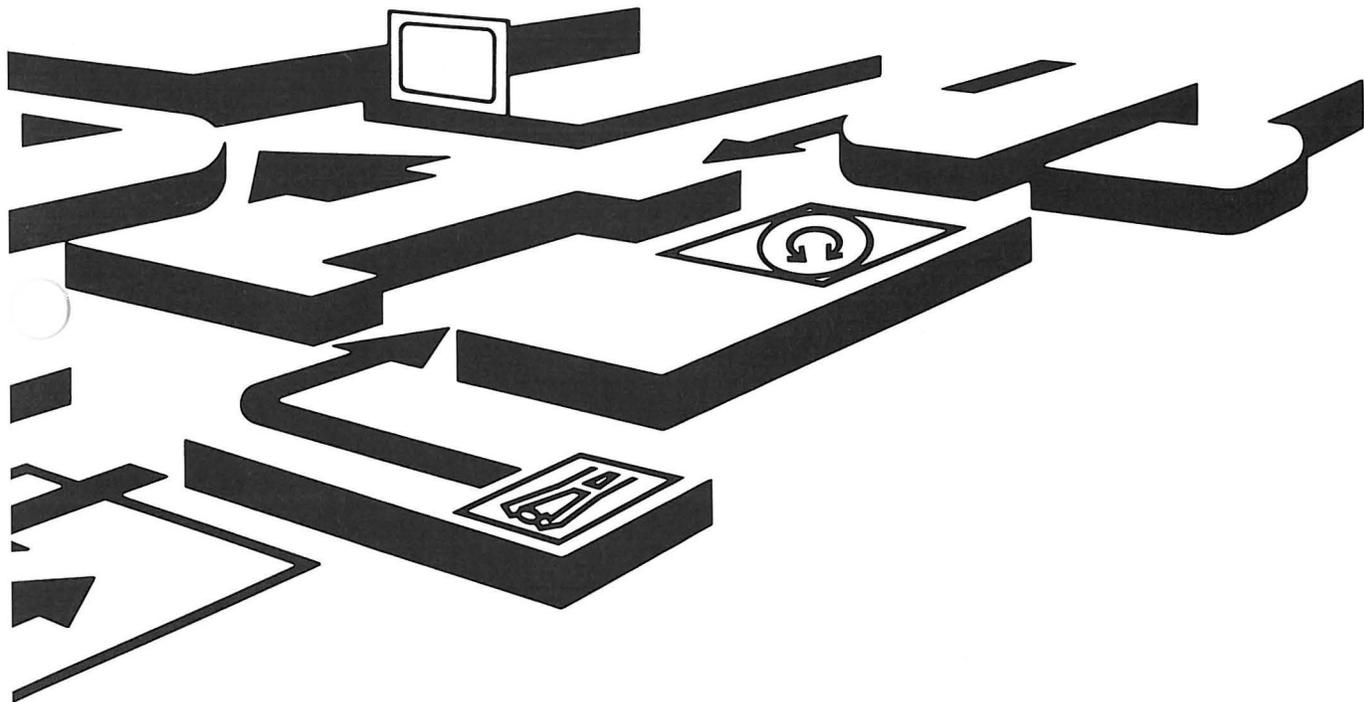




AML/2™
Application Development Environment
User's Guide



IBM Manufacturing Systems
Software Library

First Edition (August 1986)

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PREFACE

PURPOSE

Programs written in A Manufacturing Language/2 (AML/2)¹ control the movements of an IBM 7575 or 7576 Manipulator. The AML/2 Application Development Environment (ADE) is a set of tools for writing and testing AML/2 programs. It runs on a stand-alone IBM Industrial Computer or equivalent.

The IBM AML/2 Application Development Environment (ADE) consists of a set of software tools for writing and testing AML/2 application programs. The ADE includes an editor, a debugger, a simulated teach screen, utilities that facilitate the transfer of programs to or from an IBM 7575 or 7576 Manufacturing System, and a feature that allows the stand-alone computer to act as a terminal connected to the AML/2 Manufacturing Control System.

The stand-alone computer that is used for the ADE is referred to as a roll-up computer because the ADE can be used for offline development, and can then be connected to the IBM 7575 or 7576 Manufacturing System with a communications cable.

The AML/2 Application Development Environment User's Guide describes the various program development tools and how to use them. To use this book, you should:

- Be familiar with the IBM Personal Computer Disk Operating System (DOS)
- Understand basic programming concepts
- Be familiar with AML/2
- Know how to use the AML/2 Manufacturing Control System

Note: Hereafter, the Disk Operating System will be referred to simply as DOS, the IBM 7575 or 7576 Manufacturing System as the controller, and the stand-alone computer containing the ADE as the roll-up computer.

The subject matter in this manual is contained in seven chapters, two appendixes, and a glossary:

- Chapter 1, "Getting Started," discusses the hardware configuration required to use the ADE, and describes how to install and start the ADE.

¹ AML/2 is a trademark of International Business Machines Corporation.

- Chapter 2, "Menu," describes the ADE menu, which allows you to perform any of the other ADE functions.
- Chapter 3, "Editor," describes the ADE editor, which you may use to develop your application programs.
- Chapter 4, "Teach," describes the two ways to enter manipulator locations into your application program. The first way is to recall points from an IBM 7575 or 7576 Manufacturing System. The second way is to use a simulated teach screen of the manipulator workspace.
- Chapter 5, "Debugger," describes the ADE debugger, which enables you to locate errors in your application programs.
- Chapter 6, "Download/Upload," describes the ADE download and upload facilities, programs that you may use to transfer your application programs to and from an IBM 7575 or 7576 Manufacturing System.
- Chapter 7, "Online Help," describes the ADE online help facility, a menu-driven program that displays helpful information for the ADE and AML/2 language.
- Appendix A, "Messages," lists error messages and provides appropriate recovery actions.
- Appendix B, "The Files on the ADE Diskettes," describes the contents of each of the files contained on the ADE diskettes.

RELATED PUBLICATIONS

To understand this user's guide you will need to become familiar with the following manuals:

- IBM 7575 and 7576 Manufacturing System Hardware Library Operator's Guide, Part Number 70X8903

When developing and testing a program, the programmer must be able to operate the IBM 7575 or 7576 Manufacturing System. This includes powering on the system, using the operator panel, and using the pendant, a handheld device that can be used to teach points in the application. These topics are described in this book.

- IBM Manufacturing Systems Software Library AML/2 Manufacturing Control System User's Guide, Part Number 67X1370

This user's guide describes the AML/2 Manufacturing Control System, which consists of the AML/2 language, an installation procedure, a configuration utility, and a protocol for host communications. The primary emphasis of the book is on the most common features of the AML/2 language.

- IBM Personal Computer Disk Operating System (DOS) Reference, Level 3.0 or later.

This manual explains how to use the IBM Personal Computer Disk Operating System, and describes the DOS commands, some of which you will use while installing the AML/2 Application Development Environment.

- IBM Manufacturing Systems Hardware Library Industrial Computer Operator's Guide for your model of roll-up computer

This book contains information on how to use an IBM Industrial Computer.

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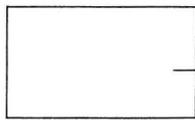
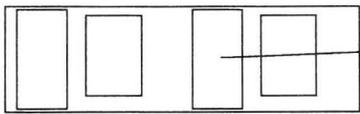
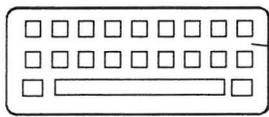
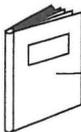
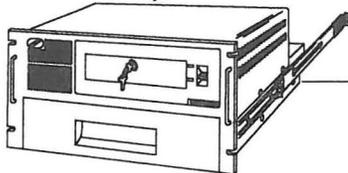
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Inventory Checklist

-  Warranty
-  Setup Instructions
-  Keyboard
-  Installation and Operations Guide
-  Keyboard Cable
-  Power Cord
-  System Unit (with 4 keys)

33F9167

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CHAPTER 1. GETTING STARTED

The ADE is distributed on two 5-1/4 inch double-sided diskettes. Before you can use the ADE, you must:

- Ensure that your roll-up computer is properly configured
- Install the ADE on an optional fixed disk or on blank diskettes
- Make changes to the AUTOEXEC.BAT and the CONFIG.SYS files

This chapter discusses the following topics:

- Configuration of the roll-up computer
- Installation on a fixed disk system
- Installation on a diskette system
- Changing AUTOEXEC.BAT and CONFIG.SYS
- Connecting the roll-up computer to the IBM 7575 or 7576 Manufacturing System

Note: The ADE program diskettes (Volumes 1 and 2) contain many files. Refer to Appendix B, "The Files on the ADE Diskettes," for a description of the contents of each file.

CONFIGURATION OF THE ROLL-UP COMPUTER

Using the ADE requires the following:

- Any IBM Industrial Computer, or equivalent.
- Two 5-1/4 inch double-sided diskette drives, or either a 5-1/4 inch double-sided or high-capacity diskette drive and one fixed disk.
- A supply of diskettes for installing the ADE and for storing application programs.
- A minimum of 256KB memory; the recommended memory size is 512KB or more.
- An RS-232-C asynchronous communications adapter and cable.
- IBM DOS 3.0 or later.
- The following IBM printers (or equivalent) are optional: IBM 5533 Industrial Graphics Printer, IBM 5152 Graphics Printer, or IBM Proprinter. To use one of these printers, an adapter containing a printer port is needed.

- A display and the appropriate graphics adapter are required. The following table lists the resolution used by the ADE simulated teach screen with different display and graphics adapter configurations:

Display	Adapter	Colors	Resolution
IBM 7534 Industrial Graphics Display	Enhanced Graphics Adapter	Four colors	350 X 640
IBM 5532 Industrial Color Display	Enhanced Graphics Adapter	Four colors	200 X 640
IBM 5532 Industrial Color Display	Color/Graphics Monitor Adapter	Black and white	200 X 640
IBM 5151 Monochrome Display	Enhanced Graphics Adapter	Green and white	350 X 640

Notes:

1. The ADE uses only four colors for the Enhanced Graphics Adapter (EGA), regardless of the amount of memory installed on the EGA or the color display being used.
2. The IBM 5151 Monochrome Display is not supported by the IBM Industrial Computer product line. However, this display may be used with any computer in the IBM Personal Computer product line.
3. An IBM 5151 Monochrome Display and IBM Monochrome Display and Printer Adapter supports every ADE utility except the simulated teach screen.

INSTALLATION ON A FIXED DISK SYSTEM

This section provides instructions on how to install the ADE on a fixed disk system; that is, the ADE files are copied into a directory on the fixed disk. If you want to install the ADE on a diskette system, refer to "Installation on a Diskette System" on page 1-5.

Note: In many of the instructions that follow, you are asked to "Enter" a command. This means you should type the information, as instructed, and then press the Enter key.

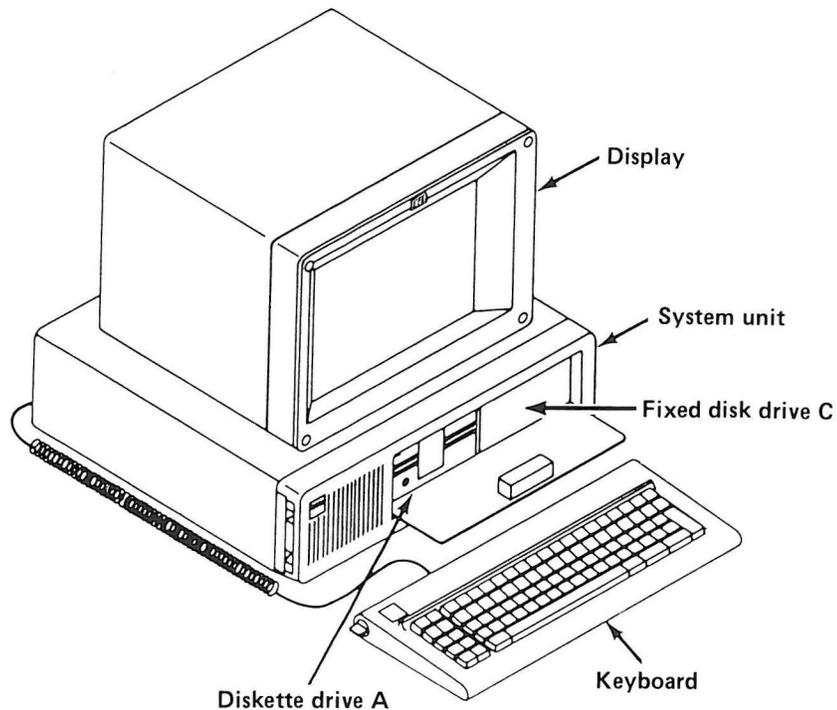


Figure 1-1. Roll-up Computer with a Fixed Disk Installed

Before installing the ADE on the fixed disk, ensure that the fixed disk has been partitioned and formatted as the system disk with DOS 3.0 or later. For help in partitioning and formatting the fixed disk, refer to the DOS reference manual. To install the ADE:

1. Power on the roll-up computer and display, and wait for DOS to finish its initialization procedure. If prompted, enter the date and time. When DOS has completed its initialization procedure, the DOS prompt is displayed.

2. Change to the root directory by entering:

```
CD\
```

3. Create a new directory for the ADE. To do this, enter:

```
MD ADE
```

Note: The following instructions assume that you create a directory called ADE. If you have chosen a different name, use that name instead of ADE in the following instructions.

4. After creating the ADE directory, enter the Change Directory command. To do this, enter:

```
CD ADE
```

The ADE provides DOS path support. This means that all the ADE programs are placed in the ADE directory, yet they can be run from any directory on the system. In order for this to work, the DOS PATH command must be executed. The PATH command can be placed in a special file called AUTOEXEC.BAT. This file is executed by DOS when the system is powered on. Refer to step 6 for more information on AUTOEXEC.BAT.

5. Transfer the ADE programs and files into the ADE directory:
 - a. Insert Volume 1 of the ADE program diskettes in diskette drive A. Close the diskette drive door.

- b. Enter:

```
A:AUTOINIT
```

- c. Watch the screen carefully. When prompted, replace Volume 1 of the ADE program diskettes with Volume 2.
 - d. Make note of any messages AUTOINIT displays about the AUTOEXEC.BAT and CONFIG.SYS files. This information is required to complete the installation.
6. Edit the AUTOEXEC.BAT file and add the following commands:
 - a. GRAFTABL
 - b. DATE and TIME (Unless the roll-up computer has a clock with battery backup)
 - c. DATE
 - d. TIME
 - e. PATH C:\ADE;

To automatically display the ADE menu, the MENU command may be added to the AUTOEXEC.BAT file. This command must be added after the DOS PATH command. "Changing AUTOEXEC.BAT and CONFIG.SYS" on page 1-7 gives detailed instructions for using the ADE editor to change AUTOEXEC.BAT.

7. To ensure that GRAFTABL.COM is in your root directory, after the DOS prompt is displayed, enter:

```
DIR \GRAFTABL.COM
```

If this file is not in the root directory, copy it from the DOS diskette.

8. Follow the instructions under "Changing AUTOEXEC.BAT and CONFIG.SYS" on page 1-7 if the AUTOINIT displayed messages indicating that you should edit the CONFIG.SYS or AUTOEXEC.BAT file.
9. Press the Alt, Ctrl, and Del keys simultaneously to restart DOS. This must be done for two reasons:
 - a. To enable communications between the roll-up computer and the IBM 7575 or 7576 Manufacturing System
 - b. To reinitialize the system so that the new AUTOEXEC.BAT is used, which sets up the new PATH and performs GRAFTABL

You are now ready to begin using the ADE. The ADE provides a menu that permits easy access to all the other ADE features. To display the ADE menu, enter:

MENU

Refer to Chapter 2, "Menu," for instructions on how to use the ADE menu.

INSTALLATION ON A DISKETTE SYSTEM

This section provides instructions on how to install the ADE on a diskette system; that is, the ADE files are copied to new diskettes. If you want to install the ADE on a fixed disk system, refer to "Installation on a Fixed Disk System" on page 1-2.

Note: In many of the instructions that follow, you are asked to "Enter" a command. This means you should type the information, as instructed, and then press the Enter key.

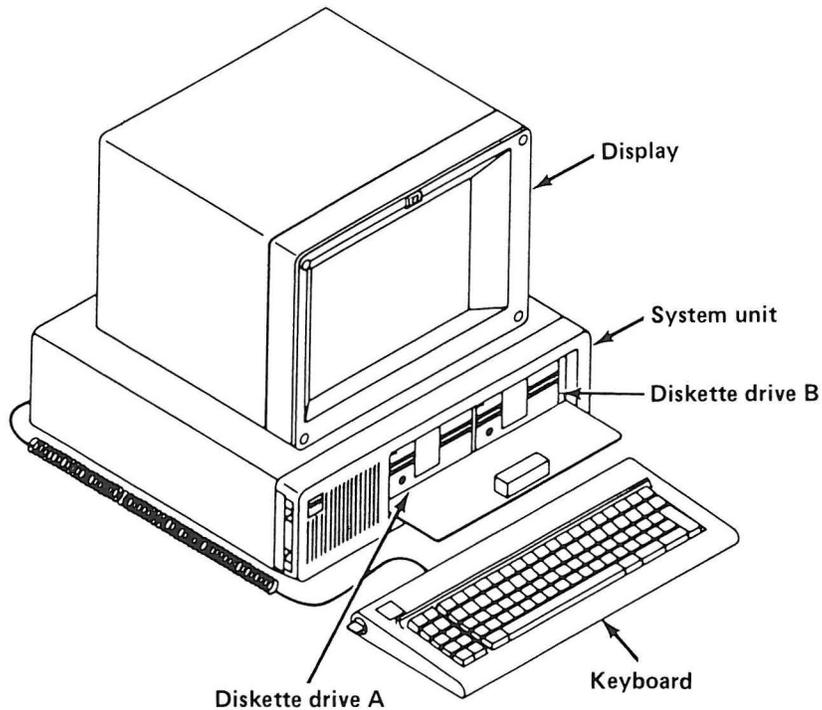


Figure 1-2. Roll-up Computer with Two Diskette Drives Installed

To install the ADE on diskettes:

1. Have available:

- DOS 3.0 (or later) program diskettes
- ADE program diskettes (Volumes 1 and 2)
- Two blank diskettes

2. Insert the DOS diskette in drive A (refer to Figure 1-2 if necessary). Close the drive door.

3. Power on the roll-up computer and display, and wait for DOS to finish its initialization procedure. If prompted, enter the date and time.

4. Insert Volume 1 of the ADE program diskettes in diskette drive B. Close the drive door.

5. Enter:

```
B:AUTOINIT
```

6. Watch for the prompts that give instructions on how to proceed. AUTOINIT prompts are easy to follow, and are different for each type of roll-up computer.

Note: Each ADE program diskette is referred to as a "source" diskette. Each blank diskette you insert in the drive is called a "target" diskette.

7. Label target diskettes in the order you remove them from the drive. The first is "ADE Volume 1"; the second is "ADE Volume 2."

Note: Do not put write-protect tabs on the ADE diskettes created by AUTOINIT.

8. The following steps must be performed before the ADE is ready to use:
 - a. Insert the created ADE Volume 1 diskette in drive A, and close the drive door.
 - b. Insert the created ADE Volume 2 diskette in drive B, and close the drive door.
 - c. Press the Alt, Ctrl, and Del keys simultaneously to restart DOS.
 - d. Enter the date and time when prompted.

You are now ready to begin using the ADE. The ADE provides a menu that permits easy access to all the other ADE features. To display the ADE menu, enter:

MENU

Note: Throughout this user's guide, references are made to the ADE diskette Volume 1 and the ADE diskette Volume 2. The copies of the diskettes just created should be used, not the original ADE diskettes.

Refer to Chapter 2, "Menu," for instructions on how to use the ADE menu.

CHANGING AUTOEXEC.BAT AND CONFIG.SYS

The AUTOEXEC.BAT and CONFIG.SYS files are special files used by DOS. AUTOEXEC.BAT contains DOS commands that are executed each time DOS is initialized. CONFIG.SYS contains configuration values and device drivers used by DOS. (Refer to "CONFIG.SYS" on page 1-9 for an explanation of device drivers.)

The AUTOINIT procedure for a diskette system creates these two files on the ADE diskette Volume 1. For a fixed disk system, AUTOINIT modifies only the CONFIG.SYS file. This section lists required and optional changes to these two files. Have the IBM Personal Computer Disk Operating System (DOS) Reference available while reviewing this section.

Note: If you make any changes to either AUTOEXEC.BAT or CONFIG.SYS, remember to press the Alt, Ctrl, and Del keys simultaneously to reinitialize DOS with the changes.

Changing AUTOEXEC.BAT on a Fixed Disk System

1. Ensure that the ADE directory is the default directory (or the current directory), by entering:

```
CD \ADE
```

2. Enter:

```
ED \AUTOEXEC.BAT
```

The edit screen is displayed.

3. Use the PgUp and PgDn keys to browse the AUTOEXEC.BAT file.
4. When ready to add commands, press F10 to move to the bottom of the AUTOEXEC.BAT file.
5. To insert blank lines, enter:

```
I
```

6. Enter:

```
GRAFTABL  
DATE  
TIME
```

Note: If the roll-up computer has a clock with battery backup, do not enter the DATE and TIME commands in AUTOEXEC.BAT.

7. If AUTOEXEC.BAT does not have a PATH command, insert a line with the ADE directory:

```
PATH C:\ADE;
```

If AUTOEXEC.BAT already has a PATH command, add the ADE directory to it as follows:

```
PATH C:\DIR1;C:\DIR2;C:\ADE;
```

8. If you want the ADE menu to be displayed automatically every time the roll-up computer is powered on, enter:

```
MENU
```
9. When you have finished adding lines to AUTOEXEC.BAT, press the Enter key on the next empty line.
10. Press F8 to save the changes to AUTOEXEC.BAT.
11. Reinitialize the system by pressing the Alt, Ctrl, and Del keys simultaneously. This reinitializes DOS with the new AUTOEXEC.BAT file.

Changing AUTOEXEC.BAT on a Diskette System

An AUTOEXEC.BAT file is automatically created on a diskette system with the following commands:

```
GRAFTABL
PATH A:\;B:\;
DATE
TIME
```

CONFIG.SYS

CONFIG.SYS is a file that DOS uses to load important configuration parameters. On a diskette system, CONFIG.SYS must be on Volume 1 of the ADE program diskettes. On a fixed disk system, CONFIG.SYS must be in the root directory. The parameters from CONFIG.SYS are loaded when DOS is initialized, and remain in effect until the next time DOS is initialized. In order to use the ADE, several values must be placed in CONFIG.SYS. AUTOINIT automatically adds the following lines to the CONFIG.SYS file:

```
BREAK=ON
FILES=20
BUFFERS=12
FCBS=16,8
DEVICE = TERMDEV1.SYS 03F8 000C 0007
DEVICE = ROLLDEV1.SYS 03F8 000C 0007 0003 0014 0008
DEVICE = TERMDEV2.SYS 02F8 000C 0007
DEVICE = ROLLDEV2.SYS 02F8 000C 0007 0003 0014 0008
```

These values are added, regardless of the other values already present in CONFIG.SYS. The first four values are DOS parameters that are explained in the IBM Personal Computer Disk Operating System (DOS) Reference manual. The last four values are the communications device drivers needed in order for the roll-up computer to communicate with an IBM 7575 or 7576 Manufacturing System.

A communications device driver is a program that allows the roll-up computer to send information through its communications ports. All roll-up computers must have at least one asynchronous communications adapter in order to communicate with the IBM 7575 or 7576 Manufacturing System. If the roll-up computer has more than one communications adapter, you must set the jumpers on the adapters so that the system knows which adapter contains the primary communications port (referred to as COM1) and which adapter contains the secondary communications port (referred to as COM2).

The ADE uses the TERMDEV1 and ROLLDEV1 device drivers to communicate through the primary communications port. The TERMDEV2 and ROLLDEV2 device drivers communicate through the secondary communications port. These are the last four lines added to CONFIG.SYS by AUTOINIT. If you wish to install additional device drivers, add a DEVICE= line to CONFIG.SYS.

To modify any of these values or to add additional device drivers, use the ADE editor as follows:

1. Enter:

```
ED \CONFIG.SYS
```

The CONFIG.SYS file is displayed in the editor's program window.

2. Make the desired changes to CONFIG.SYS. If you need help with using the keys, refer to "Using the Keyboard" on page 3-5.
3. Press F8 to save the changes and exit the editor.

Note: After any changes to CONFIG.SYS, remember to restart DOS by pressing the Alt, Ctrl, and Del keys simultaneously. This reinitializes DOS with the new CONFIG.SYS file.

USING THE ROLL-UP COMPUTER WITH THE IBM MANUFACTURING SYSTEM

If you have not used the IBM Manufacturing System hardware, review the IBM 7575 and 7576 Manufacturing System Hardware Library Operator's Guide before continuing.

To review, the manufacturing system consists of these major components:

- Manipulator

The IBM 7575 or 7576 Manipulator looks like an arm and is often referred to as a "robot." It performs manufacturing tasks. You can move the manipulator either with an AML/2 program or with the pendant.

- Pendant

The pendant, which has a keypad and display, can be connected to the system so that you can press its buttons to move the manipulator. The pendant display shows the manipulator's position as it moves.

- Controller

The IBM 7532 Industrial Computer Model 310 interprets and runs your AML/2 program. The controller has at least one diskette drive in front (Figure 1-4) and the connectors for the roll-up computer and pendant in the back (Figure 1-3).

- Servo power module

The IBM 7572 Servo Power Module, which includes the operator panel, is the electrical interface between the controller and the IBM 7575 or 7576 Manipulator. (The operator panel is shown in Figure 1-4.)

Warning: Always use extreme caution when power to the manipulator is on. The manipulator moves at high velocity. Sudden or unexpected manipulator movements can result in injury to personnel or damage to equipment in the work area.

Pressing the large red Manip Stop button on the servo power module's operator panel switches off power to the manipulator and stops it quickly.

Figure 1-4 shows the front of an IBM Manufacturing System controller and servo power module. Figure 1-3 shows the back of these units, and the back of the roll-up computer.

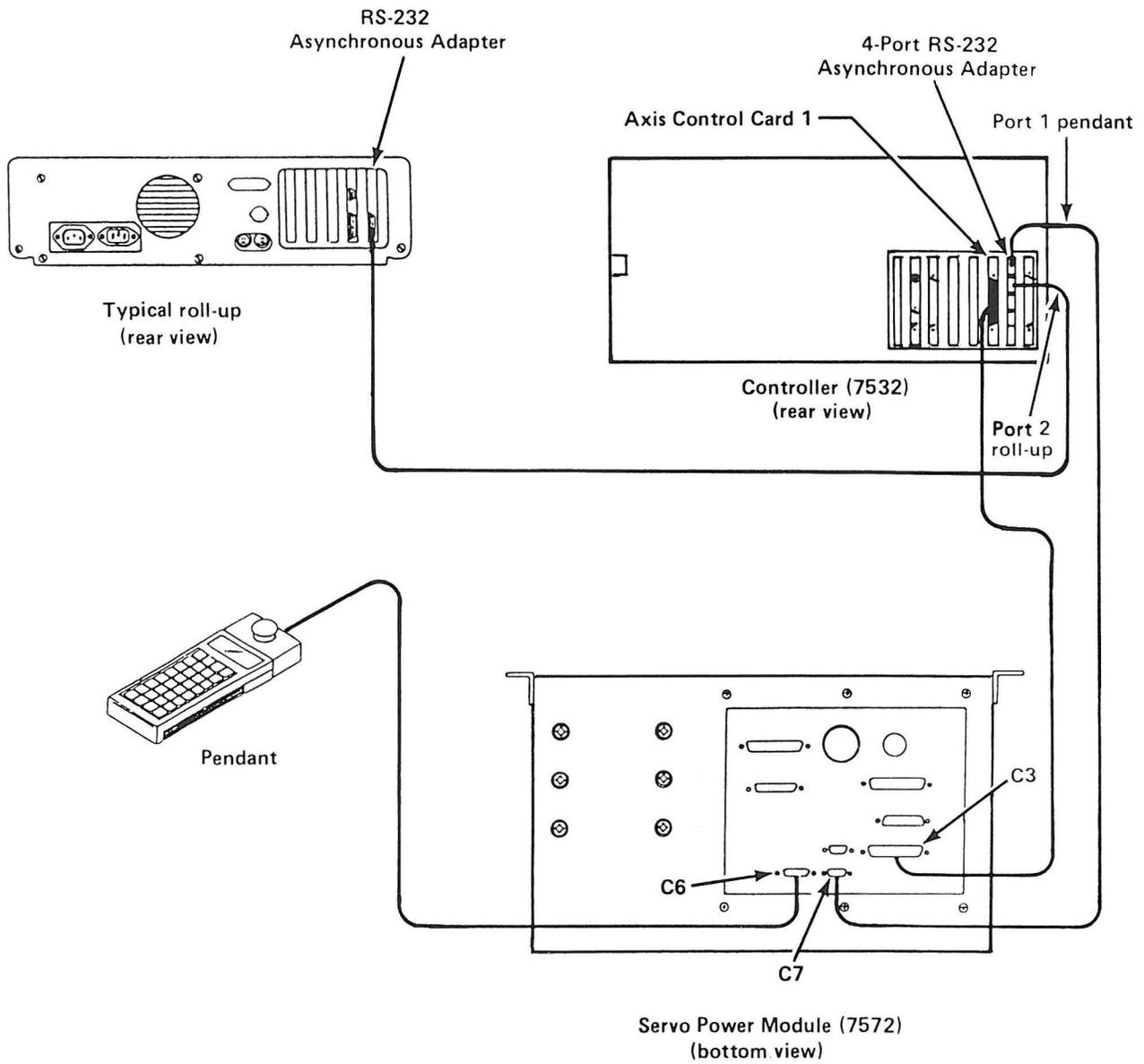


Figure 1-3. System Connections

Note: When the controller is first installed, pull the unit forward from its rack so that you can reach the back of it. Connect the communications cable at the second port from the top of the controller's asynchronous communications adapter as shown in Figure 1-3. Leave the cable connected to the controller for future use.

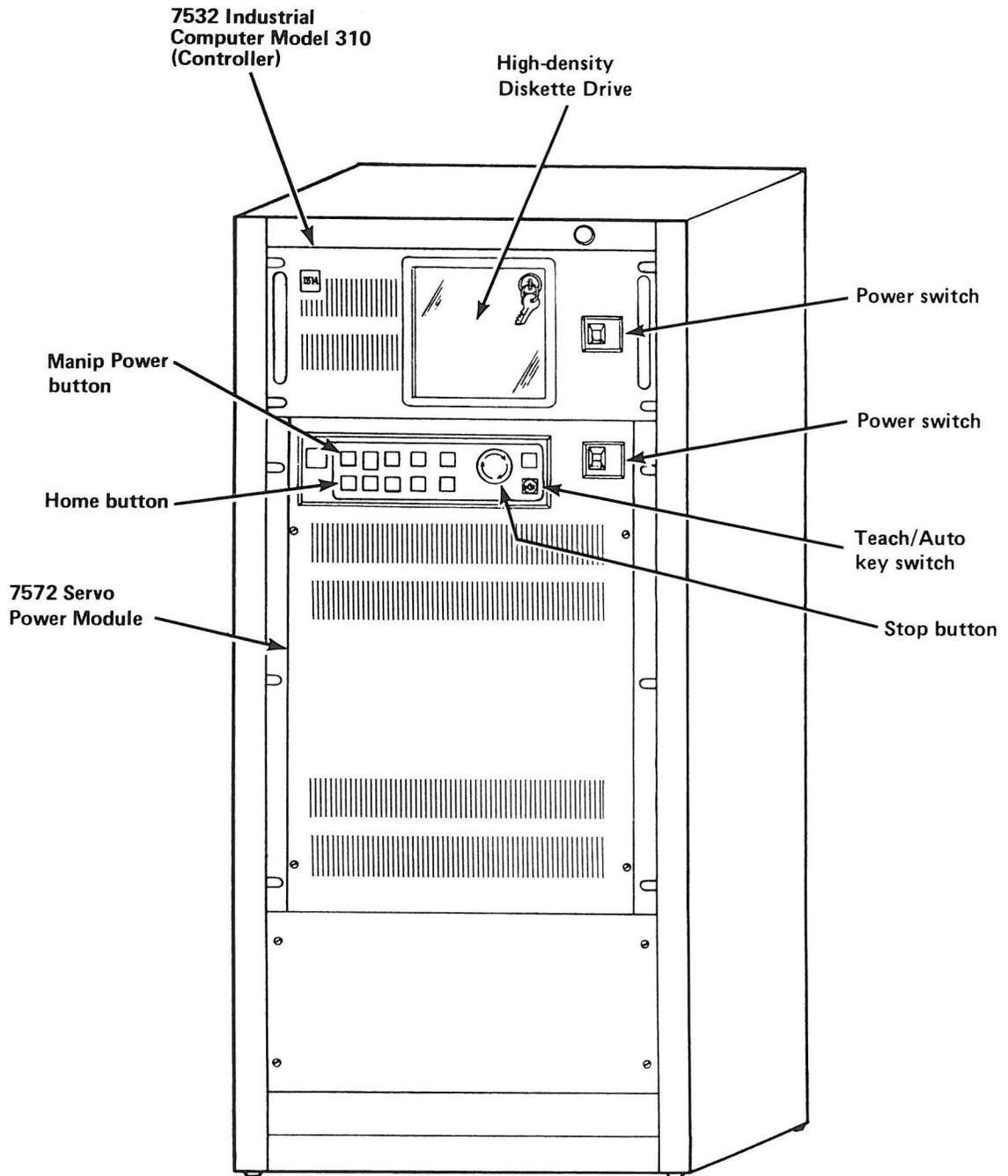


Figure 1-4. Controller and Servo Power Module (Front View)

Connecting the Roll-up Computer to the Controller

1. Move the roll-up computer to where the communications cable from the controller can reach it.

CAUTION

Place the roll-up computer and your chair where the manipulator cannot reach them as it moves.

2. Figure 1-3 shows the cable connected to the asynchronous communications adapter in the roll-up computer. Locate the same adapter on your roll-up computer, and connect the free end of the communications cable to it.

Readying the IBM Manufacturing System for Use

1. Move the Power switches on the controller and the roll-up computer to the On (|) position. (Refer to Figure 1-4.)
2. If saving or retrieving a file from a controller diskette drive, insert the diskette and close the drive door.

Complete the rest of this procedure if you will be using the manipulator. All the buttons, lights, and switches mentioned below are located on the operator panel on the servo power module.

3. If debugging with the manipulator:
 - a. Move the key switch to Auto.
 - b. If the Home light is off, press the Home button.
4. If teaching with the pendant:
 - a. Ensure that the pendant is connected. (Figure 1-3 shows the correct connections.)
 - b. Move the Stop buttons clockwise to the On position.
 - c. Press the Manip Power button to apply power to the manipulator motors.
 - d. Move the key switch to the Auto position to home the manipulator.

If the operator panel Home light is off, press the Home button.
 - e. Turn the key switch to Teach.

SAFETY

Safety cannot be overemphasized. Before performing any work on the manufacturing systems described in this book, be sure to read and understand the following safety notices.

INSTALLATION SITE SAFETY PRECAUTIONS

- Ensure compliance with all local and national safety codes for the installation and operation of the system.
- Observe the power and grounding instructions given in IBM 7575 and 7576 Manufacturing Systems Hardware Library Site Preparation, Installation, and Specifications, Part Number 70X8867.
- The system must not be installed in an explosive atmosphere.
- Fire extinguishers must be located within easy access.
- Consider installing intrusion devices or safety mats around the manipulator to drop power if the work area is penetrated.
- Consider installing additional emergency power-off (EPO) switches for feeders and other fixtures.
- Consider installing an emergency-off switch in the 19-inch rack to simultaneously power off the 7532 Industrial Computer and the 7572 Servo Power Module in an emergency.

OPERATION AND MAINTENANCE SAFETY PROCEDURES

Safety precautions should always be observed by all personnel operating or servicing IBM Manufacturing Systems. As with any electromechanical machine, unpredictable failures could occur while the system is in operation.

Whenever possible, power to the manipulator and to the Servo Power Module should be disconnected before starting any maintenance and before penetrating the manipulator work area. If it is not possible to disconnect power due to the nature of the work to be performed, extreme caution must be observed.

If you must penetrate the work area without disconnecting machine power, press the **Manip Stop** pushbutton on the Servo Power Module operator control panel or the remote **Manip Stop** pushbutton on the the end of the pendant cable to remove power to the manipulator. Then place a "DO NOT OPERATE" sign on the operator panel and, if possible, carry the remote cable into the work area with you, to ensure that you remain in control of manipulator power.

Note: Pressing the **Manip Stop** pushbutton on the Servo Power Module operator control panel or on the end of the remote cable does not remove potential dangers created by other devices in the work area. **You must make sure that all potentially hazardous devices are powered off or otherwise secured before penetrating the work area.**

Because the manipulator arm moves with such force and speed, serious injury could result from failure to observe caution whenever the work area is penetrated. As stated above, power to the manipulator must be disconnected first, whenever possible.

Before reconnecting power, always check the manipulator work area for adequate clearance; be absolutely sure no one is in the manipulator work area.

In addition to the precautions previously stated, the following precautions must also be observed when performing any maintenance or service on the manufacturing system:

- All personnel working with the system must have, at a minimum, instruction and practice in the use of the safety devices on the system. Safety procedures should be practiced enough to ensure familiarity.
- Observe safe access routes to and from the system.
- Utilize signs around the system and at power disconnects to alert others to potential hazards.
- Remove watches and rings before servicing the system.
- Always wear safety glasses around the manipulator and when servicing the system.
- If heavy units are to be installed or removed, wear safety shoes or other appropriate foot protection.
- Stay out of the manipulator work area when manipulator power is on. The manipulator arm moves rapidly and with great force.
- Press the **Manip Stop** pushbutton on the Servo Power Module operator control panel or the remote **Manip Stop** pushbutton on the the end of the pendant cable to stop the manipulator in an emergency.

SAFETY INSPECTION

Before you service the IBM Manufacturing System, you should perform the following inspection. Verify that:

- There are shields installed over all terminal blocks on power supplies and capacitors.
- The **Manip Stop** pushbuttons on both the Servo Power Module operator panel and on the end of the pendant cable will drop manipulator power when pressed.
- The **On/Off** switch located on the Servo Power Module operator panel will drop all power to the Servo Power Module and manipulator.
- The **Power** indicator located on the Servo Power Module is lit when there is power applied to the Servo Power Module.
- The **On/Off** switch located on the front of the 7532 Industrial Computer will drop all power to the 7532.
- The **Power** indicator located on the front of the 7532 Industrial Computer is lit when there is power applied to the 7532.
- All primary power cord grounds are properly attached and labeled.
- Line voltage warning labels are located inside the 7532 and inside the Servo Power Module.
- No external power sources are connected to the power supply of either the 7532 or the Servo Power Module.

ELECTRICAL SAFETY

Look for the following warning labels when working on electrical equipment.



Hazardous voltage inside. Do not open.
Gefährliche Spannung. Abdeckung nicht öffnen.
Tension dangereuse à l'intérieur. Ne pas ouvrir.
Voltaje peligroso en el interior. No abra.
Tensione pericolosa all'interno. Non aprire.



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

VORSICHT! Nur durch Teilenummer 8286121 ersetzen. Der Gebrauch eines anderen Batterietyps könnte zu einem Kurzschluss führen. Nachbestellungen nur durch autorisierten IBM Händler.

Précaution à prendre pour le remplacement de la pile N'utiliser que la pile n° 8286121. Si une pile différente est utilisée, elle peut brûler ou exploser. Adressez-vous à un distributeur agréé IBM pour commander une pile de rechange.

¡Atención! Reempláce la batería sólo por P/N 8286121. El uso de una batería diferente podría provocar su ignición o explosión. Pida el repuesto a un concesionario autorizado de productos IBM.

Precauzioni per l'uso della batteria Sostituire solo con la parte IBM N. 8286121. Altri tipi possono incendiarsi o esplodere. Ordinare ai concessionari IBM autorizzati.

6278098

1. You should not work alone under hazardous conditions or around equipment which could expose you to hazardous voltages. Always advise your manager if there is a potential problem or if you must work alone.
2. Disconnect all power before removing or assembling major components, working in the immediate area of power supplies, performing mechanical inspection of power supplies, or installing changes to machine circuitry.

-
3. Unplug the machine's power cord whenever possible before working on the machine. The wall box switch when turned off should be locked in the off position or tagged with a "DO NOT OPERATE" sign. Be aware that a non-IBM attachment to an IBM machine may be powered from another source and be controlled by a different disconnect or circuit breaker.
 4. When it is absolutely necessary to work on equipment having exposed electrical circuitry, observe the following precautions:
 - a. Another person familiar with power off controls must be in the immediate vicinity. (Someone must be there to turn off the power if it should become necessary.)
 - b. Do not wear jewelry, chains, metallic frame eyeglasses, or metal cuff links. (In the event of contact, more current can flow because of the greater contact area afforded by the metal.)
 - c. Use only those tools and test equipment that are appropriate to the task to be performed.

CAUTION

Cushioning grips are made for comfort and do not provide adequate insulation for working with live electrical circuits.

- d. Use only one hand when working on energized equipment. Keep the other hand in your pocket or behind your back. (Remember, there must be a complete circuit to cause electrical shock. This procedure will help prevent a current path through vital organs of the body.)
 - e. When using test equipment, be certain that controls are set correctly and that insulated probes of the proper capacity are used.
 - f. Avoid contacting ground potential (metal floor strips, machine frames, etc.); use suitable rubber mats purchased locally, if necessary.
- Note:** Many customers use rubber floor mats near their equipment which contain tiny carbon or metal fibers to help reduce static discharges. Be especially cautious of this type of mat and do not use it to provide protection from electrical shock.
5. Follow special safety instructions when working with extremely high voltages. These instructions are outlined in IBM safety service memorandums (SMs) and the safety portions of maintenance documentation. Use extreme care when measuring high voltage.
 6. Avoid use of tools and test equipment which have not been approved. (Electrical hand tools like wire wrap guns, drills, etc., should be inspected periodically.)
 7. Do not use worn or broken tools and test equipment.

-
8. After maintenance, restore all safety devices such as shields, guards, signs, and ground leads. Replace any safety device which is worn or defective. (These safety devices are there to protect you from hazards. You can defeat their purpose by not replacing them at the completion of service.)
 9. Safety glasses must be worn when:
 - Using a hammer to drive pins, etc.
 - Power hand drilling
 - Using spring hooks, attaching springs
 - Soldering, wire cutting, removing steel bands
 - Parts cleaning, using solvents, chemicals, and cleaners
 - All other conditions which might be hazardous to your eyes.
 10. Never assume that a circuit is de-energized. Check it first.
 11. Always be alert to potential hazards in your working environment (for example: damp floors, non-grounded extension cords, power surges, missing safety grounds, etc.).
 12. Do not touch live electrical circuits with the surface of plastic dental mirrors. The glass surface of the mirror is conductive and can result in machine damage and personal injury.
 13. Power supplies, pumps, blowers, motor generators, and other similar units must not be serviced with power on them when they are removed from their normal operating position within the machine unless specifically prescribed in the maintenance documentation. (This is done to assure that proper grounding is maintained.)

SAFETY NOTICES

This document may contain the following safety notices:

DANGER

THIS NOTICE ADVISES OF A CONDITION THAT COULD PRESENT A POTENTIAL HAZARD WHERE SERIOUS PERSONAL INJURY OR LOSS OF LIFE IS POSSIBLE UNLESS CARE IS USED.

CAUTION

This notice advises of a condition that could present a potential hazard where personal injury, except as defined for a DANGER notice, is possible unless care is used.

Warning: This notice advises of a potential condition that could cause machine or program damage unless care is used.

PREFACE

This manual provides maintenance information for the IBM 7575 and 7576 Manufacturing Systems. It can be used to help diagnose the source of failures and to repair problems on those manufacturing systems. Readers are expected to be trained on the operation and maintenance of the manufacturing systems, and they must know how to use the Triplet Model 310 Multimeter¹ (or equivalent).

The subject matter in this manual is divided into the following chapters and appendices:

- **Chapter 1, "Locations,"** provides the location of components on the manufacturing system.
- **Chapter 2, "Theory of Operation,"** explains the operational theory for the manufacturing system.
- **Chapter 3, "Removal and Replacement Procedures,"** contains the information needed to remove and replace any of the field-replacable units in the manufacturing system.
- **Chapter 4, "Checks and Adjustments,"** contains the information needed to check and adjust components of the manufacturing system.
- **Chapter 5, "Diagnostic Testing,"** describes how to run the diagnostics that help you to determine the cause of problems.
- **Chapter 6, "Card Plugging, Switch Settings, and Jumpers,"** provides information about card plugging, switch settings, and jumper positions for both standard and optional features of the 7532.
- **Chapter 7, "Preventive Maintenance,"** provides information for correct preventive maintenance of the manufacturing system.
- **Chapter 8, "Symptom/Fix,"** provides step-by-step instructions that lead you to the failing component.
- **Chapter 9, "Parts Catalog,"** contains illustrations and part numbers of all the field-replacable units.
- **Chapter 10, "Wiring Diagrams,"** contains wiring diagrams for the manufacturing system.

¹ Manufactured by the Triplet Corporation, Bluffton, Ohio 45817

- **Appendix A, "System Repacking Instructions,"** contains instructions for repacking the manufacturing system in preparation for moving it.
- **Appendix B, "Checking DI/DO Points With the Pendant,"** explains how to use the pendant to display and set DI/DO points.
- **Appendix C, "Useful AML/2 Information,"** briefly describes the AML/2 Configuration Utility and the two files APPLNAME.AML and HWDEF.CFG.

Note: The keybutton functions and procedures described in this publication assume that the standard AML/2 Manufacturing Control System² software is being used. This software can, however, be modified. If your software has been modified, the keybutton functions described herein might not work the same way.

Ordering This Publication

When ordering copies of this publication, you should request Part Number 70X8904.

Related Publications

Related publications are:

- IBM 7575 and 7576 Manufacturing Systems Hardware Library Site Preparation, Installation, and Specifications, Part Number 70X8867
- IBM 7575 and 7576 Manufacturing Systems Hardware Library Operator's Guide, Part Number 70X8903
- IBM Manufacturing Systems Software Library AML/2 Manufacturing Control System User's Guide, Part Number 67X1370
- IBM Manufacturing Systems Software Library AML/2 Language Reference, Part Number 67X1369
- IBM Manufacturing Systems Software Library AML/2 Application Development Environment User's Guide, Part Number 67X1371
- IBM Manufacturing Systems Software Library AML/2 Application Simulator User's Guide, Part Number 67X1372

² AML/2 is a trademark of International Business Machines Corporation.

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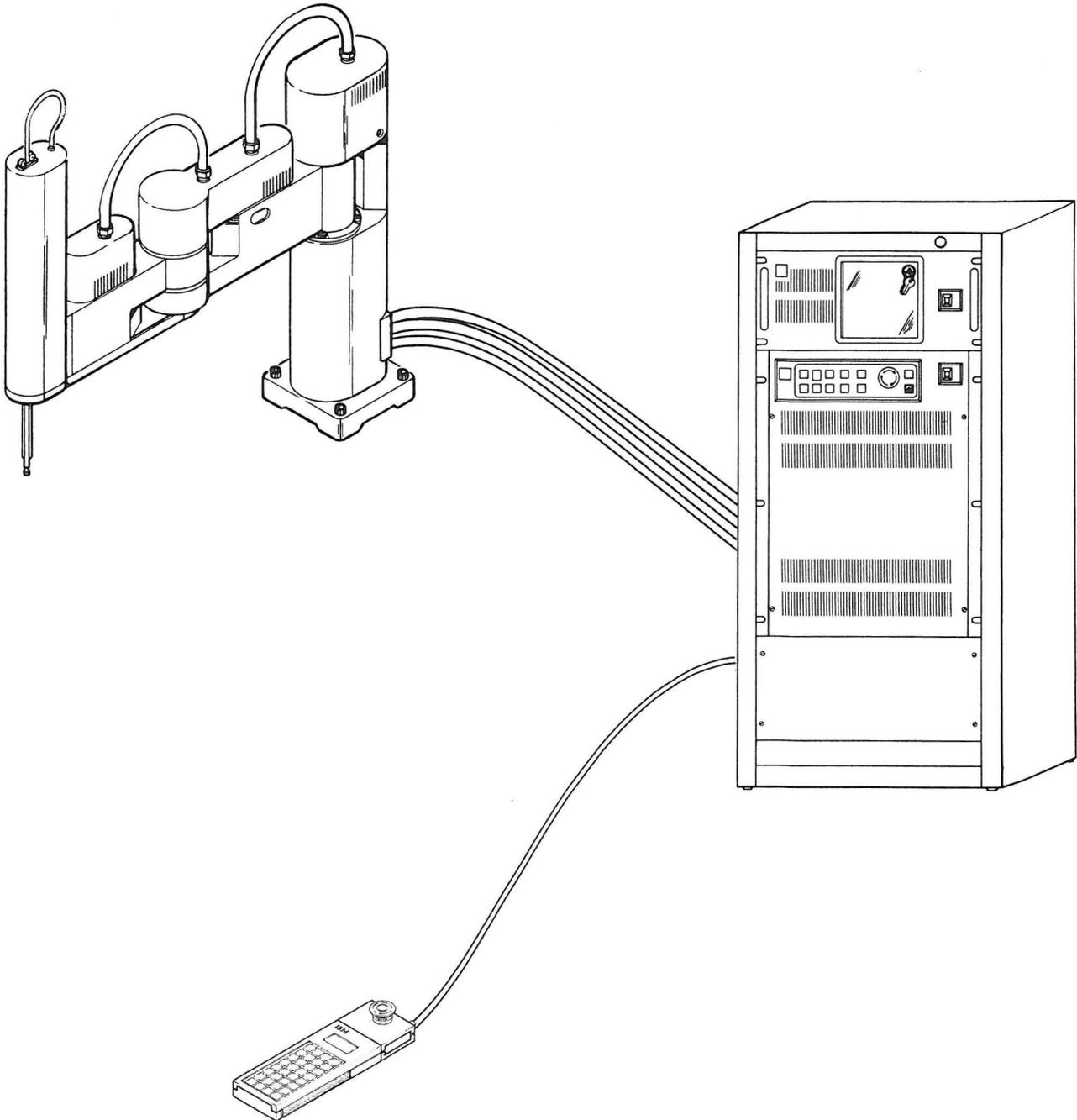
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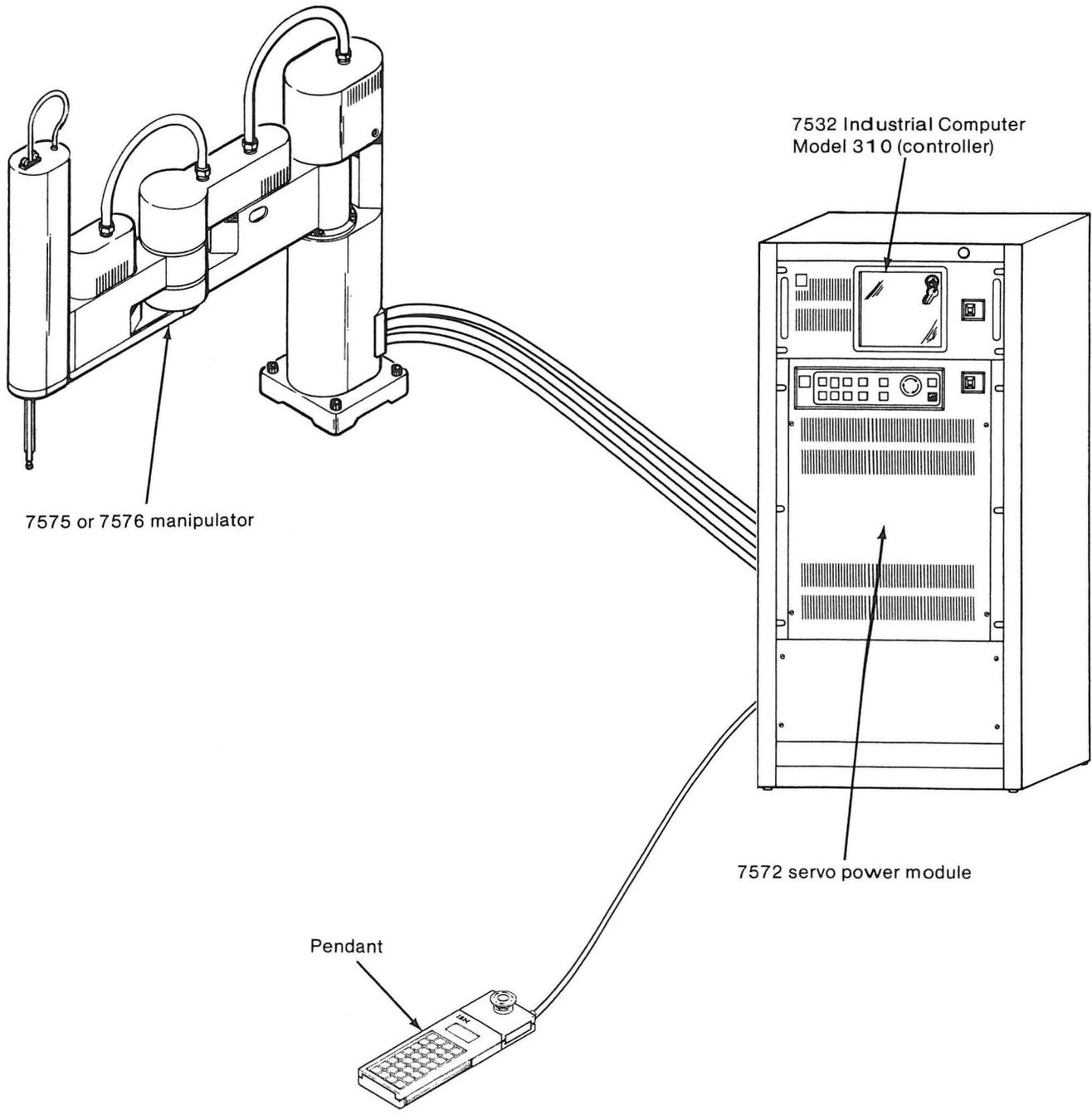
Locations

CHAPTER 1. LOCATIONS

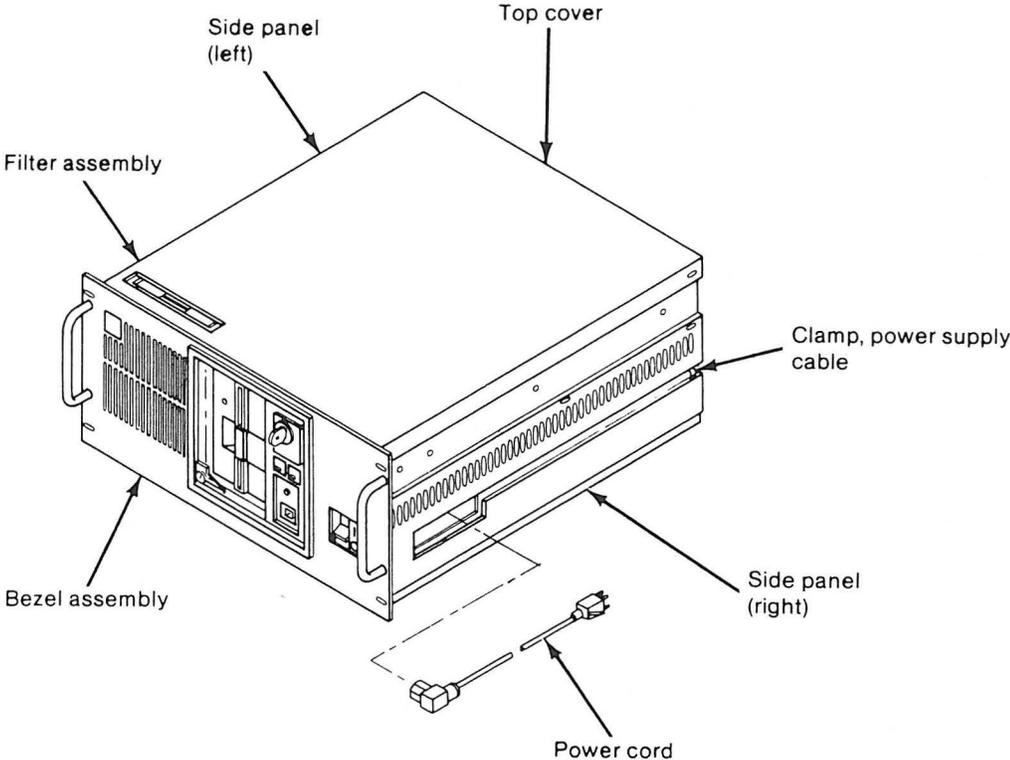
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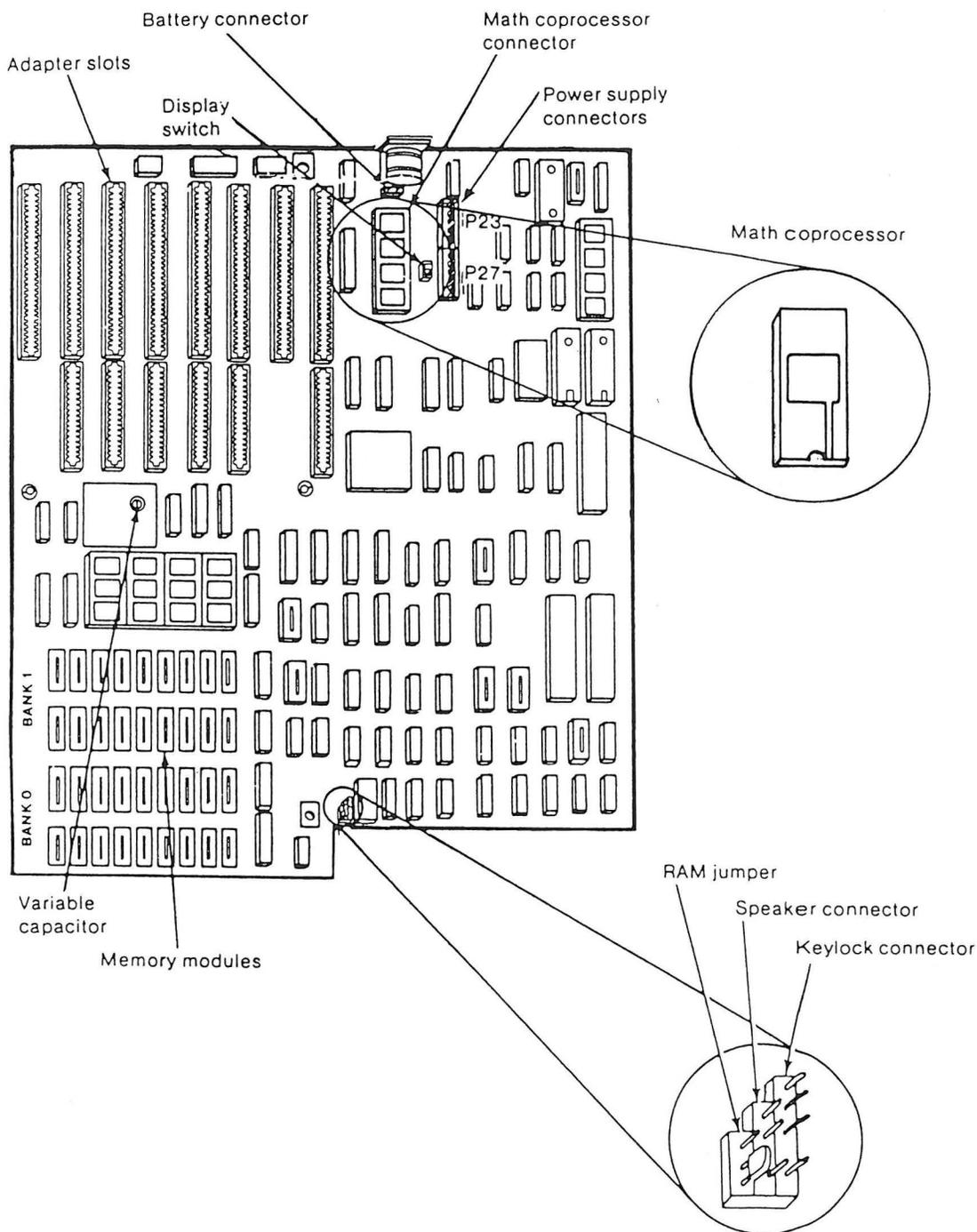
MANUFACTURING SYSTEM OVERVIEW



7532 INDUSTRIAL COMPUTER MODEL 310

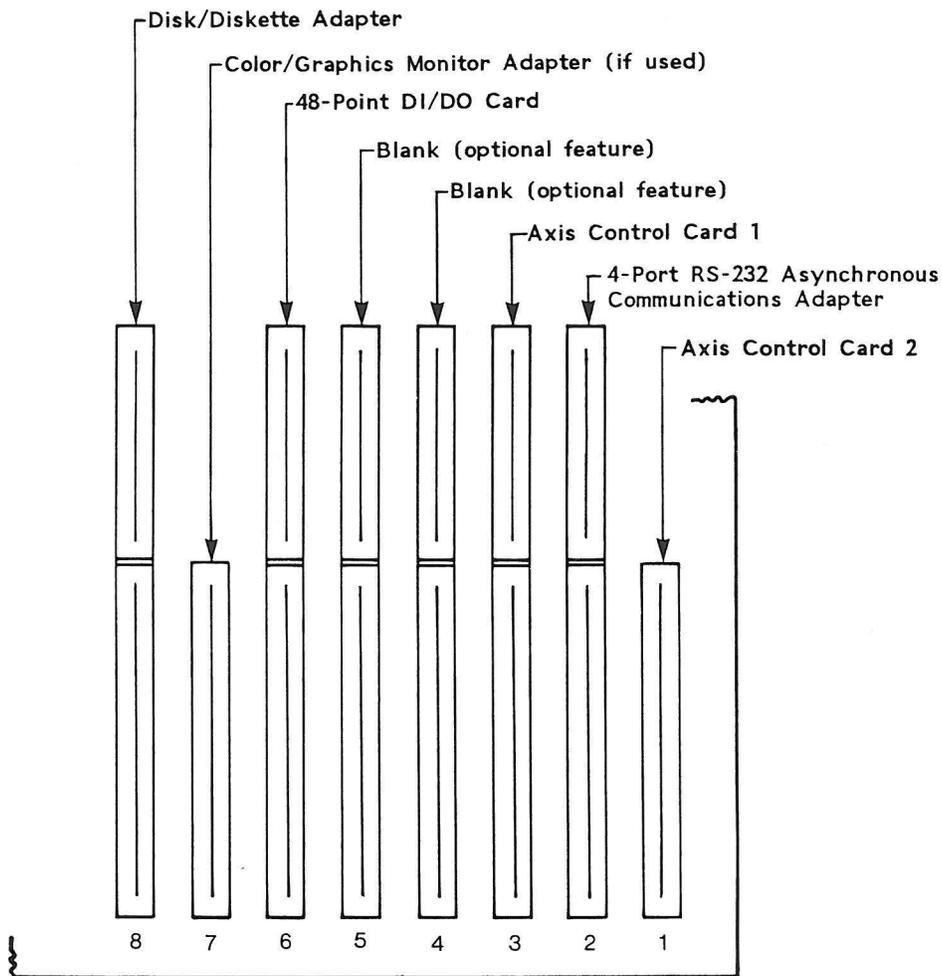


7532 System Board

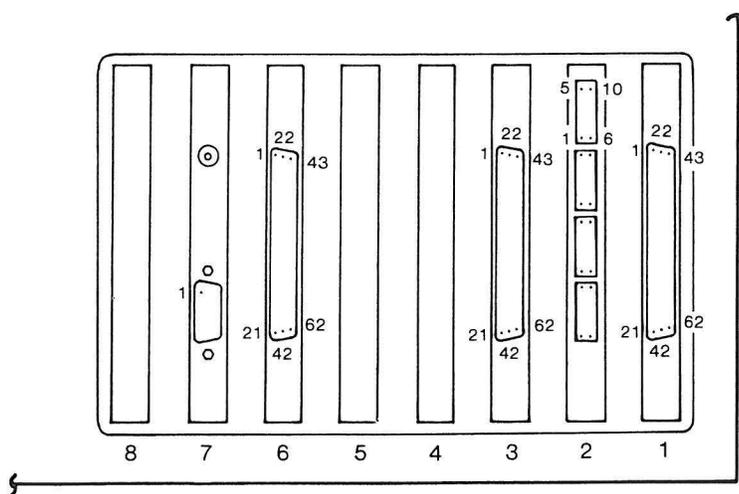


Note: The figure above shows four rows of memory modules with nine modules per row. Some 7532 system boards contain only two rows of memory modules with nine modules per row.

7532 Feature Cards

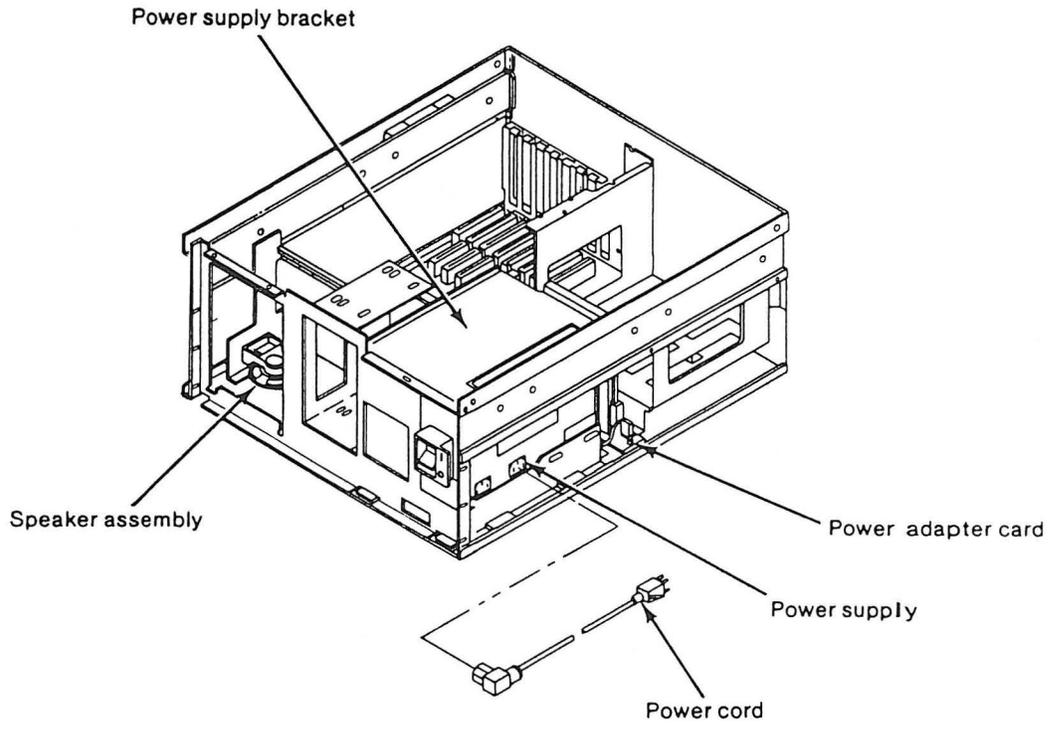


Top view of 7532, showing card slots

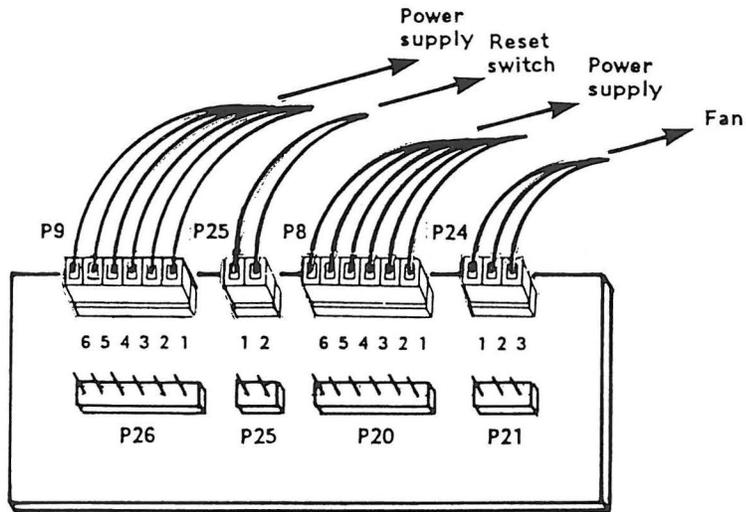


Rear view of 7532, showing card connectors

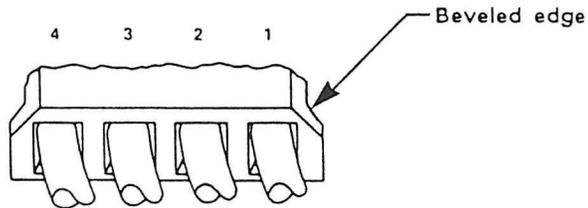
7532 Power Supply



7532 Power Connectors



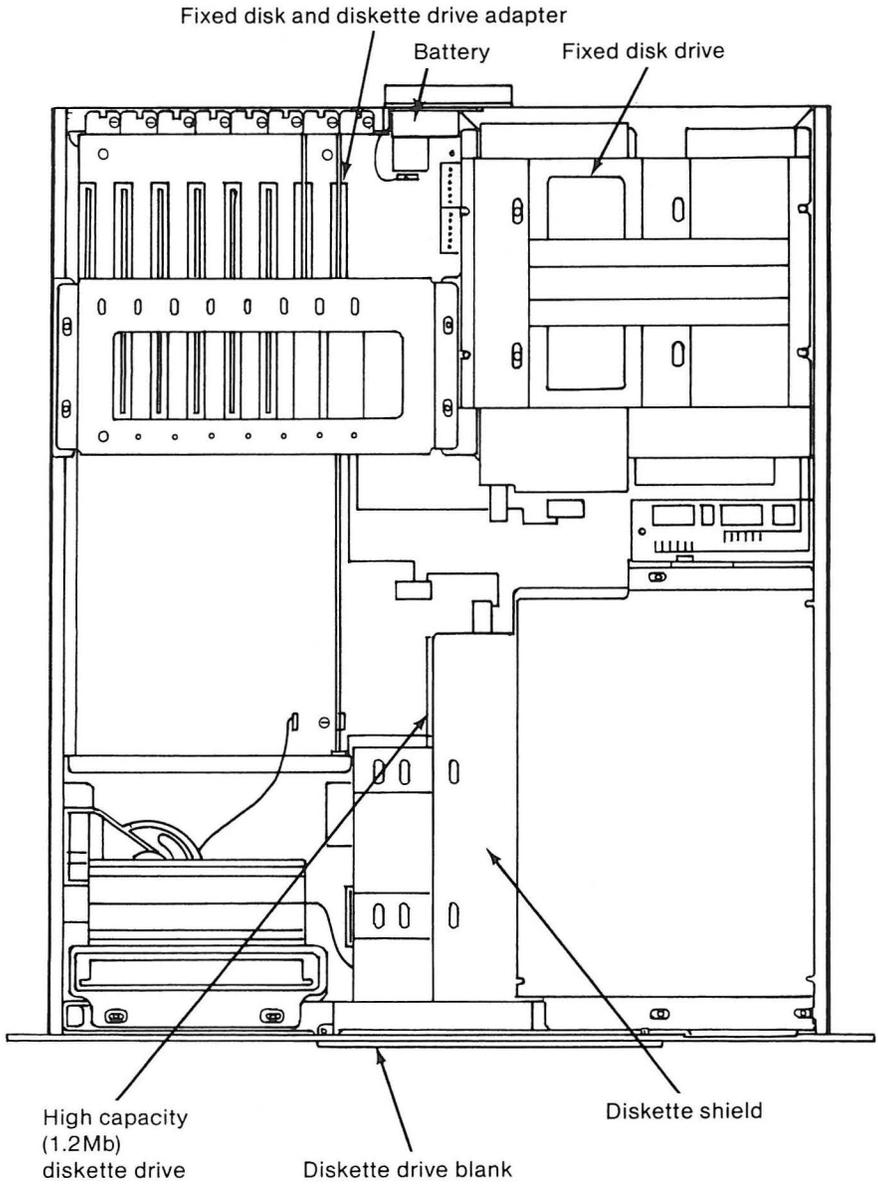
Power adapter card



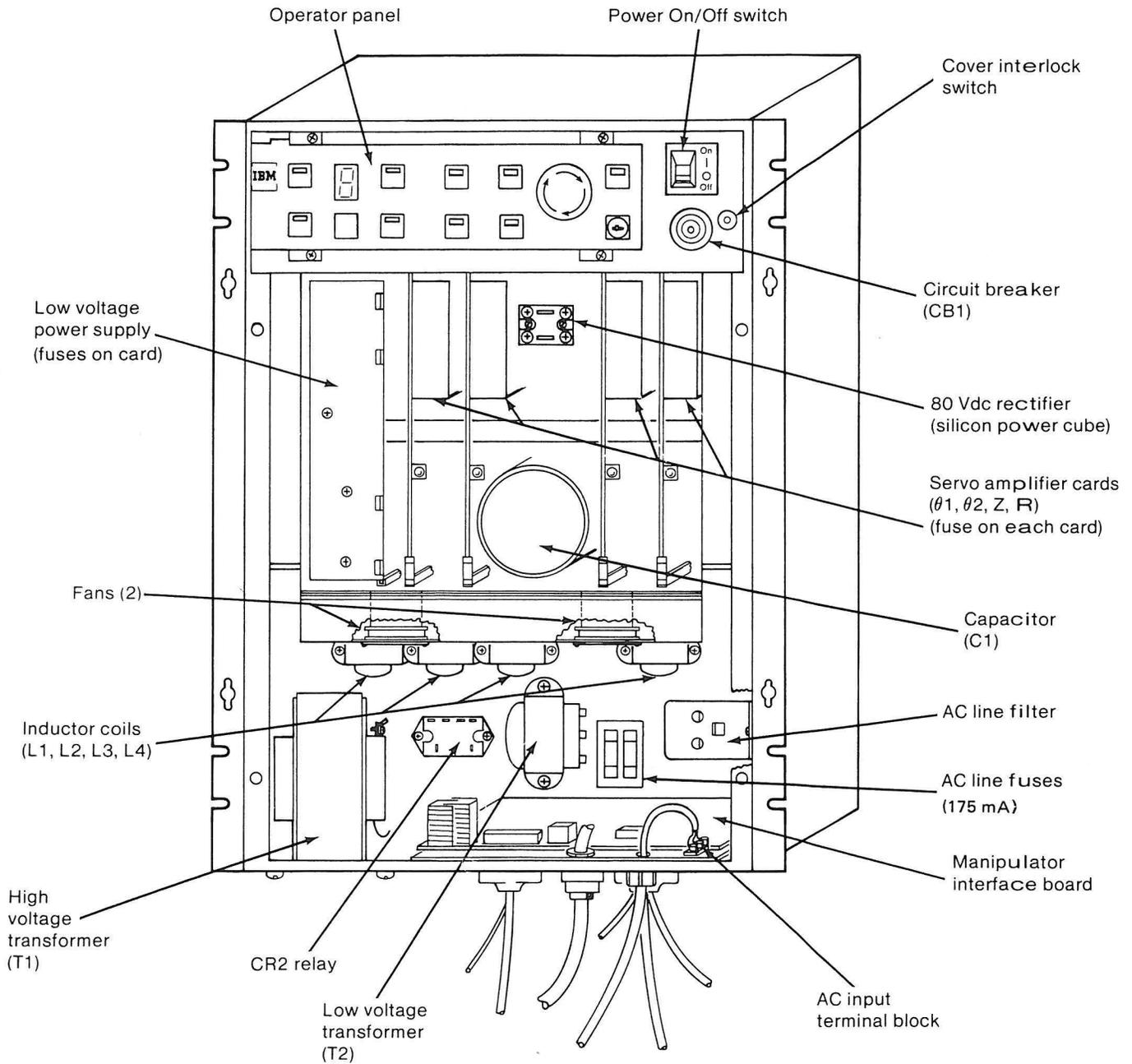
- P10 — Diskette drive A
- P11 — Diskette drive B (if installed)
- P12 — Disk drive C (if installed)

Disk/diskette drive power connectors

7532 Disk and Diskette Drives



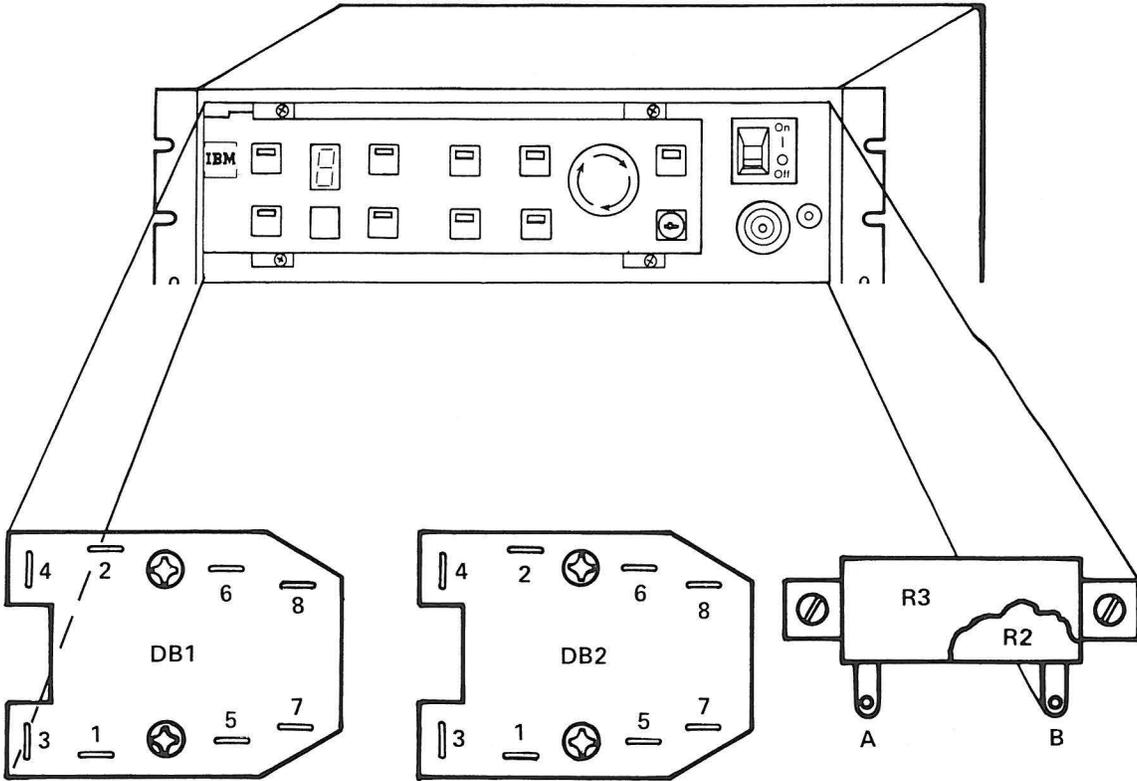
7572 SERVO POWER MODULE



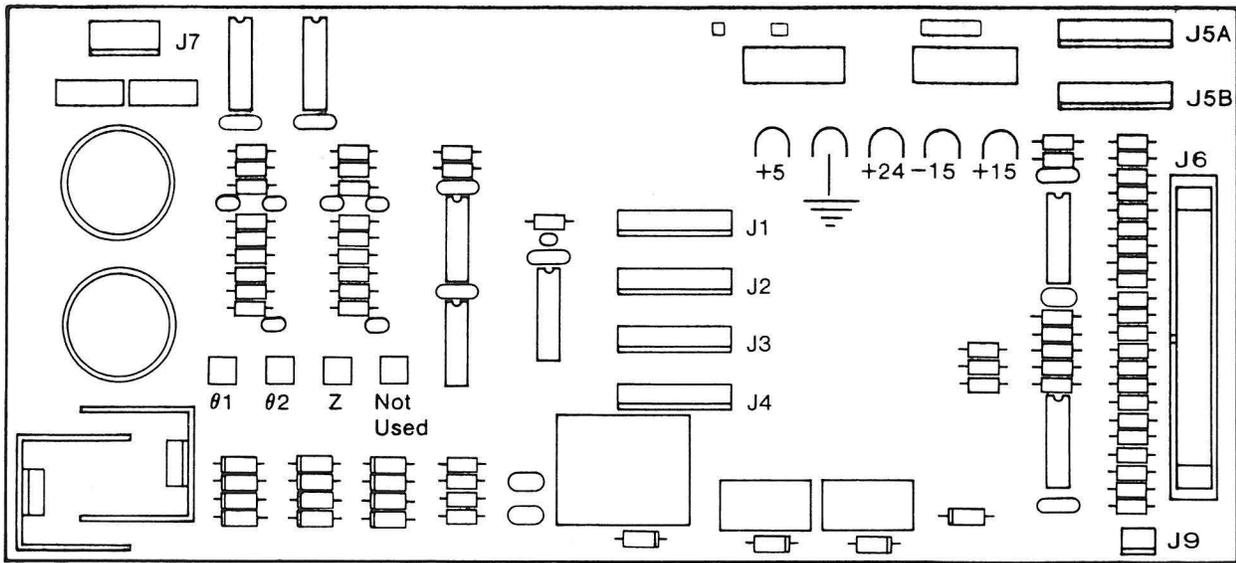
7572 Servo Power Module

7572 Dynamic Brake Relays

The dynamic brake relays are located behind the operator control panel.



7572 Manipulator Interface Board (Top View)

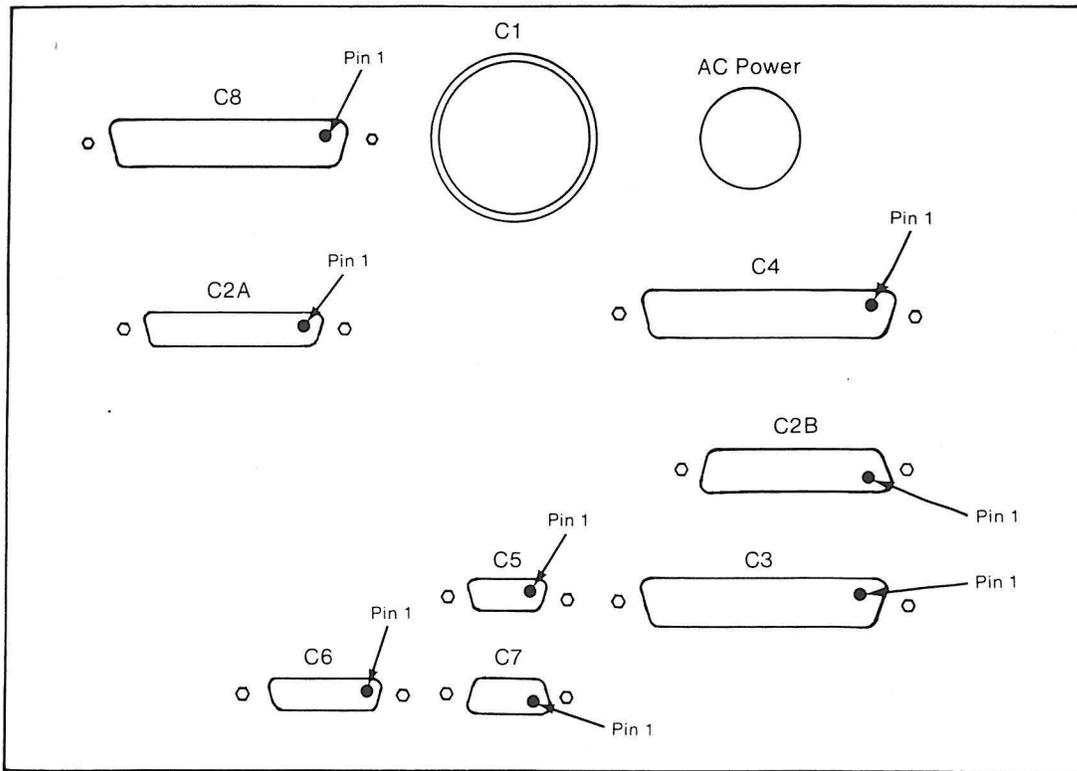


Manipulator interface board
(top view)

(front)

Note: $\theta 1$, $\theta 2$, and Z LEDs are overrun indicators.

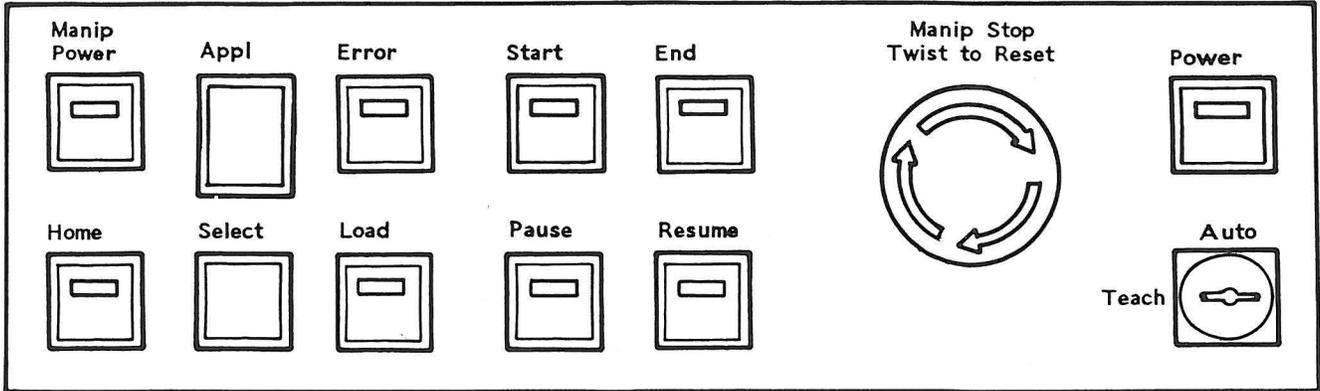
7572 Cable Connector Panel (Bottom View)



Cabling chart

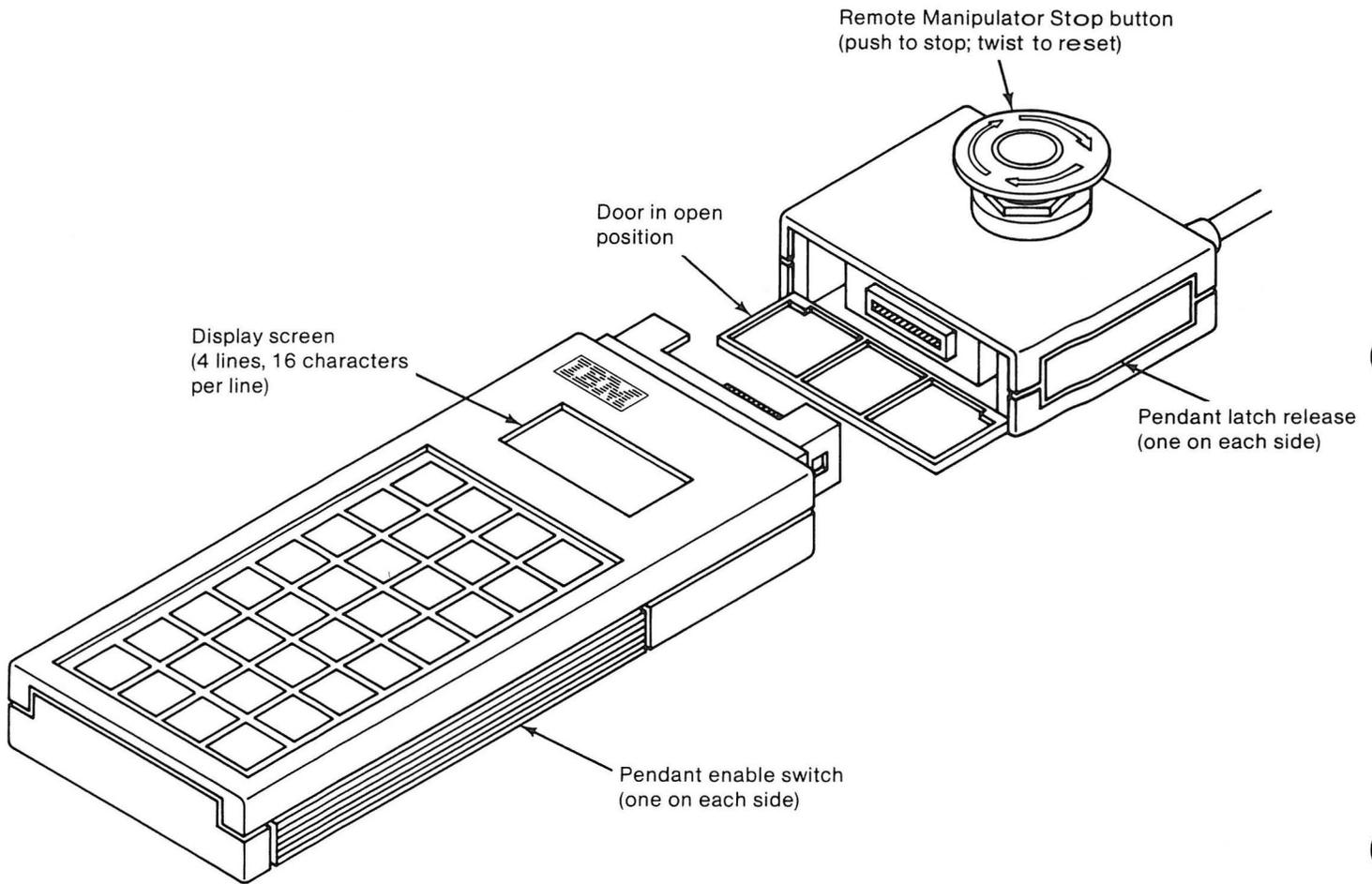
- C1 Manipulator
- C2A Manipulator
- C2B Manipulator
- C3 Axis Control Card 1 (card slot 3 in standard 7532 assignments)
- C4 Axis Control Card 2 (card slot 1 in standard 7532 assignments)
- C5 External user safety circuits
- C6 Remote "Stop" switch/Pendant
- C7 4-Port RS-232 Asynchronous Communications Adapter (card slot 2),
Port 1 (top)

7572 Operator Control Panel

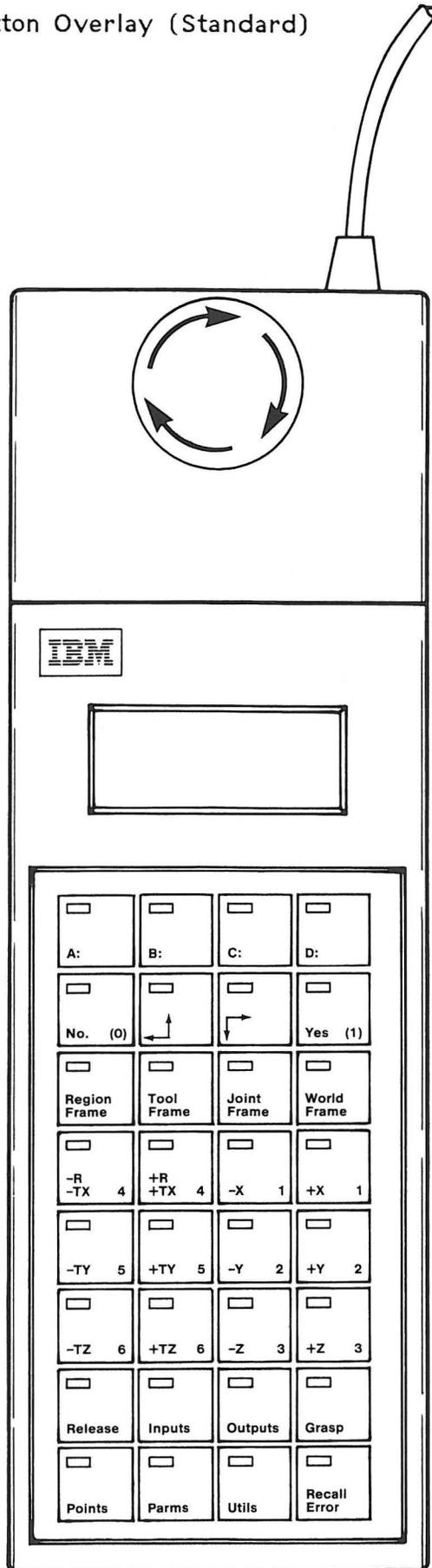


Remote Manipulator Stop Switch and Pendant

REMOTE MANIPULATOR STOP SWITCH AND PENDANT

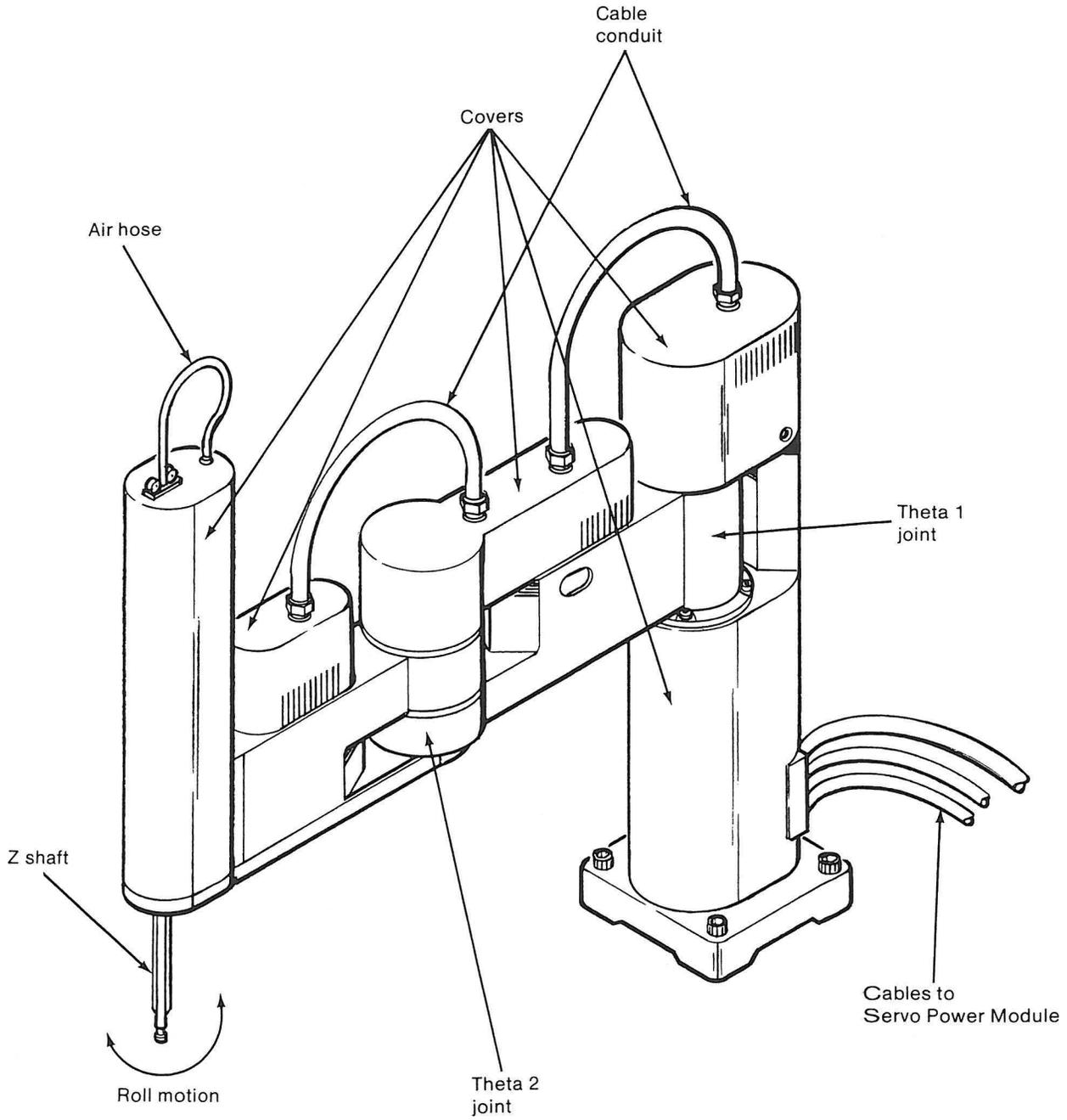


Pendant Keypbutton Overlay (Standard)

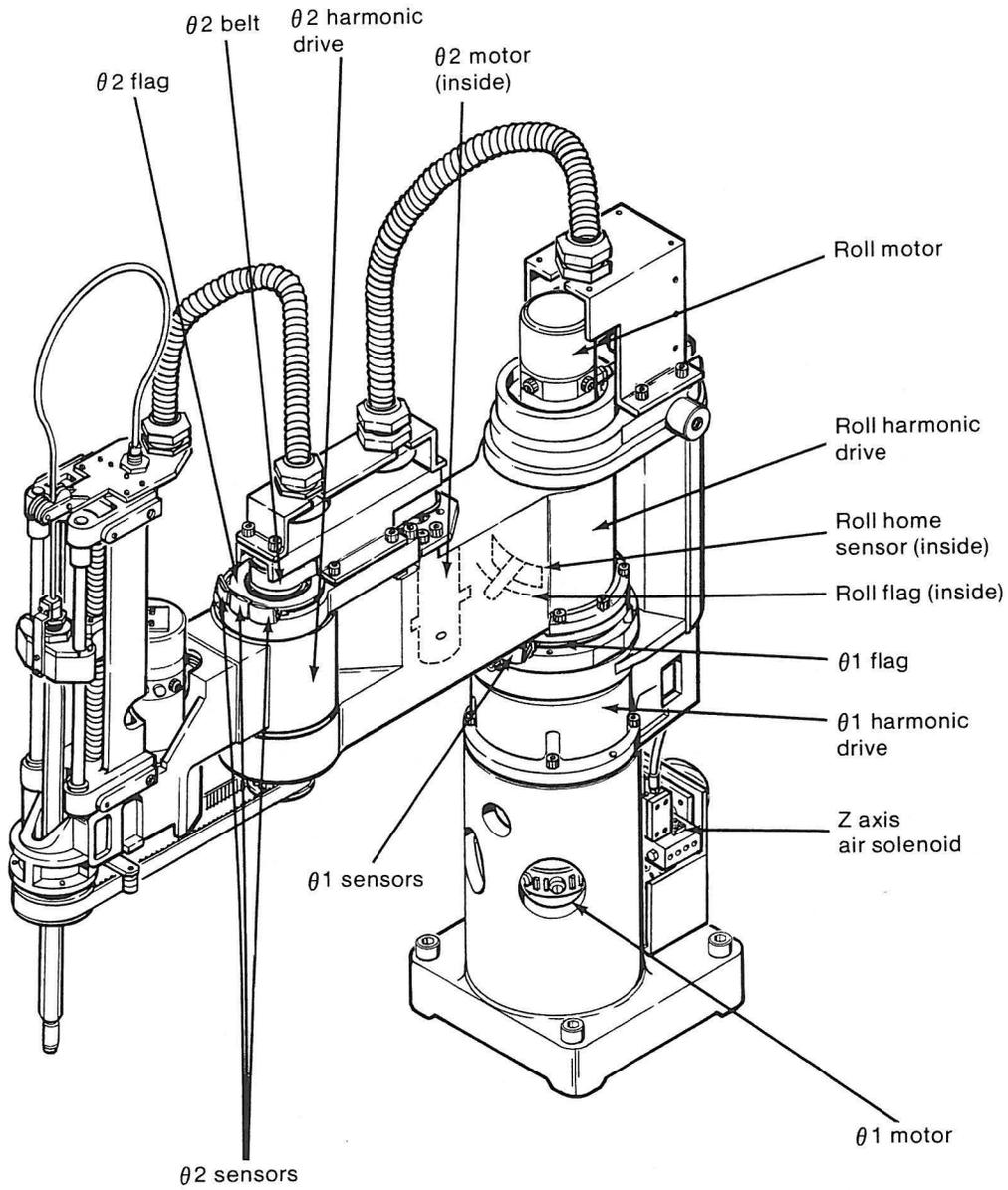


7575 AND 7576 MANIPULATORS

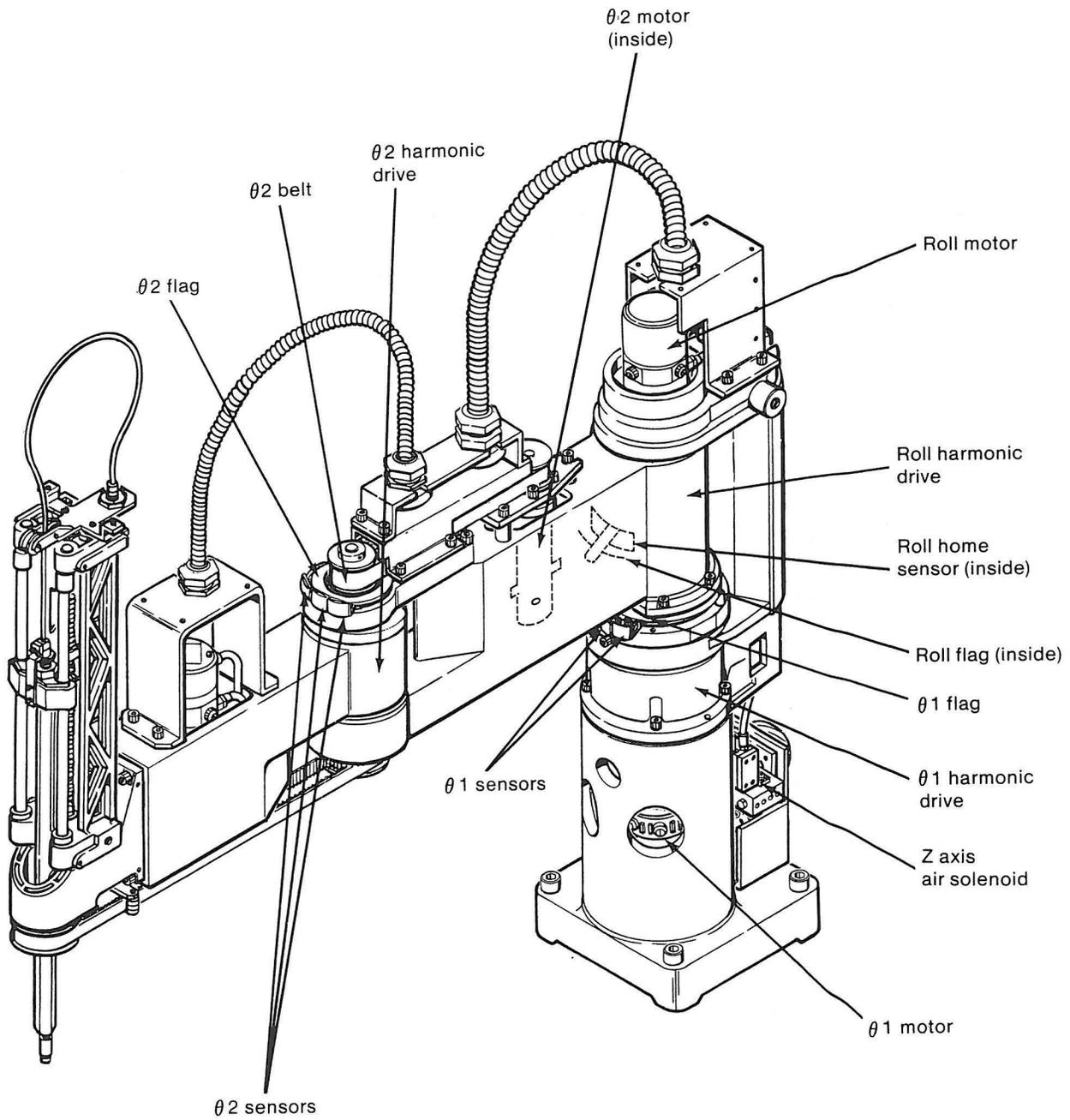
Note: This figure shows the 7576 Manipulator. All references cited are the same for the 7575 Manipulator.



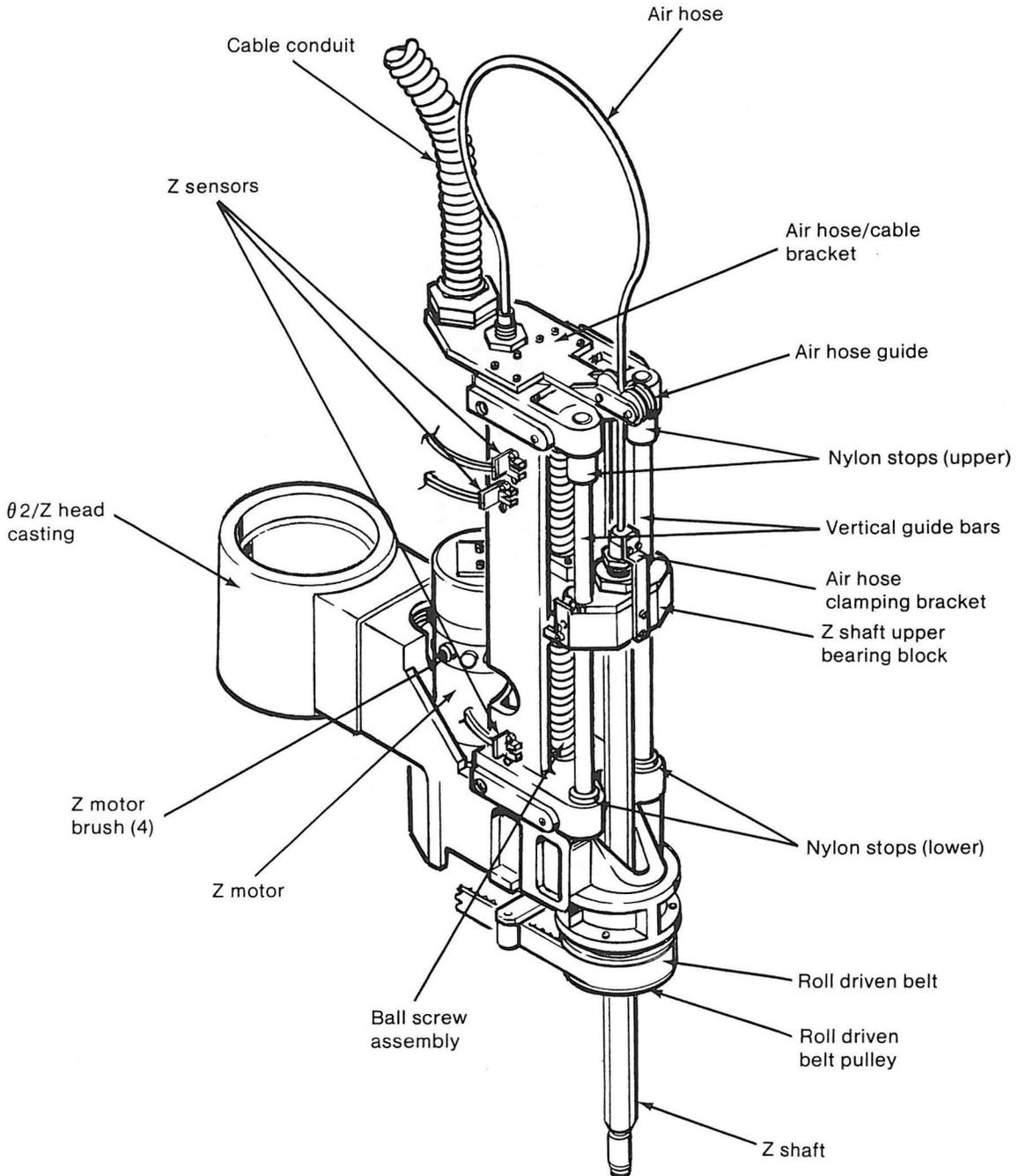
7575 Manipulator (With Covers Removed)



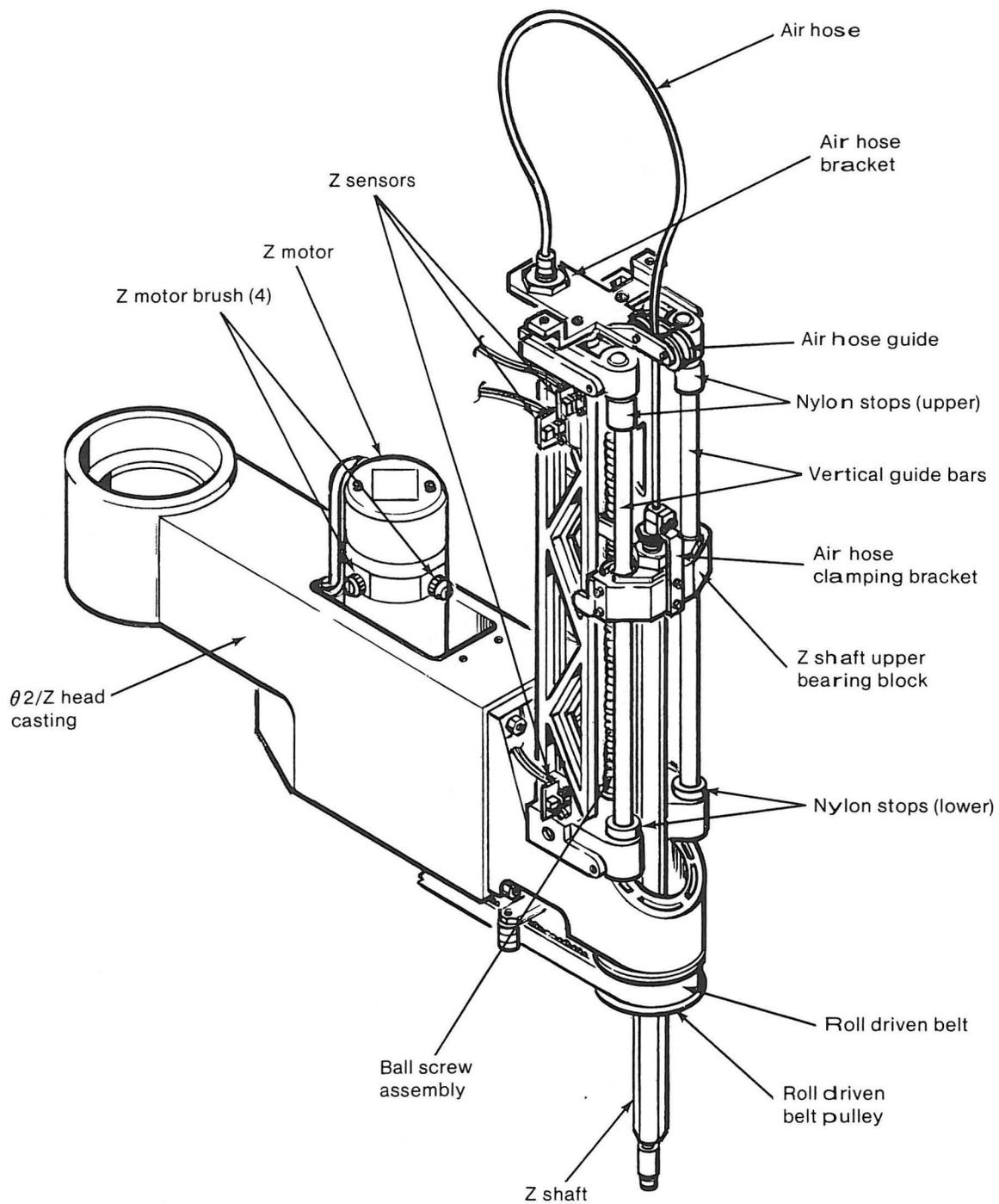
7576 Manipulator (With Covers Removed)



7575 Z-Axis Assembly



7576 Z-Axis Assembly



CHAPTER 2. THEORY OF OPERATION

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MANUFACTURING SYSTEM OVERVIEW

This section contains the theory of operation for the IBM 7575 and 7576 Manufacturing Systems. The System Configuration figure and System Data Flow diagram that appear on the next two pages can be used for reference while reading this section.

There are three main components of the IBM 7575 and 7576 Manufacturing Systems:

- IBM 7532 Industrial Computer Model 310 (Controller)
- IBM 7572 Servo Power Module
- IBM 7575 or 7576 Manipulator

Controller

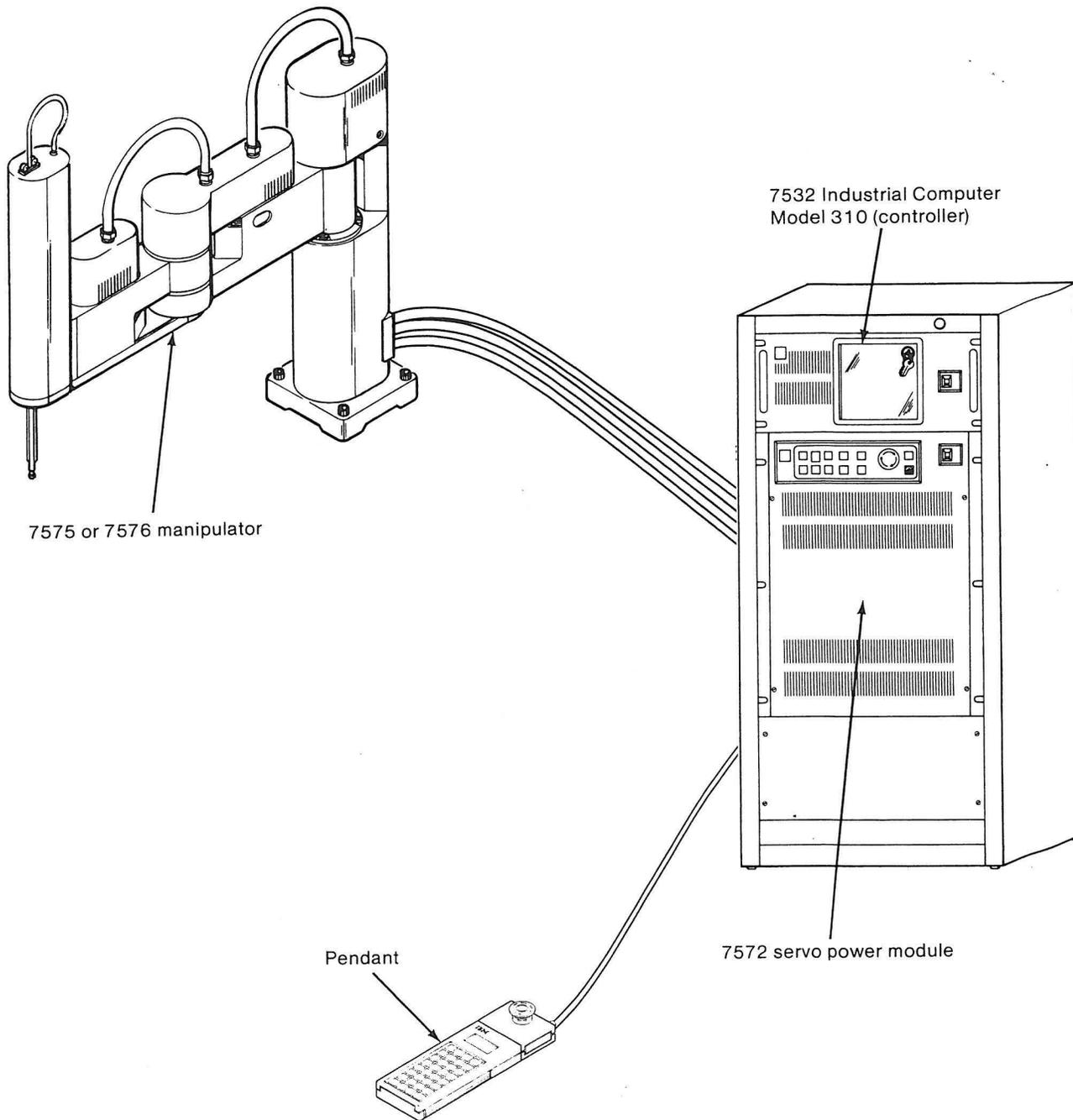
The controller, which is a rack-mounted IBM 7532 Industrial Computer Model 310, controls the manipulator's operation. It coordinates the manipulator's movement and monitors its speed and positioning. The controller receives and stores its control programs from its internal diskette drive (a disk drive is optional) and then drives the manipulator by executing the programs. (Application programs may also be downloaded from a roll-up tool, such as an IBM Industrial Computer or Personal Computer, or a host computer to the controller.) An 18-msec watchdog timer is continuously running to ensure the integrity of the system.

The controller contains the following standard features:

- 512Kb memory (may be upgraded to 640Kb maximum)
- Math Coprocessor
- 48-Point Digital Input/Digital Output (DI/DO) Card
- 4-Port RS-232 Asynchronous Communications Adapter
- Two Axis Control Cards
- Disk/Diskette Adapter
- 1.2Mb Diskette Drive

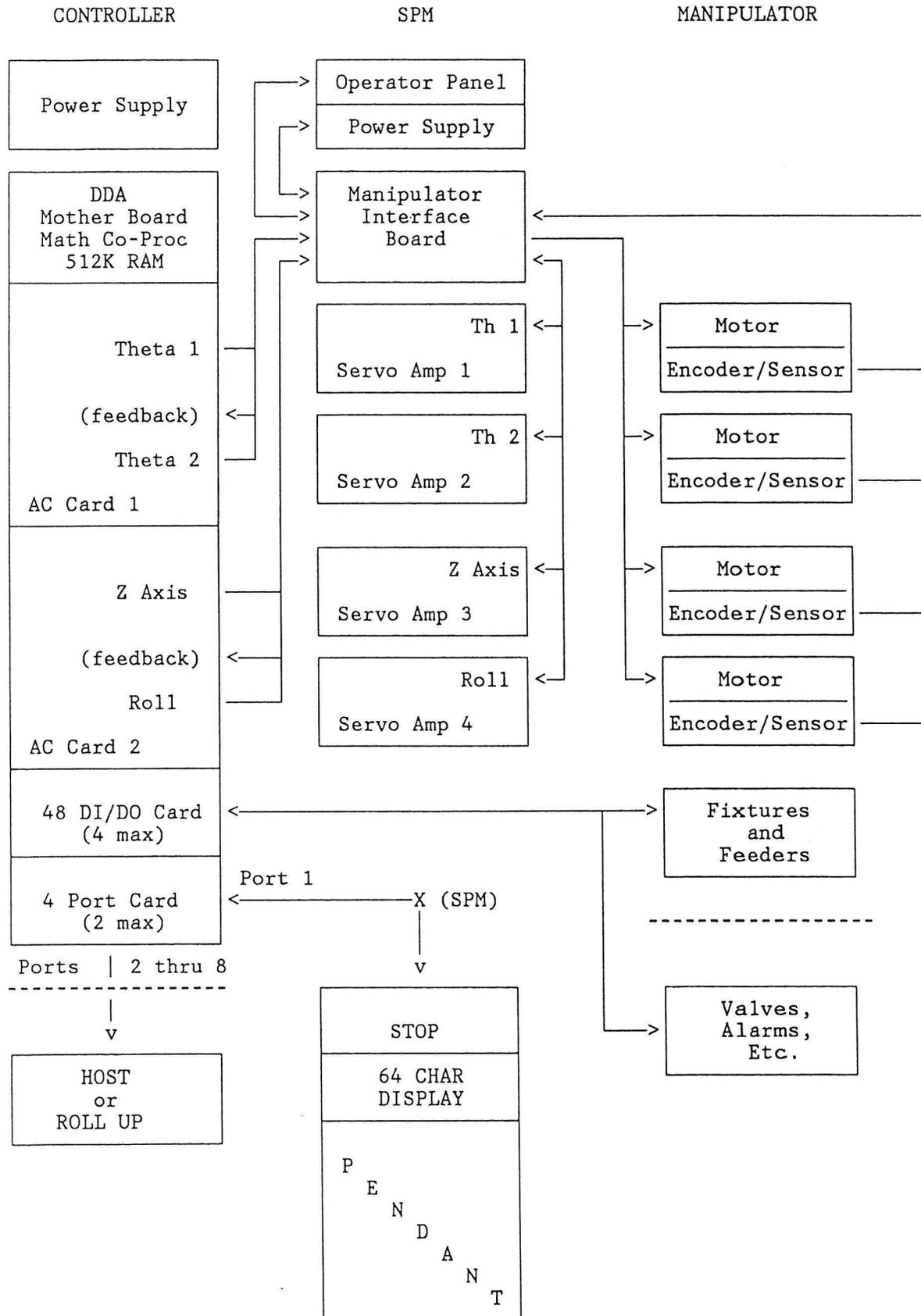
The controller power supply is a 192-watt unit.

System Configuration



Manufacturing System Overview

System Data Flow Diagram



512Kb Memory

The memory in the controller is pluggable into the system board in rows of nine modules per 128Kb. Four rows are standard for the controller, making 512Kb. With the addition of the 128Kb Memory Expansion optional feature, memory is expandable to 640Kb.

Math Coprocessor

The manufacturing control system software can contain very high levels of mathematic operations. The Math Coprocessor, a standard feature, is designed to enhance processor throughput in performing these mathematic operations.

48-Point Digital Input/Digital Output (DI/DO) Card

External devices are synchronized with the manipulator through the use of the 48-Point DI/DO card. This card provides digital input (DI) and digital output (DO) ports in banks of eight points each. The data through these ports monitor switch closures external to the system (DI) or circuit closures within the system (DO), allowing events to be synchronized.

While the standard configuration contains one 48-Point Digital Input/Digital Output (DI/DO) Card, up to three additional cards are supported.

Note: A wrap-back connector and a diagnostic are provided for troubleshooting problems with this circuit card.

4-Port RS-232 Asynchronous Communications Adapter

Communication with the system can be achieved through the use of the 4-Port RS-232 Asynchronous Communications Adapter. A 10-pin to 25-pin adapter cable is required for standard RS-232 attachments. (For further information, refer to "Communications" on page 2-34.)

Port 1 is reserved for the pendant device. (For further information, refer to "Pendant" on page 2-14.) Port 2 is reserved for the roll-up tool. (For further information, refer to "Roll-Up Tool (IBM Industrial Computer)" on page 2-13.)

Note: A wrap-back connector and a diagnostic are provided for troubleshooting problems with this circuit card.

Manufacturing System Overview

Axis Control Card

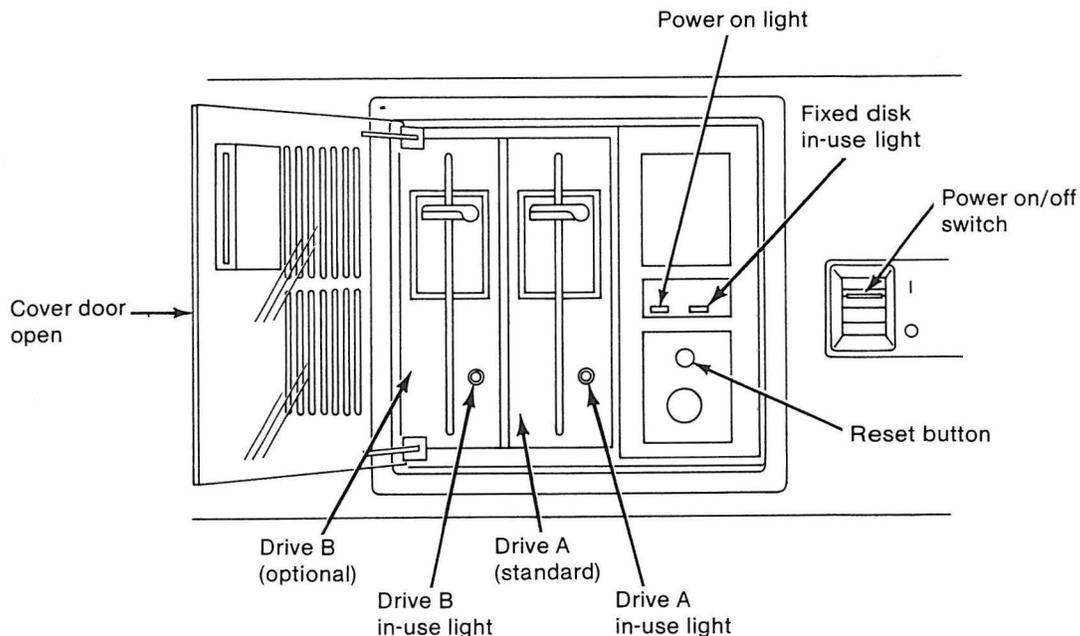
Direct motion control of the manipulator axes movement is achieved through the use of two Axis Control Cards. Each card controls two axes and contains direct-access memory and read-only memory to provide "intelligence" by continuously monitoring the motion of the manipulator. As part of this "intelligence," at each power up time, a diagnostic routine performs a basic checkout of the Axis Control Cards' circuitry. This provides integrity for a manipulator startup.

Disk/Diskette Adapter and Drive

One Disk/Diskette Drive Adapter card is standard on the controller. The standard disk/diskette device is a single 1.2 megabyte diskette drive. One additional diskette drive (either another 1.2Mb drive or a 360Kb drive) and/or a 20Mb fixed disk drive may be installed.

Note: A maximum of two diskette drives and one disk drive is supported.

In keeping with the maintenance philosophy, diagnostics are provided for all standard and optional disk/diskette drives.



Options

With the standard 7532 Model 310 configuration, three additional card slots are available for options. Diagnostics are provided for all supported options. For a list of supported options, refer to IBM 7575 and 7576 Manufacturing Systems Hardware Library Site Preparation, Installation, and Specifications, Part Number 70X8867.

7572 Servo Power Module

The 7572 Servo Power Module is a modularized interface between the manufacturing system controller (7532) and the manipulator. It provides pulse-width modulated drive power for the manipulator motors, dc power for various functions, and processing and distribution of manipulator and pendant signals.

The 7572 Servo Power Module contains:

- Four servo amplifier cards
- A pluggable power supply
- A manipulator interface board
- Various other electronic components that help to control the powering and motion functions of the manipulator.
- An operator control panel (removable for remote installation)

Aside from the controls on the operator control panel, a remote Manipulator Stop switch can be connected for controlling the manipulator. An optional pendant device can then be attached to the 7572 Servo Power Module via the remote Manip Stop switch cable. The pendant is used to "teach" points on the system, to display error messages, and execute diagnostics.

Each of the four servo amplifier cards provides motion control for one axis on the manipulator. The output of each card drives one servo motor.

All four servo amplifier cards are interchangeable without modification for troubleshooting. No adjustments are required. In addition, each servo amplifier card is an individual Field Replaceable Unit (FRU); that is, they contain no individually replaceable components (except a fuse).

The power supply is pluggable as a circuit card and is in the same card cage as the servo amplifier cards. Like the four servo amplifier cards, the power supply is a FRU and it requires no adjustments.

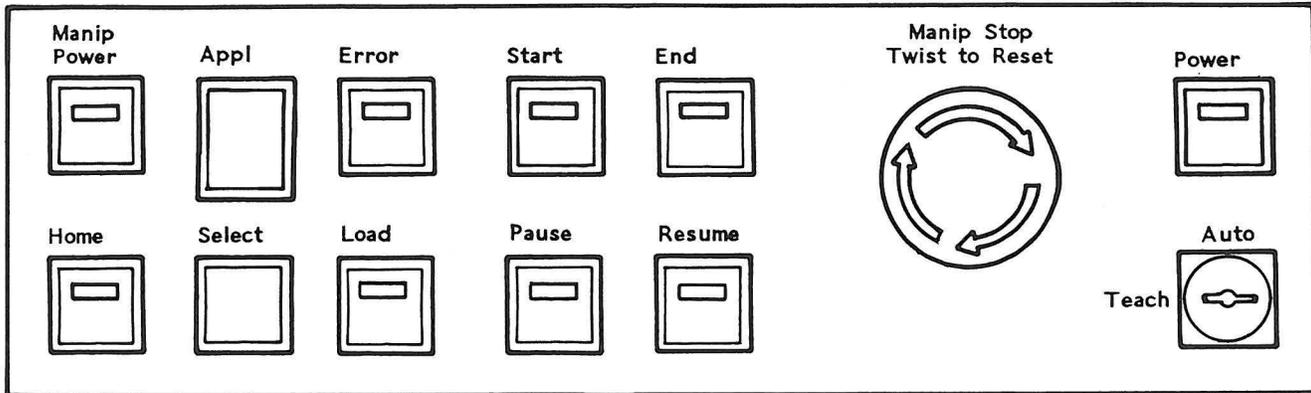
The manipulator interface board is mounted on the bottom of the Servo Power Module. The board contains the interface circuitry for inputs and outputs between the controller and the manipulator. The manipulator interface board and the input/output cable connectors constitute a single "bolt-in" FRU.

Other miscellaneous electronics incorporated in the Servo Power Module circuitry as FRUs are:

- Capacitors
- Coils
- Relays
- Transformers.

Manufacturing System Overview

The Servo Power Module operator control panel contains the pushbutton switches and LED indicators that are used by the operator to control the powering and motion of the manipulator. The operator control panel is shown below; the functions of its switches and indicators are explained in the following table.



Switch/ Indicator	Function
Manip Power	This LED blinks when system power is on. This blinking prompts the operator to press the button, thus supplying dc voltages to the manipulator servo motors (that is, powering the manipulator). While manipulator power is on, the LED stays lit.
Appl	This single digit read-out gives a number from 0 to 7, denoting which application program is currently loaded. The application program, and consequently this indicator, are stepped with the Select pushbutton. After power on, the number indicated should be a 1.
Error	When on, this LED indicates that an error has occurred. If a pendant is attached, the error will be displayed on the pendant after the Recall Error button is pressed.
Start	This button starts an application program from the beginning.
End	This button stops the current application program at the end of the program. It flashes until the end is reached and then goes on solid.
Manip Stop	This large red latching pushbutton immediately removes voltages to the manipulator servo motors and to the dynamic brake holding relay, causing the manipulator to stop. To reset, simply twist the switch cap clockwise.
Power	This LED lights to indicate that low voltage dc is active.
Home	This LED/pushbutton allows the operator to send the manipulator to the "home" position. When the LED is on solid, the manipulator has been homed.
Select	This pushbutton is used to step through the application programs numbered 1 through 7. The current program's designation is indicated by the single digit Appl display.
Load	This function loads an application program into memory. The designation of the program that is to be loaded is indicated by the single digit Appl display. The Load LED flashes while the program is loading, and is on solid when loading has completed successfully.
Pause	This LED/pushbutton can be used to cause a stop at the next PAUSE instruction in the application program. It flashes while a pause is pending and goes on solid when the pause has occurred.
Resume	After an exception has stopped the program, this button causes the Error LED to be turned off and the Start-up sequence to be rerun. Following Start-up, or after a pause or end, pressing this button will, if possible, resume program execution where it was halted.
Auto/Teach	This key-operated switch selects either Auto mode or Teach mode. Auto mode allows program selection and execution. Teach mode allows the "teach" function and defaults to a very low speed.

Remote Manip Stop Switch

A large red latching Manip Stop switch attaches to the Servo Power Module via a cable. This switch performs the same function as the Manip Stop switch on the operator panel; that is, it immediately removes voltages to the manipulator servo motors and to the dynamic brake holding relay, causing the manipulator to stop. To reset this latching switch, simply twist the switch cap clockwise.

The pendant, a hand-held multi-purpose key entry/display device, also attaches to the Servo Power Module via the cable to the remote Manip Stop switch. The pendant is used primarily for the "teach" function, but it is also required for maintenance to retrieve error codes and select diagnostics. (For information about the pendant's keybuttons, indicators, and other features, refer to "Pendant" on page 2-14.)

Manipulator

There are two models of manipulators:

- The 7575 Manipulator — with a reach of 550 mm (21.66 inches)
- The 7576 Manipulator — with a reach of 800 mm (31.50 inches)

Each manipulator is a two-jointed arm structure with four degrees of freedom. Refer to the figure on the next page for the following description of manipulator movement.

- The rotating joints of the arm, called the Theta-1 axis and the Theta 2-axis, provide two degrees of freedom through their horizontal swivel motion. Thus these two degrees of freedom define a horizontal plane known as the X-Y plane.
- The end-of-arm shaft provides a third degree of freedom through its vertical travel. This vertical travel defines the Z axis.
- The end-of-arm shaft rotation provides a fourth degree of freedom, known as roll.

Each degree of freedom is driven by its own servo motor. Theta 1, Theta 2, and roll each employ a harmonic drive to increase the torque delivered by the servo motor; while Z-shaft vertical movement employs a ball screw assembly.

Position feedback is obtained through an encoder disk on each servo motor. The encoder disks have 500 slots, thus providing a resolution just under .002 inch.

