Service Information Manual

**HP 9000 Series 300 Computers
Model 332**

HP Part Number 98572-90030

**[hp] HEWLETT
PACKARD**

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Printing History

New editions of this manual will incorporate all material updated since the previous edition. Update packages may be issued between editions and contain replacement and additional pages to be merged into the manual by the user. Each updated page will be indicated by a revision date at the bottom of the page. A vertical bar in the margin indicates the changes on each page. Note that pages which are rearranged due to changes on a previous page are not considered revised.

The manual printing date and part number indicate its current edition. The printing date changes when a new edition is printed. (Minor corrections and updates which are incorporated at reprint do not cause the date to change.) The manual part number changes when extensive technical changes are incorporated.

February 1989...Edition 1

Notices

Radio Frequency Interference Statements

FCC Statement

VCCI Statement (Japan Only)

Manufacturer's Declaration (Germany Only)

Safety Considerations

WARNINGs, CAUTIONs, and Notes

Warnings, cautions and notes are used throughout this document to alert the user to conditions of importance. They are used as follows:

- WARNINGS contain information which, if not observed, could result in injury to personnel or loss of life.

- CAUTIONS contain information which, if not observed, could result in damage to or destruction of equipment.

- Notes contain information that will assist you in accomplishing the job.

Examples:

WARNING

The power supply presents a hazard to personnel. Extreme care must be taken when connecting voltmeter probes to the test points. De-energize the product by turning it off and removing its power cord before connecting or removing test probes.

CAUTION

The printed circuit assemblies in this product are susceptible to damage by electro-static discharge. Extreme care must be taken when handling printed circuit assemblies. Use an Anti-static Workstation while handling printed circuit assemblies.

Note

Hewlett-Packard supports repair of this product only to the assembly level. The fault is diagnosed to the assembly that is causing the problem. That assembly is then replaced with a new or rebuilt one.

Information Locator

Finding Service Information

On the next page is a Service Information Locator. It shows where to find a variety of subjects dealing with servicing these products. To use this table, first find the type of information you need to reference in the left-hand column. Next, move to the right in that row to a referenced chapter number. Last, move up the column with the information's referenced chapter to the top. Across the top are manual titles and part numbers that have the information documented.

Chapter identifiers in the Locator use the following codes:

Chapter Number:	Numbers, such as 2. Inclusive chapters, such as 4-6.
Appendices:	Letters, such as A for Appendix A.
Entire Manual:	All
Varies:	* (Check Table of Contents or Index.)

In some cases, two or more references will be shown for a given information type. You should check all references to be sure you get the specific information you need.

Service Information Locator

Manuals identified in this locator are abbreviated by their initials:

SIM	Service Information Manual
IRM	Installation Reference Manual
SHB	Service Handbook
PIN	Product Installation Note
CRM	Configuration Reference Manual
TDS	Technical Data Sheet/Price List
TTM	Series 300 Test Tools Manual
ADG	Accessory Development Guide
SPM	Site Preparation Manual

Service Information Locator

Service Information	SIM	SHB	CRM	TTM	SPM	IRM	PIN	TDS	ADG
Assembly replacement	2								
Block diagrams	1, 2	9							
Booting Operating Systems	4								
Computer tests	1, 5	2		1, 2, 3					
Configurations	1	3				All		All	
CS/80 tests	1, 5	5		4					
Electrical requirements	1	1			3, A			*	
Environmental requirements	1	2			4, A			*	
Functional descriptions	3								All
HP-HIL device tests				2, 3					
Installation	2	2	All		All	All	All		
I/O Bus architecture	1, 3								All
Monitors	1	3	All		A	1		*	
People who can help					1				
Options/Accessories	1, 3	3	All			All	All	*	All
Ordering spare parts	6	8							
Part numbers	6	8	All						
Peripherals	1	3	All					*	
Preventive maintenance		2							
Product information	1	1	All		All	All	All	All	
Product numbers	1	1, 3	All		A			All	
Reference material	7	10	*			All		All	All

Service Information Locator (Continued)

Service Information	SIM	SHB	CRM	TTM	SPM	IRM	PIN	TDS	ADG
Self-tests	4, 5	5		1, 2					
Service notes	1	11							
Site preparation		2			All				
System Functional Tests	1, 5	5		1, 3					
Systems	1	3	All			All		*	
Troubleshooting	5	4		All					
Turn-on	3, 4	4, 5				2			

Table of Contents

Chapter 2: Assembly Replacement

Chapter 3: Functional Description

Chapter 4: Boot ROM Functions

Chapter 5: Troubleshooting

Chapter 6: Parts Lists

Chapter 7: References

Product Information

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Introduction

Workstations

Model 332 workstations provide state-of-the-art performance for the most demanding applications with a MC68030 operating at 16 MHz. An optional MC68882 floating point co-processor augments system performance, supporting both single and double-precision floating-point arithmetic and transcendental math functions.

These workstations are well-suited for the advanced design requirements of design engineers in electrical, mechanical, and software engineering, including such computation-intensive tasks as logic simulation and printed-circuit board routing. Many research applications previously requiring the power of a mainframe computer now can be executed locally on these powerful workstations.

Foundations of these workstations are the computers, or system processing units (SPU). Each uses a single Design Plus box that holds up to two system boards and up to two DIO interfaces.

System Configurations

Several workstation systems are available with monitors, software and a variety of peripherals. You should refer to the current *Model 332 Pricing Information and Technical Data Sheet* to find out exactly what is currently offered.

Supported configurations of hardware and software are identified in the *Series 300 Configuration Reference Manual*, part number 98561-90020.

Model 332 computer bundled systems include:

- Standard color and monochrome systems.

- BASIC-based measurement automation systems.

A typical system diagram is shown in Figure 1-1.
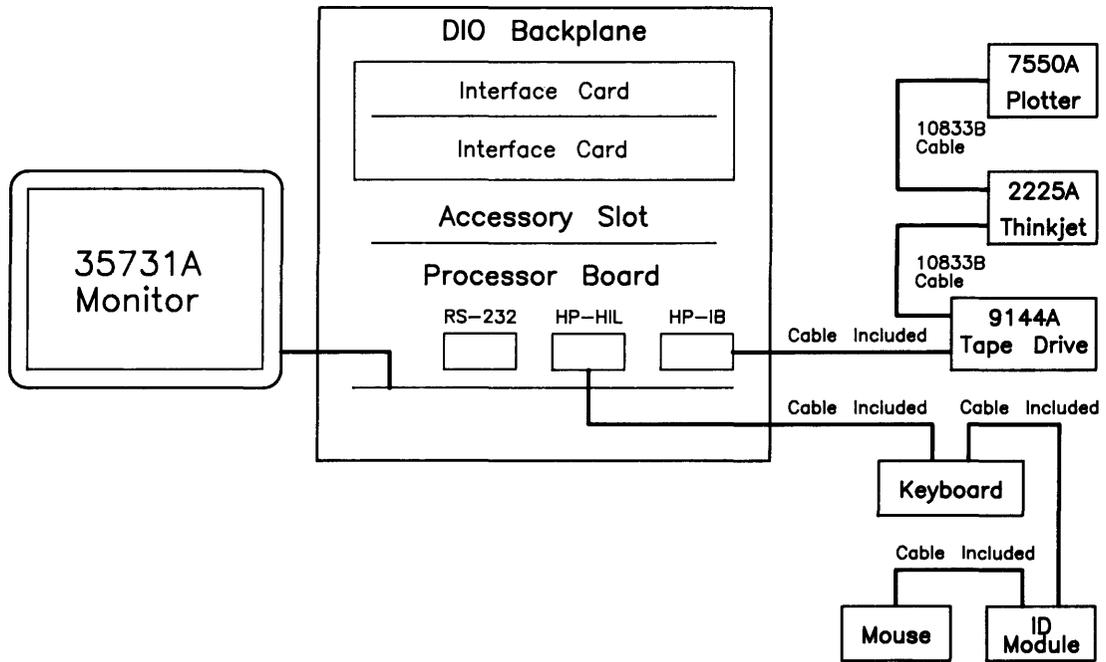
Figure 1-1. Model 332 Typical Workstation

Features

These computers have several useful features. Table 1-1 lists the main features.

Table 1-1. Model 332 Computer Features

Product Number	Description
Model 332 (HP 98572A)	Model 332 system processing unit featuring: 　　MC68030 CPU, 16 MHz 　　Maximum 8 Mbytes of parity-checking RAM 　　Optional MC68882 Floating Point 　　　Co-processor, 16 MHz 4 Gbytes Virtual Memory address space 16-bit DIO Bus IEEE-488 HP-IB Interface RS-232C Serial Interface Two channel DMA Controller HP-IB, HP-HIL, and RS-232 adapter cables.

MC68030 Processor

The Model 332 features a Motorola MC68030 CPU chip which is also found on Models 360 and 370. The 68030 is an extension of the 68020, and includes many additional features. Here is a summary of the new features:

The 68030 has an internal data cache in addition to the internal instruction cache. This means that data access during read cycles may be stored internally, where it is available for subsequent accesses. This reduces the number of external bus cycles when the data operand required by an instruction is already in the data cache.

The internal caches can be accessed in a single clock cycle. In addition, the bus controller provides a two-clock synchronous mode and burst mode accesses that can transfer data in as little as one clock per long word.

The 68030 contains an internal memory management unit that allows address translation to operate in parallel with the CPU core RAM, the internal caches and the bus controller.

Additional signals support emulation and system analysis. External debugging equipment can disable the MMU and internal caches in order to freeze the internal state of the 68030 during breakpoint processing. In addition, the 68030 indicates:

- the start of a refill of the instruction pipe

- instruction boundaries

- pending trace or interrupt processing

- exception processing

- halt conditions

This information allows external debugging equipment to trace 68030 internal activity and interact nonintrusively, thus reducing the debugging effort.

Performance

The Model 332 computer provides 3 to 4 MIPS computational performance and offers graphics display to match the CPU. They are typically used as controllers for instrumentation systems. Less frequent use is as group resource workstations (shared by several designers) and as group computational and shared peripheral resources when networked to lower performance workstations belonging to individual engineers.

Hardware

CPU -- MC68030

The Model 332 is an updated replacement for the Model 310. It performs all the functions of the Model 310, but does so at a much greater speed and at the same price.

Bus Architecture

A 16-bit I/O bus provides interfacing to most Series 200 and 300 accessory cards. This bus is called the DIO bus.

Keyboards

Two keyboards are compatible with the Model 332 HP-HIL interface:

HP 46021

Standard keyboard is the Integrated Terminal Format (ITF) Keyboard. It connects to the HP-HIL connector on the system interface board.

HP 98203C

An optional keyboard with the same keys and rotary control knob as used with several Series 200 and 300 computers. It is used on the HP-HIL interface.

HP 9000 Hardware Compatibility

Model 332 hardware compatibility ensures use and/or support of the same:

- Series 200/300 interface/accessory cards cards

- Series 300 graphics subsystems

- Peripherals supported on other Series 300 systems (except HP 98248A Floating-point Accelerator)

These workstations are fully compatible with the wide range of disk and tape drives, printers and plotters, and HP-HIL devices.

The optional HP 98568A Direct-Connect I/O Expander can be added to the Model 332, allowing system expansion as application needs increase.

Product Identification

Several terms in this manual are used to describe and identify the various parts of the computer and bus expander. This section explains the terms used to improve your understanding of service information.

Product Identification Terms

Each product has its set of included hardware similar to that in Table 1-1. Product numbering conventions used with this computer are explained here to clarify the following information:

- Systems Ordered by Customers
- Products Ordered by HP Field Offices
- Products Manufactured by Technical Computer Group at Fort Collins

Systems Ordered by Customers

When these computer systems are ordered by customers, a suffix is added to the Model number, such as Model 332MMA that identifies the computer system ordered by customers. Refer to the Model 332 Hardware Price List for a current listing of all bundled systems.

Products Ordered by HP Field Offices

A five-digit product number is used by HP field offices to order the computers. This number is strictly for ordering purposes and not for formal product identification. HP 9000 Series 300 Model 332 bundles are based on the HP 98572A.

Products Manufactured by HP Workstation Group

At the manufacturing division, the computer's are built and configured using the numbering conventions explained above. Note that these numbers relate only to the computer or bus expander and do not include peripherals, such as disk drives, some monitors and some accessories. Other HP divisions provide the rest of the products bundled with the computer system.

Serial Numbers

Serial numbers are affixed to each computer and bus expander for identification purposes. A decal on each product has the serial number. An example serial number is explained below:

Serial No.
2623 A 01234

Location: Behind the power supply access cover on the inside bottom of the chassis.

Description:

— 5-digit unique identifying number.

— Country of Origin Code.

— Product Code, decoded as:
First 2 digits + 60 = Last 2 digits of year product was introduced or significantly changed.
Last 2 digits = number of week in year product was introduced or significantly changed.

Hardware Terminology

Hardware is used to define physical elements of these products. Different parts and locations of hardware items are explained below.

Product Terms/Conventions

The following terms are used to describe products and their main parts and areas:

- **Computer** - A product containing the central processing unit (CPU) and other assemblies such as RAM, interface, and video boards, and other accessory cards. Sometimes the computer is referred to as the System Processing Unit (SPU).

- **DIO Slots** - The narrow slots for accessories in the back of the computer or expander. Four slots are available, however, only two are usable for interfaces. The distinctions between these slots are:

  - The top slot and third slot down are **accessory card slots**.

  - The second and fourth slots down are **I/O card slots**.

- **System Slots** - The wide slots in the computer or expander are for the processor or video boards.

- **Internal (circuit)** - A circuit, such as an interface, that is part of the processor board. Internal does not mean "inside the computer's case parts".

- **External (circuit)** - A circuit that is located on an assembly other than the processor board. External does not mean "outside the computer's case parts".

- **Peripheral** - A device external to the computer, such as a keyboard, monitor, disk drive, plotter, printer, bus expander, etc.

- **I/O Expander** - A device external to the computer that connects to the computer's DIO bus. This device provides power to its installed accessory cards and permits more of these cards to be used in the computer system. Sometimes they are called bus extenders. For the Model 332 computer systems, the product name is Direct-Connect System Slot I/O Expander.

- **System** - One or more computers with one or more peripherals connected together to run an application for a desired end result.

PC Boards

PC boards in the computer are made of several component parts. Identifying terms used in this manual are:

- **Cards** - Boards installed in the DIO card cage slots.

  - **I/O Card** - A card that outputs to and inputs from a peripheral device. They are installed in DIO slots. For example, an RS-232 I/O card.

  - **Accessory Card** - A card that only operates on the DIO bus and does not talk to a peripheral device. They are installed in either I/O or accessory card slots.

- **Boards** - Assemblies installed in the wide system slots or inside the product. Boards are not usually removed or installed by users.

  Two-board assemblies are those consisting of one board connecting to the motherboard and an "add-on" board attached to the bottom board.

- **Backplane** - The board in the card cage with connectors for DIO cards to plug into.

Software Terminology

As used in this manual, software refers to information stored in, or on a device. Typically, this information can be changed and can be transferred to another location in the computer system. Types of software are:

- **Firmware** - The data or instructions in Read-Only-Memory (ROM) chips.

- **Operating Systems** - Computer languages, such as BASIC, Pascal, and HP-UX. They have various commands, statements, and keywords that when executed by the CPU in a particular sequence, cause the computer to manipulate data to some desired end result.

- **Application Program** - A series of operating system program lines in a specific sequence to cause specific actions, such as accounting, electro-mechanical design, data sampling and output, etc. This information is sometimes referred to as software as it is information that is stored in or on a medium and can be transferred.

Hardware Support Documentation

The purpose of these computers and expanders Hardware Documentation is to support the installation and maintenance of these products. Hardware Support Documentation consists of six manuals for the HP 9000 Series 300 Models 332 Computer:

- Service Information Manual

- Service Handbook

- Familiarization Guides

- Service Notes

- Test Tools Manual

- HP 9000 Series 200/300/500 Site Preparation Manual

- Series 300 Computer System Configuration Reference

The following manuals also relate to hardware:

- Various Installation Notes

- Series 300 Installation Reference

- Series 200/300 Peripheral Installation Guide

A complete listing of titles and part numbers is in Chapter 7 of this manual and the Model 332 Service Handbook, Chapter 10.

Service Information Manual

This manual (the one you're reading now) contains tutorial information on the computer's and bus expander's main features, functional descriptions of each assembly, and how to replace these assemblies.

Its purpose is to serve as a learning tool in training environments wherein the service person learns how the computer and bus expander works and its parts are replaced. Most of the information in the Service Information Manual is not found in the Service Handbook.

Organization of the Service Information Manual is as follows:

Chapter No. and Title	Contents
Front Matter	Has legal notices, safety situations explained, plus a Service Information Locator to help you find service information.
Chapter 1: Product Information	Introduces the computer/bus expander, covers features, technical information, options, accessories, operating systems, repair philosophy, and a general description of the Model 332 Computers. Has an overview of how the Hardware Documentation is organized.
Chapter 2: Assembly Replacement	In this chapter, disassembly and reassembly of all field replaceable parts for the computer and bus expander are covered. Reference to the Service Handbook and Chapter 6 is made for part number information.
Chapter 3: Functional Description	Each assembly's functional description is covered to block diagram level.
Chapter 4: Boot ROM Functions	The sequence of events for power-up, self-tests, and booting an operating system are explained. Turn-on displays are shown.
Chapter 5: Troubleshooting	This chapter contains tutorial information for troubleshooting the computer and bus expander. Self-test errors for the computer and expander are explained.
Chapter 6: Parts Lists	Has parts ordering information, as well as part numbers and descriptions of field replaceable parts.
Chapter 7: Reference	Contains hardware/software manual titles, and other helpful information.

Service Handbook

This manual is intended to be used on site during service situations. It contains information useful to configuring, troubleshooting, and replacing parts. It is organized as follows:

Chapter No. and Title	Contents
Chapter 1: Product Information	Has a brief description of the product, along with configuration and similar information. Product technical information is also listed.
Chapter 2: Environmental, Installation, and PM	Gives power requirements, fuse and power cord data, and installation information. If preventive maintenance is required, it is shown in this chapter.
Chapter 3: Configuration	Lists various product configurations and explains what each one is.
Chapter 4: Troubleshooting	Lists tools required, including Test Tools, and explains several troubleshooting procedures. Flow charts are frequently used.
Chapter 5: Tests	Lists tests to run to check out the computer, some peripherals, and some accessories and interfaces.
Chapter 6: Adjustments	There's no adjustments for the computer.
Chapter 7: Systems	Refers to the Model 332 Pricing Information and Technical Data sheet for current bundled system configurations.
Chapter 8: Replacement Parts	Lists part numbers for all field-replaceable parts and explains how they may be obtained.
Chapter 9: Diagrams	Block diagrams of the products are shown here.
Chapter 10: Reference	Other documentation related to these products are listed here with their part numbers.
Chapter 11: Service Notes	When you receive Service Notes for these products, they should be inserted here.

Familiarization Guide

Familiarization Guides are condensed service manuals for accessories and associated products used in the Model 33 computer. As new products are introduced, these Guides provide service information that can be inserted in this manual. This allows you to update the Model 332 Service Information Manual with the latest service material for accessories, such as interface cards, video boards, or expanders.

Organization of Familiarization Guides follows this general format:

Chapter No. and Title	Contents
Chapter 1: General Information	Includes a product description, technical information, preventive maintenance, warranty, and support services.
Chapter 2: Functional Description	Describes how the product works to the block diagram level and configurations.
Chapter 3: Troubleshooting	Covers troubleshooting procedures and lists diagnostics that apply to the product.
Chapter 4: Adjustments	Adjustment procedures are explained.
Chapter 5: Parts	Explains how to replace assemblies, the repair philosophy, and has parts lists.

Service Notes

When a situation occurs that affects servicing of the computer or bus expander that is not covered in existing documentation, a Service Note is written to explain it. Service Notes are distributed through a Subscription Service to HP Customer Engineers and to customers on the Cooperative Support Program for these products. Being half-page in size, they are intended to be placed in Chapter 11 of the Model 332 Service Handbook.

Installation Notes

Each separately available accessory or upgrade has an Installation Note packaged with it. These Notes have instructions for configuring and installing the hardware.

Test Tools Manual

Series 200/300 Test Tools Manual supports a software package for verifying the integrity of Model 332 computer system installations. The Test Tools manual and its associated disks or tape permit troubleshooting computer systems in failure analysis. Part numbers for the complete Test Tools packages are:

- 09800-12300 for 3½-inch disk drives
- 09800-12500 for 5¼-inch disk drives
- 09800-12700 for ¼-inch tape drives

Contents of the four parts of the Test Tools Manual are:

Part No. and Title	Contents
Part I: Introduction and Built-In Tests	Introduces the Test Tools package and overviews the computer self-tests and explains what the different tests do.
Part II: Computer Tests	Covers loading and running of Series 200 and 300 Computer Tests. Each test is explained as to what it does. Error messages are listed and explained.
Part III: System Functional Tests	Tells how various computer-peripheral tests are loaded and run. Tests are explained, error messages shown and defined. Examples of some tests are given. Includes tests for HP-HIL devices.
Part IV: CS/80 Exercisers	Explains how tests for CS/80 disk drives are loaded and run, and results are interpreted. Error messages are shown as well as several examples of running the tests.

Series 300 Configuration Reference Manual

All supported configurations of Series 300 Computer Systems are explained in this manual.

Section No. and Title	Contents
Section 1: Configuration Overview	Has configuration worksheets to assist in planning the application.
Section 2: Operating Systems and Application Software	Covers supported languages and media options.
Section 3: System Packaging	Lists the Model 332 features and options available.
Section 4: Interface and Peripheral Selection	Explains Interfacing, networking, mass storage, monitors, printers, and other output peripherals.
Section 5: Support Services	Overviews Customer Training, installation and support services, and consulting.
Appendix A: Detailed Product Reference	Gives detail information about computers, accessories, and peripherals.

Site Preparation Manual

Explains site preparation and how to prepare the computer site for hardware installation. Covers physical, environmental and electrical requirements. Its organization is shown below.

Chapter No. and Title	Contents
Chapter 1: Introduction	Explains the purpose and contents of the Site Preparation Manual.
Chapter 2: Responsibilities	Identifies customer and HP responsibilities for preparing the HP 9000 Computer System site. Includes a time frame for setting up the computer system, and identifies people who can provide assistance.
Chapter 3: Preparing the Electrical Environment	Includes power technical information, dealing with electrical interference, connecting cables, and data communication configurations.
Chapter 4: Preparing the Physical Environment	Explains heat and humidity considerations, airborne contaminants, and shipping weights and dimensions for movement and storage.
Chapter 5: Providing Other Necessities	Covers media storage, equipment and record protection, computer supplies, and nearby telephones for assistance which are an integral part of preparing for and sustaining the operation of a computer system.
Chapter 6: Equipment Arrangement and Space Planning	Provides information and guidelines for planning the location of the computer system equipment at your site.
Chapter 7: When Your Computer Arrives	Discusses the final preparation for system arrival, coordinated deliveries, arrival dates, how to check for damage in shipment, unpacking the cartons, and scheduling the installation of HP 9000 Computer Systems.
Appendix A	Lists product technical information for electrical requirements, heat generation, temperature and humidity requirements, and shipping dimensions.
Appendix B	Contains forms to use for preparing the site, such as Pre-Installation Worksheet, Shipment Scheduling Form, and a Site Completion Checklist.

Installation Reference

The computer and expander each have step-by-step procedures for installing them. An Installation Card is a pictorial set of instructions to show the installer how to unpack, connect, and power up the computer, disk drive, and monitor. More detailed information is contained in the Installation Reference. To install the operating system and/or application program, the documents supplied with these software products should be referred to.

Organization of the Installation Reference is:

Chapter No. and Title	Contents
Chapter 1: Introduction	Covers how the guide is organized and explains some computer fundamentals.
Chapter 2: Installing Your Computer	Includes procedures on positioning the computer, checking voltage settings, connecting power cords, and turning on the computer.
Chapter 3: Installing Accessories	This chapter covers accessory configuration and installation, such as memory or interface cards.
Chapter 4: Installing Your Keyboard and Monitor	This chapter covers keyboard and monitor installation.
Chapter 5: Installing HP-IB Peripherals	Standard HP-IB peripheral configuration and connection procedures.
Chapter 6: Installing Non-HP-IB Peripherals	Peripheral configuration and connection procedures other than HP-IB.
Chapter 7: Reading the Self-Test	Covers procedures performed by self-test and how to interpret the results of the self-tests. Error messages are explained and help is provided should the user get into trouble at this point.
Reference	This chapter has information regarding internal configuration switches, running extended tests, Boot ROM error messages and tutorial information on data communications and interfacing.
Glossary	Provides explanations of computerese terms and phrases.

Technical Information

Electrical

Line voltage/Frequency	120 V ac @ 48-66 Hz
	240 V ac @ 48-66 Hz
Fuse	8AF 250V
Backplane Power Available	Total Power Available from motherboard:
	95 Watts @ +5 V dc
	40 Watts @ +12 V dc
	12 Watts @ −12 V dc
	Each system slot:
	23 Watts @ +5 V dc
	10 Watts @ +12 V dc
	3 Watts @ −12 V dc
	DIO backplane, all slots combined
	23 Watts @ +5 V dc
	10 Watts @ +12 V dc
	3 Watts @ −12 V dc
Line transient spike immunity (1 nsec rise, 800 nsec duration)	1 KV dc
Power Consumption	250 Watts maximum
Current Requirements	5.0 A @ 120 V ac
	3.0 A @ 240 V ac
Maximum Heat Dissipation	853 BTU/hr
	250 Kcal/hr
Battery Back-up	Real-Time Clock on Processor Board

Environmental

Operating temperature	0 - 55° C
Operating humidity	5 - 95% relative
Operating altitude	4 572 metres (15 000 feet)

Electromagnetic Interference

Standards met   FCC Class A
                                 VCCI Class 2
                                 VDE Class B, VDE 1046/84

Regulatory Requirements

Standards met   UL 478. 5th Edition
                                 CSA 154M-1983
                                 IEC 380, 3rd Edition; 435, 2nd Edition

Physical

Dimensions   130 mm (5.12 inches)
    Height

    Width   325 mm (12.8 inches)

    Length   376 mm (14.8 inches)

Weight   11.8 kg (26 pounds) maximum

Vibration Standard   Meets Class B requirements

Shipping Information

The shipping container for each computer includes the Localization Kit, which includes power cords, fuse, keyboard cable, HP-HIL cable, and Installation Reference.

Shipping Weight   15.9 kg (35 pounds)

Container Dimensions   Width - 502 mm (19.75 inches)
                                 Length - 559 mm (22 inches)
                                 Depth - 267 mm (10.5 inches
                                 Cube - 0.07 m^3 (2.65 feet^3)

Processor Board

CPU

    Type   Motorola MC68030

    Clock Frequency   16 MHz

    Internal Architecture   32-bit data and address registers

    Address range   4 Gbytes virtual mapped to
                                 4 Gbytes physical

    Data bus   32-bit synchronous to:
                                     1 to 8 Mbytes On-board RAM

Floating point Co-processor   16-bit synchronous to:
                                     DIO devices

    Type   Motorola MC68882

    Clock Frequency   16 MHz

Add-on Memory

Type	Byte parity error checking
System bus width	32 bits address; 32 bits data
Bandwidth	16.7 Mbyte/sec
Average cycle time	240 nsec read; 300 nsec write
Size	1 to 8 Mbytes, add-on boards furnished in 1 and 4 Mbytes
Minimum RAM	1 Mbyte
Maximum RAM	8 Mbytes (RAM quantities of 1, 2, 4, 5 and 8 Mbytes are supported)

DIO Bus

Width	23 bits address; 16 bits data
Bandwidth	6 Mb/sec

Parallel Interface

Type	IEEE 488
Data Rate	370 Kbyte/sec
Connected devices	15 per interface devices supported

Serial Interface

Type	RS-232C standard
Connector	DB25

Battery-backed
Real-Time Clock

Resolution	10 milliseconds
Accuracy	±5 seconds/day
Battery type	Lithium; 1 year expected life
Keyboard requirements	HP 46021A (ITF) with HP-HIL interface, 107-key low profile with numeric keypad, 8 special-function keys
	HP 98203C with HP-HIL interface, 106-key with rotary control knob, including 10 special-function keys.

HP-HIL and Video Accessories

Listed below are HP-HIL and video accessories compatible with the Model 332 workstations. For a complete list, consult the *HP 9000 Series 300 Model 332 Hardware Price List*, Part Number 5954-7061D.

Table 1-2. HP-HIL Devices

Product Number	Product Name/Description
46021A	ITF keyboard
46060A	2-button Mouse
46083A	HP-HIL Knob
46084A	ID Module
46085A	Control Dial Module
46086A	32-button Control Box
46087A	ANSI A/ISO A4-size digitizer
46088A	ANSI A/ISO A3-size digitizer
46089A	4-button cursor for 46087A and 46088A
46094A	Quadrature port
46095A	3-button mouse for 46094A
98203C	Large Keyboard with Knob

Table 1-3. Video Accessories

Bus and Type	Product Number	Product Name/Description
DIO Video Card	HP 98546A	Display Compatibility Interface
	HP 98542A	Medium Resolution Monochrome Video Board
	HP 98543A	Medium Resolution Color Video Board
	HP 98544B	High Resolution Monochrome Video Board
	HP 98547A	6-plane High-performance Color Video Board
	HP 98548A	High Resolution Color Video Board
	HP 98549A	Low Cost Color Video Board
	HP 98550A	High Resolution Color Video Board

Hewlett-Packard Support

Support services and policies mentioned in this section are subject to change. Please consult your local Hewlett-Packard Sales and Service Office for the current support policies.

Repair Philosophy

Field Repair Philosophy for the Model 332 Computer is assembly, or board level. This means that when a failure occurs, the problem is diagnosed to the assembly having the failed part. That assembly is then replaced. Replacement assemblies are available through local HP Sales and Service Offices.

Some assemblies may be exchanged for rebuilt ones. Other assemblies are only available as new ones. Refer to Chapter 6, or the Service Handbook, Chapter 8, for information on replacement parts.

Schematics

In support of the repair philosophy, this manual contains information to the assembly level. Schematics are not available for these products.

Supported Configurations

Only computer systems with Hewlett-Packard approved parts, accessories, peripherals, operating systems and application programs are supported by Hewlett-Packard. Any computer system with other than HP approved hardware or software connected or installed must have the non-HP approved hardware and software removed by the customer before On-Site or Service Center repair is accomplished.

Repair Services

Hewlett-Packard provides repair services in three ways:

- On-Site Repair.

- Service Center Repair.

- Customer Repair.

On-Site Repair

For On-Site Repair, an HP Customer Engineer goes to the customers site, troubleshoots, and repairs the hardware to the assembly level. The defective assembly is replaced with a new or rebuilt assembly. This service is available through a service contract or a time-and-materials basis.

Hewlett-Packard Service Center Repair

The customer returns the defective product to the nearest HP Repair Center. An HP Customer Engineer repairs the product to the assembly level in the same manner as On-Site Repair. Upon being repaired, the product is returned to the customer. Contact your nearest HP Sales and Service Office for the location of the HP Repair Center, typical turn-around times, and shipping instructions.

Customer Repair

Customers have the option of repairing their own HP computer products. Contact your nearest HP Sales and Service Office for information concerning service training, special tools and test equipment, and spare parts.

Hewlett-Packard offers a Customer Cooperative Support Program to assist customers in maintaining their HP computer products. A variety of technical services and information are available. Your local HP Sales and Service can provide you with information about the Cooperative Support Program.

Hardware Support Services

There are many hardware support options available, from utilizing on-site maintenance groups to buying full support from the local sales office. Please contact your local Hewlett-Packard Sales and Service Office for these services.

Operating Systems Support

Primary Support

There are numerous operating system support options:

- Account Management Support (AMS) provides a local SE, on-site assistance, one Response Center caller and one alternate for telephone assistance, and a Software Materials Subscription.

- Response Center Support (RCS) provides one Response Center caller and one alternate for telephone assistance, and Software Materials Subscription.

- Software Materials Subscription (SMS) provides software and manual updates, Software Status Bulletins, and HP communicator magazine. Updates to ROM-based systems are not provided.

Support For An Additional System

The following options support an additional system:

- Additional System Coverage extends AMS or RCS coverage on the operating system to one additional system under the same system manager. All support is delivered through the central system.

- Extended Materials Support extends SMS by providing the right to make one copy of all central system materials for use on one additional system.

- Additional Response Center Caller provides one additional caller and one alternate for access to the HP Response Center

- Manual Update Service (MUS) provides one copy of updates to software reference manuals.

- Software Notification Service (SNS) provides issues of the HP Communicator and Software Status Bulletin.

Assembly Replacement

2

Introduction

Tools Required

| CAUTION |

The computer uses metric screws requiring the use of Pozidriv®
screwdrivers. Do not use other cross-tip screwdrivers, such as Phillips
or Reed-Prince. They will eventually damage the Pozidriv® screw
head recess making screws hard to remove.

All field replaceable parts can be accessed with these tools:

- Static-free Workstation, HP Part Number 9300-0794

- #1 Pozidriv® screwdriver, 4-inch (100 mm) blade.

  Used for all screws except the power supply ground tab screw.

- #2 Pozidriv® screwdriver, 4-inch (100 mm) blade.

  Used for the power supply ground tab screw.

- Flat-tip screwdriver, 0.125-inch (3 mm) wide tip, 4-inch (100 mm) blade.

- IC extraction tool, AMP 6810, AMP p/n 821566-1.

  Used to extract the floating-point accelerator chip.

- Anti-Static Bags

Parts Diagrams

Figure 2-1 shows an exploded view of the computer. This diagram should help you determine how the parts are installed or replaced.
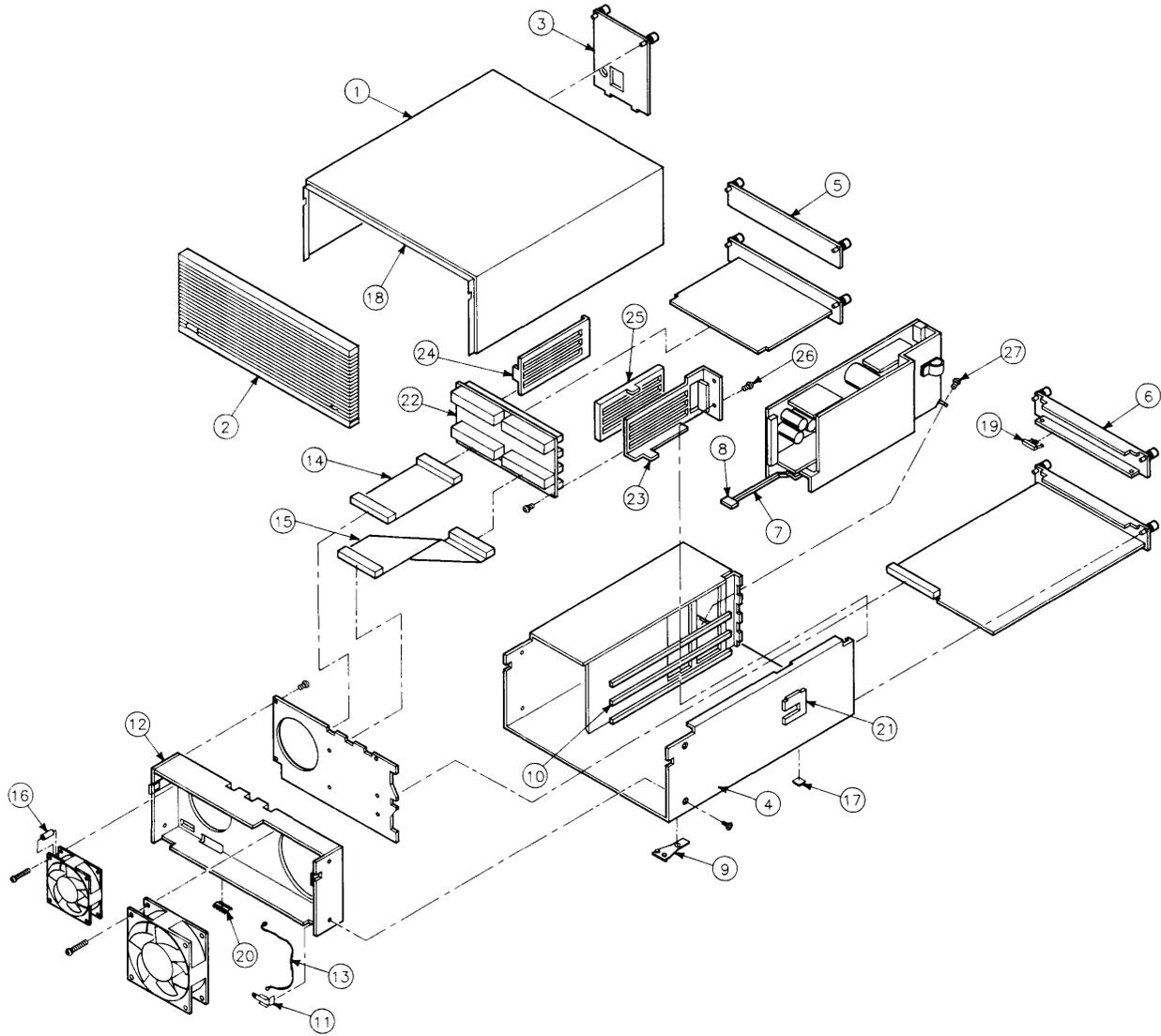
Figure 2-1. Computer Exploded Diagram

Safety Precautions

Electrical Precautions

As with any electrical/electronic product, certain safety precautions must be practiced. These safety precautions, when followed protect both you and the equipment from injury and possible permanent damage.

WARNING

Always turn off the unit and remove the power cord before opening the unit to remove or replace an assembly. If maintenance activity requires power to be applied while the protective covers are removed, proceed only with extreme caution using safe, live-unit maintenance procedures. Do not touch energized components or parts with your fingers. Heed and follow all "WARNING-HAZARDOUS VOLTAGE" labels. Failure to follow these safety precautions may result in serious injury, or worse.

System Board Installation

CAUTION

Do not use excessive force to seat system boards in the system slot connectors.

If excessive force seems to be needed to install a board, remove the board, and inspect the motherboard's connector for bent pins. Straighten any pins that appear to be bent.

Remove the top cover and all boards above the one that is difficult to seat.

Re-insert the board to the motherboard's connectors and adjust the position of the board's connector to mate correctly with the motherboard's connector. Carefully seat the board. Reinstall the other boards in the same manner, then replace the top cover.

Electro-Static Discharge Precautions

Integrated circuit components in these products can be damaged by electro-static discharge. It doesn't make any difference whether the ICs are installed on a printed circuit board or laying on a table. Static charges can build up in people to a potential of several thousand volts by simply walking across a room.

These circuits in the computer, bus expander, accessories and peripherals can be protected by using a static free workstation and wearing clothes that do not hold static charges before handling any of the unit's PC boards.

When you need to remove or install a part, remove power from the product first. With the static free workstation in place, touch sheet metal with your fingers before touching the printed circuit assembly. If the assembly is not going to be re-installed, place the assembly in an anti-static bag and set it aside.

Following these precautions will extend the life of the computer products you maintain.

Assembly Replacement Procedures

Overview

In this section, procedures are listed for removing and installing each assembly. For each assembly, a list of Preliminary Requirements is listed. To perform these Preliminary Requirements, follow the steps shown in each Preliminary Item's replacement procedure.

Instructions are based on the following orientation of the hardware:

- The right side is the side on your right as you face the front of the unit. For example, the Power-On LED is on the unit's right side.

- The left side is the side on your left as you face the front of the unit. For example, the power supply is on the unit's left side.

- The front is the end toward you as you face the front panel. For example, the power switch is on the unit's front end.

- The back is the end away from you as you face the front panel. For example, the fuse is on the unit's back end.

- The top and bottom are relative to their normal positions.

These references are used in the procedures and should be followed regardless of how you are facing the unit. Figure 2-2 shows the hardware orientation.
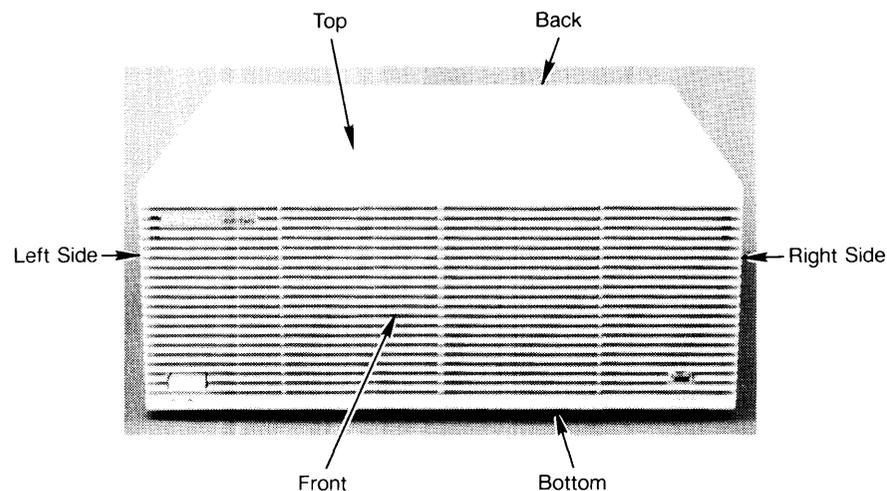
Figure 2-2. Hardware Orientation

Fuse

Preliminary Requirements

1. Turn the unit off.

2. Remove the power cord.

Procedures

1. Using a flat-tip screwdriver, press in on the fuse cap and rotate it counter-clockwise about ¼ turn. The fuse should pop out a little.

2. Pull out the fuse cap containing the fuse.

3. Remove the fuse from the fuse cap and replace it.

4. Reverse steps 1 through 3 to install the fuse.

Processor Board

Preliminary Requirements

Turn the computer off and remove the power cord.

Procedures

1. Leverage the processor board out with its board extractors.

2. Remove the processor board.

3. To install the processor board, reverse the above steps.

Floating-point Accelerator Chip

Preliminary Requirements

Turn the computer off and remove the power cord.

Procedures

1. Remove the processor board from the chassis and place it on an anti-static surface.

2. Use the AMP IC extractor tool to remove the IC from its socket.

When reinstalling a floating-point chip, make sure that it is aligned as in this figure:
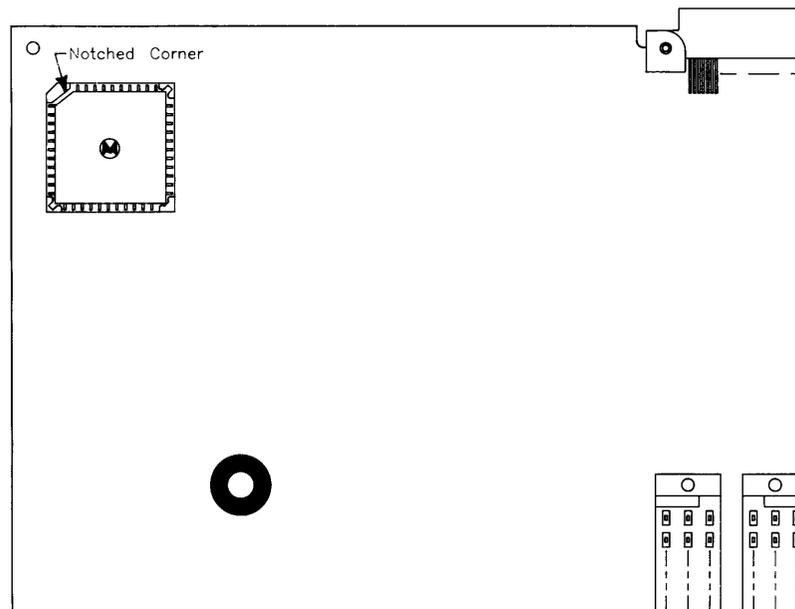
Figure 2-3. Floating-point Accelerator IC Alignment

Video Boards

Large video boards must be located in the bottom system slot. DIO video cards are in the DIO slots.

Preliminary Requirements

1. Turn the unit off.

2. Remove the power cord.

Procedures

1. Disconnect the video cables from the video board.

2. Using a #1 Pozidriv or your fingers, unscrew the two captive screws holding the video board in its system slot.

3. Remove the video board.

4. To install the video board, reverse steps 1, 2, and 3.

Interface Boards/Cards

These procedures apply to graphics display station or system interface boards in a system slot and I/O cards in a DIO slot.

Preliminary Requirements

1. Turn the unit off.

2. Remove the power cord.

Procedures

1. Disconnect the cables from the interface.

2. Unscrew the two captive screws holding the interface in the slot.

CAUTION

Some accessories consist of two assemblies connected together by ribbon cables. Do not completely remove these accessories with the panel on it until the cable has been disconnected. When reassembling these assemblies, sets, insert the top assembly first, then insert the lower one before connecting them together.

---

3. Remove the interface board/card from its slot.

Note

Before installing interface boards or cards, ensure they are correctly configured for the application and/or peripherals.

---

4. To install the interface, reverse steps 1 through 3.

Battery Replacement

WARNING

Replace battery with Matsushita Electric 3V Lithium battery #BR 2325 (HP part number 1420-0314) ONLY! Use of another cell may present a risk of fire or explosion.

To replace the real-time clock's battery:

1. Remove the battery by holding the processor board with the configuration switches up and raise the battery holder's positive (+) tab with your fingernail or a thin-blade screwdriver. Let the battery slide out of its holder.

WARNING

The lithium battery may explode if mistreated. Do not dispose of the battery in fire, try to recharge or disassemble.

---

2. Install a new battery by raising the positive (+) tab and inserting a new battery with its positive (+) side against the tab.

Add-On RAM Boards

This procedure tells how to remove these assemblies:

- 98269-66521 1 Mbyte RAM add-on

- 98269-66524 4 Mbyte RAM add-on

Preliminary Requirements

Turn the computer off. Remove the power cord and the following assemblies:

- Remove the processor board.

Procedure

1. Turn the processor board over and remove the two screws holding the add-on board to the processor board.

2. Pull the add-on board straight up and away from the processor board.

DIO Accessory Cards

Preliminary Requirements

1. Turn the unit off.

2. Remove the power cord.

Procedures

1. If the card is behind a slot cover, remove the slot cover.

2. If the card is above and behind another card's rear panel, disconnect the cables from the card's panel, then remove the card.

3. Raise the card's extractor levers with your fingers and unseat the card from the unit's DIO backplane connector.

4. Remove the card.

Note

Before installing DIO accessory cards, ensure they are correctly configured for the application and/or peripherals. Refer to the DIO accessory's Installation Note for the correct configuration.

---

5. To install the DIO accessory card, reverse steps 1, 2, 3, and 4.

Power Supply

Preliminary Requirements

1. Turn the unit off.

2. Remove the power cord.

Procedures

1. Unscrew the two captive screws holding the power supply access cover in place. Refer to Figure 2-4.

WARNING

A shock hazard exists on the power supply until about one minute after the unit is turned off. Use caution in handling the power supply.
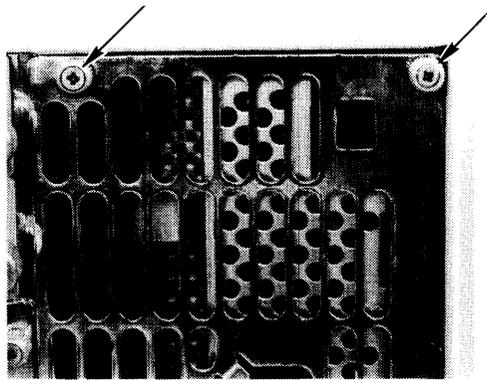
Figure 2-4. Power Supply Access Cover Screws

2. Remove the power supply access cover.

3. Remove the power supply grounding tab screw. Refer to Figure 2-5.
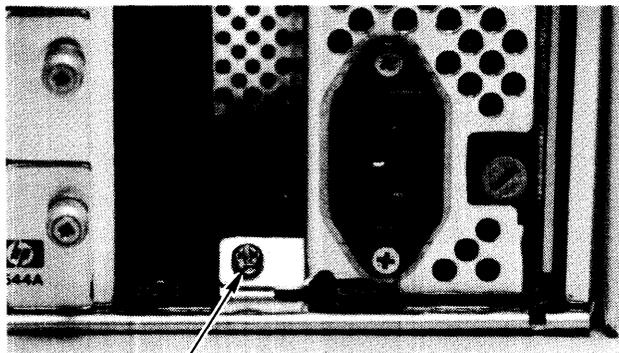
Figure 2-5. Power Supply Grounding Tab Screw

$$\boxed{\textbf{CAUTION}}$$

The ON-OFF button on the front of the computer is connected to the power supply by a long shaft. When removing the power supply, slide the power supply out carefully so you don't damage the ON-OFF switch shaft.

---

4. Remove the power supply.

Note

Replacement power supplies do not have the switch shaft connected. Install the switch shaft from the failed power supply on the replacement power supply.

---

5. Remove the switch shaft guide by pinching the tab shown in Figure 2-6 and removing the guide.

Switch Shaft
Guide

Figure 2-6. ON-OFF Switch Shaft Guide Removal

6. Remove the switch shaft from the ON-OFF switch by gently pulling the switch shaft off the switch. Refer to Figure 2-7.

Switch Shaft
Connection
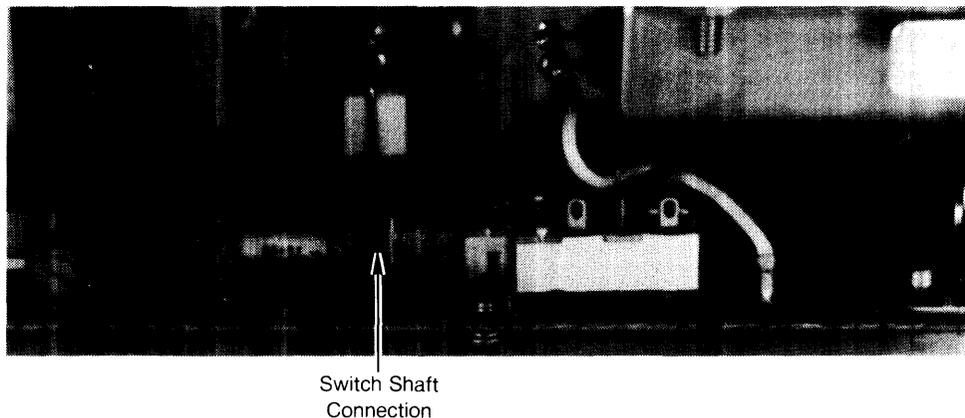
Figure 2-7. ON-OFF Switch Shaft Connection.

7. To install the power supply, reverse steps 1 through 6. Be sure to replace the power supply grounding screw.

Top Cover

Preliminary Requirements

Turn the unit(s) off. Remove the power cord(s) and these assemblies:

1. All cables from the installed accessory cards.

2. Power supply access cover.

3. Expander top cover, if the computer's top cover needs to be removed.

Expander Top Cover

When an expander is mounted on top of the computer, its original top cover is placed on the computer and the computer's top cover is placed on the expander. Keep this in mind if top covers need replaced. Chapter 8 in the Service Handbook lists top cover part numbers with their original unit.

1. Slide the expander's top cover to the rear and lift up on the back of the cover to remove it.

2. To install the top cover, place the top cover on the chassis, ensuring the RF shield plates are outside the sides of the chassis.

Assembly Note

When installing the top cover, ensure the lip on the back edge of the top cover catches the tab on the chassis when the top cover is fully seated in place.

---

3. Slide the top cover forward and fit the front of the top cover inside the front cover edges and engage the lip on both sides at the rear of the cover in the tabs on the chassis.

Computer Top Cover

When an computer is used with an expander, its original top cover is placed on the expander and the expander's top cover is placed on the computer. Keep this in mind if top covers need replaced. Chapter 8 in the Service Handbook lists top cover part numbers with their original unit.

1. If an expander is installed:

    a. Remove the expander's attaching screws shown in Figure 2-8.
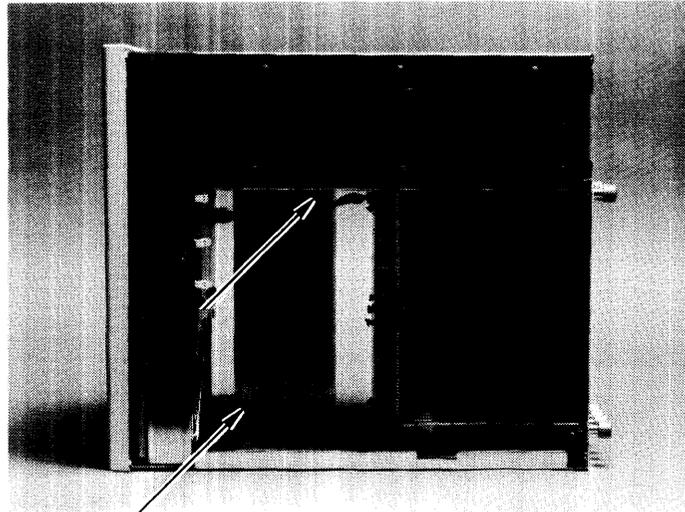
Figure 2-8. Expander to Computer Attaching Screws

    b. Remove the expander from the computer and install the connector's protective sleeve or set the expander on its side.

    c. Remove the flat-head screw that holds the computer's top cover to the motherboard connector.

2. Slide the computer's top cover to the rear and lift up on the back of the cover to remove it.

3. To install the top cover, place the top cover on the chassis, ensuring the RF shield plates are outside the sides of the chassis.

Assembly Note

When installing the top cover, ensure the lip on the back edge of the top cover catches the tab on the chassis when the top cover is fully seated in place.

---

4. Slide the top cover forward and fit the front of the top cover inside the front cover edges and engage the lip on both sides at the rear of the cover in the tabs on the chassis.

5. If an expander is to be installed:

    a. Replace the top cover screw.

    b. Install the expander.

    c. Replace the two expander attaching screws.

    d. Replace the expander top cover.

Front Panel

Preliminary Requirements

1. Turn the unit off.

2. Remove the power cord.

Procedures

1. Using a thin blade flat-tip screwdriver, release the front panel catches on the right and left sides by pressing them inward as shown in Figure 2-9.
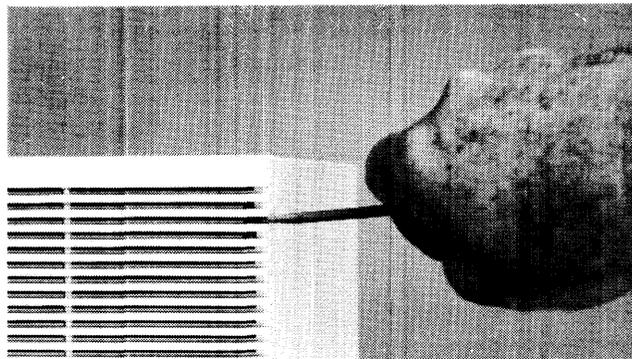
Figure 2-9. Releasing the Front Panel Catches

2. Carefully tilt the front panel forward to a 45° angle.

3. The front panel can be removed and set aside.

Note

When installing the front panel, ensure the lip at the bottom of the front panel fits over the sheet metal on the bottom of the fan housing.

---

4. To install the front panel, reverse steps 1 through 4.

Fans

Preliminary Requirements

1. Turn the unit off.

2. Remove the power cord.

3. Remove the front panel.

Procedures

1. Using needlenose pliers, disconnect the fan wire connector from its pins on the motherboard. Refer to Figure 2-10.

Voltage Test   Fan Wire   LED Wire
Points   Connectors   Connector
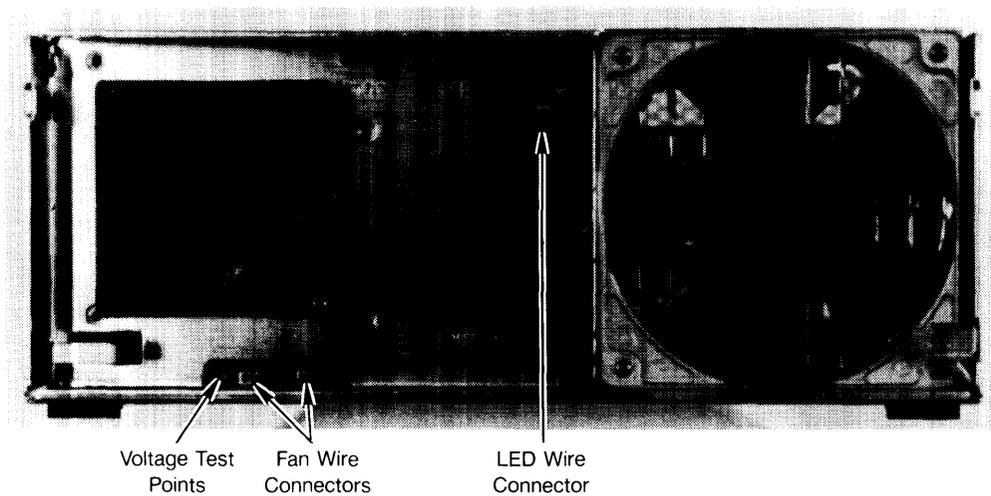
Figure 2-10. Fan Wire Connectors

2. For the large fan, slide the power-on LED/bracket toward the front and bend the wires aside.

3. Remove one of mounting screws from the fan to be replaced. Refer to Figure 2-11.
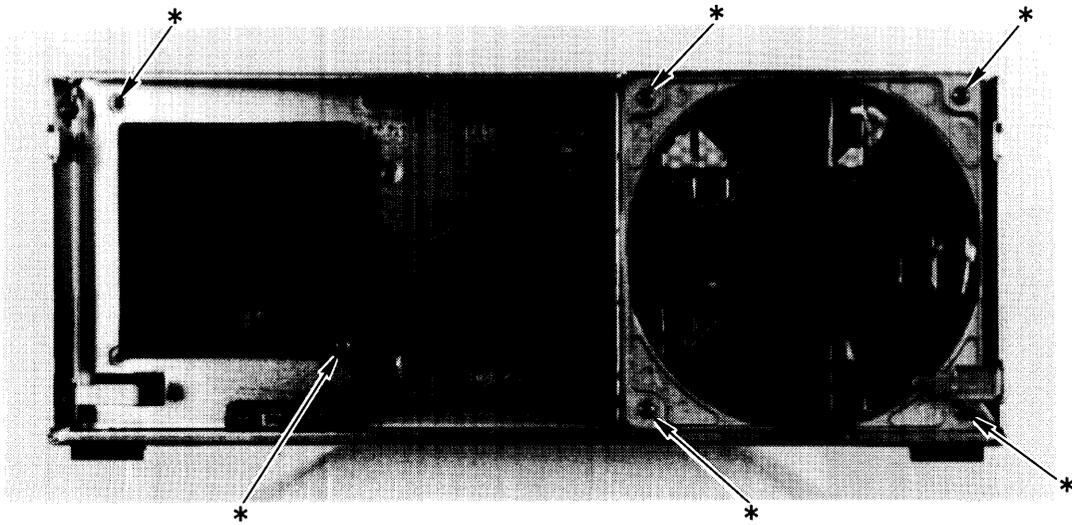
Figure 2-11. Fan Mounting Screws

4. While holding the fan in place with one hand, remove the other mounting screw from the fan.

4. Remove the fan.

5. To install the fan, reverse steps 1 through 3.

DIO Card Cage

Preliminary Requirements

Turn the unit off. Remove the power cord and these items:

1. All cables from DIO cards in the slots.

2. DIO slot cover if installed.

3. Power supply access cover.

4. Remove the expander from the computer.

5. Top cover.

Procedure

1. Disconnect the DIO ribbon cables from the motherboard.

2. Remove the screw holding the right side of the DIO card cage to the card cage bracket. Refer to Figure 2-12.

   a. The card cage bracket is a tab that is part of the sheet-metal chassis on the right side of the computer.
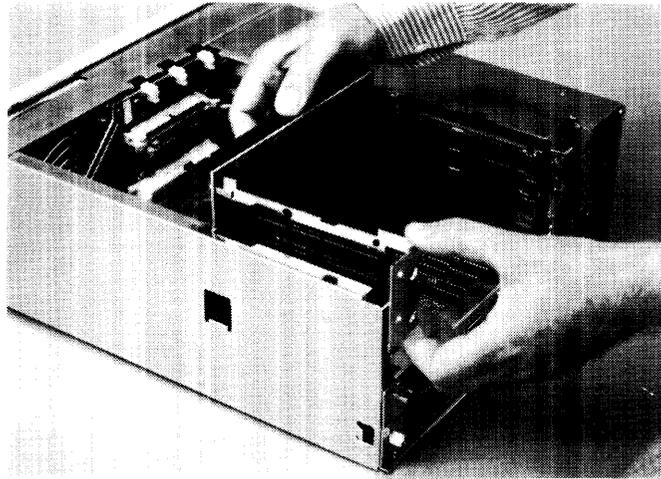
Figure 2-12. DIO Card Cage Bracket

3. Remove the screws holding the card cage to the chassis. Refer to Figure 2-13.
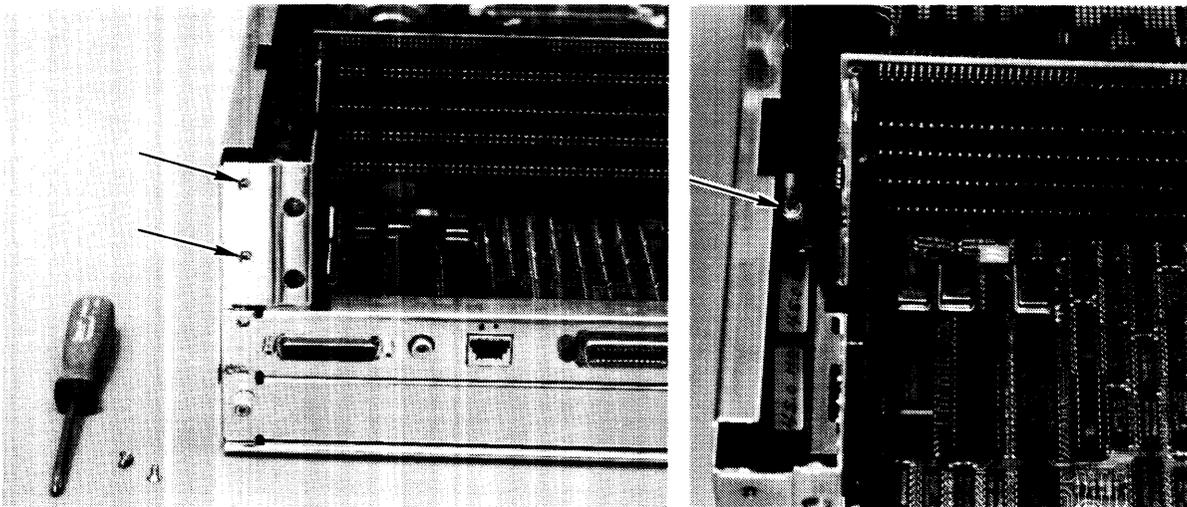
Figure 2-13. DIO Card Cage Screws

3. Slide the card cage out of position by rotating it to the right until the tabs on its left side clear their mounting slots and remove the card cage.

Assembly Note

Note that the left side of the card cage fits outside the chassis and the right side fits inside the chassis.

---

4. To install the card cage, reverse steps 1, 2, and 3.

DIO Backplane

Each 4-slot DIO adaptor has a backplane for cards to connect to. When this backplane needs to be replaced, here's what you need to do.

Remove these parts first.

1. Power cord after turning the unit off.

2. Power supply access cover.

3. Top cover.

4. DIO adaptor.

Procedures

1. Note what ribbon cable is attached to the motherboard and backplane connectors, then remove the ribbon cables from the backplane.

2. Remove the screws holding the backplane PC board to the card guides. The number of screws will differ depending on the specific backplane.

Note

If the DIO backplane is installed with the ribbon cables hooked up to the backplane's top two connectors and a DIO card is installed, the card won't work. There are no power traces from the top backplane connectors to the DIO card slots. **Ribbon cables must connect only to the bottom backplane connectors.**

---

3. To install a backplane, reverse these steps.

Fan Housing

Preliminary Requirements

Turn the unit off. Remove the power cord plus these assemblies:

1. All assemblies from the DIO and/or system slots.

2. Front panel.

3. Power supply access cover.

4. Power supply.

5. Top cover.

Procedures

1. Disconnect any attached ribbon cables from the motherboard.

2. Disconnect both fan connectors from the motherboard.

3. Remove the four screws holding the fan housing in place. Refer to Figure 2-14.
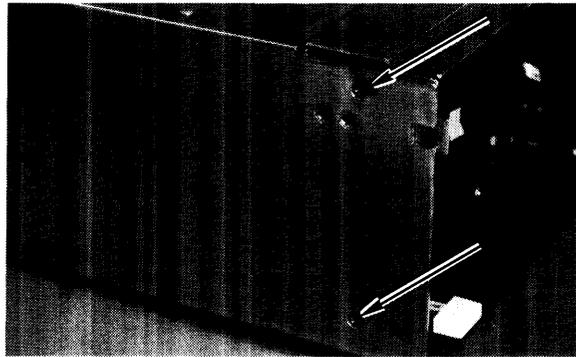
Figure 2-14. Fan Housing Screws

4. Pull the fan housing forward and remove it.

5. To install the fan housing, reverse steps 1 through 4.

Motherboard

Preliminary Requirements

Turn the unit off and remove the power cord. Then remove these assemblies:

1. All boards from the system slots.

2. Power supply.

3. Top cover

4. Front panel.

5. Ribbon cables to motherboard.

6. Fan housing.

Procedure

1. Remove the LED and both fan wire connectors from the motherboard.

2. Remove the screws holding the motherboard to the fan housing, and remove it. Refer to Figure 2-15.

3. To install the motherboard, reverse steps 1 and 2.
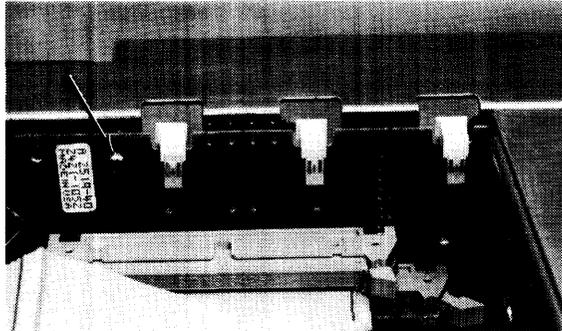
Figure 2-15. Motherboard Screws

Card Guides

Card guides on the left-hand side (power supply side) of the cage just snap into place. They may be removed by carefully unsnapping them.

Be sure they are replaced correctly, with the correct end toward the front and back of the unit.

Functional Description

3

Introduction

Computer Overview

The Model 332 is an improved version of the Model 310. It has been redesigned for higher performance to meet the compute-intensive requirements for measurement automation, as well as scientific analysis, and general purpose computation. It is similar in construction and uses the same power supply.

Computer Architecture

Here's an overview of the architecture used in the Model 332 computer. You'll note that this computer provides the peak performance potential of the Motorola architecture and maintains Series 300 compatibility.

Figure 3-1 is a block diagram of the Model 332 architecture.
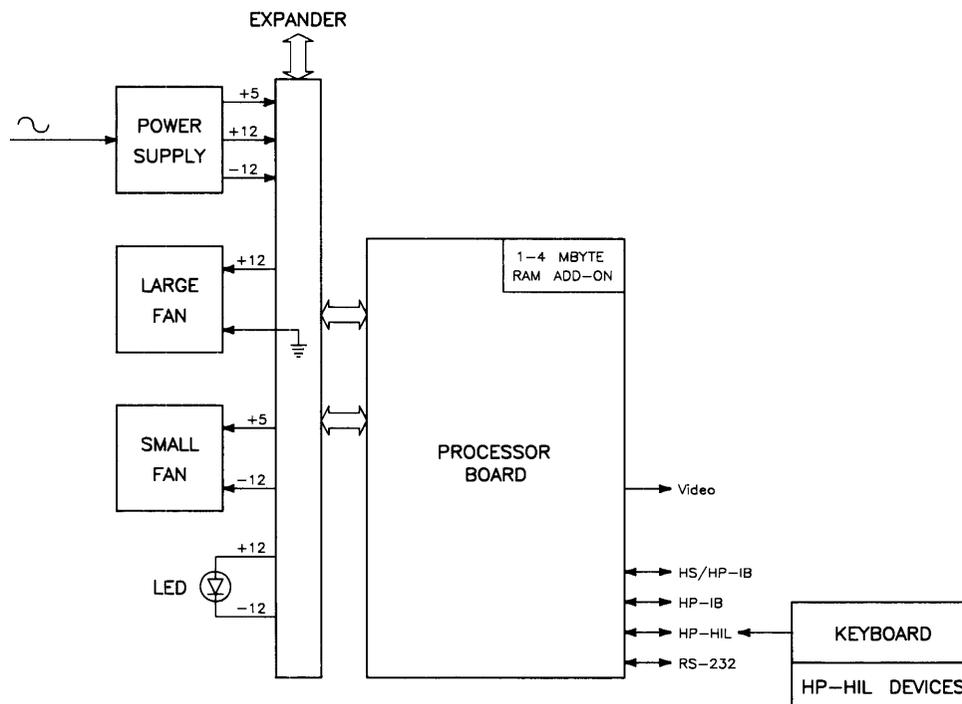
Figure 3-1. Model 332 Block Diagram

Computer Packaging

Each is packaged in a Series 300 chassis like the Models 310 and 320. For most applications, an expander is not necessary.

The computer has two system slots. The processor board must be installed in the bottom one. If a separate video board is used, it must go in the bottom slot after the processor board has been moved up one slot.

System Implementation

Processor Board

- 16 MHz MC68030, optional 16 MHz MC68882 coprocessor, 1 to 8 Mbytes RAM.

- On-board I/O including HP-IB, RS-232, DMA, Audio, HP-HIL, Battery-backed real-time clock.

- Two sockets for add-on RAM array boards.

- Choice of medium-resolution monochrome video, high-resolution monochrome video or no video (in order to use separate video boards). Medium-resolution video can be upgraded to high-resolution via customer-installable upgrade kit.

RAM Boards

The following RAM boards are supported in the computer system:

- HP 98269A 1 Mbyte parity error checking RAM board

- HP 98269B 4 Mbyte parity error checking RAM board

Standard RAM configurations are:

- At least one 1 or 4 Mbyte RAM board is required

- An additional 1 or 4 Mbyte RAM board may be added for a total of 1, 2, 4, 5 or 8 Mbytes

Video

The processor contains a monochrome video driver which is orderable as medium-resolution or high-resolution (or the video can be deleted if the customer wishes to use a separate video driver). Once installed, a medium-resolution video driver can be upgraded to a high-resolution driver, and both can be disabled in order to use a separate video driver.

The Model 332 computer supports the following separate video boards:

- HP 98542A Medium-resolution Monochrome Video Board
- HP 98543A Medium-resolution Color Video Board
- HP 98544A High-resolution Monochrome Video Board
- HP 98546A Display Compatibility Interface Card
- HP 98547A High-resolution Color Video Board
- HP 98548A High-resolution Monochrome Graphics Board
- HP 98549A Low-cost High-resolution Color Graphics Board
- HP 98550A High-resolution Color Graphics Board

Refer to the Series 300 Configuration Reference Manual for the current list of supported video boards.

Human Interface

The processor board is designed to meet most, if not all of the computer's human interface needs in a single system slot. It integrates RS-232, HP-IB, Audio, HP-HIL, Battery-backed real-time clock and DMA, as well as medium- or high-resolution monochrome video.

To maintain software compatibility, the designs of other interface cards are used. These cards are the HP 98625B, 98643, 98620B, and the original DIO size Series 300 human interface board. Each of these four sections of the board operates independently.

DMA is implemented on the processor board with a semi-custom CMOS standard cell. The chip features an HP-proprietary 1.5 micron CMOS process and is a compatible superset of the HP 98620B DMA interface card.

Power Supply

Introduction

The power supply provides all power to the assemblies installed in the unit. It is a non-adjustable switching supply that is an exchange assembly.

Power Supply Characteristics

Power supply characteristics are

- Operates on 120 or 240 V ac, 50-60 Hz.

- Outputs these voltages:

    - +5 V dc

    - +12 V dc

    - −12 V dc

- Power-Up RESET signal sent to processor board to initialize CPU.

Maximum power consumed by the computer or expander is 250 watts. For the computer, power consumption by the power supply and assemblies in the system slots is included in the 250 watts. The remaining 147 watts is available for assemblies in the units system or DIO slots. In the expander, most of the power is available for system boards or DIO cards.

The following table shows the power available to all combined motherboard, DIO, and system slots for Model 332 computers.

Voltage	Power Available	Current Available
+5 V dc	95 Watts	19 Amps
+12 V dc	40 Watts	3.3 Amps
−12 V dc	12 Watts	1 Amp

CAUTION

When boards are installed in the unit, they use power and the amount left over is less than shown in the table above.

Before installing boards or cards in the unit, ensure the total maximum power consumed by all cards and boards for each voltage in the unit does not exceed the power available at that voltage. If the board or card to be installed require more power than is available, damage to the accessory or computer/expander may result. Refer to the Service Handbook, Chapter 3.

Figure 3-2 is a block diagram of the power supply used in the computer and expander.
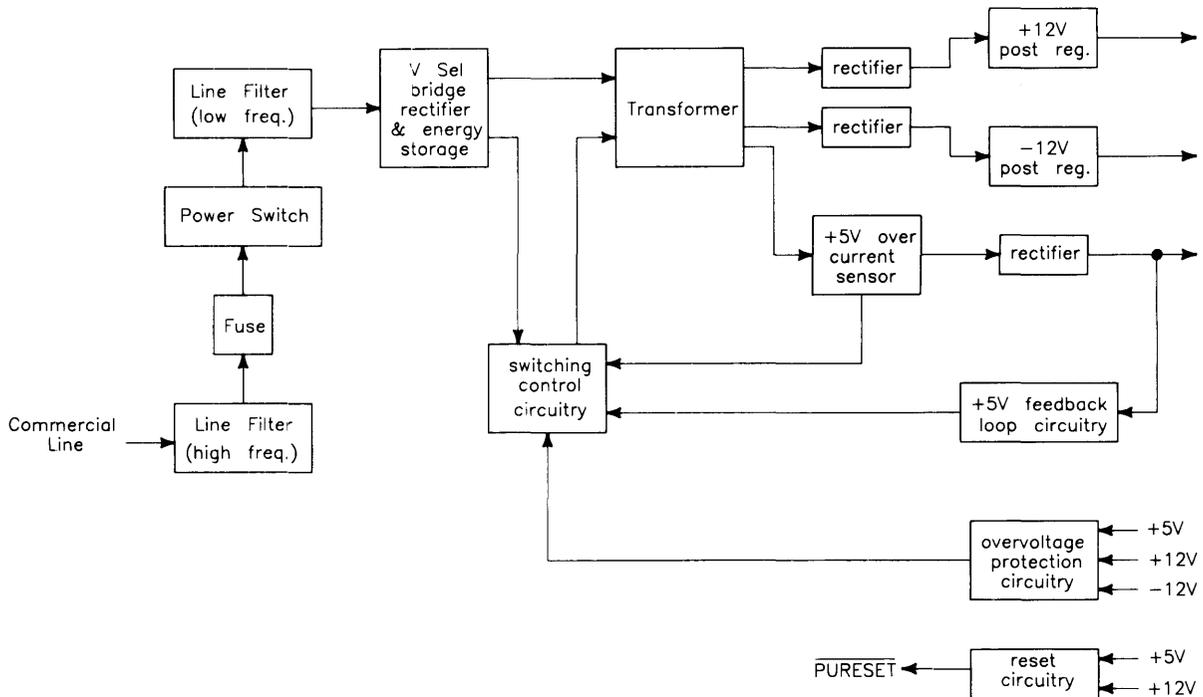
Figure 3-2. Power Supply Block Diagram

Input Section

Ac line voltage is supplied to the input section through the power cord. Functions of the input section are:

- High Frequency Filtering.
- Fusing.
- On-Off Switching.
- Input Voltage Selection.
- Low Frequency Filtering.

High Frequency Filtering

Line input voltage through the power cord is applied to a high-frequency line filter. This filter traps high frequency noise from both entering or leaving the power supply. It enables the output voltages to be virtually free from voltage spikes that may appear at the input. The filtered output is sent to the fuse and power switch.

Fuse

For both line voltage ranges, the same size fuse protects the power supply. Voltage selection and fuse size are shown in Table 3-1.

Table 3-1. Voltage Ranges and Fusing

Voltage Setting	Tolerance	Fuse Rating
120 V ac	+10%, −25%	8AF 250 Volt
240 V ac	+4%, −19%	8AF 250 Volt

The fuse rating 8AF means an 8 ampere fuse with a type F delay before opening. In both cases, the line frequency is 48-66 Hz.

Low Frequency Filtering

When the power switch is turned on, voltage is applied to the Low Frequency Filtering circuits. These circuits trap low frequencies entering or leaving the power supply. They also reduce ripple in the output voltages. After filtering, the line voltage is sent to the Bridge Rectifier Section.

On-Off Switching

This operator-controlled switch connects power to the Low Frequency Line Filter. Located on the computer (or expander) front panel, it is mechanically connected to the power supply by a switch extension. When turned to the ON position, a green LED on the front panel is lit. The LED is connected to the voltage outputs and indicates that all power supplies are operating.

Input Voltage Selection

A voltage select switch is set to either the 120 V ac or 240 V ac position, depending on the line voltage. Voltage selection changes the input voltage to the bridge rectifier to make the bridge output the same for either line voltage.

Rectification and Switching Control Circuits

Functions of the Rectification and Switching Control circuits are:

- Full-Wave Bridge Rectifier.

- Switching Control Circuit.

- Power Transformer.

Full-Wave Bridge Rectifier

Part of the input ac voltage is applied across a full-wave bridge network that outputs a DC voltage. Large storage capacitors charge up to this voltage and provide a constant energy supply to the individual power supply circuits.

Switching Control Circuit

Voltage from the rectifier feeds a Switching Control Circuit that controls the amount of power going to each of the output voltage regulators. +5 V dc feedback is applied to the Switching Control Circuit to regulate the +5 V dc output. Overvoltage protection signals also input the Switching Control Circuit that will cause the power supply to shut down if voltage in the output supplies goes too high. A +5 V dc over-current sensor input is another input to the Switching Control Circuit.

Power Transformer

Input ac voltage is also applied to the primary windings of a power transformer. Three sets of secondary windings each feed a voltage regulator for the output voltages. A voltage select switch is set to the line voltage range and causes the power transformer to have the same voltage output for both line voltage ranges.

Power Supply Regulators

Functions of the Power Supply Regulators are:

- +5 V dc Power Supply.
- +12 V dc Power Supply.
- −12 V dc Power Supply.

+5 V dc

Voltage from the power transformer feeds through a +5 V dc current sensor than goes to the +5 V dc rectifier. Output from the +5 V dc rectifier is nominally 5.07 V dc ±0.18 V dc. The +5 V dc output is also fed to the +5 V dc Feedback Loop Circuit for regulation. It also is fed to the Overvoltage Protection Circuit and Reset Circuit. If the +5 V dc fails, the Power-On LED on the front panel will go out as the +5 V dc is part of the controlling voltage for the Switching Control Circuit.

+12 V dc

Voltage from the power transformer feeds through a rectifier then to a +12 V dc Post Regulator. The output from the Post Regulator is nominally +12.29 V dc ±0.43 V dc. In addition to being distributed in the computer (or expander), the +12 V dc output is also fed to the Overvoltage Protection Circuit and Reset Circuit. External to the power supply, the +12 V dc is connected to one side of the Power-On LED on the front panel.

−12 V dc

Voltage from the power transformer feeds directly to a −12 V dc Post Regulator. The output from the Post Regulator is nominally −12.29 V dc ±0.43 V dc. In addition to being distributed in the computer (or expander), the +12 V dc output is also fed to the Overvoltage Protection Circuit and Reset Circuit. External to the power supply, the −12 V dc is connected to the other side of the Power-On LED on the front panel.

Protection and Reset Circuits

Functions of the Protection and Reset Circuits are:

- Overvoltage Protection.

- Reset Signal Generation.

Overvoltage Protection Circuit

All output voltages are inputs to the Overvoltage Protection Circuit. If the voltage goes high, the circuit will shut down the power supply, protecting its components as well as components in other areas of the computer (or expander). The output of the Overvoltage Protection Circuit feeds the Switching Control Circuit.

Reset Circuit

When ac line voltage is applied, the power supplies start building up their output voltages. The +5 and +12 V dc supplies input the Reset Circuit. As these inputs reach their operating voltages, the processor board circuits are also being powered up. When normal operating levels are reached, a Power-Up RESET (PURESET) signal is sent to the CPU to initialize it and start the Boot ROM sequence.

Power Distribution

Power Distribution routes power to the assemblies installed in the unit. Figure 3-3 shows how power is distributed in the computer.
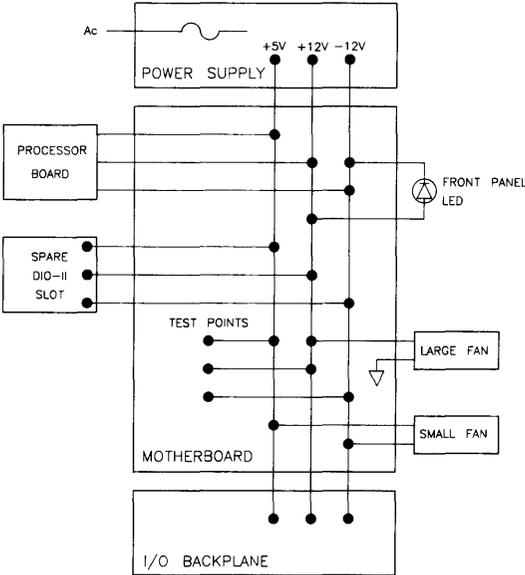
Figure 3-3. Computer Power Distribution

Processor Board

Introduction

The Model 332 processor board consists of these three major sections, as shown in Figure 3-4:

- CPU/RAM
- Human Interface
- Optional Video
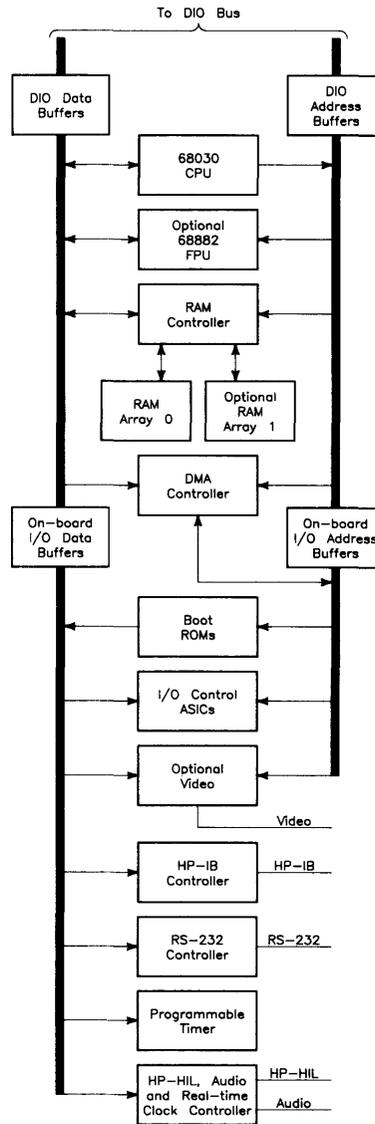
Figure 3-4. Processor Board Block Diagram

CPU/RAM Section

The CPU/RAM section consists of these major functions:

- Central Processing Unit
- System Timer
- RAM Controller
- Boot ROM and Self-Test LEDs
- Floating-point Co-processor

A simplified way of regarding the Model 332 processor is as a Model 310 processor board with the RAM array mounted on a separate daughterboard, combined with a 98561-6653X Human Interface Board with the LAN section removed.

Central Processing Unit

A Motorola MC68030 CPU functions as the main processor chip on this assembly. Operating at 16 MHz, it provides fast instruction time.

The CPU chip includes a memory management unit and data and instruction caches. CPU accesses are accomplished via a 32-bit address and data bus. The CPU runs four types of bus cycles: RAM, DIO (I/O), interrupt and floating-point (if installed). A bus error will occur if the CPU attempts a floating-point cycle without the optional MC68882 floating-point co-processor installed.

When an external busmaster, such as the DMA controller, requests the DIO bus, the DIO bus arbitrator takes control of the bus away from the MC68030 and effectively suspends its operation. However, this cannot occur during a Read/Modify/Write cycle.

System Timer

With the variety of processor boards and the difference in instruction execution speeds between many of these boards, Series 300 software required hardware support for its time-dependent operations. The MC6840 timer is the device this processor board uses.

The Model 332 utilizes an MC6840 programmable timer. It has three independent, software-controllable counters/timers which have a resolution of 4 μseconds.

Random-access Memory

The Model 332 supports from 1 to 8 Mbytes of parity RAM. Although the RAM arrays are located on daughterboards, RAM appears to the CPU to be on-board (that is, the DIO bus is not used for RAM accesses).

Two RAM array boards are used in the Model 332:

- HP 98269A 1 Mbyte add-on RAM Board
- HP 98269B 4 Mbyte Add-On RAM Board

For Model 332 computers, 1 to 8 Mbytes of RAM are supported. Since RAM is available in quantities of 1 and 4 Mbytes and there are two slots for RAM, quantities of 1, 2, 4, 5 and 8 Mbytes are supported.

The RAM controller is capable of four types of RAM cycles: read, write, burst read and refresh. During a burst read, four long words each consisting of four bytes are read in rapid succession into CPU's internal instruction and data caches.

Operation of the parity error checking circuitry is similar to other Series 300 implementations, such as the HP 98258A/B/C.

RAM Configuration

All Model 332 RAM is completely auto-configuring. That is, they do not need to have address switches set as do many Series 300 RAM boards. However, there is one configuration restriction.

The two RAM slots are prioritized. That is, the RAM board in the priority slot must always be as large as or larger than the RAM board in the other slot.

Here is a diagram of the processor board showing the two RAM slots:
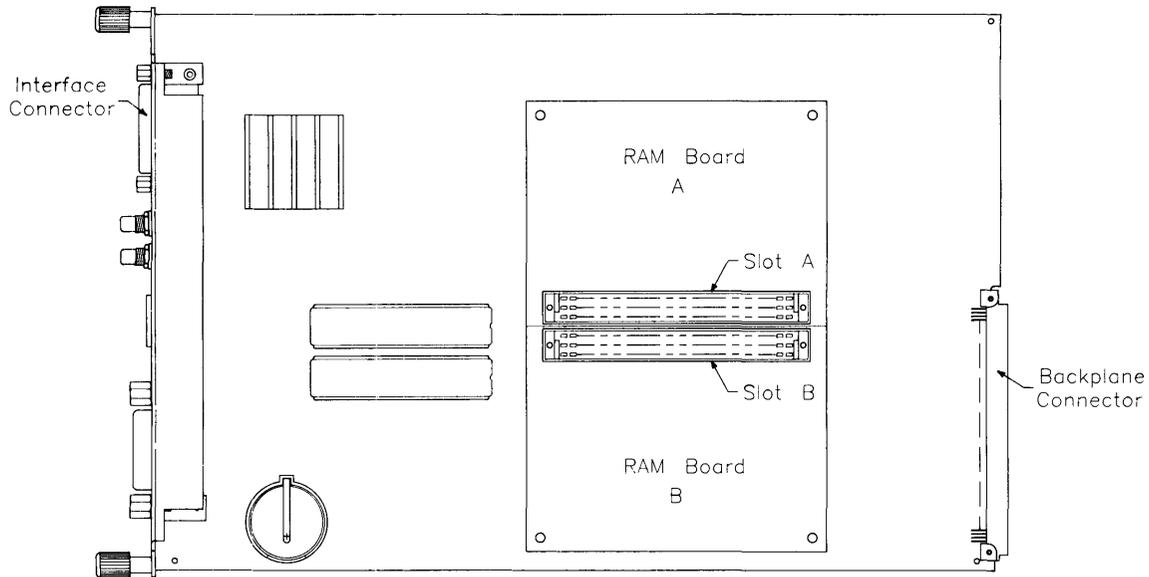
Figure 3-5. Add-on RAM Slots

The slot labelled "A" has a higher priority than the "B" slot. What this means in terms of configuration is that the RAM installed in slot "A" must be as large as or larger than the RAM, if any, in slot "B". Here is a chart showing all legal combinations:

Slot A	Slot B
1 Mbyte	Empty
1 Mbyte	1 Mbyte
4 Mbytes	Empty
4 Mbytes	1 Mbyte
4 Mbytes	4 Mbytes

All other combinations will not function properly:

Slot A	Slot B
Empty	Empty
Empty	1 Mbyte
Empty	4 Mbytes
1 Mbyte	4 Mbytes

Boot ROM and Self-Test LEDs

A Boot ROM (actually two chips) whose instructions are executed by the CPU shortly after power up is used on this processor board.

A set of eight test LEDs are visible through the front cover slots. Different patterns of on and off (1s and 0s) correspond to binary or hexadecimal error codes. These codes help you find out what's working and what is not.

The test LEDs are driven by code in the boot ROM. Thus, operation of the test LEDs is identical to that of other Series 300 computers with the C1 boot ROM, such as Models 340, 360 and 370.

Chapter 4 provides an in-depth explanation of the Boot ROM functions. Chapter 5 explains the error codes and other troubleshooting processes.

Floating-point Coprocessor

An optional floating-point coprocessor is used to increase system performance when certain math routines are part of the application. An MC68882 chip performs these functions. It implements the required IEEE standard capabilities. Performance is significantly greater than the HP 98635A Floating-Point Card.

Floating-point instructions become part of the language of the CPU in its operation. HP-UX requires the floating-point co-processor, although the computer will boot up and appear to function normally if the co-processor is not installed.

Other Circuits

An Intel 8042 Universal Peripheral Interface 8-Bit Microcomputer performs several functions on the processor board:

- Interfaced to a SN76494 digital complex sound generator IC.

- Provides several 10 millisecond resolution timers.

- Performs key-code conversions for the keyboard.

- Manages the HP-HIL Interface.

- Has a battery-backed Real-Time Clock tied to its peripheral data path.

Human Interface Section

The human interface or I/O section consists of these major functions:

- HP-IB Interface

- RS-232 Interface

- Direct Memory Addressing

- HP-HIL Link

- Battery-backed Real-time Clock

HP-IB Interface

Hewlett-Packard Interface Bus (HP-IB) is HP's version of the IEEE 488 interface standard. HP-IB on this board is much like HP-IB implementations on other HP 9000 Series 200/300 computers. It uses a TMS9914 HP-IB controller which allows data transfer rates up to 450 Kbytes/second. The TMS9914 is a memory-mapped I/O device which is multiple-mapped within a 64 Kbyte internal I/O device.

Two registers control hardware which can generate an interrupt as a result of a HP-IB device responding to a parallel poll. It has the ability to generate an interrupt from a parallel poll response. For this feature, two registers external to the TMS9914 are used. These registers are in addition to the two external registers that exist for internal HP-IB interfaces in other Series 200 computers.

All registers associated with the HP-IB are multiple-mapped within a 64 Kbyte block of memory in the internal I/O address range.

Information on the TMS9914A and its registers can be found in the 'TMS9914A General Purpose Interface Bus (GPIB) Controller' Data Manual.

A switch on the processor board is associated with the HP-IB interface. It performs this function:

- **SC** -- Causes the internal HP-IB interface to be the System Controller.
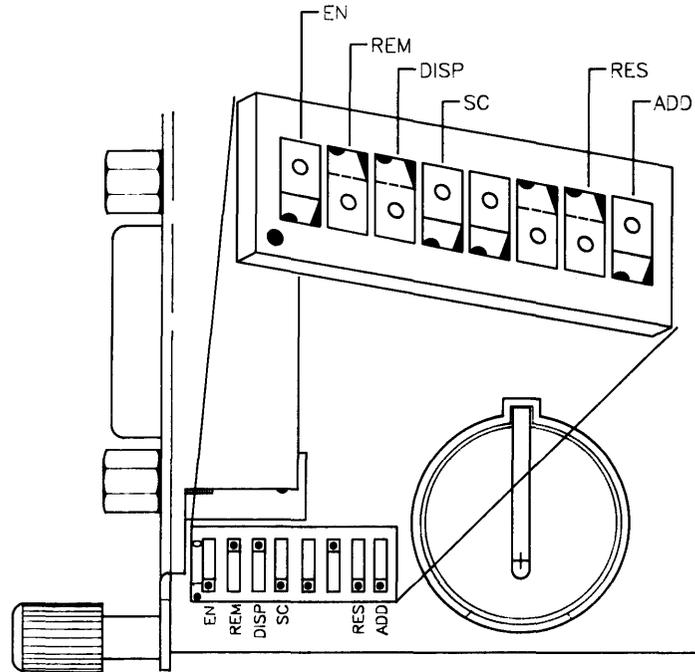
Figure 3-6. Processor Board HP-IB Switches

Table 3-2. HP-IB Configuration Switch

Switch Label	Function/How It's Used
SC	Internal HP-IB System Controller 0 = Not System Controller 1 = System Controller (Shipped setting)

RS-232 Interface

An RS-232 Interface section is part of the processor board's electronics. Using an INS8250 UART, it's almost identical to the HP 98644A RS-232 Serial Interface Card. It differs from the HP 98644A Interface Card in that it:

- Allows interrupts at level 5 only. There are no switches to change the interrupt level. It is the same as the HP 98644 Card.

- Permanently sets the select code to 9. The HP 98644 card has switches which allow this address to be changed.

- Does not allow reconfiguration to change the RS-232's ID to that of the HP 98626 card.

Three switches on the processor board are associated with the RS-232 interface. They perform the following functions:

- **REM** -- Controls the local/remote bit in the ID register.

- **EN** -- Sets the handshake input lines to their default condition (all ones).

- **ADD** -- Causes the RS-232 interface to appear or not appear in the address space.
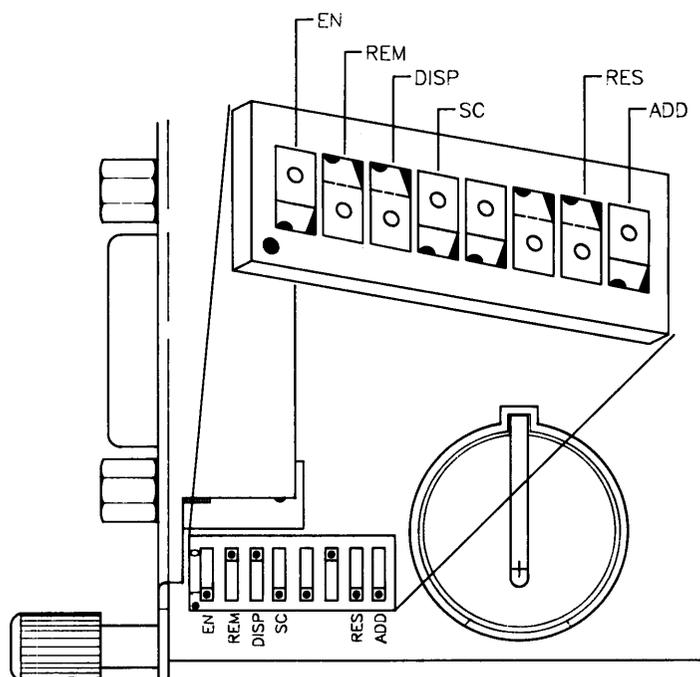
Figure 3-7. Processor Board RS-232 Switches

Table 3-3. RS-232 Configuration Switches

Switch Label	Function/How It's Used
EN	RS-232 Control Line Defeat 0 = Control lines defeated 1 = Control lines enabled (Shipped setting)
REM	Remote Terminal Enable 0 = Local Mode (Shipped setting) 1 = Remote Mode
ADD	RS-232 in Address Space 0 = RS-232 appears in address space (Shipped setting) 1 = RS-232 does not appear in address space

Direct Memory Addressing

DMA chip architecture is a compatible superset of the HP 98620B DMA Controller which is used with HP 9000 series 200 and 300 computers. The chip is a Standard-Cell design implemented in a CMOS process. Refer to Table 3-4 for DMA specifications.

Table 3-4. DMA Specifications

Feature	Specification
Input Clock	10 MHz
Channels	2
Channel Priority	Programmable, high or low, each channel
Channel Arbitration	Round-robin
Bus Arbitration	DIO daisy chain
Transfer Types	8-bit (byte) 16-bit (word) 32-bit (long word)
Max Transfers	4G transfers per arming
Bus Bandwidth Use Limits	Programmable: 100%, 50%, 25%, 12.5%
Min Cycle Time	300 ns
Max Theoretical Transfer Rate	13.3 Mbytes/sec
Typical Burst Transfer Rate	2.8 Mbytes/sec
Interrupt levels	Programmable: 7, 6, 5, 4, 3
Address range	FFFFFFFF - 00000000

HP-HIL Link

Hewlett-Packard Human Interface Link (HP-HIL) is an HP standard for interfacing Series 300 computers and other workstations to human input devices. A list of HP-HIL devices is shown in Table 3-5.

Asynchronous serial communications protocol enables you to select a set of input devices, connect them to your computer, and work with any application program.

A link controller on the processor board controls the HP-HIL. Each HP-HIL device has an circuit to interface information to and from the device. Limitations for the HP-HIL are:

- Up to seven devices can be on the link.

- Maximum distance between devices is 2.4 metres, total link maximum length is 16.8 metres. This does not include the 15 or 30 metre extensions.

- Series 300 Maximum link current is 1 A.

A block diagram of a typical link controller is shown in Figure 3-8.
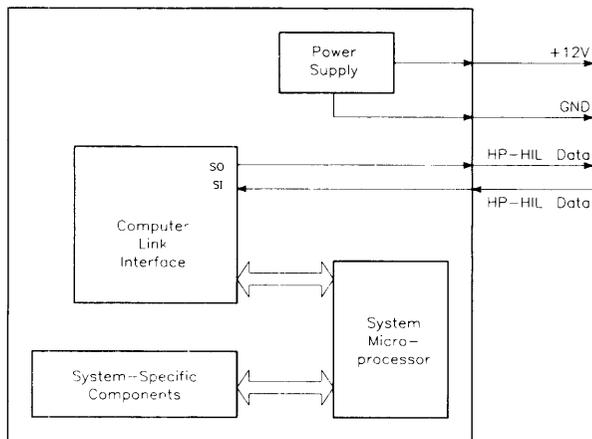
Figure 3-8. HP-HIL Link Controller Block Diagram

The HP-HIL link receives its electrical supply from the host computer. One voltage, +12 Vdc is taken from the host computer and output as a regulated power supply to external devices on the link. From the HP-HIL cable, +12 V dc is regulated down to +5Vdc for use by device components. The +12 V dc input is also sent to components needing that supply.

Up to 1 A total can be supplied to devices. When configuring HP-HIL devices with Series 300 computers, care must be used to ensure the total power drawn by all devices does not exceed 1 A. In Table 3-5, devices are listed with their power requirements.

Table 3-5. HP-HIL Devices and Power Requirements

Product Number	Device Name	Milliamps	Watts
HP 35723A	Touchscreen Bezel	250	3.0
HP 46021A	ITF Keyboard	100	1.2
HP 46021A	ITF Keyboard	145	1.74
HP 46060A	HP Mouse	200	2.4
HP 46080A	Extension Module	25	0.3
HP 46081A	Speaker Extension	25	0.3
HP 46082A/B	15/30 Metre Extension[1]	50	0.6
HP 46083A	Rotary Control Knob	110	1.32
HP 46084A	ID Module	60	0.72
HP 46085A	Control Dials	370	4.2
HP 46086A	Button Box	80	0.96
HP 46087A[2]	"A"-Size Digitizer[2]	200	2.4
HP 46088A[2]	"B"-Size Digitizer[2]	200	2.4
HP 46094A	Quadrature Port Device[3]	80	1.2
HP 46095A	Three-Button Mouse	80	0.96
HP 92916A	Barcode Reader	100	1.2

Notes: [1] Extension cables have two boxes, each draws 25 mA.
[2] Includes HP 46089A 4-Button Cursor.
[3] Port devices require 80 mA; devices attached cannot exceed 120 mA.

Model 332 computer DIO bus architecture is interfaced to the HP-HIL microprocessor in these circuits:

- Microprocessor

- Link Interface

A four-wire cable connects HP-HIL devices to each other and to the computer. AMP Shielded Data Link (SDL) connectors are used and are easily installed and removed from the computer or device. Keyboard cable connectors are keyed and are marked with dots to indicate where they are connected.

Audio Driver

The processor board contains an audio driver circuit. There is, however, no speaker included on the board as in the Model 340. The Model 332 requires an external speaker, such as is found in the HP 35731A and HP 35741A monitors or the HP 46081A Speaker Extension Module.

DIO Bus Architecture

The standard 16-bit DIO as used in previous Series 300 computers is used. All existing Series 300 I/O cards will function normally, except for the following:

- HP 98254A 64 Kbyte Memory Card (not actually supported in the 310)
- HP 98256A 256 Kbyte Memory Card
- HP 98257A 1 Mbyte Memory Card
- HP 98603A ROM BASIC 4.0 Card
- HP 98603B ROM BASIC 5.1 Card
- HP 98620A/B DMA card

In addition, note that the HP 98635A Floating-point Accelerator Card is supported by the Model 332 unless the optional MC68882 floating-point co-processor IC is installed on the Model 332 processor board.

Video Section

All the electronics for sending video to a monochromatic bit-mapped display are also part of the processor board. There is a choice of two resolutions, or the video can be completely disabled for use with a separate video board. An upgrade kit is available for conversion from the lower resolution to the higher resolution. The kit is customer installable.

The video circuits have the following functions:

- Frame Buffer, consisting of 390 lines by 512 pixels per line or 768 lines by 1024 pixels per line.
- Frame Buffer Controller, the same as on the Video Output Boards.
- Display ID ROM, in an 8 K-byte ROM.
- A video shift-register.
- A pixel clock.

The frame buffer for these video circuits is memory mapped to addresses in the display frame buffer block of RAM. A single bit-mapped plane organized as one byte per pixel is used. Due to the resolution of 1024 horizontal by 400 vertical dots, the pixels are not square. When the frame buffer is read, invalid data is returned for the unused planes.

In some cases, the computer application will require a separate video board, such as when color video is desired. The on-board video can be switch-disabled so that it does not conflict with the separate video board.

Two switches on the processor board are associated with the video. They perform the following functions:

- **RES** -- Selects high- or medium-resolution video.
- **DISP** -- Enables or disables the on-board video.
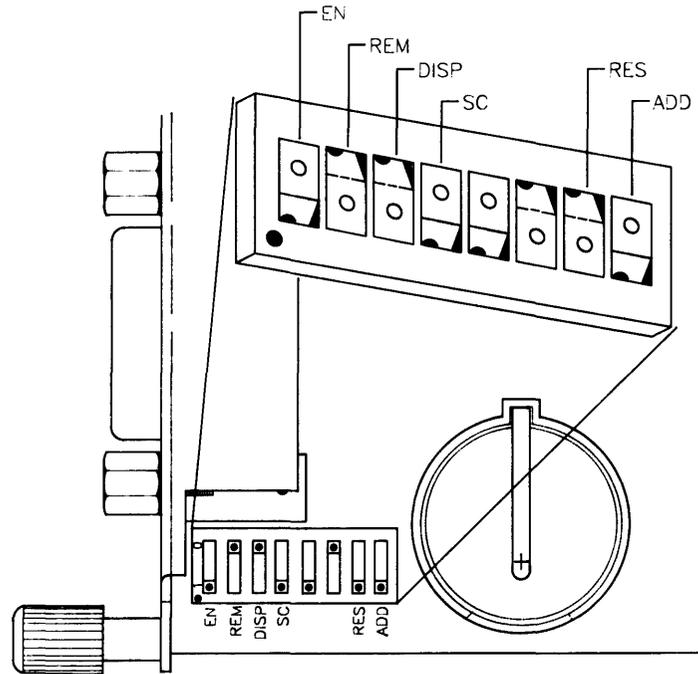
Figure 3-9. Processor Board Video Switches

Table 3-6. Video Configuration Switches

Switch Label	Function/How It's Used
DISP	Processor Board Display Disable
	0 = Processor Board Display Enabled (Shipped setting) 1 = Processor Board Display Disabled
RES	Graphics Resolution
	0 = Medium resolution 1 = High resolution Shipped setting depends on graphics.

Video Resolution

Changing the resolution of the video section is accomplished by doing two things:

1. changing the position of the switch mentioned in the paragraph above, and

2. changing two components.

Both of these must be done in order to change the video resolution. The HP 98285A kit contains the necessary parts and instructions for changing the video output from medium resolution to high resolution. There is no kit available for changing from high resolution to medium resolution. The parts are socket-mounted to make the conversion process easy.

Motherboard

Introduction

Virtually all assemblies connect directly or indirectly to the motherboard. It has connectors for other assemblies to interface with each other. Test points for power supply voltages are marked on the board.

Functions

Power is connected from the motherboard to the DIO backplane via a ribbon cable. In the computer, boards in the system slots are powered directly from the motherboard through two system slot connectors. Voltage test points are on the back of the motherboard and are accessible from behind the front panel.

Two fans are connected to motherboard power connections. The large fan is tied to the +12 and ground. The small fan is tied between +5 and −12 V dc. Wires from the front-panel LED are connected to the +12 and −12 V dc voltages on the motherboard.

Separate Video Boards

Introduction

Although the Model 332 processor board contains a video driver, some users may find it unsuitable for their particular application. For instance, anyone wishing to use a color monitor will not be able to use the on-board video. For this reason, the processor board contains a switch whose function is to disable the on-board video. This allows any of several add-on video boards to be installed in the computer.

Video boards allow the computer to send bit-mapped display information to medium or high resolution monitors. The user may upgrade his computer system from medium to high resolution by installing a different board. Upgrading is accomplished through an exchange program. It may be performed by the user with common tools without CE support.

A variety of monochromatic and color video boards are available for Series 300 computer systems. The color boards provide four-plane color display capability allowing the user to display 16 colors from a palette of over 16 million colors. A description of these boards follows:

- HP 98542A Medium-Resolution Monochromatic Video Board. This version displays 512 by 400 pixels and drives the low resolution monochromatic monitors.

- HP 98543A Medium-Resolution Color Video Board. This version displays 512 by 400 pixel pairs and drives the low-resolution color monitors.

- HP 98544B High-Resolution Monochromatic Video Board. This version displays 1024 by 768 individual pixels and drives the high-resolution color monitors.

- HP 98547A High-Resolution Color Video Output Board. This version displays 1024 by 768 individual pixels and drives the high-resolution color monitors.

- HP 98548B High-Resolution Monochromatic Video Board. This version displays 1024 by 768 individual pixels and drives the high-resolution color monitors.

- HP 98549A Low-Cost Color Video Output Board. This version displays 1024 by 768 individual pixels and drives the high-resolution color monitors.

- HP 98550A High-Resolution Color Video Output Board. This version displays 1280 by 1024 individual pixels and drives the high-resolution color monitors.

These boards make extensive use of large scale integrated (LSI) circuits. Up to six (depending on the board) NMOS III Display Controller chips provide an integrated bit mapped display with window-move hardware and frame buffer support. Color mapping is entirely handled by another NMOS III chip called the Frame Buffer Controller. This chip performs color mapping and D to A conversion. Video memory consists of uses nibble-wide (4-bit) Display RAM (DRAM). The major difference between these assemblies is the amount of DRAM each has.

Video boards perform the similar functions, which are:

- Establish display clock frequency in the computer system.

- Initialize according to the specific monitor used.

- Identifies itself and set character shape by ID/FONT ROM.

- Respond to interrupts on the DIO bus to change color map data.

- Control the display RAM maps.

- Color boards output Red-Green/Sync-Blue Video to the color monitor.

- Monochromatic boards output Video/Sync to the monochromatic monitor.

Each of these is explained in the following functional description. Refer to Figure 3-10.
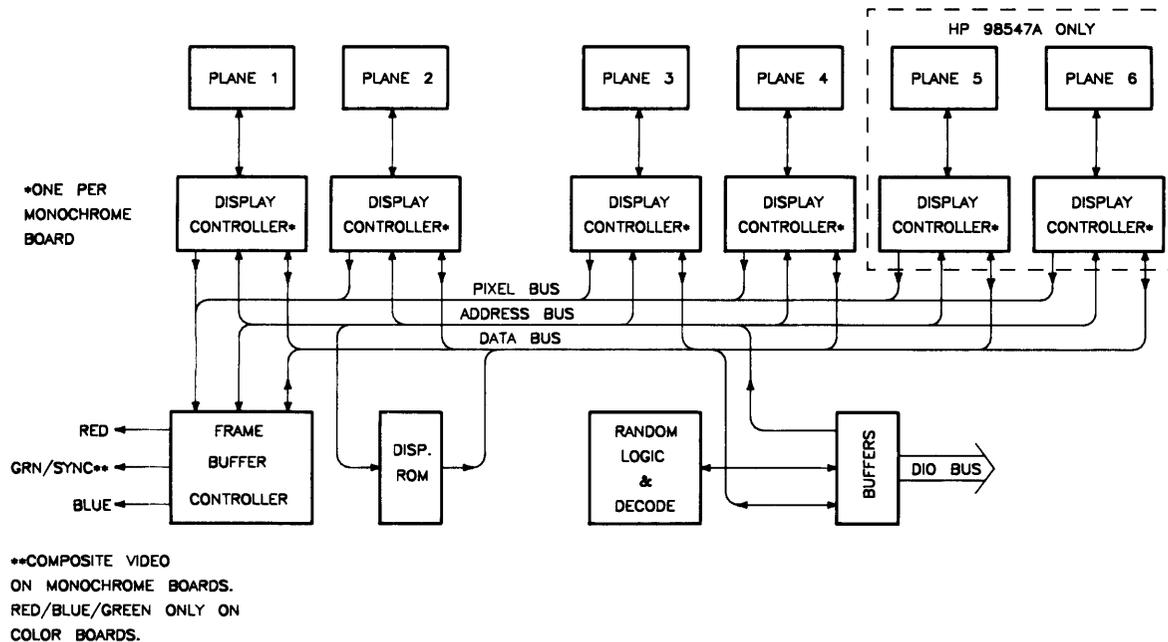
Figure 3-10. Typical Video Board Block Diagram

Video RAM

Both high- and medium-resolution color video boards have four or six planes of memory. The medium-resolution board uses eight memory chips per plane. This is enough to display 512 doubled pixels by 400 scan lines. High-resolution boards requires more memory chips per plane. Resolution is 1024 by 768 single pixels.

Color Mapping

Color boards have four or six plane color mapping. Mapping is entirely under control of the Frame Buffer Controller. The high-resolution board has more RAM than the medium-resolution board.

Display Controller

The Display Controllers are the heart of these video boards. They provide complete video control and bit-mapped alpha support for one graphics plane. Interfacing directly with the computer CPU, it integrates and manages most display functions. The functions of the Display Controllers are:

- Provide horizontal and vertical timing signals to the sweep section of the video board.
- Provide refresh data to the frame buffer.
- Generate the blinking underline cursor.
- Enable window move operations.
- Output video and sync signals to the frame buffers.

Architecture provides for either color or grey-scale monochromatic display use. The display is organized with one memory byte for each display pixel. This corresponds to a maximum capability of eight planes with one byte per pixel per plane. Each bit in the byte goes to a separate frame buffer memory plane. Pixel data is transferred 32 bits (or pixels) at a time by read and write operations with display RAM by the video board. Logic internal to this chip enables software to perform byte-per-pixel access.

Frame Buffer Controller

The Frame Buffer Controller resides on two busses; the computer's DIO bus, and the frame buffer data bus. It performs the following functions:

- Receives frame buffer data for DRAM refresh.
- Maps 4 bits per pixel into 256 colors out of more than 16 million possibilities.
- Generates graphics video outputs.
- Allows the CPU to read and write the color map.

Communication on the CPU bus consists of register reads and writes in byte format under control of the CPU. On the memory bus, communication consists of frame buffer word loads under control of the Color Display Controller.

Video Output

Video output is compatible with several HP monitors. Standard Red, Green (with sync), and Blue outputs are available through BNC connectors on the color boards. For monochromatic boards, composite video with sync is output through a single BNC connector.

For color boards, a data merging circuit in the Frame Buffer Controller combines color and blanking data from the display memory into a 24-bit data stream. Three digital to analog converters change this data stream into a current source for each of the three color outputs. These outputs connect through cables to the video amplifiers in the color monitor.

Display RAM Control

Frame buffer and the Frame Buffer Controller register set are fixed in internal address space. Frame Buffer Controller registers and the processor board's Frame Buffer Controller both use the same addresses.

Interrupt Structure

The interrupt structure is similar to DIO interrupts. On receiving an interrupt and verifying the interrupt is coming from the video board, the CPU must then poll the video boards to determine the interrupting device.

Identification and Font ROM

Each video board has an ID/FONT ROM. This is a 16 Kbyte wide ROM that supplies the CPU with information about the video board type. Initialization and dot clock frequency information is also provided.

Alpha character font is the size and shape of the dot matrix used to create letters, numbers, and other keyboard symbols. The system monitor will display the font defined in the ID/FONT ROM during computer power-up and self test. If another font is required for the application, the operating system or application software can specify another available font to be used. Standard FONT, or pixel display matrix for the video boards is shown below:

Table 3-7. Pixel Display Matrix

Video Board	Character Matrix	Character Cell
Medium-Resolution	9 by 12	10 by 15
High-Resolution	6 by 10	8 by 16

Clocks and Timing

The display clock frequency is different for each video board. At power-up, the CPU executes instructions from the Boot ROM to determine the presence of and type of the video board. Data in the ID/FONT ROM is placed in a Display Controller register to set the display clock frequency.

Boot ROM Functions

4

Introduction

A Series 300 Boot ROM, Revision C1, is used in the Model 332. The C1 boot ROM has a large feature set, some of which are not implemented by the Model 332, since the 332 is positioned as a 310 replacement rather than a high-end performance machine. Some general functions not implemented in the 332 are LAN and SCSI. However, a LAN card is available for the Model 332 and a SCSI card eventually may be. Therefore, these functions and other unincluded functions are included in this discussion where they are appropriate.

When the computer is turned on, three Boot ROM instruction sets are executed by the CPU:

- Power-Up Sequence.
- Self-Tests.
- Booting Operating Systems.

Power-Up Sequence

When the computer is turned on the CPU executes a power-up sequence of events (the complete algorithm is described later in this chapter) before an operating system is booted. This is required to initialize and test hardware to make sure the computer is ready to boot an operating system. Power-up sequence is shown below.

1. Test CPU.
2. Determine 24- or 32-bit address range.
3. Turn on self-test LEDs.
4. Turn on the compatibility display interface.
5. Test the top 16 Kbytes of RAM.
6. Set up data structures.
7. Search for any boot extension ROMs and call any valid ones.
8. Determine processor type (i.e., MC68030).
9. Initialize and test processor board timer.
10. Look for a RAM monitor/debugger.
11. Reset all I/O.
12. Initialize the video circuits.
13. Checksum the Boot ROM.

14. Display CPU type.

15. Look for floating point co-processor.

16. Look for MS-DOS co-processor.

17. Initialize keyboard electronics.

18. Drop interrupt level.

19. Preload for main RAM test.

20. Initialize and clear compatibility display graphics.

21. Test internal HP-IB.

22. Test DMA.

23. Test remaining RAM and set up bottom of memory.

24. Report any memory failures and the amount of memory found.

25. Initialize the bottom of memory.

26. Find external I/O cards. Report all found. Test the following at select codes 0 through 31 and 132 through 255.

    a. HP 98629 SRM controller.

    b. HP 98527 RGB color video output card.

    c. HP 98624 TI9914 low-speed HP-IB.

    d. HP 98626 RS-232.

    e. HP 98644 RS-232.

    f. HP 98628 RS-232.

    g. HP 98642 4-port multiplexed RS-232.

    h. HP 98643 LAN.

    i. SCSI interface.

    j. HP 98625 High-Speed HP-IB.

27. All bit-mapped video circuits are initialized and cleared.

28. All interfaces with I/O Dependent Code test capability are tested.

29. Checksum any ROMs in ROM space and report any problems.

30. Output final LED value.

Configure Mode Software Override

Configure mode is a Boot ROM feature that allows the modification of some power-up defaults independent of which operating system will eventually be booted. To enter configure mode press ⌈CTRL⌉-⌈C⌉ before a system is booted but after the keyboard is initialized (e.g. after the keyboard message is displayed).

All mass storage operations lock-out and defer the response to the ⌈CTRL⌉-⌈C⌉ (just as they defer RESETs). This is to prevent leaving a mass storage device stranded in a strange state (e.g. disc spinning).

```
Copyright 1988,          KEY  ACTION
Hewlett-Packard Company.   T  Extended Self-Test
All Rights Reserved.       L  Continuous Self-Test Loop

BOOTROM Rev. C1
Bit Mapped Display
MC68030 Processor
MC68882 Coprocessor
Keyboard
HP-IB
DMA-CO
RAM 524128 Bytes
HP98644 at 9
HP98625 (HPIB) at 14
HP98643 at 21 01019FFA0001




CONFIGURE MODE
RESET To Power-Up                    1H
```

Figure 4-1. Example Configure Mode Display

Once in Configure Mode, two options are displayed. If no key is depressed within approximately 5 minutes, the Boot ROM will time-out and start power-up over again. Regardless of the option chosen, most of the self-test will be repeated. If the memory test has already been completed and the extended self-test option is chosen, then the main memory test portion of the self-test will be repeated. otherwise it will not.

Extended Testing

If ⌈T⌉ is pressed, the self-test will be started over and the long memory test will be executed (a marching/walking ones and zeros test, taking approximately 4 seconds per megabyte depending on clock speed) rather than the default. short memory test (an address/address compliment test, taking approximately 1 second per megabyte depending on clock speed). Interfaces having IODC download test code will also perform extended testing.

Extended Test Mode can be invoked while running in looping mode. The result is continuous extended testing.

Continuous Self-Test

Pressing ⌷L⌷ causes the Boot ROM to continuously repeat the self-test portion of its code. This is a toggle switch, so entering configure mode by typing ⌷CTRL⌷-⌷C⌷ while already in continuous self-test mode, and typing ⌷L⌷ again, will stop the continuous self-test and will cause the Boot ROM to continue normal operation.

While in continuous self-test mode, the Boot ROM will not wait, beep or stop for most failures, but will just continue looping through self-test. The following failures will stop self-test looping:

- **A memory failure in the top 16K bytes.**

  In this case the Boot ROM stops with the display blanked and oooooo●● on the LEDs. If a compatibility (old style alpha/graphics) display controller is present, then the message RAM FAILED ABOVE FFFFC000 will be displayed.

- **Boot ROM checksum failure**

  In this case the Boot ROM stops with the message CONTINUE AT OWN RISK (RETURN To Continue) is displayed, the value oooo●●●o on the LEDs, and then beeps appropriate low and high tones. Pressing ⌷Return⌷ will cause the Boot ROM to continue self-test looping.

50/60 Hz CRT

The 50/60 Hz CRT options are only available when a compatibility (old style alpha/graphics) display controller is present. Then, if ⌷5⌷ or ⌷6⌷ is pressed, a soft override of the power-up CRT frequency occurs. The power-up CRT frequency of the compatibility display controller is determined by a switch on the controller card. When this switch is set to 0, the power-up default is 60 Hz, when this switch is set to 1, the power-up default is 50 Hz. If ⌷5⌷ or ⌷6⌷ is pressed during configure mode when there is both an alpha/graphics display controller and a bit mapped display controller present, then the key pressed will effect the alpha CRT (even though the '5' and '6' are not displayed). If no alpha/graphics display controller is present and ⌷5⌷ or ⌷6⌷ is pressed, the Boot ROM will re-enter self test, but the CRT will not be effected.

The Human Interface

Several devices can act as the "console", or primary human interface, for the Boot ROM. The list of possible console devices as of revision C1 is explained in the next section.

Output Devices

- HP 98642 (4-port, multiplexed RS-232) card with the remote bit set (with a supported HP terminal).

- Supported HP terminals are defined as those terminals supported by HP on HP-UX for Series 300. See the section of this chapter describing Remote Human Interface for Boot ROM requirements.

- HP 98626 RS-232 card with the remote bit set (with a supported HP terminal).

- HP 98644 RS-232 card with the remote bit set (with a supported HP terminal).

- Internal RS-232 controller (same as 98644 card, but built into CPU board or Human Interface accessory board) with the remote bit set (with a supported HP terminal).*

- A bit-mapped video circuit at internal address 560000_{16}. This includes:

    - HP 98548A

    - HP 98549A

    - HP 98550A

    The Boot ROM tries to talk to devices with a primary DIO ID of 25 and a secondary DIO ID of 1, and it expects these devices to have ID/INITIALIZATION ROMs containing ID information.

- A bit-mapped video circuit at any DIO II address 01000000 up to $01C00000_{16}$. These correspond to select codes 132 to 255. These include:

    - HP 98548A.

    - HP 98549A.

- A "compatibility" display controller. This alpha/graphics display controller is a modification of the HP 98204B card. It must have the same CRT ID register as the HP 98204B. Note that the Boot ROM will turn off video to this display controller just before booting a system. It is up to the operating system to restore video if this display is to be used.

- HP 98627 RGB color display controller.

The Boot ROM chooses the output devices in the following manner:

- If there is a remote card, choose the one with the lowest select code.

- If there is an internal bit mapped display controller, choose it as console.

- If there is a bit mapped display controller in DIO 2 space, choose the one with the lowest select code. If not go the next step.

- If there is a compatibility display controller, choose it as console. If not go to the next step.

- If there is an HP 98627 RGB display controller then choose it as console. If not go on to the next step.

- Use dummy display drivers.

Only one output device at a time will be used as the console output device, however, the Boot ROM will initialize and clear any bit mapped display controller and any compatibility display controller that it finds, even if that controller is not chosen as the console device. Note that if a device fails self-test then for the above algorithm, the device is considered "not present". The Boot ROM always tests a device before choosing it as the console output device.

Input Devices

- Remote HP 98642 card with supported HP terminal.

- Remote HP 98626 card with supported HP terminal.

- Remote HP 98644 card with supported HP terminal.

- Remote internal RS-232 controller (same as 98644 card, but built into CPU board or Human Interface accessory board) with supported HP terminal.

- Internal HP-HIL keyboard/HP-IB card (or built-in hardware).

- External HP-HIL keyboard. The only version of this hardware currently in existence is the keyboard built-in the HP 98720 display controller.

The Boot ROM chooses input devices in the following manner:

Note that if an internal HP-HIL interface and a remote terminal are both present in a system, they will both be enabled. Similarly, if an external HP-HIL interface and a remote console are both present in a system, they will both be enabled, provided no internal keyboard is present.

An external interface will never be enabled when an internal interface is present.

When more than one external keyboard is present, then only one with the lowest select code is enabled. If several HP 98720s exist on a system, then it is the user's responsibility to ensure that the external keyboard associated with the HP 98720 display controller at the address 560000 has the lowest select code of all the external keyboards in the system. This must be done to ensure that the keyboard associated with HP 98720 "A" is not input console while the display of HP 98720 "B" is output console. The Boot ROM does not attempt to verify the display/keyboard relationship.

Note that if a keyboard controller or a remote RS-232 card fails, then it is considered by the above algorithm to be "not present". For example, if an internal keyboard fails self-test, a "Keyboard Failed" message will be displayed, however, the input device search algorithm will go ahead and look for an external keyboard. The Boot ROM always tests a device before choosing it as the console input device.

If no output device is present, but a keyboard is present, then that keyboard will still act as the console input device. Similarly, if no input device is present, but a display controller is present, then that display controller will still act as the console output device. If neither an input device nor an output device is present, the Boot ROM will go ahead and automatically boot the default operating systems as long as no errors are discovered during self test (see the section on Self-Test for more details).

Remote terminals as consoles are discussed in more detail in the next section.

Remote Human Interface

Very early in the power-up sequence, a search is made for an:

- HP 98642 4 port, multiplexed RS-232,

- HP 98626 RS-232 interface or

- HP 98644 RS-232 interface.

with its "remote" bit set. The search starts at select code 0 and ends at select code 31 or when a remote 98642, 98626 or 98644 card is found that passes self-test. If one is found, it becomes the remote human interface. If the remote human interface is a 98642 card, the terminal on port 1 will be used as the console. All other ports are ignored by the Boot ROM.

Note that the internal RS-232 (on CPU board or on Human Interface accessory board) is really a 98644 card and will be treated as such by the Boot ROM.

To indicate that a remote human interface has been found (at, for example, select code 9), the first line of the internal display, if present, will display:

```
Remote Interface at 9
```

After this point the internal display will not change until a system is booted. Any internal or external keyboard, if present, will work just as it would if there were no remote console (see previous section for details).

To use the remote interface, an 80 wide terminal with at least 24 lines that accepts the following HP standard terminal escape sequences is required:

Key Sequence	Function
Escape H Escape J	To Clear Screen and reset cursor
Escape &aDDY	To Move Cursor to Row DD
Escape &aDDC	To Move Cursor to Column DD

With the 98626 card, the Boot ROM will use the baud rate, pacing, and line characteristics specified by the 98626 card's switches. The "handshake type" bits in the Line Control Switch Register are shown as "reserved for future use" in the Installation Manual; the definition given these bits by other OS's, and the one adhered to by the Rev C1 Boot ROM is:

Bit 6	Bit 7	Handshake Type
0	0	ENQ/ACK
0	1	No handshake
1	1	No handshake

Note

HP 98626 cards are currently shipped with these switches at zero. When booted with ENQ/ACK enabled on the HP 98626 card and XON/XOFF enabled on the terminal, the Boot ROM hangs, waiting forever for an ACK in response to it's ENQ.

Since the HP 98644 and HP 98642 cards have no switches, they will always be assigned the following characteristics when used as remote console by the Boot ROM:

- 8 bits/char

- no parity

- a single stop bit

- 9600 baud

- XON/XOFF handshaking.

The display on the terminal will be the same as the display on a display controller. The keyboard functionality will also be the same, except that the Break key on the terminal is mapped to the RESET key on the local keyboard.

During the self-test of I/O cards, the card driving the remote interface will not be disturbed. It was tested earlier and passed. (Otherwise, the interface could be confused or disabled from the test.)

Note that use of the Enter and Tab keys during Boot ROM execution can cause the terminal's display to become scrambled.

Booting Operating Systems

Boot System Selection

The Boot ROM provides two modes of operation, attended and unattended. These two modes allow a user to either select from multiple operating systems on multiple boot devices or to automatically boot a system with no human intervention.

Unattended Operation

In an unattended situation, the first system found will be loaded and given control. To find a system the Boot ROM will search a boot list of prioritized devices. The first system found on one of these devices will be booted. If no system is found, the boot list will be searched again until a system is found. This allows discs not present at power-up be found after their initialization is complete.

Once a device has been successfully accessed, it will never be accessed again until re-power-up or a reset. This minimizes wear on mass storage devices and limits the confusion of systems disappearing and re-appearing on shared resources such as the SRM.

To force the boot of a particular system when the machine is unattended, the user has the following options:

Make sure that the system to be booted is the first to be found according to the boot list search. (This is quite easy to do simply by changing device addresses, select codes, or system names, or by moving systems. The prioritized boot list is discussed in detail latter in this chapter.)

On an SRM with multiple systems, make the first system to be found a system that looks at the host's SRM node address and uses the node address to decide what secondary system to boot. (The Boot ROM can then be called to boot a particular system.)

Attended Operation

To force the boot of a system not chosen by the boot list, the user must enter "attended mode." This mode is entered by typing **SPACE**, ⌐Return⌐, or any letter or number during power-up after the input portion of the human interface (i.e., the keyboard or terminal) has been initialized but before a default system is booted. A good way to do this is to hold down the space bar until the system selection menu is seen. This will cause a boot selection menu to be displayed. A user can be sure that the input human interface has been initialized when one of the following (depending on the human interface provided) is displayed in the self-test list:

```
Keyboard

Console Keyboard at XX (where XX is the select code of an external
                          keyboard)
```

The boot selection menu displays all accessible systems as the Boot ROM locates them. A system is selected by typing the one to three character string (a single letter or a 1 to 2 digit number followed by a single letter) listed in the menu. Note that the character used to enter attended mode is considered part of this string.

As the keys are accepted they appear in the lower right hand corner of the display.

An example menu screen is displayed below:

```
Copyright 1988,
Hewlett-Packard Company.          :REMOTE, 21, 0, 8
All Rights Reserved.              1B SYSTEM_BASIC
                                  :ROM
BOOTROM Rev. C1                   B
Bit Mapped Display
MC68030 Processor
MC68882 Coprocessor
Keyboard
HP-IB
DMA-CO                            :HP8290X, 706, 0
RAM 1572704 Bytes
HP98642 at 8                      :HP7908, 803, 0
HP98626 at 9                      1H SYSTEM_HP-UX
HP98625 (HPIB) at 14             :REMOTE, 20, 0, 8
HP98629 at 20                     1F SYSTEM_FORTRAN
                                  2F SYSTEM_FORTH
                                  1Z SYSTEM_4TH
                                  1P SYSTEM_PASCAL
                                  1b SYSburp


SEARCHING FOR A SYSTEM (RETURN To Pause)
RESET To Power-Up                                            1H
```

Figure 4-2. Example Menu Screen

A ROM system is selected by a single letter. If the user knows that a particular choice is desired (such as "2F" or "31B"), then the user can type that response as the machine powers up to make a selection. This simple human interface makes it possible to make a selection without even having or seeing a CRT.

The state machine is executed in the interrupt service routine for the human interface input device.

Note that only keys A-Z, a-z, and 0-9 are allowed to select a system. Other keys are simply ignored. This makes the handling of all localized keyboards much simpler.

Because it is possible to find more systems than there are lines on the display, the search scan can be paused and continued by toggling the RETURN key. The line next to the bottom of the screen indicates the current state with one of two messages:

```
SEARCHING FOR A SYSTEM (RETURN To Pause), or
PAUSED (RETURN To Continue)
```

The menu will wrap around to the top of the screen and overwrite itself whenever all available lines are used. When the Boot ROM is paused, all activity stops. Because the keyboard is polled, there may be a delay before a key press takes effect.

Boot System Priority Control

Devices are searched in priority order for systems. This priority order is determined by the boot list shown below:

1. External discs at select codes 0-31 on bus address 0, unit 0, volume 0 (HP-IB)

2. An SRM at node 0 at select code 21 on volume 8

3. A LAN interface at select code 21

4. HP 98259 Bubble RAM on select code 30

5. HP 98255 EPROM card "disk", unit 0

6. Remaining external discs at select codes 0-31, bus addresses 0-7, units 0-16, volumes 0-7

7. Remaining SRMs at select codes 0-31

8. Remaining LANs at select codes 0-20 and 22-31

9. Remaining HP 98259 Bubble RAM card on select codes 0 through 29 and 31

10. Remaining HP 98255 "disk" (EPROM) units

Each device is allowed to have multiple systems. Again, if the machine is unattended, it will boot the first system found. If the machine is attended (i.e. a key was struck after the input human interface was initialized), it will display all systems found until a system is selected and that system is found.

For each category in the boot list, there is also an order of search based on address location. In all cases, lower addresses are found first. This means a device at select code 0 will be found before a device at select code 7. If a device has multiple addresses to locate it, then searching is done at a local level first. For example, after looking at select code 7, bus address 1, unit 1, the Boot ROM will look at select code 7, bus address 1, unit 2 before going to select code 8.

The boot list was designed to make it easy to change and control which system will be booted in the unattended mode. The guidelines used to establish the boot list are as follows:

- High priority addresses before low priority addresses.

- Soft systems before hard systems.

- Local systems before remote systems (Local refers to dedicated devices and remote refers to shared devices, i.e. an SRM).

- Removable media before non-removable media.

- Internal systems before external systems (Internal refers to operating systems on integrated devices).

- Small capacity devices before large capacity devices.

Default Mass Storage Is

The Boot ROM is responsible for setting up the default mass storage variable, DE-FAULT_MSUS. It is used by systems for three purposes as the:

- Default MSUS for operating systems,

- Device from which to load an autostart program, and

- Device from which to do a secondary load.

The DEFAULT_MSUS is set to the following algorithm which is the:

- Same as the MSUS of the booted system for all but ROM systems, OR a A non-ROM value passed in DEFAULT_MSUS to the booter routine (this is done only by systems calling the booter, not by the Boot ROM itself), or

- The first device found with L.I.F., S.D.F., or UNIX formatted media present if ROM is specified in DEFAULT_MSUS, or

- The first device found present in the boot list if ROM is specified in DEFAULT_MSUS and no media can be found (i.e., an on-line disc drive with no media present), or

- A L.I.F. media in a 8290XM drive at HP-IB 700 drive 0, if ROM is specified in DEFAULT_MSUS and no devices are present.

Supported Boot Configurations

Listed below are all hardware interfaces over which the Rev C1 Boot ROM can boot a system (on all 32 I/O Select Codes where applicable):

- Internal HP-IB (If not present, external select code 7 is available for any of the other interfaces.)

- HP 98624 9914 HP-IB card

- HP 98629 SRM card

- HP 98643 LAN card

- SCSI card

- HP 98625A/B HP-IB cards (Except never with 8290X due to hardware timing problems)

- HP 98255 EPROM card

- HP 98259 Bubble RAM card

The following interface protocols can be used to boot a system with the Rev C1 Boot ROM:

- CS/80

- SS/80

- Amigo

- LAN RMP boot protocol

- SCSI direct address device

- SRM

- EPROM

- BUBBLES

The following is a list of all media formats from which a system may be booted using the Revision C1 Boot ROM:

- L.I.F. 8000_{16}.

- SRM

- UNIX (3000) (Boot Area) (Note that this is different from HP-UX)

The Revision C1 Boot ROM can boot systems from the following boot devices:

- ROM systems

- SRM via HP 98629 card, /SYSTEMS directory only

- AMIGO protocol HP-IB Discs (e.g. 8290XM, 9895, L-Codes and 7906/20/25)

- SCSI and LAN boot servers

- "Disc" format EPROMs (HP 98255)

- HP 98259 Bubble RAM card

- CS/80 protocol HP-IB discs (e.g. 7908)

- SS/80 protocol HP-IB discs (e.g. 9122)

- CS/80 Tape

Note

Some of these devices, namely the HP 7906/20/25, may not meet EMI requirements when used with Series 300 computers, but their support in the drivers comes inexpensively with other disks that are supported.

For all devices there are seven generic error messages:

- `No Device` -- The device disappeared.

- `No Medium` -- There was no media (e.g. flexible disk) present.

- `Not Ready` -- The device was not ready.

- `Read Error` -- An error occurred while reading from the device.

- `Bad Hardware` -- A hardware fault occurred.

- `Bad State` -- The device is in an unknown or unexpected error state.

- `Bus Error` -- A bus error occurred during a memory transfer.

If the error terminates the actual load of a system it will appear in the next to the bottom line of the display followed by the device mass storage specifier (e.g. :HP7908, 803, 0). If the error occurs during scanning for systems, it will not terminate the scan. In this case the error(s) will be listed on the left hand side of the screen. Below is an example display with several errors.

```
Copyright 1988,
Hewlett-Packard Company.          :REMOTE, 21, 0, 8
All Rights Reserved.              2B SYSTEM_BASIC
                                  :ROM
BOOTROM Rev. C1                   B
Bit Mapped Display
MC68030 Processor
Console Keyboard at 14
HP-IB                             :HP9895, 801, 2
DMA-CO                            3B SYSTEM_BAS
RAM 1572704 Bytes                 1Z SYSTEM_4TH
HP98626 at 2                      :HP7908, 803, 0
HP98625 at 8                      1b SYSburp
HP98642 at 9                      :REMOTE, 20, 0, 8
HP98629 at 20                     1F SYSTEM_FORTRAN
HP98629 at 21                     2F SYSTEM_FORTH
:HP8290X, 804, 0                  1P SYSTEM_PASCAL
Bad Hardware
:REMOTE, 20, 1, 8
No Device



SEARCHING FOR A SYSTEM (RETURN To Pause)
RESET To Power-Up                                        1H
```

Figure 4-3. Example Display with Errors

Booting From The SRM

Placing bootable systems on sector oriented devices is fairly straight forward. On LIF devices a system file must be created, and on SDF and HP-UX devices a boot area must be created. For the SRM, systems to be booted must be placed in system files in the directory /SYSTEMS.

Because the SRM is a shared resource, unavoidable and peculiar behavior that can be exhibited if the /SYSTEMS directory changes while the Boot ROM is scanning it. During the scanning or booting process, the order of the directory can be re-arranged, and system files can be deleted or added. This means that the Boot ROM may show a system that does not exist anymore, may not show a system that does exist, or may never show a system that has always been there.

If a system that does not exist is chosen to be booted, the Boot ROM will stop with the error "NOT FOUND". A RESET is required to try again.

As long as the /SYSTEMS directory is stable, which is usually the case, everything will work as expected.

RESET will re-start Boot ROM execution. RESETs are locked-out or deferred during all mass storage operations to prevent leaving devices stranded in strange states.

Self-Tests

When the computer first powers up, the CPU starts executing Boot ROM code. Before code is executed to boot an operating system, several things need to be set up and tested. The Boot ROM has several code segments to manage these responsibilities:

- **Hardware Initialization Support**.

  Some hardware must be initialized at power-up as soon as possible to prevent improper operation. This initialization is cheaper in the Boot ROM than in the hardware. (Examples are display initialization and floating RAM positioning -- neither of which can wait for a system to be loaded.)

- Field Replaceable Unit Go/No-Go Self-Test Support.

  The primary objective is to tell user that the computer is okay. This consists of indicating all such devices present and reporting all detectable failures.

  Boot ROM self-tests are by no means guaranteed to handle all hardware failures correctly. Several things contribute to this. They include current hardware design, limited code space, limited development time, and the fact that testing for unknown or unexperienced failures is virtually impossible.

  Several "UNEXPECTED" failure messages may be displayed at any time. When the CPU executes an instruction set, certain events are expected to occur. Should an interrupt (either internally from the CPU or externally from some other device) occur and cause a RAM or CPU address to be used out of sequence, an "UNEXPECTED USE OF (address) error message is displayed. Table 4-1 lists these messages. The addresses 5 most significant digits are FFFFF so only the 3 least significant digits (LSD) are used in the table. When a range of addresses is shown, each address is the range is 6 addresses apart.

  When an "UNEXPECTED" failure message equates to an interrupt level, vectored interrupt, or trap, the following situations normally exist:

- **Interrupt level 1 through 7:** Can happen at any time and are usually caused by an interface set to the indicated interrupt level. If the error repeats, the interface should be replaced.

- **CPU traps:** Usually occurs when the operating system is being used. A CPU trap indicates something in the CPU didn't go right. If the error repeats, the processor board should be replaced.

- **Other errors:** Several things can cause these errors, either on the processor board on in an interface circuit. If the error repeats, the processor board or interface should be replaced.

Table 4-1. "UNEXPECTED USE OF (address)" Failure Messages

3 Hex LSDs	What Unexpected Event Occurred
FFA	Bus error
FF4	Address error
FFE	Illegal instruction
FE8	Zero by zero trap
FE2	Check trap
FDC	TRAPV TRAP
FD6	Privilege violation
FD0	Trace trap
FCA	1010 Opcode
FC4	1111 Opcode
FBE	Interrupt level 1 (keyboard)
FB8	Interrupt level 2 (not used)
FB2	Interrupt level 3
FAC	Interrupt level 4
FA6	Interrupt level 5
FA0	Interrupt level 6
F9A	Interrupt level 7 (RESET from keyboard)
F3A to F94	CPU Traps
F34	Reset from keyboard
F2E	Keyboard timeout (fast handshake)
F28	Battery backup interrupt
F22	NMI from the backplane
F1C	Spurious interrupt
EEC to F16	Vectored interrupts
EE6	Format error, co-processor violation or unknown.
EE0	MC68882 Co-processor exception vectors.

Failure Indications

As the self-test progresses, the LEDs display the current state. At the end of the test, a power-up with no errors is indicated by all LEDs turned off and by immediate entry into the boot scanner.

If a failure occurred during the self-tests, then that failure will be indicated on the LEDs at the end of the tests. If there was more than one failure, the highest priority failure will be indicated on the LEDs. All the LED values are listed below.

The highest priority failure is also sounded off on the beeper, if present. The lower 7 bits of the LED value are sounded off, most significant bit first, one second per bit, with a zero represented by a low tone and a one represented by a high tone. If no failure occurs, the beeper will not sound off.

If the failure was a Boot ROM checksum error, the following message will be displayed:

```
CONTINUE AT OWN RISK (Press RETURN To Continue)
```

Once this message has been printed, the RETURN key must be pressed to continue to the boot scanner. The probability is fairly low that the error will adversely affect the user, but if it does, it could be catastrophic.

For all other failures, the message:

```
WAITING 1 MINUTE (Press RETURN To Abort Wait)
```

will be displayed. The Boot ROM will time out after approximately one minute and will then continue into the boot scanner. This allows time for the CRT to warm up and for the user to read the error messages. These failures are usually non-fatal so, in an unattended mode, the Boot ROM will still boot the first system it finds. Pushing the RETURN key will terminate the beeping error code and abort the one minute wait. Pushing the RETURN key will also make the machine attended.

This means that the Boot ROM will display all systems found and will not boot a system until one in chosen and entered by the user.

General Description of Failure Codes

Table 4-2 shows the general meaning of error codes. These codes are explained further in other tables. LED patterns are represented by a black dot for on and a white dot for off. Letter designator's indicate the LED in that position is on or off, depending on the binary code used to represent the device or failure type.

Table 4-2. General Failure LED Indications

Upper 2 Bits Fail Indicator	LED Code and Failure Description
State Indication Only:	ooSS SSSS
	Where SS SSSS Indicates State of Power-up
Required Device Missing or	o●DD DDDD
DTACK Failure:	Where DD DDDD Indicates Device
Failing Device:	●oDD DDDD
	Where DD DDDD Indicates Device
Special Codes (Special Case Highest	●●●● ●●●●
Priority Codes):	LEDs Never Accessed (or Unused Code)
	o●●● ●●●●
	LEDs Failed to DTACK
	oooo ooo●
	Timer on processor board has failed or is missing.

Lower 2 Bits State or Device Codes	LED Code and Failure Description
Miscellaneous (Highest Priority):	XXoo FFFF
	Where FFFF indicates Failure (Xs are don't-care bits)
Internal Peripheral Failure (Medium Priority):	XXo● PPPP
	Where PPPP is Peripheral Number
I/O Card Failure (Lowest Priority):	XX●S SSSS
	Where S SSSS is Select Code

State and Failure Codes

Table 4-3 lists the LED failure codes used in the computer's Boot ROMs. Codes are listed here in numerical order for easy reference, and then again in order of occurrence and priority.

Table 4-3a. Self-Test LED Special State and Failure Codes

(In numerical order):

LEDs	Explanation
oooo oooo	No failure.
oooo ooo●	Failed CPU register test.
oooo oo●o	Testing top 16 Kbytes of RAM.
oooo oo●●	Failure in top 16 Kbytes of RAM.
oooo o●oo	Top 16 Kbytes of RAM missing or not found by CPU.
oooo o●o●	Searching for user-supplied Extension ROM.
oooo o●●o	Start executing Extension ROM instructions.
oooo o●●●	Starting Test Vector list.
oooo ●ooo	Resetting all interfaces.
oooo ●oo●	Searching for alpha video circuits.
oooo ●o●o	Testing RAM for I/O on-board test code.
oooo ●o●●	I/O on-board test code running.
oooo ●●oo	Internal BMD checksum.
oooo ●●o●	DIO-II console testing.
oooo ●●●o	Failed Boot ROM checksum.
oooo ●●●●	Pre-loading RAM for main test.
ooo● oooo	RAM Testing.
ooo● ooo●	Failure: Not enough RAM.
ooo● oo●o	Failure: ROM system.
ooo● oo●●	Failure: Boot error.
ooo● o●oo	Failure: OS loading address too high.
ooo● o●o●	Failure: Not enough RAM to load OS.

Table 4-3b. Self-Test LED State and Failure Codes for Interfaces

(In numerical order)

LEDs	Explanation
oo●o oooo	Failure: 4 ms timer.
oo●o oo●o	Failure: Processor board keyboard circuit.
oo●o oo●●	Failure: External keyboard circuit.
oo●o o●oo	Failure: Internal HP-IB circuit.
oo●o ●ooo	Failure: DMA circuit.
oo●o ●●oo	Failure - one of these high-res video circuits: Font ROM is bad. Font ROM is not usable. Could not find US ASCII character set.
oo●o ●●o●	Failure: Video board bit map circuit.
o●oo oooo	Failure: I/O circuit at select code 0. Each successive LED pattern represents an I/O failure at select codes 2 through 30.
o●o● ●●●●	Failure: I/O circuit at select code 31.

Table 4-4a. Turn-On, Self-Test, and Boot Displayed Messages

Displayed Message	Explanation and Procedure
RAM FAILED ABOVE FFFFC000	Failure in top 16 Kbytes of RAM. Replace processor board.
RAM GONE ABOVE FFFFC000	CPU could not find top 16 Kbytes of RAM. Replace RAM board in slot A.
TESTING MEMORY	User RAM is being tested.
LOADING MEMORY	RAM is loading with Boot ROM code.
BOOTING A SYSTEM	An OS is being loaded into RAM.
SEARCHING FOR A SYSTEM (ENTER To Pause)	Looking for an OS on mass storage devices. Press [Enter] to stop the search.
SEARCHING FOR A SYSTEM (RETURN To Pause)	Looking for an OS on mass storage devices. Press [Return] to stop the search.
PAUSED (ENTER To Continue)	Computer has paused. Press [Enter] To Continue.
PAUSED (RETURN To Continue)	Computer has paused. Press [Return] To Continue.
CONFIGURE MODE	Self-test is in configure mode. Press [T] for extended self-test. Press [L] for continuous self-test.
SELF-TEST MODE	Computer is in self-test mode.
RESET To Power-Up	Press [Reset] to re-start power up sequence.
RESET TO RE-Try	Press [Reset] to re-try what failed before.
CONTINUE AT OWN RISK (ENTER To Continue)	A self-test was not completed. You may continue but errors may occur. Press [Enter] to re-start power up sequence.
CONTINUE AT OWN RISK (RETURN To Continue)	A self-test was not completed. You may continue but errors may occur. Press [Return] to re-start power up sequence.
WAITING 1 MINUTE (ENTER To Abort Wait)	Computer has paused while you decide what to do next. Press [Enter] to abort wait and continue.
WAITING 1 MINUTE (RETURN To Abort Wait)	Computer has paused while you decide what to do next. Press [Return] to abort wait and continue.
UNEXPECTED USE OF HHHHHHHH	Refer to Table 4-3.
NOT ENOUGH MEMORY	Not enough RAM to load OS.

Table 4-4b. Turn-On, Self-Test, and Boot Displayed Messages (cont.)

Displayed Message	Explanation and Procedure

SYSTEM WOULD LOAD TOO HIGH	An addressing error would make the OS start loading at too high of a RAM address.
	One of these situations probably occurred:
	    1. Bad OS media.
	    2. Error in information transfer.
	    3. Error in CPU, I/O or mass storage hardware.
	Try again. If error message repeats, troubleshoot or replace the above items.

SYSTEM NOT FOUND	Selected OS was not found on available mass storage devices. Verify desired OS is on a mass storage device and retry.
Bit Mapped Display	Bit-mapped video circuits on video board identified.
Keyboard	Processor board's keyboard circuits identified.
Console Keyboard at SC	Remote keyboard circuits identified at select code SC.
HP-IB	Processor board's HP-IB circuits identified.
HP98260	Interface (HP 98260 or equivalent) identified.
DMA	Processor board's DMA circuits identified.
MC68030 Processor	MC68030 CPU identified.
MC68882 CoProcessor	MC68882 Floating-Point Co-processor identified.
BBBBBBB Bytes	BBBBBBB is the amount of RAM in bytes the self-test found in the computer.

MEMORY FAILED AT HHHHHHHH	Memory failed at hex address HHHHHHHH.
	Replace one of these assemblies, depending on which one has the failed memory address:
	    Processor board.
	    Add-On RAM board.

DATA PARITY ERROR AT HHHHHHHH	A parity error occurred with hex address HHHHHHHH.
	Replace one of these assemblies, depending on which one has the failed memory address:
	    Processor board.
	    Add-On RAM board.

PARITY BIT ERROR AT HHHHHHHH	A parity bit error occurred with hex address HHHHHHHH.
	Replace one of these assemblies, depending on which one has the failed memory address:
	    Processor board.
	    Add-On RAM board.

Table 4-4c. Turn-On, Self-Test, and Boot Displayed Messages (cont.)

Displayed Message	Explanation and Procedure

MEMORY GONE AT HHHHHHHH	A read or write cycle was attempted at address HH-HHHHHH but no memory found at that address. Replace one of these assemblies, depending on which one has the failed memory address:
	    Processor board.
	    Add-On RAM board.

F Disc Error	An error occurred in disc drive information. Troubleshoot disc drive/media and replace one of these assemblies:
	    Media.
	    Disc drive board.

XXXXXXXX at SC	An accessory card or the equivalent circuit was found at select code SC and is identified by its HP product number and type.
Remote Interface at SC	A remote interface was identified at select code SC.

Tests Performed By the Revision C1 BootROM
Unextendable Code Segment

The first section of code in the Boot ROM consists of a series of tests and initialization routines which set up the computer so the rest of the Boot ROM code can function safely. For example, the first part of this code section cannot depend on a working stack. The first priority of this code section is to set up the computer so a stack can be used.

The first part of the unextendable code segment, the part that must work without a stack includes the following routines (note that, before each step, the LEDs are set to a new value which reflects that step):

- Bus Error Handler.

  The BUS ERROR vector is set up to point a routine which, based on the value of the stack pointer, decides if we have a stack.

- CPU Test.

  Three different values are passed, one at a time, through each of the CPU registers. If the value that comes out of the last register is different from the value that went into the first register, for any of the three values, then the Boot ROM halts with a "CPU Failed" code on the LEDs.

- Position Floating RAM and Pre-load the Top of Memory.

  The stack pointer is set and a register is set to point to the address of the next routine. The Boot ROM steps through the first 16 Kbytes of memory, pre-loading it and to initialize for the top memory test. If a bus error does not occur, the Boot ROM reads every 64 Kbyte boundary until a bus error occurs or until just before location $FFFF800000_{16}$ is reached.

- Cycle LEDs.

  A register is set to the address of the next routine in case a bus error occurs. The LEDs are rippled from all on to all off except one. There is a small delay for each ripple state which is used to cause a delay between memory pre-load and the test to check for refresh failures. If the LED ripple is successful, then this is noted in a data register.

- Check for Test ROM.

  If the Boot ROM is not at power-up, then this step is skipped. A register is set to the next step.

- Check for Video Circuits.

  If the Boot ROM is not at power-up and is not returning from the test ROM, then this step is skipped. A check is done for the CRT ID register of a compatibility (alpha/graphics) video circuit. Then the Boot ROM looks for a bit-mapped video board by checking location 560000_{16} for a primary DIO ID of 25 and a secondary ID of 1. If the proper ID is found, then a flag is set to indicate the presence of a bit mapped display.

- Determine if Internal HP-IB is Present.

  Register A6 is set to the address of the next step. Channel zero of the DMA card is disarmed if the DMA card is present. An internal HP-IB card is present if register three is set up such that bit 7 = 1, bit 6 = 0 and bit 0 = 0, and if bits 7 and 6 are unaffected by writing, and if bits 7, 6, and 0 are unaffected by bus precharging.

- Determine Which, if Any, Alpha Video Circuit is Present.

  Register A6 is set to the location of the top RAM test routine. An algorithm is used to determine which video board, if any, is present.

- Initialize and Blank Alpha Video Circuit, if Present.

  If a compatibility (alpha) display controller is present, then it will be initialized and blanked.

- Top RAM Test.

  Register A6 is set to the location of the fatal error handler routine. A memory test is executed on just enough RAM to allow the rest of the Boot ROM code to operate. (A "fatal error" will occur when there is not enough RAM.) If there is a memory failure, ●ooo o●oo will be displayed on LEDs. If memory is missing, o●oo o●oo will be displayed on LEDs. If an alpha display controller is present, the Boot ROM will also write the messages "RAM FAILED ABOVE FFC000" and "RAM GONE ABOVE FFC000" for memory failure and memory missing, respectively. These messages will not be printed on a bit mapped display controller as it is too difficult to write to a bit mapped controller without any stack space or RAM.

  If high RAM fails or is missing, then the LEDs and beeper will give the only notification on a system with a bit-mapped or remote console.

The second part of this code section depends upon a working RAM stack, and includes the following (as in the previous section, the LEDs are set to a new value before each step):

- Set Up Data Structures.
- The test list is set up in temporary RAM.
- The boot list and device driver list are set up.

Extendable Code Segment

This section of code allows one to add, replace or delete parts of the power-up sequence without requiring that the Boot ROM be replaced. These upgrades can be done via a boot extension ROM. In this section the Boot ROM calls any boot extensions, executes the test list vectors, and loops through self-test if continuous self-test is enabled.

The following is a step by step list of what happens in the extendable code segment. As before, each step is preceded by an indication of that step on the LEDs.

1. **Call All Boot Extensions:**

   Any boot extensions are called to allow changes to the test list and the boot list. If the boot extension header indicates that the extension code can be checksummed, then the checksum will be executed before any part of that extension is executed.

2. **Execute The Test List:**

   The test list (like the boot list) is a temporary structure used by the Boot ROM to allow upgrades and extensions. The test list is a linked list whose elements are vectors which point to test code for various devices. The test and/or initialization code for a given devices is generally of the format:

   a. Indicate on LEDs the device being tested.

   b. If the device is present, then

      If the test or initialization fails, then indicate the failure.

   c. Otherwise indicate the presence of the device.

The test list for the Series 300 Rev. C1 Boot ROM is as follows:

1. **Which CPU:**

   An exception format word is pushed onto the stack, and an RTE is executed. The state of the stack indicates whether or not the processor chip is an MC68000. If the processor was not an MC68000, then a divide by zero is executed and the stack is checked to distinguish between an MC68010, an MC68020 and an MC68030.

2. **Initialize Timer:**

   The Boot ROM determines if there is a timer on the CPU board. If there is one, then it is tested and initialized. If one is not present, or if a failure occurred, then the Boot ROM halts with oooo o●o● on the LEDs.

3. **Initialize Monitor:**

   The Boot ROM determines if a RAM video circuit is present at 00880000_{16}. If there is one, then its presence is indicated.

4. **Reset I/O:**

   A RESET instruction is executed to clear all I/O. The Boot ROM checks the internal keyboard controller, if present, to ensure that its timer does not lose time.

5. **Initialize and Test Display:**

   The output human interface soft vectors are set up to handle whichever video circuits are installed or dummy video drivers are set up if no controller is present.

   If an alpha video circuit is present, then a memory test of the alpha, and highlight memories is executed.

   If a bit map video circuit is present, then its ID/INIT ROM is checksummed and the circuit is initialized and cleared.

   If a failure is discovered it is indicated on the LEDs and the problem is remembered in F_AREA. The message SELF-TEST MODE is displayed on the bottom line of the display. See the section in this chapter on Human Interface for the console selection algorithms.

6. **Display Copyright Notice:**

   The Boot ROM displays a 1988 copyright message.

7. **Boot ROM Checksum:**

   If the Boot ROM checksums successfully, then BOOTROM Rev. C is displayed, otherwise the message BOOTROM Rev. C Failed is displayed. If there was a video circuit memory failure discovered in the alpha display initialization and test routine, then it will be displayed as:

   ```
   Memory Failed at <Hex-Address>
   (W:<Hex-Write-Pattern>, R:<Hex-Read-Pattern>)
   ```

8. **Display CPU Type:**

   The Boot ROM displays the type of CPU.

9. **Identify Floating Point Hardware:**

   The Boot ROM looks for and, if present, identifies the HP 98248A/B floating point accelerator board or the MC68882 floating point coprocessor chip.

10. **Initialize, and Test Keyboard Electronics:**

    The keyboard human interface vectors are set up for the internal keyboard , if one is present, and the keyboard self-test value is checked. If the keyboard failed self-test, then the message Keyboard Failed is displayed and the appropriate error code is set to the LEDs and the beeper. If the internal keyboard interface is present and passed self-test, then the message Keyboard is displayed. If no internal keyboard is present, then the external I/O space is searched for an external keyboard. If an external keyboard is found, it is treated just like an internal keyboard except that the message Console Keyboard at XX (where XX is the select code of the external keyboard) is displayed if the keyboard passes self-test, and the message Console Keyboard at XX Failed is displayed if the keyboard fails self-test.

    Note that only the external keyboard chosen as Console Keyboard will be tested. Other external keyboards will be identified, but not tested.

    The message RESET to Power-Up is shown on the bottom line of the display.

11. **Drop Interrupt Level:**

    The interrupt level is dropped to zero.

12. **Pre-load Memory:**

The message `LOADING MEMORY` is shown on the bottom line of the display while the end of memory is found by pre-loading the RAM not currently in use by the Boot ROM code.

If a long test is to be done, the RAM is loaded with $EEEE1111_{16}$. If the fast test is to be done, each RAM location is loaded with its own address. When pre-loading is finished, the message `SELF-TEST MODE` is shown on the last line of the display. Then a 300 ms delay is executed to catch refresh failures.

13. **Test and Initialize Old Style Graphics:**

If a compatibility monitor with graphics memory is present, then it is tested with a byte-wide RAM test. If the graphics test is passed, then the message `Graphics` is displayed. If the graphics test is failed, then the message `Graphics Failed` is displayed and the appropriate value is sent to the LEDs. If there is a graphics memory failure, it is indicated on the display as following two lines:

```
Memory Failed at <Hex-Address>
(W:<Hex-Write-Pattern>, R:<Hex-Read-Pattern>)
```

Finally, graphics memory is cleared.

14. **Test HP-IB:**

If the internal HP-IB hardware is present and if it is the system controller then the Boot ROM will test it. If the HP-IB hardware fails the test, then the message `HP-IB Failed` is displayed and the appropriate value is sent to the LEDs. If the HP-IB hardware is present and had no failures, then `HP-IB` is displayed.

15. **Check For DMA Presence:**

16. **I/O Card Tests:**

The Boot ROM scans select codes 0 through 31. For each select code the following steps are taken:

    a. The appropriate value is sent to the LEDs indicating which select code is being examined,

       If one of the following cards is found at the current select code, it will be tested by the Boot ROM:

        HP 98629 SRM controller card,

        HP 98627 color display controller card,

        HP 98624 HP-IB card,

        HP 98626 RS-232 card,

        HP 98643 LAN card,

        LAN card,

        HP 98644 RS-232 card,

        HP 98628 RS-232 card, or

        HP 98642 4-port multiplexed RS-232 card.

b. If the card at the current select code has no failures, then the message `HP98XXX` is displayed for that card. If the card fails, then the message `"HP98XXX Failed` is displayed for that card and the appropriate value is displayed on the LEDs. A memory failure on the HP 98627 card is indicated by the message:

```
Memory Failure at <Hex-Address>
(W:<Hex-Write-Pattern>, R:<Hex-Read-Pattern>)
```

c. The following I/O cards are identified by the Boot ROM, but are not tested:

HP 98625B HP-IB

HP 98622 GPIO

HP 98623 BCD

HP 98640 ACD

HP 98695 3270 Emulator

External bit-mapped video circuits with a primary ID of 25 and and secondary ID of 0 or 1

External keyboard (i.e., keyboard in the external I/O space) with ID 9 (will be identified as Keyboard at XX where XX is its select code)

HP 98653 EPROM Programmer

HP 98633 Multiprogrammer Interface

HP 98659 Bubble RAM

HP 98641

HP 98691

d. If the Boot ROM finds an external I/O card that it does not recognize, it will display the message

```
IDXX at YY
```

where XX is the combined value of the card's primary and secondary IDs, and YY is the card's select code.

17. **Test ROM Systems:**

The Boot ROM searches the ROM space from 64 Kbytes to 4 Mbytes. For each ROM header found, that ROM is checksummed unless the checksum disable bit is set. ROMs which fail checksum are indicated on the LEDs and the message `ROM X at <address> Failed` is displayed. Any ROM which supports only 50 character wide alpha display controllers will be ignored. and the message `ROM X at <address> Ignored` will be displayed, and the appropriate value will be sent to the LEDs.

18. **Test RAM:**

The message `TESTING MEMORY` is shown on the bottom line of the display, and the rest of memory is tested.

19. **Set Up Memory:**

The message SELF-TEST MODE appears on the bottom line of the display. If a memory failure occurred, then the appropriate value is sent to the LEDs and following message is displayed:

```
Memory Failed at <Hex-Address>
(W:<Hex-Write-Pattern>, R:<Hex-Read-Pattern>)
```

After a failure, the Boot ROM drops back to the next 64 Kbyte boundary. If the failure was is in the top 64K, the Boot ROM drops back to the next 2K boundary.

The available RAM is displayed as <Base-Ten-Number> Bytes. It should equal 174 bytes less than the amount of RAM installed.

20. **Allocate Memory:**

Temporary memory is set up for the boot scanner and booter routines.

21. **Display Final LED Value:**

If an error occurred during self-test, then the appropriate value will be sent to the LEDs and sounded off on the beeper. The lower seven bits of LED value are sounded off (MSB first) with ones represented by high frequency long notes and zeros represented by low frequency short notes.

If a Boot ROM checksum error has occurred, then the Boot ROM will stop execution with the message CONTINUE AT OWN RISK (RETURN To Continue) on the bottom line of the display. The Boot ROM will continue if Return is pressed.

If an error has occurred and continuous self-test looping is not enabled, and the error was not a Boot ROM checksum error, then the Boot ROM will wait one minute for the CRT to warm up before continuing, and will display the message WAITING 1 MINUTE (RETURN To Abort Wait). Pressing Return will cause the Boot ROM to abort the one minute wait and continue.

Memory Tests

Word (16 bit) wide tests are executed on main memory. There are two types of word wide tests used. Tests on the upper 16 Kbytes and all peripherals always use the slower, walking ones and zeros, test. The rest of main memory may use either the slow test, or a faster "address in memory" test.

Byte (8 bit) wide tests always use the walking ones/zeros test. This test is used on any peripheral that has less than full word wide memory (e.g. alpha display controller memory, and some graphics memory).

The same messages are used for reporting all memory failures, but they are interpreted slightly differently for word and byte memory tests.

For word wide memory test errors, the following message is displayed:

```
Memory Failed at AAAAAAAA        (W:BBCCDDEE, R:FFGGHHII)
```

Where:

- W: BBCCDDEE is the write pattern,
- R: FFGGHHII is the read pattern,
- BB and FF are at address AAAAAAAA,
- CC and GG are at address AAAAAAAA+1,
- DD and EE are at address AAAAAAAA+2, and
- EE and II are at address AAAAAAAA+3.

For byte wide memory test errors, the following message is displayed:

```
Memory Failed at AAAAAAAA        (W:BBCCDDEE, R:FFGGHHII)
```

Where:

- W: BBCCDDEE is the write pattern,
- R: FFGGHHII is the read pattern,
- BB and FF are at address AAAAAAAA,
- CC and GG are at address AAAAAAAA+2,
- DD and EE are at address AAAAAAAA+4, and
- EE and II are at address AAAAAAAA+6.

I/O Dependent Code Test

A major new test capability has been added to Rev C and later bootROMs. The concept is taken from HPPA and is known as I/O Dependent Code (IODC) entry point test. The basic concept is that an interface will carry its own test code in on-board ROM. This code is moved to system main RAM and executed by the host CPU. From a user's perspective, there are effects on how failures are reported.

The simplest change is that instead of a Failed message at the end of an interface identification, there will be one or more lines of indented text saying which part of the interface failed.

The most complex change is that under extended test mode, the user may be asked to perform certain actions and will be given more information about what happened during one or more steps in the test.

During extended test mode the display is organized into several sections.

```
 ----------------------------------------------------------------------------
 |     device identification       |result : test section description    |
 |     status messages             |                                     |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |-------------------------------------|
 |                                 |          general messages           |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |                                     |
 |                                 |                                     |
 +---------------------------------+-------------------------------------+
 | prompt line                                                           |
 +-----------------------------------------------------------------------+
 | reset action line                            system selection field |
 +-----------------------------------------------------------------------+
```
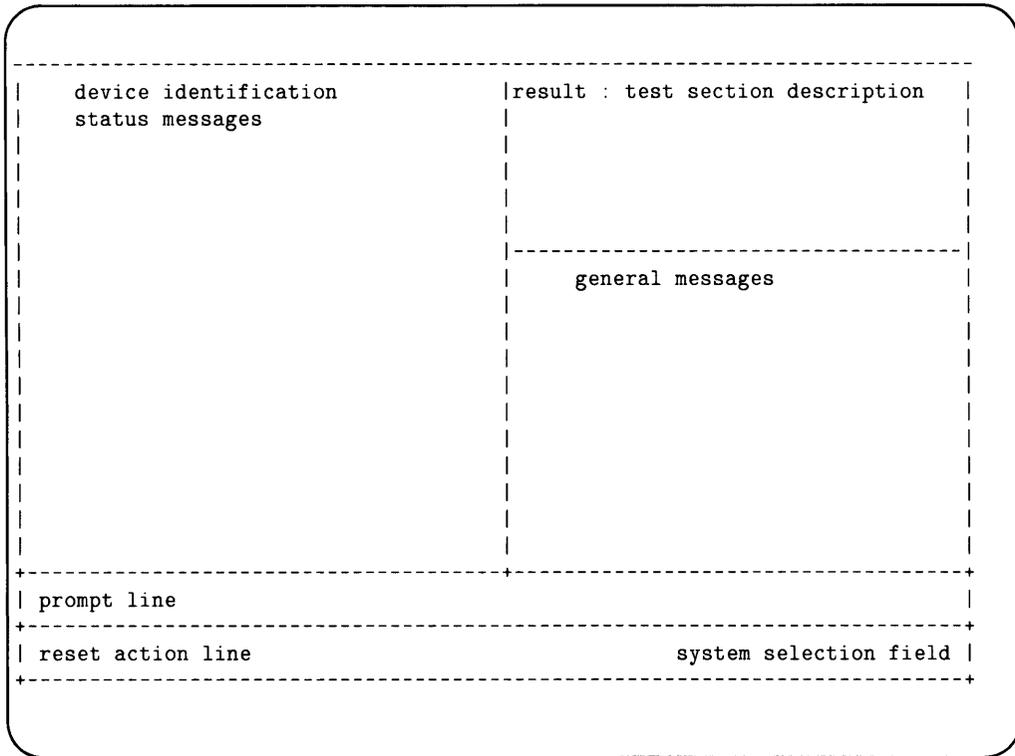
Figure 4-4. Extended Test Mode Display Organization

The left section contains the name and status of interfaces and system components identified and or tested so far. The lowest one on the display is the interface currently being tested.

The prompt line normally shows the SELF-TEST MODE message but when the user is asked for input, this line will describe which keys may be pressed and what they will do.

The only keys recognized at this point are:

- [Reset] which will abort the whole test operation and go to the RESET state It is described earlier in this chapter.

- **SPACE**

- [Return]

- [A] through [Z]

- [a] through [z]

- [0] through [9]

- All other keys are ignored.

The reset line shows that the RESET function is active and the selection field shows the current system selector. Information on this line has been fully described earlier in this chapter.

The upper right hand area contains one line identification/descriptions of each section of the test, possibly one for each FRU in the interface. The left end of each line will contain a result. The result will be "passed" or "failed" indicating that the test has been run and the result of the test. If this field is blank it indicates that either the section has been skipped or not run. Test sections are performed in the order shown on the display.

The area below the section descriptions is used to display general information about a test section, direct user actions and display failure messages. Failure messages will also appear in the left half of the display. This general information area is cleared after each section has been done.

The size of the two right hand areas is determined by the number of test sections.

Small Computer Systems Interface

The SCSI is identified by one of these messages:

```
PPPPPPP (SCSI x y) at SC
```

where: `PPPPPPP` is the HP product or equivalent thereof.
x is an S for single-ended line drivers.
x is a D for differential line drivers.
y is 16 for a 16-bit wide DMA path.
y is 32 for a 32-bit wide DMA path.

There is no way to add a SCSI interface to the Model 332 at this writing. However, the following material is included in case a SCSI interface becomes available in the future.

SCSI Testing

There are two levels of SCSI testing: normal and extended.

Normal testing is done at power-up or if the bootrom is in LOOPING test mode. This test only checks the general functionality of various registers on the interface. It will only detect gross failures.

The identification line may be followed by one of these error messages:

```
register test failed
fuse burned out
```

If any of these messages appear, no attempt will be made to use the interface as a boot source.

The "fuse" is an electronic fuse which can be reset by either pressing [Reset] to cause the boot rom to restart or by cycling power to the computer.

Extended testing is done in a non-looping extended test mode. This mode uses the IODC interface as described above. There are 3 sections to this test.

- Register test (as done in normal testing).

  This test is always run and if it fails, the remaining sections will be skipped.

- Loopback test.

  This test displays these messages in the order listed and the indicated actions are required:

  `Turn OFF ALL SCSI devices`, which means to turn off power to ALL SCSI peripherals. If a particular sequence is required for proper system shut-down, that sequence must be followed.

  `Disconnect cable at nearest device`, meaning remove the SCSI cable at the first SCSI peripheral down the SCSI interface from the computer.

  `X cancels, RETURN continues testing`, wherein pressing $\boxed{X}$ cancels the test or $\boxed{Return}$ continues the SCSI test.

  This test checks transmit and receive functionality both with and without DMA interaction. If there is only one device attached to the interface, the test can be performed with the device turned off and the cable still attached. If there is more than one device then the cable must be detached from the device before running this test. If this test fails, cable test can still be executed. If the user cancels testing at this point by typing X in response to the prompt, this section and the following sections are skipped. It will take a second or so with bit-mapped video circuits to clear the display and shut down the IODC interface.

- Cable test.

  This test displays these messages in the order listed and the indicated actions are required:

  `Attach SINGLE-ENDED test connector`, meaning connect the single-ended part of the SCSI test connector to the SCSI port on the back panel of the computer.

  `X cancels, RETURN continues testing`, the same as before.

  This test requires the use of a special test connector and should be skipped if one is not available. The purpose of this test is to check the cable for shorted or broken wires. If the loopback test failed, this test may also fail due to failed circuitry on the interface board rather than due to a bad cable. At the end of this test, it is VERY important that the test connector be removed. Failure to do so will cause the bootrom to hang while trying to use the interface connected to this cable.

- Reconfiguring the System.

  These messages are displayed after the SCSI tests are completed and the indicated actions are required:

  `Remove test connector`, here's when you remove the SCSI test connector from the SCSI port on the computer. This message is only given if the cable test has been run.

  `Connect cable to device`, meaning connect the SCSI interface cable to the SCSI peripheral it was earlier removed from.

  `Restore power to devices`, this is when you turn on all SCSI peripherals.

  `RETURN continues operations`, and pressing $\boxed{Return}$ continues with the next part of the self-test and booting operations.

SCSI Interface ID Situations

During the search for a system phase of the boot process, the Rev. C Boot ROM looks for an SCSI interface by checking only the least significant 3 bits of each interface ID. This means any interface whose ID code has the least significant 3 bits set to 1 will be accessed as if they were an SCSI interface. Interfaces and their ID involved are:

- HP 98265A SCSI Interface Card; ID 7 (00111) (not available on Model 332).

- HP 98630A Breadboard Card; ID 15 (01111).

- Datacomm devices; ID 23 (10111).

- HP internal devices; ID 31 (11111).

Of these interfaces, the HP 98630A Breadboard Card may cause the most concern. The Breadboard Card may need to have a higher select code than the HP-IB or SCSI interface to prevent this problem. Otherwise, the Breadboard Card should have an ID of 16 (1000).

User Interface Specifications For LAN Boot Operations

LAN interfaces are identified by its product number or circuit equivalent, then (LAN) then the select code, and link address of the interface as:

```
HP98643 (LAN) at 21, 080009000001
```

Any time the interface is identified certain tests are also run. Before the test the display will show

```
HP98643 (LAN) at 21
```

then

```
HP98643 (LAN) at 21, 080009000001
```

If a failure is detected in the power-up test, the following failure message will be displayed:

```
HP98643 (LAN) at 21, 080009000001 Failed
```

This shows that one of the internal tests on the card failed. The tests include register operations, shared RAM, non-volatile RAM checksum and several different internal loopback tests.

If extended testing is selected by pressing CTRL - C then T, the LAN card is subject to the normal testing plus external loopback tests. The following error messages may be displayed below the LAN identification message:

- CABLE Failed

  This shows that the cable is not connected or improperly terminated.

- MAU Failed

  This shows that the MAU circuitry failed. This is not likely on computers where the interface is built-in. On non built-in LAN cards this could mean that the MAU was not plugged into the card.

- NO HEARTBEAT

  This message is only a warning. This shows that the interfaces self-test (done after every transmission) is failing. In can also appear on Ether Net type MAUs because this self check feature is not implemented. This message is new for REV C. The same condition occurring with REV B will be detected by the normal test passing and the extended test showing only a Failed message.

If no servers respond to the Boot ROM's attempts to initiate a boot session then the user will see no other indication of LAN activity.

For each server that responds, display will show :LAN, followed by the select code, followed by either the servers name or its Link Address. Under this will appear the list of systems provided by that server:

```
:LAN, 21, 080009000008
1H SYSTEM_HPUX
2B SYSTEM_BKUP
```

Error conditions
LAN error messages will show at the lower left of the display and consist of an error name followed by the same identification string shown above the list of system names.

Error Message	Meaning
SYSTEM NOT FOUND	The server could not open the selected file, or the file was of the wrong type.
No Server	The server did not respond to a boot request
Not Ready	LAN hardware powerup or reset failed.
Read Error	Open worked but server has since failed to respond or has sent an eof message.
Bad Hardware	LAN hardware failed to respond to some operation or it reported some catastrophic failure.
Bad State	Bootrom code damaged.

Read Interface Technical Information
The LAN drivers will support the read interface as used by secondary loaders.

The LAN MSUS is

- fmt = 7

- dev = 2

- sc = card select code

In hex this is E2xxSCxx. The x fields are don't cares, the SC field is the select code. Other fields in the msus may be non zero but are not significant for read interface purposes.

The LIF volume images allowed for LAN booting deviate from the LIF standard in that:

- The directory must begin on either sector 1 or sector 2.
- The files in the directory MUST all have the same start, length and type values.
- Empty entries are skipped.
- Both the logical and physical end of directory conditions are recognized.

The LAN boot protocol is intended only to transport files NOT directories. The LIF volume image is used as a mechanism to provide the information normally supplied by the directory on a LIF volume. Neither the volume name or file names are ever examined. It is assumed that the correct name was used given to the server.

The multiple files with identical type, start and length values is used by the HP-UX secondary loader. All HP-UX type system files boot the same physical file, which is the secondary loader. This loader then examines the name under which it was booted then loads the corresponding a.out file.

The M_READ MEDIA parameter is used as follows:

- If the file is a LIF volume image then
  - If MEDIA is true then offsets are volume image relative.
  - If MEDIA is false then offsets are from the start address given in a directory entry.
- If the file is not a LIF volume image then then offsets are always from the beginning of the file.

Errors are signaled by the standard read interface escape codes. Table 4-5 lists the Lan boot errors.

Table 4-5. LAN Boot Errors

Error Message	Meaning
No Server	(M_FOPEN only) The server did not respond to a boot request.
Not Ready	(M_FOPEN or M_READ) LAN hardware powerup or reset failed, or M_FOPEN was called without calling M_INIT, or M_READ was called without calling M_FOPEN.
Read Error	For M_FOPEN, the open operation worked but the server has since then failed to respond to a read request or the server sent eof. For M_READ, the server failed to respond to a read request or the server sent eof.
Bad Hardware	(M_FOPEN or M_READ) the LAN hardware failed to respond to some operation or reported a catastrophic error.
Bad State	(M_FOPEN or M_READ) damaged bootrom code.

If a system calls the bootrom to boot/re-boot a system and a file name is specified and the msus is for LAN, the bootrom will retry indefinitely to contact the server at the given link address. All other devices have a fixed number of retries/timeout and will report No Medium or SYSTEM NOT FOUND.

The system call for a boot/re-boot on LAN is the only time an indefinite retry/timeout is used.

Troubleshooting

5

Introduction

Analytic Troubleshooting

Troubleshooting computers is the process of getting answers to these five questions:

- What exactly is wrong, or what are the bad symptoms?
- Where are the bad symptoms appearing?
- When do the bad symptoms occur?
- How bad is the problem or to what extent does it occur?
- What actually caused the problem in the first place?

Getting the answers to these questions usually makes the troubleshooting process much more effective and less costly. When a failure in a computer system occurs, remember these questions and get the answers to each of them.

After you have all answers possible, decide what's the most probable cause of the problem. Sometimes you'll arrive at several choices for a cause. For each choice, qualify it against the answers to the questions above. The most probable cause is the one that logically justifies the correct answers to these questions.

Materials Required

Several items are required to troubleshoot the computer to the failed assembly:

- Model 332 Computer Service Handbook
- Series 200/300 Test Tools Package.
- Digital Voltmeter.
- Anti-Static Workstation.

Test LED Displays

Note

LED displays in this chapter are for Revision C1 bootROMs.

Eight test LEDs are located behind the front panel and are visible from the front of the computer. In this manual, the LED's are shown in the following context:

$\bullet$ = LED On

o = LED Off

Troubleshooting Procedures

System Level

System level troubleshooting consists of finding out what part of a computer system is not working correctly. A system consists of the computer and its installed accessories, interfaces, peripherals, power source **and the users**. Each of these system elements is subject to the environment which includes, physical, electrical, and human factors.

When part or all of the computer system fails, your initial activity should be finding the part of the system has the problem. One of the best things to do first is to talk to the users and ask them to give specific information on what they and the system were doing when the system, or part of it, failed. You may have to duplicate their activities in order to make the failure occur. If the failure is intermittent, this process may take some time.

Running tests on the system can also be helpful. A test is nothing more than a specific action with the system that should result in a specific response. Simple tests are nothing more than typing in simple instructions on the keyboard and executing them. A command to print or plot specific date is an example. Mass storage, graphics, or other functions can be checked in the same way. These type of tests are called Quick Checks.

After determining what part, or product, of the system is failing, the next step is to find out what part of the product is causing the problem. In this case, it is assumed that the computer or expander has the problem. The rest of this chapter covers troubleshooting the computer and expander.

Computer/Expander Troubleshooting

Both units may be analyzed alike, except for the processor in a computer's system slot. Each has the same power supply, motherboard, fans, and backplane system.

Three levels of troubleshooting these products are explained. For each level different portions of these products must be operational. A summary of these levels and what must be operational is shown in Table 5-1.

In order to choose the best approach to start with, obtain as much information as possible from the user. If the unit is not working at all, the Inoperative Unit Procedure is a good place to start. If the user indicates that most of the unit is operating properly, the Functional Unit Procedure may be a good place to start. If the users information is not conclusive, use the following procedure to determine the problem area:

1. Turn the unit on and check for fan and Self-Test LED operation.

2. If the fans or LED's aren't working, go to the Inoperative Unit Procedure. If they do work, go to the Functional Unit Procedure.

Table 5-1. Computer Troubleshooting Procedures

Procedure	What MUST Function
Inoperative Unit	Nothing
Live Unit	Power Supply Motherboard
Functional Unit	Power Supply Part of processor Part of motherboard Top 16K of RAM DIO Bus Some inputs from keyboard Output to operate monitor

Inoperative Unit Procedure

An Inoperative Unit is one which does not appear to function at all. No power-on or self-test LEDs, fan rotation, or response to keyboard inputs are typical symptoms. Nearly all inoperative units have one of these basic problems:

- Defective power supply.

- Voltage select switch in wrong position

- Improper line voltage/frequency or defective power cord.

Follow this procedure to isolate the problem. If an assembly is defective, this procedure indicates which assembly should be replaced to eliminate the problem.

WARNING

Hazardous voltages are present in the unit when it is plugged in. Turn the unit off and unplug the unit before placing test leads, checking fuses, or removing/installing assemblies.

---

1. Check that the voltage select switch is set correctly. Refer to Chapter 2 in the Service Handbook for the correct procedures.

2. Check that the fuse is good and of the correct size. If the fuse is defective, replace it. If the fuse is good, skip to Step 4.

3. Turn the unit on, then turn it off and recheck the fuse. If the fuse is defective skip to Step 5, otherwise go on to Step 4.

4. If one or both fans are not rotating, check the voltage across the inoperative fan's voltage terminals. If the voltage is correct, the fan is defective. If not, continue with the voltage check procedure. Fan voltage should be as shown below.

    a. Large fan voltage: +12 V dc.

    b. Small fan voltage: +17 V dc (+5 and −12 V dc).

5. If the fuse is open, one of the installed assemblies is defective.

6. Remove all assemblies from the slots.

7. Replace the fuse. Install the power cord and turn the unit on, then turn it off and recheck the fuse. If the fuse is good, one of the removed assemblies is defective. If the fuse is open, the power supply, motherboard, or backplane is defective; go to Step 8.

8. Disconnect the card cage ribbon cables. After installing a new fuse turn the unit on, then off, and check the fuse. If the fuse is good, the backplane is defective, If the fuse is blown, the power supply or motherboard is defective.

9. Repeat Step 8 but instead remove the motherboard. If the fuse is good, the motherboard is defective. Otherwise, the power supply is defective. After replacing the defective unit, you should now be able to perform Live Unit Troubleshooting Procedures.

Live Unit Procedure

A live unit is one which has a motherboard and properly functioning power supply but the unit will not function. One of the assemblies installed (other than the power supply) is usually defective. Live units often are very difficult to troubleshoot, since a problem anywhere on a bus in the computer or bus expander can shut the system down and prevent the execution of any instructions, even those from the self-test.

The Live Unit Procedure is a method for finding the defective assembly which is preventing the processor from executing instructions. It assumes that the power supply is operating properly, and the self-test tried to run, but didn't. Refer to Figure 5-1.

CAUTION

Remember to turn the unit off and unplug it before removing any assembly. Use ESD precautions and a static-free workstation.

---

1. Turn the unit off.

2. Remove the bus expander from the computer if installed.

3. Remove the top cover and disconnect the ribbon cables from the DIO backplane.

4. If a separate video board is installed, pull it loose from the backplane. Leave the processor board in.

5. Plug the unit in and turn it on. The Self-Test LED's should ripple and change state several times.

6. If the LEDs DO run through to the completion of the test (that is, all off), skip down to step 8. If the LEDs DO NOT run through to the completion of the test (that is, all off), turn the computer off and remove the add-on RAM board(s) from the processor board.

7. Now retry the Self-Test. If the LEDs stop at 04, one of the RAM boards is defective. Otherwise, the processor board is defective.

8. Re-install the video board and retry the Self-Test. If the LEDs DO NOT run through to the completion of the test (that is, all off), the video board is defective.

9. If the LEDs DO run through to the completion of the test (that is, all off), remove all cards from the DIO backplane and reconnect the backplane ribbon cables.

10. Now retry the Self-Test. If the LEDs DO NOT run through to the completion of the test (that is, all off), the DIO backplane is defective. If the LEDs DO run through to the completion of the test (that is, all off), re-install the DIO backplane cards one at a time until the Self-Test does not run through to completion. The last board installed is the defective one.
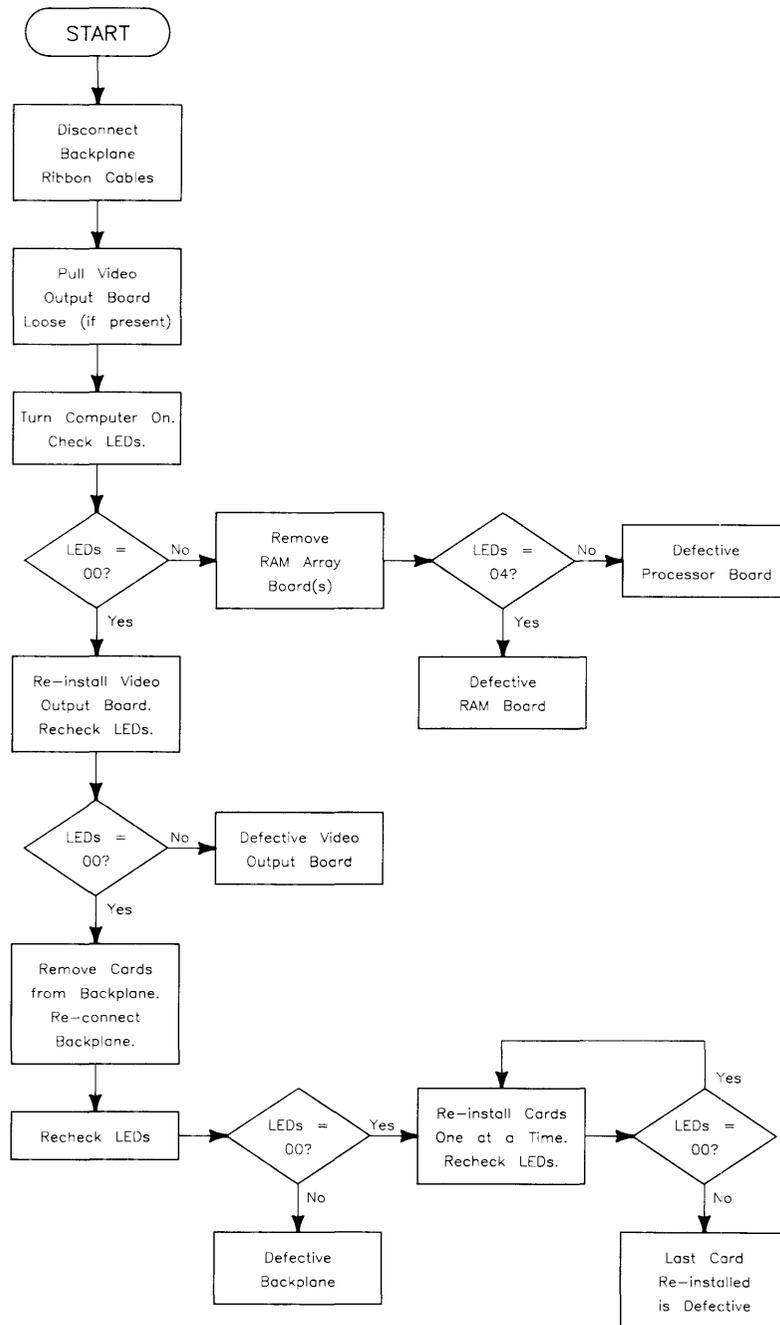
Figure 5-1. Live Unit Troubleshooting Flowchart

Once this level of operation is achieved, a similar process can be used to install and check other accessories, interfaces, and peripherals in the complete system. This also may be a good point to load and run one of the tests in the Series 200/300 Test Tools Package. Refer to the Test Tools Manual for tests information such as:

- Minimum Hardware Configuration Required.

- Test Loading and Running.

- Interpreting Test Results.

Series 300 Test Tools are explained in the next section.

Test Tools

Overview

Series 200/300 Test Tools is a software package for verifying the integrity of various computer system installations. While the tests do not provide totally comprehensive system diagnostics, they are a valuable tool for trained service personnel when installing, servicing, and troubleshooting these computer's workstations. The tests can also be used by less-experienced users and operators for determining whether or not professional assistance is needed to identify and fix a system malfunction.

The tests described in this manual are for testing and troubleshooting Series 300 systems that do not require formal verification of operation before use. Series 300 HP-UX systems have a more critical need for system verification tests, so these tests may be used as part of the standard HP-UX operating system (HP-UX System Functional Tests and CS/80 Exerciser programs are very similar to the equivalent tests described in this manual). The Series 300 Computer Tests described in Part II of this manual can be used for troubleshooting beyond the testing level provided by HP-UX test programs, provided the system being tested has an internal or external flexible disk drive for loading and running the test software.

Series 200/300 Test Tools provide the following test capabilities when combined with the computer's Boot ROM self-test.

Computer Tests

Series 300 Computer Tests are supplied on one of two disks, the other is for Series 200 computers. They test the processor board. RAM. video and interface electronics, and other functions.

System Functional Tests

Five disks contain these tests. The first disk contains the Pascal-based operating system environment and the main menu; the other disks contains the test programs. These tests are used to verify communication between the computer and supported peripherals. They do not add significantly to the confidence levels achieved by the Boot ROM self-test program, though they expand confidence in overall system integrity by providing visible proof that communication with selected peripherals is correct and that interfacing is connected and set up correctly. The tests do not provide any worst-case tests at maximum speed or similar margin-of-safety tests.

CS/80 Exercisers

CS/80 Exerciser Programs are supplied on a single disk and is used to verify that CS/80 disk drives are correctly connected to the computer, and that the computer can successfully write and retrieve data to and from the disk or tape. The Pascal-based program also provides access to CS/80 disk and tape error logs for analyzing drive and media performance. This information is useful for troubleshooting, and for planning preventive maintenance programs.

Package Contents

The combined Series 200/300 Test Tools software package is provided on a variety of media as shown below:

Media	Part Number
one 1/4-inch tape	09800-12700
eight 3 1/2-inch disks	09800-12300
eight 5 1/4-inch disks	09800-12500

The tape version consists of one tape and the manual.

The disk versions consist of the manual and these disks:

    Series 200 Computer Tests Disk Rev. 1.1
    Series 300 Computer Tests Disk Rev. 3.1
    Series 200/300 System Functional Tests Disks:
        SFT0 Disk Rev. 1.2
        SFT1 Disk Rev. 1.2
        SFT2 Disk Rev. 1.2
        SFT3 Disk Rev. 1.2
        SFT4 Disk Rev. 1.2
    CS/80 Exerciser Disk Rev. 3.1

Note

Revision 3.0 of the Series 300 Computer Tests is completely functional on the Model 332. However, it doesn't completely test the Model 332. Although most areas are adequately tested, there is one area left out.

Revision 3.0 does not test the 1 Mbyte RAM array board. It does test the 4 Mbyte RAM board. Also, the 1 Mbyte board is tested by the less extensive routines in the bootROM.

Thus, if you seriously suspect a 1 Mbyte RAM board which passes when tested by the Revision 3.0 Computer Tests, replace it temporarily and see if the problem goes away.

Self-Test

Use the self-test to troubleshoot a unit which can execute some instructions, but cannot accept, store or output data correctly. This means that the basic elements of the computer are functioning. The basic elements include the power supply, processor board, and at least the first 16K bytes of RAM. If any of these are not known to be functional, refer to the Initial Troubleshooting Procedure section.

The self-test checks most assemblies in the computer and displays error displays in binary on the LED display. LED's are located behind the front panel and are visible through the holes in the front panel.

For a functional description of the self-tests, refer to Chapter 4.

Failure Indications

As the self-test progresses, the LED's display the current state. At the end of the test, a power-up with no errors is indicated by all LEDs turned off and by immediate entry into the boot scanner.

Should a failure occur during the self-tests, it will be indicated on the LEDs at the end of the tests. If there was more than one failure, the highest priority failure will be indicated on the LEDs. All the LED values are shown in Table 5-3.

The highest priority failure is also output to the beeper, if present. The LED value is beeped in seven tones as follows:

- Most significant bit first.

- One second beep per bit.

- A zero (LED off) is represented by a low tone.

- A one (LED on) is represented by a high tone.

If no failure occurs, the beeper will not sound off. If the failure was a Boot ROM checksum error, the following message will be displayed:

        CONTINUE AT OWN RISK (Press RETURN To Continue)

Once this message has been printed, the [Return] key must be pressed to adversely affect the user, but if it does, it could be catastrophic.

For all other failures, the message:

        WAITING 1 MINUTE (Press RETURN To Abort Wait)

will be displayed.

The Boot ROM will time out after approximately one minute and will then continue into the boot scanner. This allows time for the display to warm up and for the user to read the error messages. These failures are usually non-fatal so, in an Unattended Mode, the Boot ROM will still boot the first OS it finds. Pressing [Return] will terminate the beeping error code and abort the one minute wait. Pressing [Return] will also make the computer revert to the Attended Mode. This means that the Boot ROM will display all OSs found and will not boot one until one in chosen and entered by the user.

General Description of Failure Codes

Table 5-3 shows the general meaning of error codes. These codes are explained further in other tables. LED patterns are represented by a black dot for on and a white dot for off. Letter designators indicate the LED in that position is on or off, depending on the binary code used to represent the device or failure type.

Table 5-3. General Failure LED Indications

Upper 2 Bits Fail Indicator	LED Code and Failure Description
State Indication Only:	ooSS SSSS Where SS SSSS Indicates State of Power-up
Required Device Missing or DTACK Failure:	o●DD DDDD Where DD DDDD Indicates Device
Failing Device:	●oDD DDDD Where DD DDDD Indicates Device
Special Codes (Special Case Highest Priority Codes):	●●●● ●●●● LEDs Never Accessed (or Unused Code) o●●● ●●●● LEDs Failed to DTACK oooo ooo● Timer on processor board has failed or is missing.

Lower 2 Bits State or Device Codes	LED Code and Failure Description
Miscellaneous (Highest Priority):	XXoo FFFF Where FFFF indicates Failure (Xs are don't-care bits)
Internal Peripheral Failure (Medium Priority):	XXo● PPPP Where PPPP is Peripheral Number
I/O Card Failure (Lowest Priority):	XX●S SSSS Where S SSSS is Select Code

State and Failure Codes

Table 5-4 lists the LED failure codes used in the computer's Boot ROMs. Codes are listed here in numerical order for easy reference, and then again in order of occurrence and priority.

Table 5-4a. Self-Test LED Special State and Failure Codes

(In numerical order):

LEDs	Explanation
oooo oooo	No failure.
oooo ooo●	Failed CPU register test.
oooo oo●o	Testing top 16 Kbytes of RAM.
oooo oo●●	Failure in top 16 Kbytes of RAM.
oooo o●oo	Top 16 Kbytes of RAM missing or not found by CPU.
oooo o●o●	Searching for user-supplied Extension ROM.
oooo o●●o	Start executing Extension ROM instructions.
oooo o●●●	Starting Test Vector list.
oooo ●ooo	Resetting all interfaces.
oooo ●oo●	Searching for alpha video circuits.
oooo ●o●o	Testing RAM for I/O on-board test code.
oooo ●o●●	I/O on-board test code running.
oooo ●●oo	Internal BMD checksum.
oooo ●●o●	DIO-II console testing.
oooo ●●●o	Failed Boot ROM checksum.
oooo ●●●●	Pre-loading RAM for main test.
ooo● oooo	RAM Testing.
ooo● ooo●	Failure: Not enough RAM.
ooo● oo●o	Failure: ROM system.
ooo● oo●●	Failure: Boot error.
ooo● o●oo	Failure: OS loading address too high.
ooo● o●o●	Failure: Not enough RAM to load OS.

Table 5-4b. Self-Test LED State and Failure Codes for Interfaces

(In numerical order)

LEDs	Explanation
oo●o oooo	Failure: 4 ms timer.
oo●o oo●o	Failure: Processor board keyboard circuit.
oo●o oo●●	Failure: External keyboard circuit.
oo●o o●oo	Failure: Internal HP-IB circuit
oo●o ●ooo	Failure: DMA circuit.
oo●o ●●oo	Failure - one of these high-res video circuits: 　　　Font ROM is bad. 　　　Font ROM is not usable. 　　　Could not find US ASCII character set.
oo●o ●●o●	Failure: Video board bit map circuit.
o●oo oooo	Failure: I/O circuit at select code 0. Each successive LED pattern represents an I/O failure at select codes 2 through 30.
o●o● ●●●●	Failure: I/O circuit at select code 31.

Model 310 RAM

Although the HP 98256 and HP 98257 RAM boards are not supported in the Model 332, they are physically compatible and may find their way into a Model 332. For instance, a person upgrading a Model 310 to a 332 may inadvertently leave the RAM boards in the backplane.

These Model 310 RAM boards are not functional in the Model 332. At a minimum, they will cause the system to crash, and they may cause the file system to be corrupted.

Parts Lists

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6

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Replacement Parts Information

Introduction

Field replaceable parts are listed in this chapter for the computers and expanders. Components, such as ICs, are not available for field repair.

Parts are available direct from:

> Corporate Parts Center
> 333 Logue Avenue
> Mountain View, California 94042 USA
>
> Telephone: (415) 968-9200

Parts may be ordered through your local HP Sales and Service Office. To help get parts as soon as possible, please write the address and telephone number of your local HP Office in the spaces below.

Name: _____

Address: _____

City, State ZIP: _____

Telephone: _____

Cooperative Support Program

HP's Cooperative Support Program is available for customers that can provide technical assistance, manual updates, and other helpful information for hardware support. Your local HP Sales and Service Office can provide the information for this support service.

Exchange Parts

Exchange parts are available for some items at a reduced cost. When an exchange part is ordered, your account will be charged for a new part. Customers have 15 days to return the failed part to receive credit for the difference between a new and exchange part.

Please return failed exchange parts to your local HP Sales and Service Office as soon as possible. Place them in anti-static bags (see Parts List for part numbers) and package them securely in a sturdy container. It's a good idea to save the containers and static-free bags you receive parts in and use them to ship parts in.

Part Number Lists

The parts listed in this section apply to the Model 332 computer only. Although the HP 98568A expander is usable with the Model 332, it is not included since it will generally not be needed and it is covered extensively in the Model 310 support materials. Various interfaces, accessories and HP-HIL devices are also listed.

Printed Circuit Boards

Exchange Part No.	New Part No.	Description	Notes
	0950-1760	Power supply (without switch shaft)	
98572-69510	98572-66510	Medium-res video Processor board	
98572-69511	98572-66511	Processor board (no video)	
98572-69510	98572-66512	High-res video Processor board	
98269-69521	98269-66521	1 Mbyte add-on RAM board	
98269-69524	98269-66524	4 Mbyte add-on RAM board	
	98562-66501	Motherboard	
	98562-66506	2-slot DIO backplane	
98542-69570	98542-66570	Medium-res monochrome video board	
98543-69570	98543-66570	Medium-res color video board	
98544-69570	98544-66570	High-res monochrome video board	
98546-69571	98546-66571	Display compatibility video card	
98204-69577	98204-66577	Display compatibility graphics card	
98547-69570	98547-66570	High-res color video board	
98548-69570	98548-66570	High-res monochrome video board	
98549-69570	98549-66570	High-res color video board	
98550-69572	98550-66572	High-res color video board	

Processor Boards

Note that only two of the three processor boards are supplied as replacements. The medium-resolution video processor board (98572-69510) can be converted into either of the other two boards and is the replacement board for the high-resolution video processor board (98572-69512). Conversion details are listed immediately following this section. Note also that several items attach directly to the processor board and must be removed from a defective one before it is returned to the Corporate Parts Center or other HP entity.

The add-on RAM board is a separate assembly. You must always remove the add-on RAM board(s). There will always be at least one and there may be two.

The optional floating-point coprocessor IC is a separate assembly. Check to see if one is installed on the board. If so, remove it and reinstall it on the replacement board. You will need a special tool. It is the AMP 6810, part number 821566-1.

Converting to a 98572-66512 Board

To convert the -10 processor board to a -12 processor board, do the following:

- Change the position of the Graphics Resolution switch (segment 7, labelled RES) to a 1 (toward the board edge).

- Swap the display crystal ICs on the two boards.

- Swap the display video ROMs on the two boards.

Here is a drawing showing the location of these items:
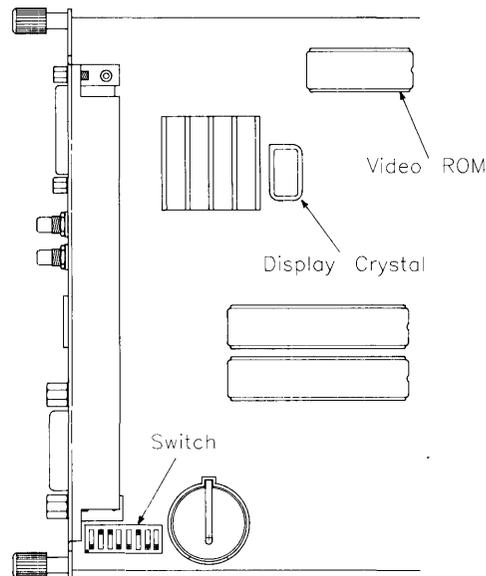
Figure 6-1. Locating Processor Board Components

Converting to a 98572-66511 Board

To convert the -10 processor board into a -11 processor board, disable the video. That is, change the position of the Video Disable switch (segment 3, labelled DISP) to a 1 (toward the board edge).

Here is how to tell the video resolution of a processor board:

Resolution	ROM Part No.	Crystal Frequency
Medium	1818-3908	35.904 MHz
High	5180-1334	64.1088 MHz

Static-Free Bags

Part No.	Description	Notes
9222-0978	9-inch by 10-inch cushioned pouch, for DIO-width cards	
9222-0980	9-inch by 15-inch cushioned pouch, for system-width boards	

Electrical Parts
Miscellaneous Electrical Parts

Part No.	Description	Notes
1820-6334	68882 floating-point co-processor	
1250-0781	BNC coax adaptor	
5180-0410	Large fan	
5180-1303	Small fan	
5180-0407	LED cable assembly	
98561-61601	DIO Bus cable (short)	
98561-61602	DIO Bus cable (long)	
98561-61604	RS-232 cable	

Case Parts
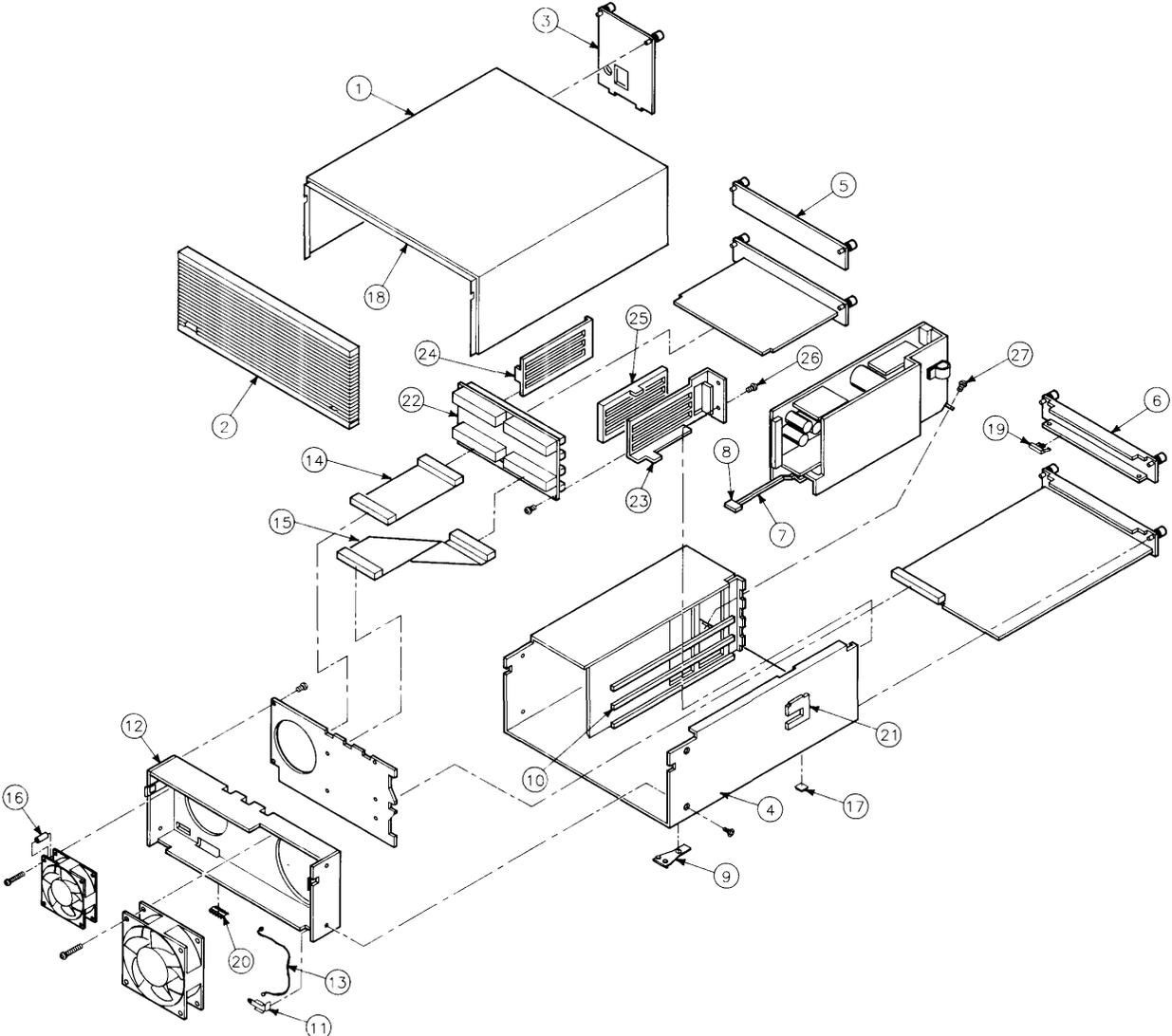
Figure 6-2. Model 332 Case Parts

Case Parts List

Ref.	Part No.	Description	Notes
1	5001-9009	Top cover	
2	5041-2413	Front panel	
3	5001-3700	Power supply cover	
4	5001-3696	Chassis	
5	98561-04107	DIO slot cover plate	
6		System slot cover plate	
7	5041-2412	Power switch shaft	
8	5041-1203	ON-OFF pushbutton	
9	09121-48303	Moulded foot	
10	0403-0379	PC board guide	
11	5001-9001	LED bracket	
12	5001-9011	Fan plate	
13	09817-47700	Light pipe	
14	98561-61601	Short ribbon cable	
15	98561-61602	Long ribbon cable	
16	0380-0012	Round spacer, 0.875-in. long	
17	0403-0427	Mounting foot bumper	
18	5041-2420	Top cover insulator	
19	5180-0409	Spring clip	
20	8160-0389	Double RFI finger	
21	5001-3694	Card guide bracket	
22	98561-66500	Four-slot backplane	
23	5001-3694	Card cage brace	
24	5001-3695	Card cage brace	
25	5041-2414	Card guide	
26	0515-0219	Screw M3 × 6, flat head	
27	0515-0389	Screw M3.3 × 8, pan head, ext. lock washer	
	0515-0536	Screw M3 × 0.5, machine	
	0515-0990	Screw M3 × 3.5, pan head, ext. lock washer	
	0515-1146	Screw M3 × 6, pan head patch	

Labels

Part No.	Description	Notes
98562-84002	Identification Label	
5958-4325	UL Info Label	
7120-3428	CSA Label	
7121-4858	Service Warning Label	
7121-4733	Serial Label	
7124-2083	Voltage warning label	
7121-4859	Fuse Rating Label	
98562-84005	Battery Warning Label	
5955-8036	Computer compliance label	
5955-8037	Peripheral compliance label	
9320-5673	Blank ID# label	

External Cables

Part No.	Description	Notes
8120-3616	Color Cable	
8120-4704	Audio Cable. RCA-RCA	
09920-61602	Interface Cable	
8120-4483	Video Cable	
1252-1112	Adaptor. RCA-earphone	
HP 98290	Color Cable. High-resolution	
5061-6533	Video Cable. RCA-RCA	

HP-HIL Devices

Exchange Part No.	New Part No.	Description	Notes
35723-69003	35723-66003	Touchscreen PC board	
	46021-60201	ASCII Keyboard	
	46020-60001	Keyboard Cable	
	46080-61601	Video Cable, 3-conductor	
	46081-61601	2.4-metre extension cable	
	46082-61601	Short audio cable	
	46082-61602	30-metre audio extension cable	
	46082-61603	30-metre video cable	
	46082-61604	15-metre remote cable	
	46082-61605	15-metre video cable	
	46083-61601	Short audio cable	
	46083-67901	Switch cap assembly	
	HP 46085A	Control dials	
	46085-85000	Overlay	
	0403-0430	Moulded foot	
	QEDS-7099	RPG Pot assembly	
	5041-2416	RPG knob	
	HP 46084A	ID module	
	HP 46086A	Button box	
	HP 46087A	"A" size digitizer	
	HP 46088A	"B" size digitizer	
	HP 46094A	Quadrature port device	
	HP 46095A	3-button mouse	
	HP 46060A	HP Mouse	
	HP 92916A	Bar code reader	

References

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Introduction

Information in this chapter should help you in various situations. The references include part numbers of many hardware documents used with Model 332 computer systems.

Service and installation information is listed in this chapter as follows:

- *Familiarization Guides* provide service information, including functional descriptions, configurations, testing and part numbers.

- *Installation Manuals/Notes* show how the products are installed in Model 332 computer systems.

- *Accessory Development Guides* and *References* have technical information about the product to assist in hardware development or service.

Service Information Locator

A Service Information Locator is located in the front of this manual and in the front of the Model 332 Service Handbook. It lists subjects and shows chapter numbers in other Hardware Support Document that has the information.

Localized System Identification

Model 332 computer systems have keyboards and display characters localized for the language spoken and written in several countries. When an HP field office orders a computer system, a letter suffix is added to the field office ordering number to ensure the correct keyboard and character font is bundled with the hardware. Table 7-1 identifies the letter suffixes to product numbers for these systems.

For example, a system ordered from an HP field office in Toronto, Canada, to be used by English-speaking Canadians, the field would order 98572AL.

Table 7-1. Localized System Suffixes

Local Language	Localized System Suffix
U.S. English	A
French Canadian	C
German	D
European Spanish	E
French	F
Dutch	H
Katakana (Japanese)	J
Intercontinental English	K
Canadian English	L
Latin Spanish	M
Norwegian	N
Swiss German	P
Swiss French	Q
Swedish	S
UK English	U
Belgian Dutch	W
Finnish	X
Danish	Y
Italian	Z

Related Hardware Documentation

Hardware Support Documentation

Table 7-2. Hardware Support Documentation

Printed Pages Part Number	Manual Title
09000-90041	HP 9000 Series 200/300/500 Site Preparation Manual
09800-90001	HP 9000 Series 200/300 Test Tools Manual
98547-90600	HP 98547A Video Board Hardware Notice
98548-90000	HP 98548A Color Video Board Familiarization Guide
98549-90000	HP 98549A Graphics Interface Familiarization Guide
98549-90800	HP 98549A Graphics Interface Familiarization Guide Update
98550-90000	HP 98550A Graphics Interface Familiarization Guide
98550-90800	HP 98550A Graphics Interface Familiarization Guide Update
98561-90020	Series 300 Configuration Reference Manual
98572-90030	HP 9000 Series 300 Model 332 Service Information Manual
98572-90039	HP 9000 Series 300 Model 332 Service Handbook

Installation Manuals/Notes

Table 7-3. Installation Manuals/Notes

Printed Pages Part Number	Manual Title
5958-4342	HP 98542/3/4/5A Video Board Installation Note
5958-4343	HP 98569A Rack-Mount Kit Installation Note
5958-4344	HP 98567A Rack-Mount Kit Installation Note
5958-4351	HP 98567B Rack-Mount Kit Installation Note
98243-90602	HP 98243C Model 310-to-332 Upgrade Installation Note
98284-90601	HP 98284A MC68882 Floating Point Unit Chip Installation Note
98285-90601	HP 98285A Graphics Upgrade Kit Installation Note
98269-90600	HP 98269A/B RAM Board Installation Note
98546-90600	HP 98546A Display Compatibility Interface Installation Note
98548-90601	HP 98548A Color Interface Installation Note
98549-90602	HP 98549A Color Video Board Installation Note
98550-90603	HP 98550A Color Video Board Installation Note
98568-90600	HP 98568A Eight-Slot Bus Expander Installation Note
98622-90000	HP 98622A GPIO Installation Manual
98623-90000	HP 98623A BCD Installation Note
98624-90000	HP 98624A HP-IB Installation Note
98625-90000	HP 98625A/B Disk Interface Installation Manual
98626-90000	HP 98626A RS-232 Installation Manual
98627-90000	HP 98627A Color Video Interface Installation Manual
98628-90001	HP 98628/98691 Datacomm Installation Manual
98630-90000	HP 98630A Breadboard Installation Manual

Table 7-4. Document Binders

Binder Part Number	Description
9282-1077	1-inch, 3-ring, 8.5 by 11-inch page size, 300 pages
9282-1078	1.5-inch, 3-ring, 8.5 by 11-inch page size, 350 pages
9282-1079	2-inch, 3-ring, 8.5 by 11-inch page size, 600 pages
9282-1080	2.5-inch, 3-ring, 8.5 by 11-inch page size, 750 pages
9282-1081	1-inch, 3-ring, 7 by 8.5-inch page size, 300 pages
9282-1082	1.25-inch, 3-ring, 7 by 8.5-inch page size, 450 pages
9282-1080	1.5-inch, 3-ring, 7 by 8.5-inch page size, 600 pages

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PACKARD**

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