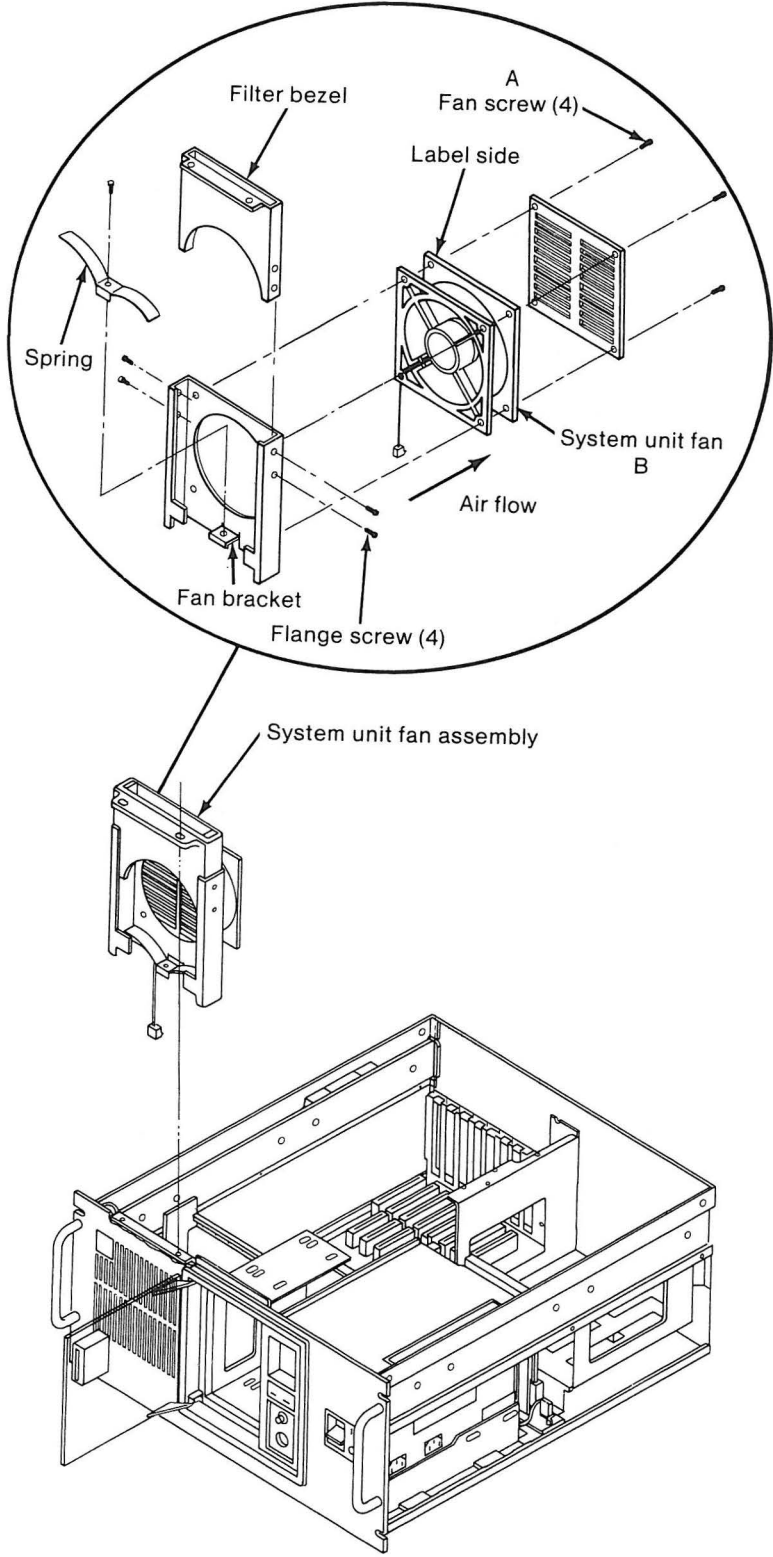
1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top and left side covers (3101 and 3102).
3. Disconnect the speaker cable J19.
4. Release the mounting clips (D) and remove the speaker assembly (E) from the controller.
5. For replacement, reverse the above procedure.



3100 Controller

3111 Cooling Fan

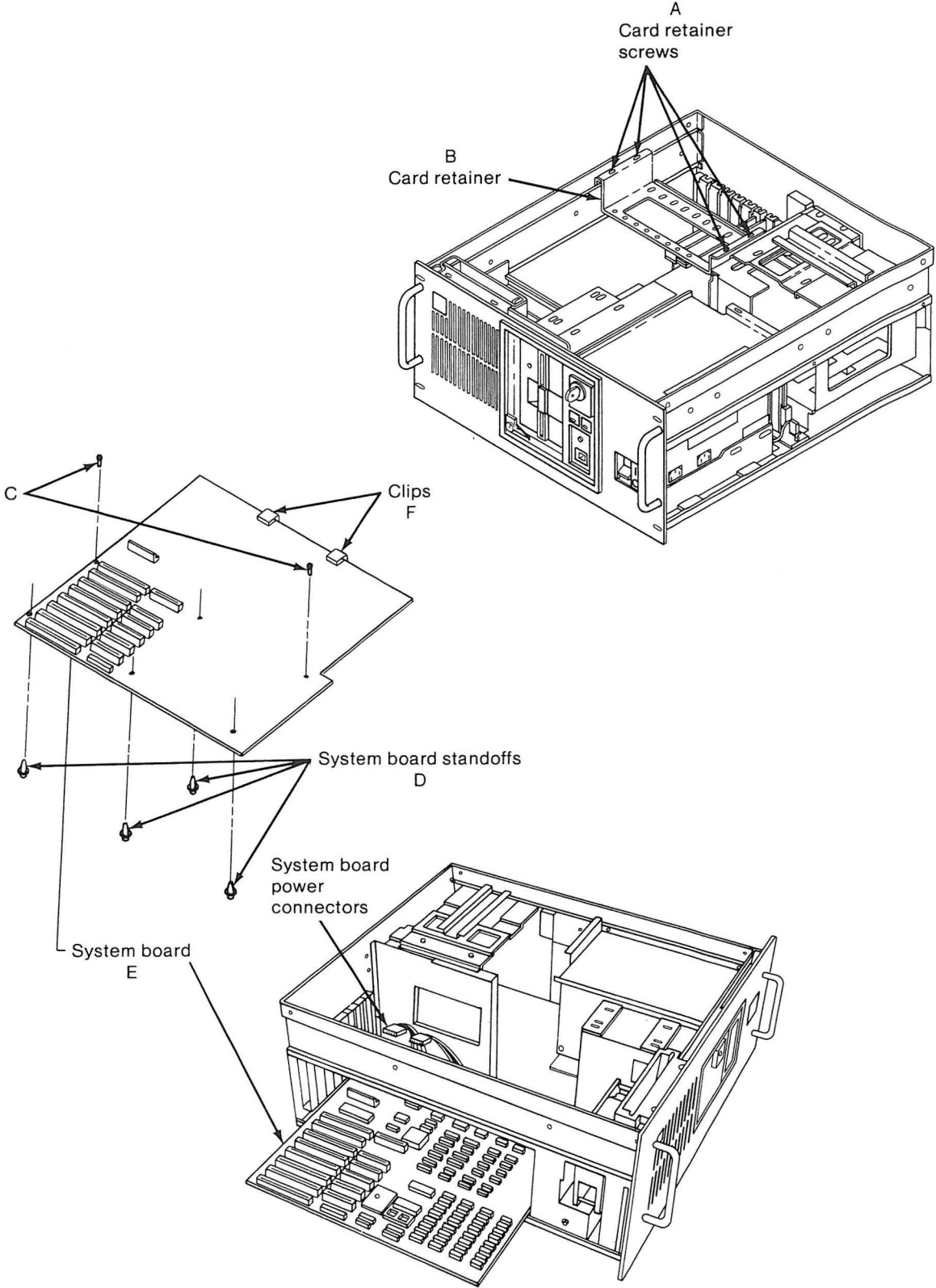
1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top cover (3101).
3. Disconnect the fan cable P24 from the power supply adapter card P21.
4. Remove the four mounting screws (A) and the fan (B) from the controller.
5. For replacement, reverse the above procedure.



3112 System Board

1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top and left side covers (3101 and 3102).
3. Remove the four screws (A) holding the card retainer (B).
4. Remove the card retainer.
5. Remove the adapter cards' external and internal cables.
6. Remove the adapter cards and **all** card support brackets, including the empty adapter card slots.
7. Disconnect the system board cables.
8. Remove the two system board screws (C).
9. Remove the system board (E) by sliding the board out and lifting it up slightly to release the four standoffs (D). Be careful not to lose the two clips (F).
10. For replacement, reverse the above procedure.

Note: Start by positioning the two clips (F) so that they will locate the system board. Don't forget to replace the Math Coprocessor and/or memory modules, and to reset the video switch, as appropriate.



3113 Math Coprocessor

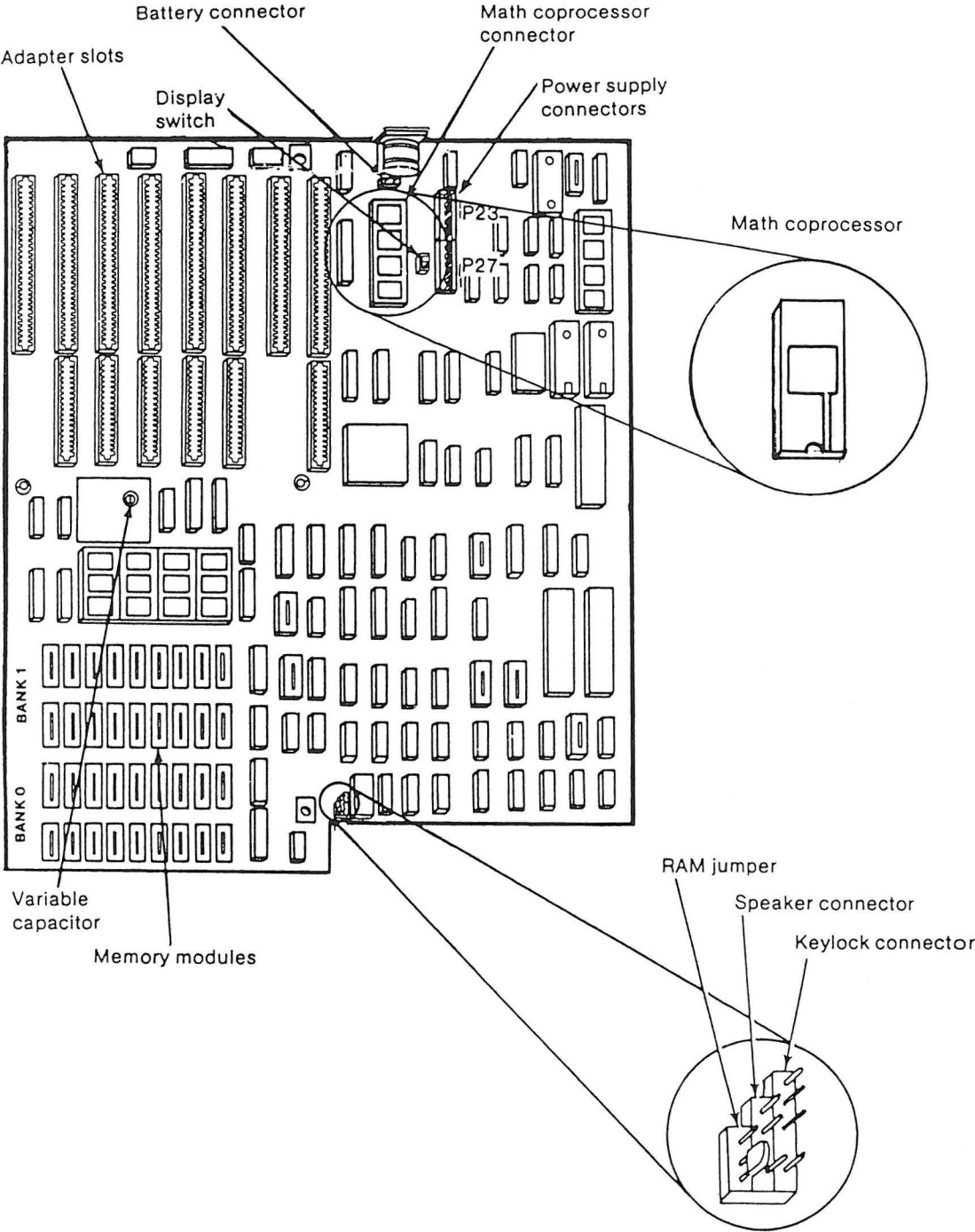
1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top cover (3101).
3. Remove the four screws of the card retainer, then the card retainer. (Refer to the figure for 3112.)
4. Remove enough adapter cards to access the Math Coprocessor.
5. The replacement Math Coprocessor kit will have a special tool for removing and inserting the Math Coprocessor module.
6. Using this tool, remove the Math Coprocessor from the system board. Employ a slight rocking motion to dislodge the module.
7. For replacement, reverse the above procedure.

3114 Battery

CAUTION

Replace only with IBM P/N 8286121. Use of a different battery could result in ignition or explosion of battery. Order replacement from an IBM authorized dealer.

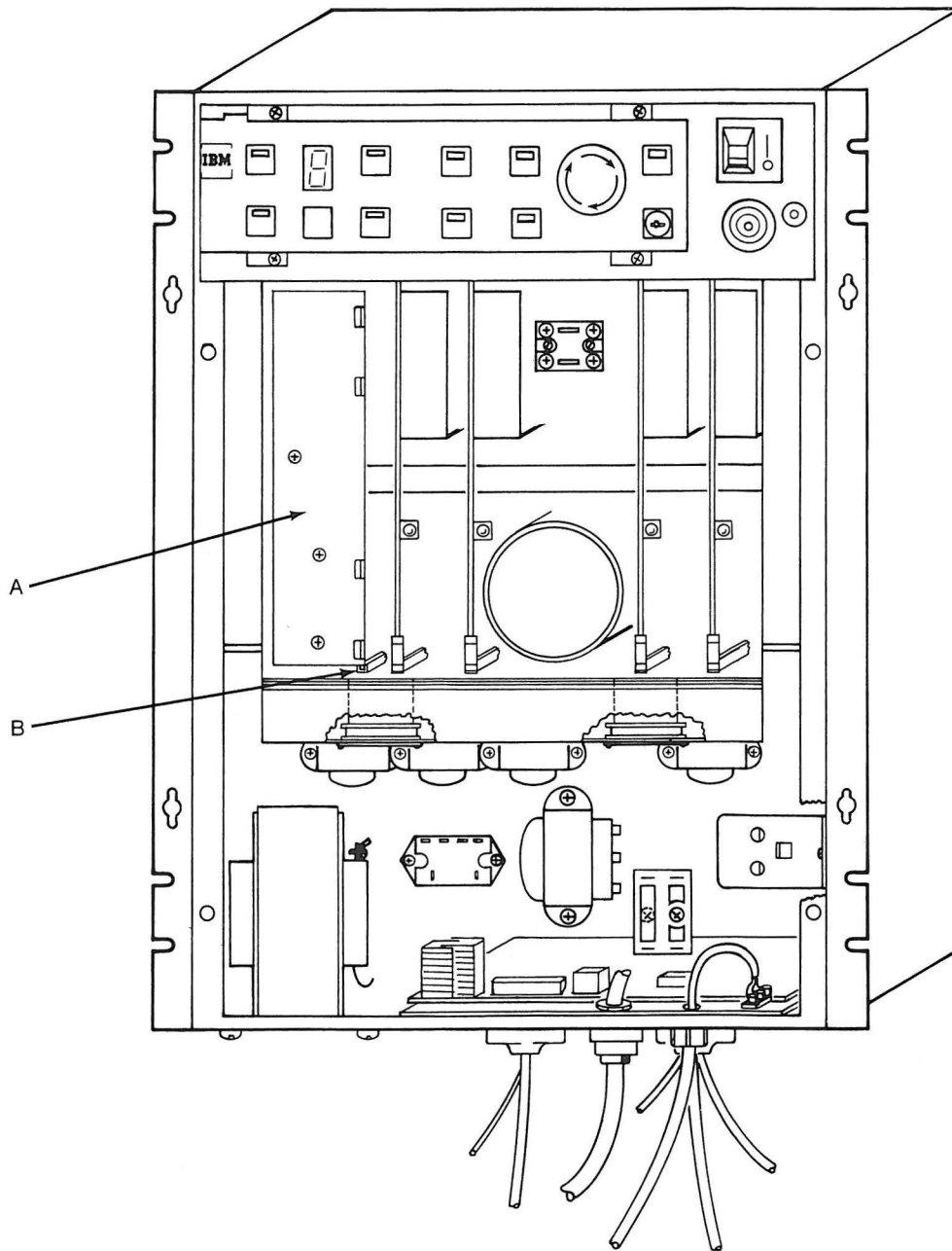
1. Remove the front panel screws and pull the controller forward from the rack.
2. Remove the top cover (3101).
3. Loosen the battery from its pin-and-loop strip mounting.
4. Remove the connector J21.
5. For replacement, reverse the above procedure.



3200 SERVO POWER MODULE REMOVALS AND REPLACEMENTS

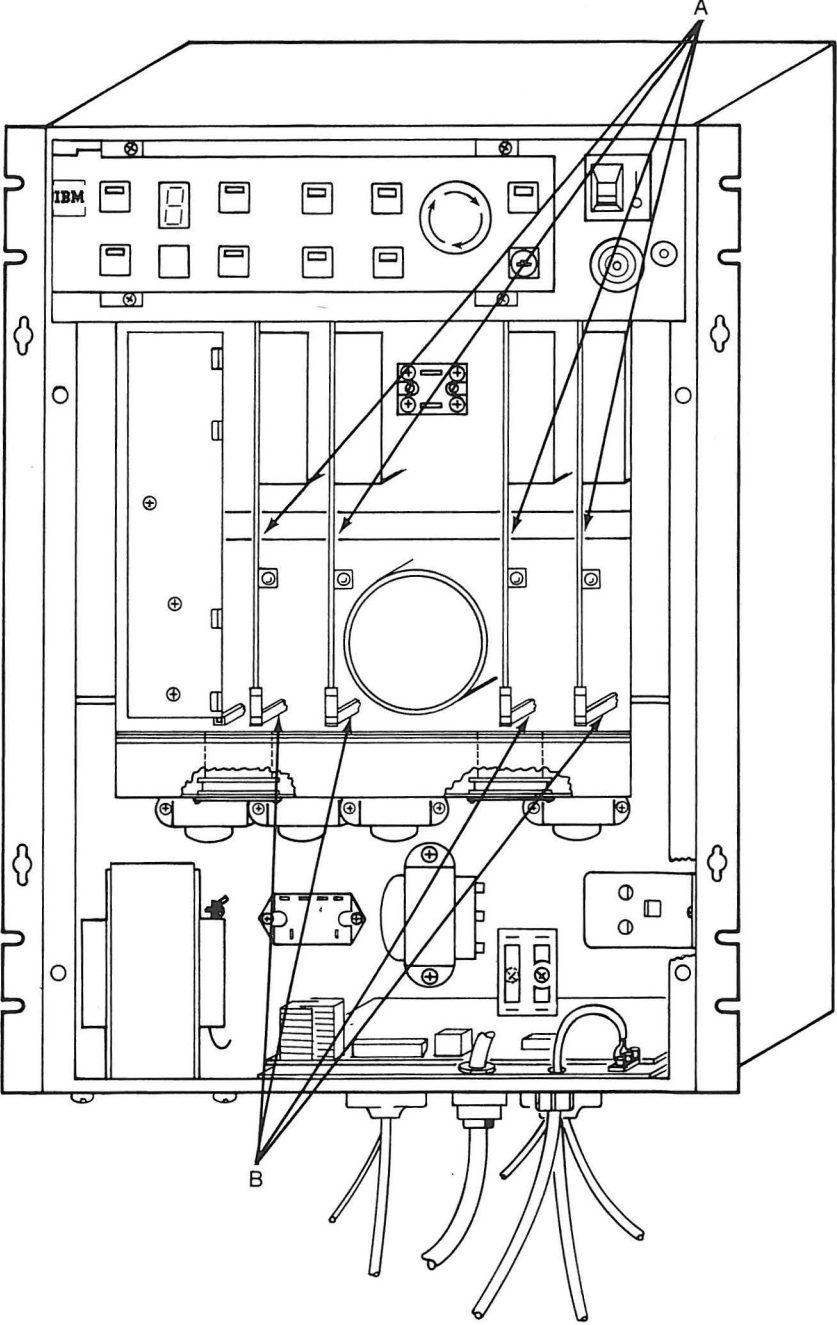
3201 DC Power Supply

1. Ensure that power has been turned off and removed from all units.
2. Remove the Servo Power Module front cover.
3. Remove the dc power supply (A) from its card slot (B).
4. Plug the new power supply, ensuring proper seating, into its card slot (B).
5. Power up the Servo Power Module and ensure that power up routines perform satisfactorily.
6. Replace the Servo Power Module front cover.



3202 Servo Amplifier Card

1. Ensure that power has been turned off and removed from all units.
2. Remove the Servo Power Module front cover.
3. Remove the appropriate servo amplifier card (A) from its card slot (B).
4. Plug the new servo amplifier card, ensuring proper seating, into its card slot (B).
5. Power up the Servo Power Module and ensure that power up routines perform satisfactorily.
6. Replace the Servo Power Module front cover.



3203 Cooling Fan Removal

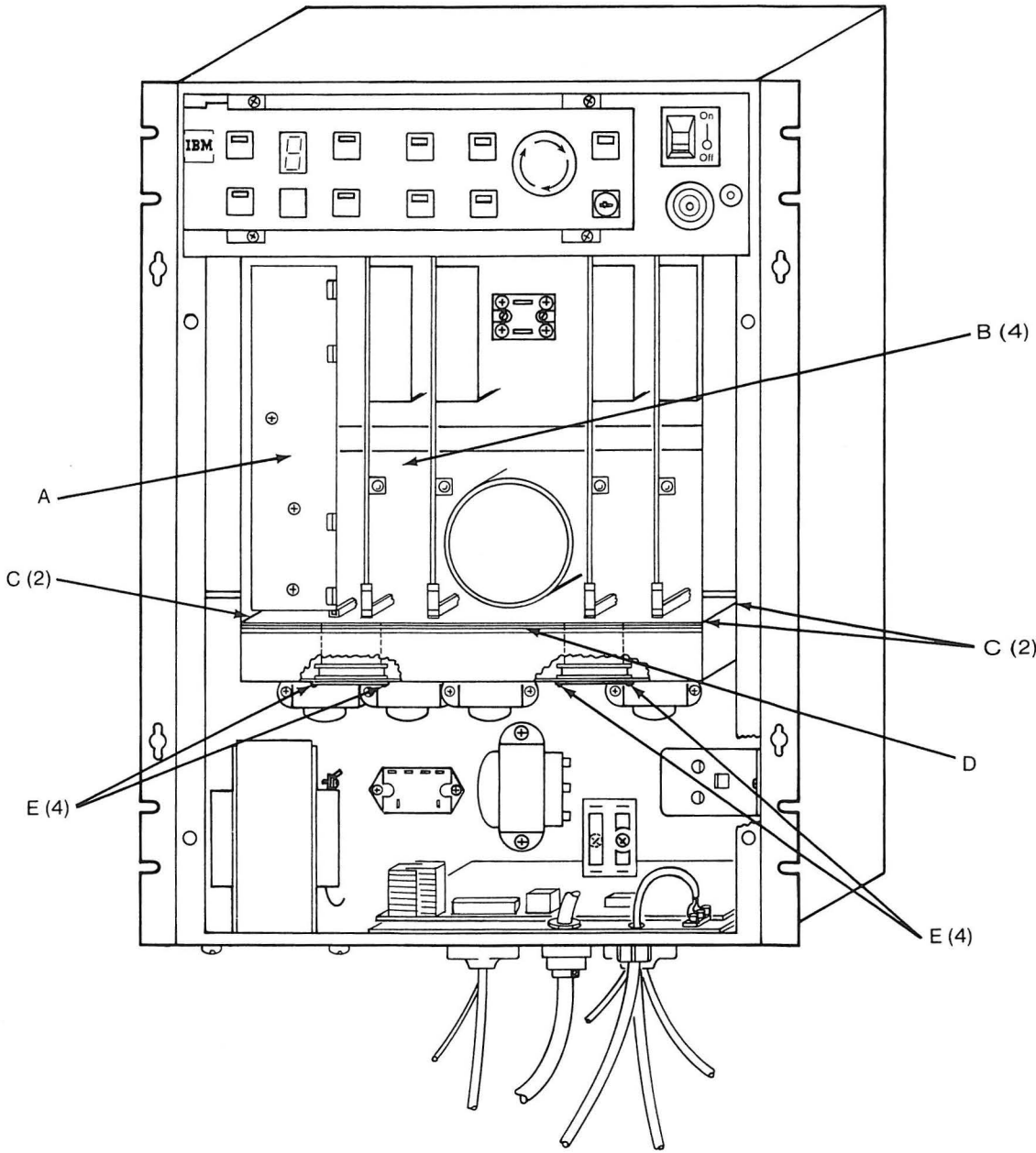
DANGER

THIS PROCEDURE REQUIRES THAT THE 230 VAC BE TURNED OFF AND DISCONNECTED AT THE POWER SOURCE PRIOR TO STARTING THE PROCEDURE. TURNING OFF THE SWITCH IS NOT SUFFICIENT.

1. Ensure that electrical power has been turned off and removed from all units.
2. Remove the Servo Power Module front cover.
3. Remove all four servo amplifier cards (B).
4. Remove the Servo Power Module power supply (A) (3201).
5. Locate and remove the four mounting screws (C) that hold the cooling fan mounting bracket to the bottom of the servo card cage (D).
6. Carefully remove the fan mounting bracket and turn it over (fans facing up).
7. Disconnect the power cable and the ground wire from the fan being replaced.

Note: Observe the position of the power connector on the fan in relation to the bracket for correct reassembly.

8. Remove the four fan mounting screws (E).
9. Remove the fan from the fan mounting bracket.



3204 Cooling Fan Replacement

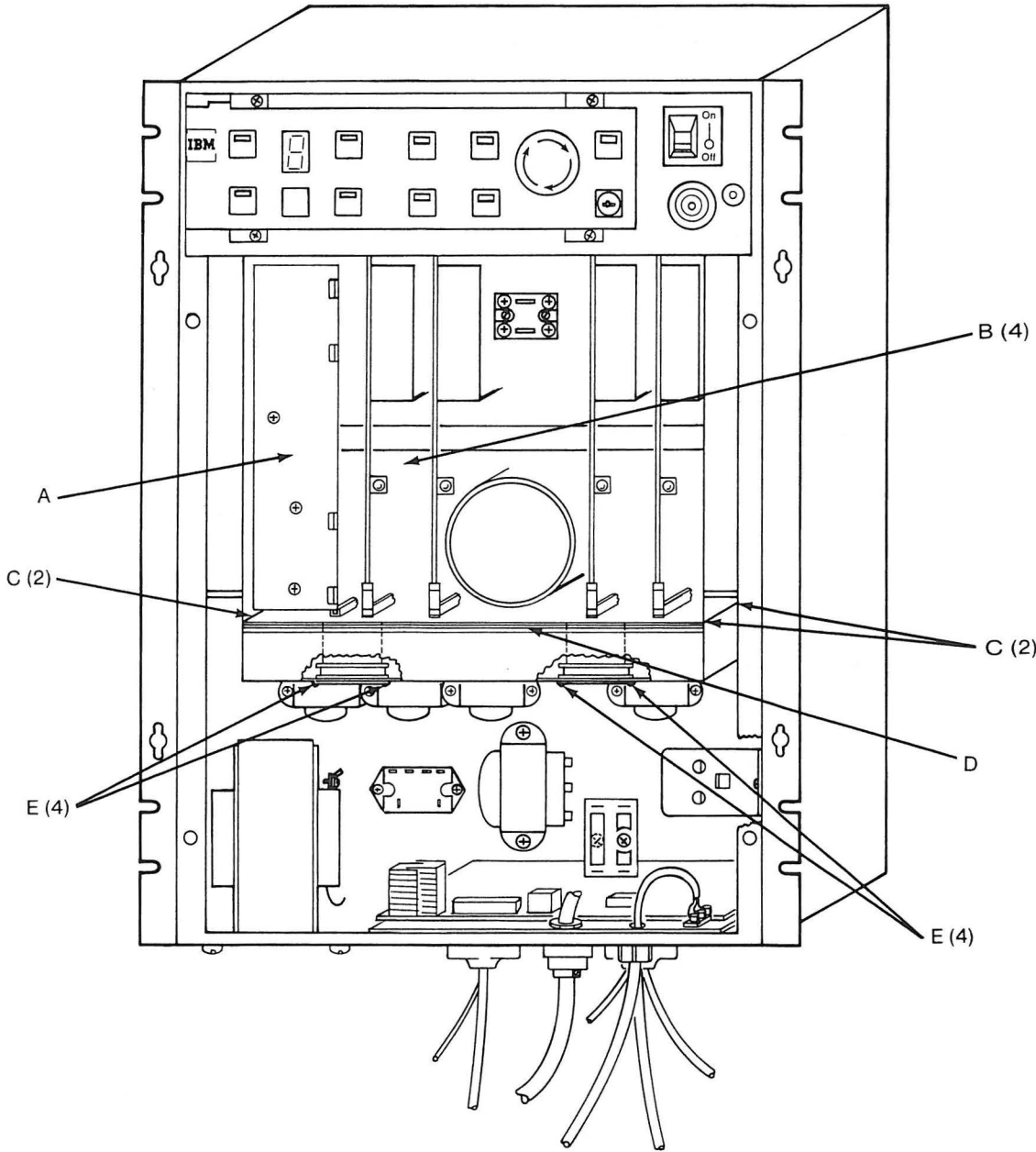
DANGER

THIS PROCEDURE REQUIRES THAT THE 230 VAC BE TURNED OFF AND DISCONNECTED AT THE POWER SOURCE PRIOR TO STARTING THE PROCEDURE. TURNING OFF THE SWITCH IS NOT SUFFICIENT.

1. Ensure that electrical power has been turned off and removed from all units.

Note: Observe the position of the power connector on the fan in relation to the bracket for correct reassembly.

2. Install the fan on the fan mounting bracket with the four fan mounting screws (E).
3. Connect the power cable and the ground wire to the fan being replaced.
4. Position the fan mounting bracket under the card cage.
5. Install the four mounting screws (C) that hold the cooling fan mounting bracket to the bottom of the servo card cage (D).
6. Install the Servo Power Module power supply (3202).
7. Install the four servo amplifier cards (B).
8. Install the Servo Power Module front cover.
9. Reconnect power to the Servo Power Module at its source.

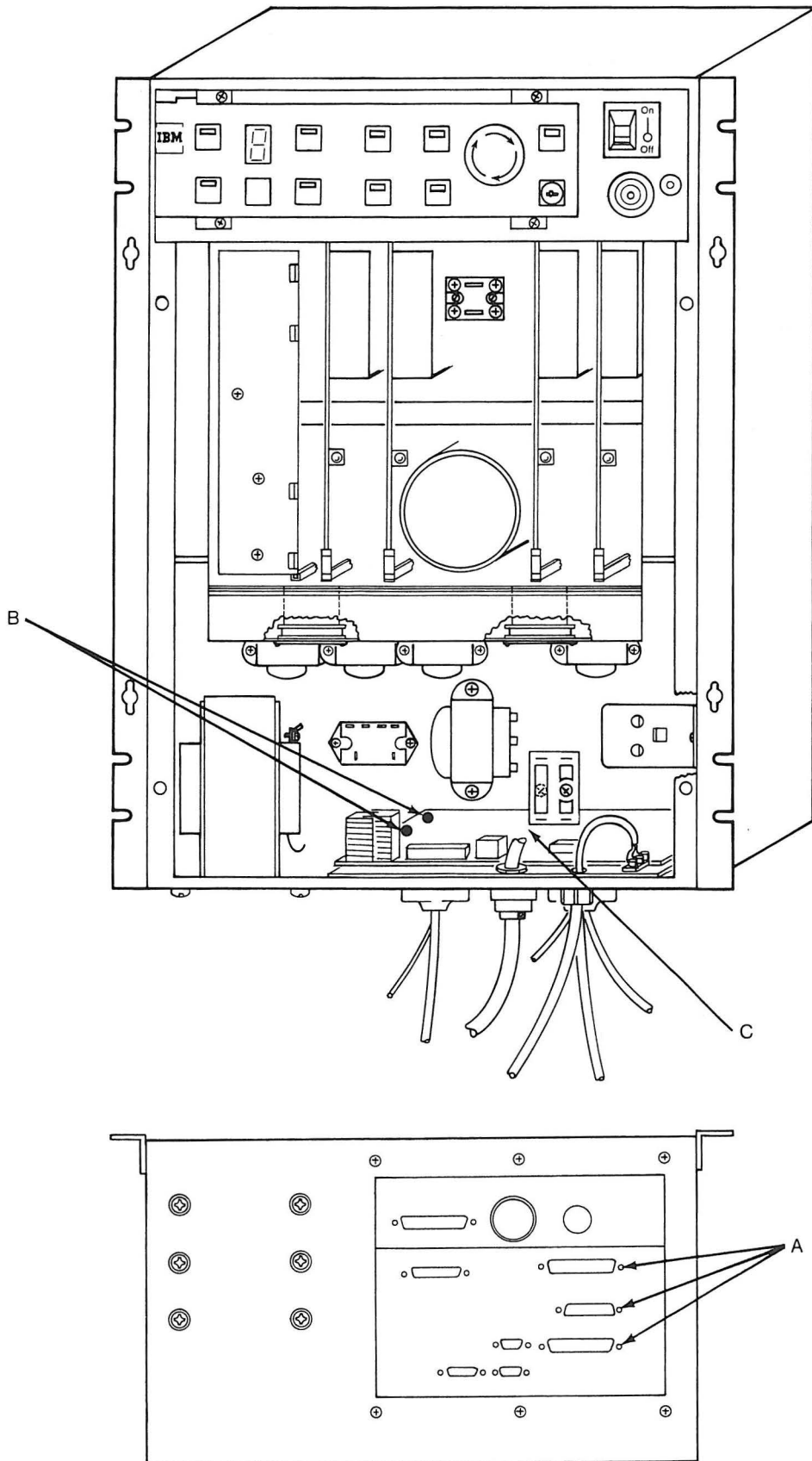


3205 Manipulator Interface Board Removal

DANGER

THIS PROCEDURE REQUIRES THE TECHNICIAN TO WORK AROUND THE 230 VAC INPUT WIRING. THE 230 VAC MUST BE OFF AND DISCONNECTED AT THE POWER SOURCE PRIOR TO STARTING THIS PROCEDURE. TURNING OFF THE SWITCH IS NOT SUFFICIENT.

1. Ensure that power has been turned off and removed from all units.
2. Remove the Servo Power Module front cover.
3. Disconnect all D-shell connector cables from underneath the Servo Power Module.
4. Remove the 14 nuts (A) holding the connectors to the connector panel from underneath the Servo Power Module.
5. Remove the two screws (B) that hold the manipulator interface board (C) to the stand-offs.
6. Pull the manipulator interface board assembly up and forward, and disconnect the nine cables from the top of the manipulator interface board assembly (C).
7. Lift the manipulator interface board assembly (C) out of the Servo Power Module cabinet.

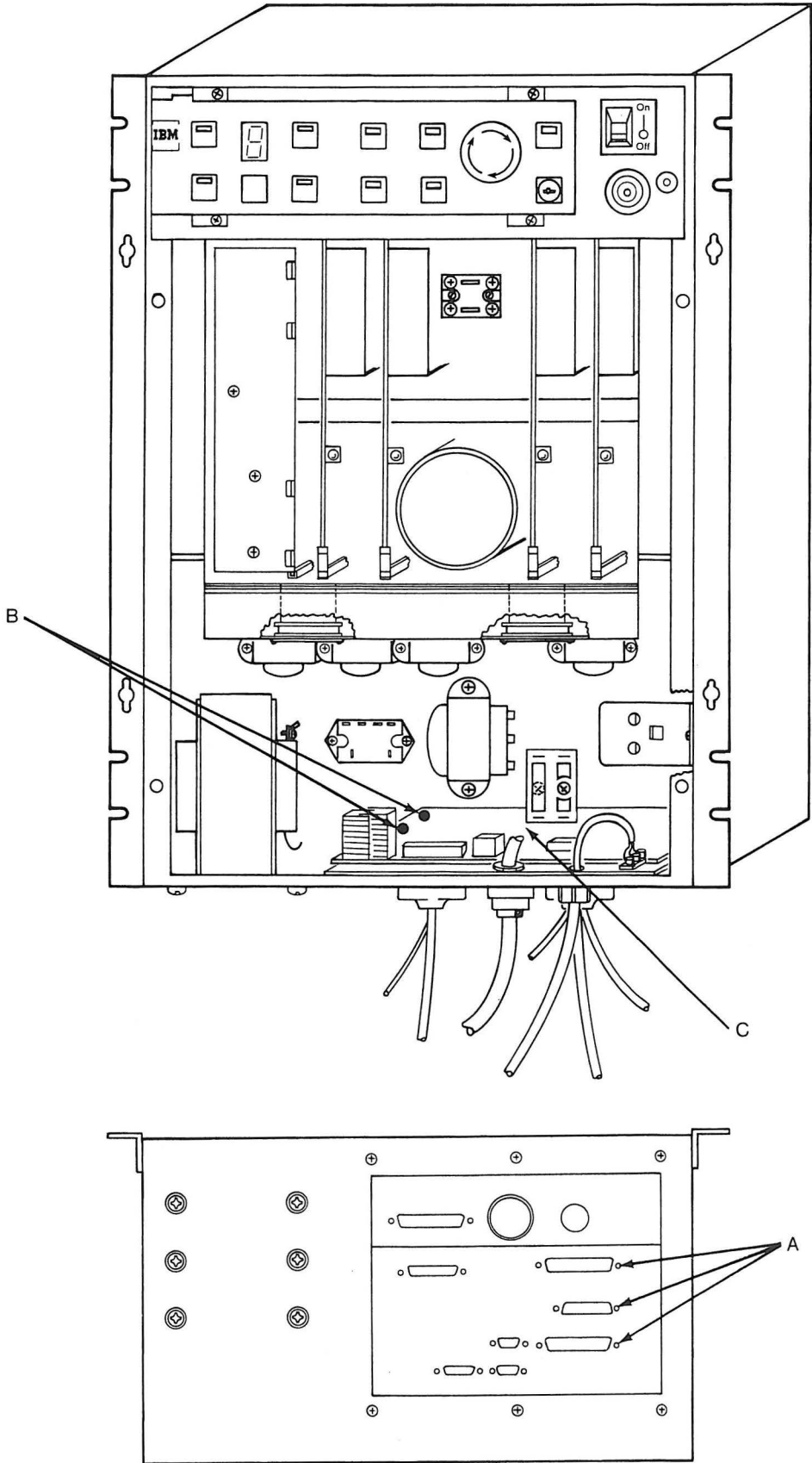


3206 Manipulator Interface Board Replacement

DANGER

THIS PROCEDURE REQUIRES THE TECHNICIAN TO WORK AROUND THE 230 VAC INPUT WIRING. THE 230 VAC MUST BE OFF AND DISCONNECTED AT THE POWER SOURCE PRIOR TO STARTING THIS PROCEDURE. TURNING OFF THE SWITCH IS NOT SUFFICIENT.

1. Ensure that power has been turned off and removed from all units.
2. Place the manipulator interface board assembly (C) in the Servo Power Module.
3. Install the nine cables on the top of the manipulator interface board.
4. Place the manipulator interface board assembly (C) in its final position and install the two screws (B) that hold the manipulator interface board to the stand-offs.
5. From underneath the Servo Power Module, install the 14 nuts (A) that hold the manipulator interface board assembly.
6. Connect the cables underneath the manipulator interface board panel.
7. Replace the front cover on the Servo Power Module.
8. Reconnect the power to the Servo Power Module circuit at the source.



3207 Silicon Power Rectifier

1. Ensure that power has been turned off and removed from all units.
2. Remove the Servo Power Module front cover.
3. Remove all four servo amplifier cards (C) from the card cage.
4. Disconnect each lead from the terminals on the silicon power rectifier (A), marking each with its location for replacement.
5. Remove the two screws (B) holding the silicon power rectifier (A) to the rear panel and remove the silicon power rectifier.

Note: Retain the frame ground lead from the negative (-) terminal for reinstallation.

6. For replacement, reverse the above procedure.

3208 AC Line Filter

1. Ensure that power has been turned off and removed from all units.
2. Remove the Servo Power Module front cover.
3. Disconnect each lead from the terminals on the ac line filter (D), marking each with its location for replacement.
4. Remove the two screws (E) holding the ac line filter (D) to the side panel and remove the filter.
5. For replacement, reverse the above procedure.