Theory of Operation

PowerBook

Functional Operation

Understanding the function of the major components in PowerBook computers is essential for accurate and efficient service. In this document, you learn about the functions of major PowerBook components, modem technology, and power management.

PowerBook computers operate in much the same way as other Apple computers do, and exhibit the same icons and sounds during system startup—those exhibited by a properly functioning computer, and those exhibited by a hardware or software failure. With the exception of power-management features (discussed later) and some control panels unique to PowerBook computers, system software, applications, and peripherals operate in the same manner on the PowerBook computer as they do on other Apple computers.

Major Components

This section provides a functional description of the major components used in PowerBook computers. One or two components discussed may not be present, or may function somewhat differently, in specific PowerBook computers. The components discussed in this section include
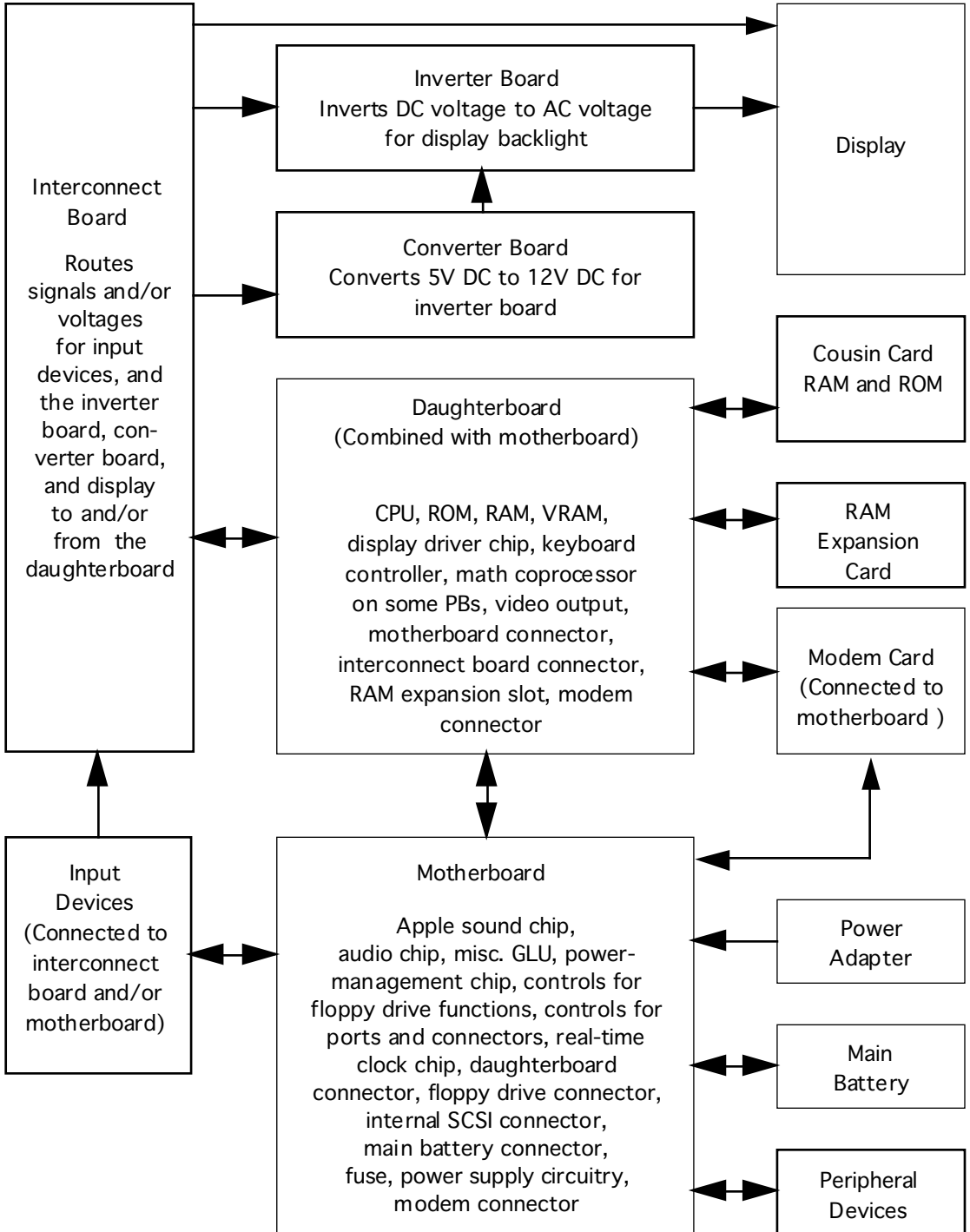
- Motherboard
- Interconnect board
- Daughterboard
- Modem card
- Cousin card
- RAM expansion card
- Inverter board
- Displays
- Converter board
- Input devices

PowerBook Components

Interconnect Board Routes signals and/or voltages for input devices, and the inverter board, converter board, and display to and/or from the daughterboard	**Inverter Board** Inverts DC voltage to AC voltage for display backlight
	Converter Board Converts 5V DC to 12V DC for inverter board

Display

Daughterboard
(Combined with motherboard)

CPU, ROM, RAM, VRAM, display driver chip, keyboard controller, math coprocessor on some PBs, video output, motherboard connector, interconnect board connector, RAM expansion slot, modem connector

Cousin Card
RAM and ROM

RAM Expansion Card

Modem Card
(Connected to motherboard)

Input Devices
(Connected to interconnect board and/or motherboard)

Motherboard

Apple sound chip, audio chip, misc. GLU, power-management chip, controls for floppy drive functions, controls for ports and connectors, real-time clock chip, daughterboard connector, floppy drive connector, internal SCSI connector, main battery connector, fuse, power supply circuitry, modem connector

Power Adapter

Main Battery

Peripheral Devices

Motherboard

The motherboard, in general, controls power management, battery recharging, interface circuitry, and peripheral and expansion interfaces. Specifically, the following components are on the motherboard:

- **Apple sound chip**—Generates audio output.
- **Audio chip**—Converts audio from analog to digital.
- **Miscellaneous general logic unit** (Misc. GLU)—Controls modem/serial port mixing, sound power control, and clock control logic functions.
- **Power management chip** (PMC)—Controls power-management functions.

  The power management chip runs most of the power-management system, including battery charging, parameter RAM, keyboard scanning, trackball encoding, real-time clock, screen, and backlight control to maximize performance. To the user, the

power manager operates in three modes: full power run, sleep, and shutdown.

Some service procedures require that the power management chip be reset. To reset the power management chip:

– Simultaneously press the reset and interrupt switches.
– Press the power button to begin the startup sequence.

- **SWIM chip**—Controls the reading, writing, and formatting of floppy disks.
- **Combo chip**—Controls the serial and SCSI ports.
- **Versatile interface adapter** (VIA)—Provides the interface between the power management chip and the microprocessor, generates microprocessor interrupts, monitors use of the sound jack, and controls the real-time clock chip.

- **Real-time clock chip** (RTC)—Controls timing of the computer and contains parameter RAM. The RTC is backed up by the PowerBook's backup battery when the computer is shut down, or when the main battery is discharged or removed.
- **Daughterboard connector**—Some PowerBook computers combine the functionality of the daughterboard and the motherboard into one logic board.
- **Floppy drive connector.**
- **Internal SCSI connector.**
- **Main battery connector.**
- **External ports/connectors.**
- **Fuse.**

- **Power supply circuitry**—The main battery supplies power to the motherboard, where the power supply circuitry converts the voltage to the +5 DC and -5 volts DC required by the computer. The floppy drive, display (by way of the inverter and interconnect boards), internal input devices, external ADB devices, modem card, internal floppy drive, and internal SCSI hard drive receive power from the motherboard. When the power adapter is connected to an electrical outlet and to the PowerBook, the power circuitry charges the main battery. When the power adapter is not connected and the main battery is low, the backup battery provides enough power to maintain parameter RAM on all PowerBooks, and to refresh RAM on some PowerBooks, while the main battery is being replaced.

Always shut down the computer or put it to sleep before charging the main battery. The backup battery does not have enough power to both refresh RAM and run the computer. More power-management information is provided in the "Power Management" section.

Daughterboard

Generally, the daughterboard controls computer processing, and contains computer ROM and RAM. Some PowerBook computers do not have a daughterboard. All the functionality of the daughterboard is included on the motherboard. Specifically, the daughterboard contains the following components:

- **Central processor unit** (CPU)—Controls the processing of all information and memory management.
- **ROM**—Contains system command sets.
- **Keyboard controller**—Controls operation of the keyboard.
- **Display driver chip**—Controls the interface between the CPU, video (DDC) RAM, and the display. Sends data and control signals to the display. Refreshes the display through the interconnect board.
- **Video RAM**—Supplies display memory additional to that provided in main memory.

- **RAM**— Provides memory for system software and applications. Power from the main battery maintains the contents of system RAM when the computer is awake or in sleep mode. Shutting down the computer erases RAM contents.
- **CPU general logic unit** (CPU GLU)—Provides the interface between the microprocessor and RAM and ROM on the daughterboard, and the chips on the motherboard.
- **Math coprocessor**—Also known as the Floating-Point arithmetic Unit (FPU), adds arithmetic and trigonometric processing additional to that provided by the CPU on those PowerBooks containing an FPU.
- **Video output**—Grayscale controller, a video output chip, a video connector, and/or a color look-up chip.
- **Motherboard connector.**
- **Interconnect board connector.**
- **RAM expansion slot**—Allows installation of a RAM expansion card.

Cousin Card

Some PowerBook computers have a cousin card connected to and resting on top of the daughterboard. The cousin card contains a daughterboard connector and system RAM and ROM. Normally, system RAM and ROM are located on the daughterboard. PowerBook computers that contain a cousin card will not have system RAM or ROM on the daughterboard.

Note: System RAM or ROM failure is most likely the result of a faulty cousin card on computers containing a cousin card.

Interconnect Board

The interconnect board routes signals and/or voltage for a variety of components (keyboard, trackball/trackpad, display, inverter board, and, if present, the converter board) to and/or from the daughterboard.

Note: If the daughterboard and motherboard function properly, but any component connected to the interconnect board is not functional and there is no startup sound, the interconnect board must be replaced before the faulty component can be checked.

Inverter Board

The inverter board inverts battery DC voltage (received by way of the interconnect board) to AC voltage required to power the display backlight. Displays and their accompanying inverter boards are not all interchangeable. Check the appropriate manual for compatibility information on displays and boards.

Note: A failure of the display backlight is most likely the result of a faulty backlight or a faulty inverter board.

Converter Board

In addition to the inverter board, some PowerBook computers have a converter board. The converter board converts 5 VDC to 12 VDC and sends it to the inverter board, where it is inverted to AC voltage required to power the display backlight in some color displays.

Note: On computers having both a converter board and an inverter board, a failure of the backlight can be caused by either one or both of these boards, as well as a faulty backlight.

Modem Card

The modem card and the supporting software dial and establish a connection between computers. The modem card also converts the analog signal received from a telephone line to digital data, and reconverts digital data to an analog signal before sending it over the telephone line. The modem card, and the supporting software, control the flow of data across the telephone line so that transmission takes place with optimal speed and accuracy.

The modem card is connected to the motherboard on some PowerBooks, and to the daughterboard on other PowerBooks. When a modem card is installed, additional controls and settings appear in the PowerBook control panel, and/or a Modem control panel is added to the Control Panels folder. Additional information on modem technology is presented later in this document.

Note: Failure of the PowerBook to communicate with another computer, or failure of the modem card to appear in the PowerBook Setup control panel and/or Modem control panel, is likely the result of a faulty or improperly installed modem card or supporting modem software.

RAM Expansion Card

The RAM expansion card installed in the RAM expansion slot on the daughterboard, increases the amount of system RAM.

Note: If a system RAM failure occurs, both the RAM expansion card and the daughterboard must be checked.

Display

The display creates an image by turning pixels on and off in front of a lighted background (the backlight). The pixels, which are similar in appearance to pixels found in CRT displays, turn black when turned on and white when turned off. Pixels are faulty when they stay on or off at inappropriate times.

The PowerBook's brightness control adjusts the brightness of the display backlight, and the contrast control adjusts the intensity, or darkness, of the display pixels. The display receives data, voltage, and control signals from the daughterboard through the interconnect board. The daughterboard also refreshes the display.

Each PowerBook requires a specific combination of display, display cable, inverter board, and converter board (on those computers that have one). Refer to the appropriate service manual for specific display, display cable, and board specifications.

Note: If the display fails to operate properly, the daughterboard (which contains the display driver chip and video RAM), the inverter board, the interconnect board, and the converter board (on PowerBook computers having one), as well as the display, should be checked to determine the cause of the failure.

Input Devices

Three input devices are used with PowerBook computers.

- **Mouse**—Connected to the ADB port, the mouse positions the cursor or pointer. The user moves the mouse to move the cursor or pointer and presses the mouse button to click or select items. Only low-power devices should be used.
- **Trackball**—Included with many PowerBook computers, the trackball performs the same function as a mouse. The user rotates the ball to move the cursor or pointer, and presses the button below the trackball (as the user would use the mouse button) to click or select items.
- **Trackpad**—Like the trackball, the trackpad performs the same function as a mouse. The user lightly traces his or her finger over the pad to move the cursor or pointer, and presses the button below the trackpad, to click or select items.

Modem Technology

An internal modem is a standard or optional feature on all PowerBook computers. Servicing a modem often requires verifying that appropriate settings have been established. In this section, you learn the functions of the major settings common to all modems. This section does not, however, review specific modems or modem applications.

Handshaking

When two computers are connected through their modems, the first task of the modems is to reach agreement on basic communication settings (such as baud rate, error control, and data compression). The exchange of signals that enable them to reach agreement is called "handshaking."

The internal modem is already set to automatically make the best possible handshaking agreement. Some users, though, may manually change these settings, or try to communicate with a modem that does not support the required settings. In these situations, you must verify that the appropriate settings have been established, or are able to be established, when troubleshooting some modem problems.

Baud Rate

The baud rate is the number of bits per second of information received and sent by the modem. Common baud rates include 300 bps (bits per second), 1200 bps, 2400 bps, 4800 bps, 9600 bps, 14.4K bps, 19.2K bps, and so on. Initially, the PowerBook modem tries to connect at its fastest speed. If the remote modem can't connect at that speed, the PowerBook computer's modem falls back to the next highest speed. Fallback continues until the two modems agree on their capabilities.

Error control

Error control is a method of checking data for errors. The PowerBook computer's modem and the remote modem must agree on an error-control method. Your modem will try to use a type of error control called V.42 and MNP class 2-4. If the remote modem doesn't support this type of error control, it falls back until the modems agree.

Data compression

Data compression increases modem speed by eliminating gaps and redundancies from the data. For example, if you connect at 9600 baud with data compression enabled, the speed can increase up to four times the noncompression speed. The Apple internal modem uses a type of data compression called V.42 bis, or MNP class 5. If the remote modem doesn't support these types of data compression, data compression cannot be used.

Verifying Customer's Settings

When a customer's modem fails to communicate with a remote modem, verify (or have the customer verify) that the baud rate, error control, and data compression settings on that modem match those of the remote modem. If they do not, have the customer make the appropriate changes.

AT Command Set

Most modem applications automatically set baud rate, error control, and data compression parameters that match those of the remote modem. Some modem applications also allow you to manually set these parameters by using AT commands. The AT Command Set is a commonly used command language that allows for the manual setting of modem operation. You will not be required to use the AT Command Set when servicing PowerBook modems. "AT" refers to the command prefix (ATtention sequence) that precedes each command to the modem.

Wake on Ring

As a means of saving energy, you should turn off the modem and place your PowerBook computer in sleep mode when it is not in use. It's still possible, though, to receive incoming calls while the computer is in sleep mode if you select the "Wake on ring" setting. This setting is found (depending on the version of installed system software and modem software) in the PowerBook control panel (called "Portable" in some versions of system software) and/or the Modem control panel. When set to "Wake on ring," the PowerBook will wake from sleep mode to process the incoming call. If this setting is not selected, incoming calls to the modem are not received.

Power Management

Understanding power-management features is essential to operating and servicing PowerBook computers. This section discusses the function and operation of PowerBook computer power-management features.

Power Management Features

All PowerBook computers can be powered either by a
battery or by a power adapter. A variety of software
features programmed into the system software allow for
determining the charge level of a battery and controlling
power usage. How these power-management features are
used determines the length of time the computer can be used
between charges, and the length of the life of the battery.

All PowerBook computers have three power modes:
• **Awake**—Computer is fully functional and ready to be used.
• **Sleep**—Computer is fully functional, but in a resting
  state. The computer appears to be shut down, but is
  instead operating at a reduced power level that conserves
  power. Choose the Sleep command in the Special menu to
  place the computer in sleep mode, and press any key
  (except Caps Lock) to wake up the computer.

To save power, system software will automatically place the computer into sleep mode after a user-specified period of unuse. The computer will not automatically go into sleep mode, though, under any of the following circumstances:
- An external monitor is used.
- AppleTalk is turned on in the Chooser and the power adapter is plugged in.
- The computer is connected to a shared disk on the network.
- The computer's printer or modem port is in use.

- **Shut Down**—Computer is powered off and must be restarted to become functional. Choose the Shut Down command from the Special menu to shut down the computer.

New power-management options and features have been added to system software versions 7.1.1 and above. To ensure a comprehensive understanding of power-management options and features, system software versions below 7.1.1 will be reviewed first, followed by a review of versions 7.1.1 and above.

System Software Versions Below 7.1.1

Power-management options and features in system software versions below 7.1.1 are found in the
• Battery Desk Accessory
• PowerBook control panel

Battery Desk Accessory

Open the Battery desk accessory by choosing Battery from the Apple menu. The battery gauge allows you to see the level decrease while the battery is in use, and increase while the battery is recharging in the computer. When you click the lever in the upper-right corner of the battery gauge, a Sleep button appears. You may find it convenient to put the computer to sleep by clicking this button instead of choosing the Sleep command from the Special menu.

PowerBook Control Panel

The PowerBook control panel allows you to regulate the computer's power consumption by selecting the Battery Conservation setting along a scale from maximum performance to maximum battery conservation.

Note: Some versions of the PowerBook control panel look somewhat different, and some versions use the control panel name "Portable" instead of "PowerBook."

Use the Battery conservation slider on the PowerBook control panel to choose the setting you prefer. There are four settings along the scale. Each setting determines how long the system and hard drive will operate, while not being used, before being automatically placed in sleep mode. When you change the Battery Conservation setting, the change takes place immediately.

The Battery Conservation window of the PowerBook control panel includes a button labeled "Options." Click this button to see more options for regulating power consumption. If the power adapter is plugged in, you can prevent automatic sleep by clicking "Don't sleep when plugged in."

Processor Speed

The processor speed option allows you to decrease the computer's microprocessor speed. Some programs may work more slowly, but you may gain up to 15-20 minutes of work time before you must recharge the battery. (The amount of time you gain depends on how you are using the computer.)

To decrease the processor speed, follow these steps:

1   Click "Reduced speed."

2   Click OK.

3   Choose Restart from the Special menu.

The computer runs at the lower microprocessor speed until you click "Standard speed" and restart the computer.

Processor Cycling

Processor cycling reduces the power consumption of the microprocessor by reducing its speed when it is not in use. The microprocessor comes back up to speed instantaneously when you resume work. Processor cycling is the default setting, so you do not have to select it. However, if you notice that one of your programs performs very slowly, you might want to turn off processor cycling while using that program.

To turn off processor cycling, follow these steps:

1   Hold down the Option key on your keyboard and click the
    Options button in the PowerBook control panel. (If you
    are running System 7.1, you don't need to hold down the
    Option key.)

2   Click "Don't allow cycling."

3   Close the PowerBook control panel.

To turn processor cycling back on, click "Allow cycling."

In addition to slow response, you may notice other effects of
processor cycling. For example, if you have open programs
doing something in the background, processor cycling may
slow down those programs. You may also notice that the
Alarm Clock is updated irregularly, or that the wristwatch
pointer appears often. These effects do not indicate a
problem with your computer. To conserve battery power,

leave on processor cycling as much as possible. Turn off processor cycling only when it interferes with program operation.

When you turn off processor cycling, the computer drains the battery faster. The computer may also become very warm to the touch, especially on the bottom of the computer beneath the keyboard. These effects do not indicate a problem with your computer.

System Software Versions 7.1.1 and Above

Several new power-management features were added to
system software beginning with version 7.1.1. These new
features include the

• Control Strip
• PowerBook control panel

Control Strip

The Control Strip replaces the Battery desk accessory found
in earlier versions of system software. The Control Strip
appears at the bottom of the display and provides easy,
direct access to power-management features and frequently
used controls. Use the Control Strip control panel to show or
hide the Control Strip, and the Close Box on the Control Strip
to hide it.

Each icon in the Control Strip is called a "module." Control Strip modules may vary from one PowerBook computer to another, depending on available features. The modules on the Control Strip work the same way as control panels, but, for the most part, control panels offer more options. The Control Strip provides access to the controls you use most often.

The battery module allows you to control battery operation, and has four parts:

- **Battery icon**—A battery icon is displayed for each installed battery pack (one or two, depending on the PowerBook computer model). When the computer is powered by battery, positive and negative signs appear on the battery icons. When the power adapter is connected to the computer and to a power source, a lightning bolt appears on the battery icons when the batteries are being charged, and a plug appears on the battery icons when the batteries are fully charged.
- **Battery charge scale**—A battery charge scale is displayed for each installed battery between the two battery icons. When a scale is completely dark, the corresponding battery is fully charged. When a scale is partially darkened, the corresponding battery is partially charged.

- **Battery consumption rate scale**—The rate of total battery consumption is displayed when the computer is powered by battery. As you use more components and features (such as activating the AppleTalk network system and accessing the hard drive), the rate of power consumption increases, causing the consumption-rate needle to move toward the right. Activating power-saving features (such as hard drive spin down) causes the needle to move toward the left.
- **Estimated work time remaining display**—The estimated work time remaining is displayed, in hours and minutes, when the computer is powered by battery. Use this time-remaining estimate to gauge how long the computer can be used before recharging the batteries.

The battery charge level, battery consumption rate, and estimated work time remaining fluctuate according to the software, hardware, and power-saving features you use.

The battery consumption rate and estimated work time remaining are displayed only when the computer is powered by battery.

The open/close button allows you to close the Control Strip so that only the tab is visible. When only the Control Strip tab is visible, the open/close button allows you to open the Control Strip.

The AppleTalk switch module allows you to turn the AppleTalk network system on or off. When the AppleTalk network is on, cables are shown coming from the icon. When the AppleTalk network is off, the icon is shown without cables.

The file sharing icon allows you to turn file sharing on or off. When file sharing is turned on, cables are shown coming from the folder. When file sharing is turned off, the folder is shown without cables.

The hard disk module allows you to "spin down" the hard disk to reduce power consumption. The hard disk is one of the main consumers of battery power. To extend work time while using the battery, turn off the hard disk when it's not in use. This is called "spinning down" the hard disk. The hard disk will return to full operation when information stored on the hard disk is required.

The power settings module allows you to control your computer's power consumption. Selecting the Open PowerBook control panel opens the PowerBook control panel in the Control Panels folder.

Selecting Better Conservation increases available work time by reducing the amount of time before the system goes to sleep, the hard disk spins down, and the screen dims.

Selecting Better Performance allows you to work with the fewest interruptions by increasing the amount of time before the system goes to sleep, the hard disk spins down, and the screen dims.

The Sleep Now module allows you to put the computer to sleep, which is the highest state of conservation. When the computer is in sleep mode, the green sleep-mode LED, found on some PowerBook computers, flashes.

The Sound Volume module allows you to increase or decrease sound volume.

The Video Mirroring icon allows you to display video on a second monitor connected to the computer.

The Control Strip tab allows you to resize the Control Strip to display more or fewer Control Strip modules. If you press the Option key on the keyboard while clicking this tab, you

can reposition the Control Strip in any area of the display, attached to either the right or left side of the display.

PowerBook Control Panel

The PowerBook control panel provides several ways to control your computer's power consumption, and offers additional features not found on control panels in earlier versions of system software. You can access the PowerBook control panel by choosing Control Panels from the Apple menu, or by clicking the Power Settings module on the Control Strip. When selected, the PowerBook control panel opens in Easy View.

Easy View offers five settings. Better Performance gives you the maximum amount of time before the computer is placed in sleep mode, and Better Conservation gives you the least. The Maximum Performance option uses the most battery

power, and the Maximum Conservation option uses the least.

Select Custom View and click the space below the button in the upper-right corner of the control panel to view additional options. In Custom View, more power-conservation options are made available.

The three sliders in the middle of the PowerBook control panel allow you to manually set the minutes of inactivity that elapse before the system, hard drive, and screen are placed in sleep mode. The Auto option, at the bottom of the PowerBook control panel, allows you to select the settings you desire when using only battery power and when using the power adapter. The settings you select will change automatically when the power adapter is connected and disconnected.

One additional power-management feature, processor cycling, is available if the Option key is held down while

selecting Custom View in the PowerBook control panel. Just as in earlier versions of system software, if this option is selected, the processor slows down when it is not in use, thus saving additional energy.

Responding to Low-Power Messages

When the battery charge drops to about 15 percent, the computer displays a series of low-power messages. The work time remaining after you see the first message varies, depending on how you are using the computer. You should act promptly.

When you see a low-power message, do either of the following:
• Plug in the power adapter.
• Save your work and put the computer to sleep.

The first low-power message indicates that it's time to recharge the battery. Right after this message appears, the screen brightness dims automatically to save power. If you continue to work without plugging in the power adapter, the computer displays a second low-power message.

The second message is followed almost immediately by a third and final message that indicates the computer is about to put itself to sleep. When time is up, the computer goes to sleep automatically to protect the contents of RAM. At that point, you must plug in a power adapter to continue working.

If you continue working until the computer goes to sleep automatically, you may not be able to wake it again until you recharge the depleted battery in the computer for 15 minutes.

If you can't plug in the power adapter, the contents of RAM are retained in sleep for at least two days. If you leave the battery in the computer and recharge it within two days, you should be able to wake the computer and resume work where you left off.

Important: Recharge a depleted battery as soon as possible. Leaving a depleted battery in the computer for longer than two weeks (especially in a hot location, such as the trunk of a car) may damage the battery so that it can't be recharged. If this happens, you must replace the battery.

Recharging the Battery

The two ways to recharge a battery are
- Plug in the power adapter to recharge the battery without removing it from the computer.
- Remove the battery and recharge it in the (optional) recharger.

Most batteries have movable tabs or buttons on them. These tabs and buttons have nothing to do with recharging, and are changed by the user to indicate that a battery is charged or needs to be charged.

Recharging with the Power Adapter

Plug in the power adapter. (You do not need to shut down the computer before plugging in the adapter.)

Caution: Use only the power adapter that came with your PowerBook computer. Adapters for other electronic devices (including other portable computers) may look similar, but they can damage your computer.

You can continue to use the computer while the battery is recharging, but the battery will take longer to recharge if you do. Battery recharging time while the computer is in use depends on how often you use the hard drive, how bright the screen is, whether you are using an external monitor, how deeply the battery is depleted, and other factors.

If you are using several power-consuming features (such as an external monitor and a program that requires frequent hard drive access) and you are not using the features designed to conserve power (such as processor cycling), the battery may not recharge until you put the computer to sleep or shut it down.

While the computer is shut down and the power adapter is plugged in, you can remove a charged battery from the computer and replace it with a battery you want to charge. If you do this, disconnect and then reconnect the power adapter after inserting the second battery. Otherwise, the second battery will not recharge.

Recharging with a Recharger

A battery recharger and additional batteries are available as PowerBook options. If you purchase a recharger and an extra battery, you can charge one battery while you use the other, so you always have a fully charged battery on hand.

The recharger accommodates two batteries. The battery slots work independently, so you can put batteries in or take them out at different times.

The recharger must be plugged into an electrical outlet to charge a battery. You can plug it in using the power adapter that came with your computer, or you can purchase an additional (identical) power adapter from your authorized Apple dealer.

Caution: Use only the power adapter that came with the computer. Using another adapter may damage the adapter, the recharger, or both.

To recharge a battery with a recharger, follow these steps:

1   Place the recharger on a level surface.

2   Connect the power adapter or the power cable (depending on recharger model) to the battery recharger and to an electrical outlet.

3   Place the battery in the recharger.

Note: You must use only the power adapter, battery recharger, and batteries that are designed to work with the PowerBook you are servicing. Refer to the appropriate manual for power specifications.

When you place a battery in a recharger, charging begins immediately. You can remove a battery from the recharger at any time.

Important: To preserve a battery's charge, don't leave the battery in the recharger if the power adapter is not plugged into an electrical outlet.

The lights on the recharger indicate the following:
- **Yellow**—The battery is charging.
- **Green**—The battery is charged to at least 80 percent of its capacity and can be used.
- **Red**—The battery recharger is unable to charge this type of battery. Some PowerBook computers require that a battery INIT file be installed in the PowerBook that is using the battery. Install the battery INIT, use the battery in the PowerBook with the battery INIT, and then recharge it using the battery recharger.

Guidelines for Recharging Batteries

All PowerBook models do not use the same kind of battery, so it's important to know which type of battery you're using in order to recharge it properly.

Apple uses three different types of batteries for PowerBook computers:
• Sealed Lead Acid (SLA)
• Nickel Cadmium (NiCad)
• Nickel Metal Hydride (NiMH)

Each type of battery requires a different recharging technique to ensure maximum battery life. Refer to the appropriate manual for specific battery requirements for the PowerBook computer you are servicing.

• **Sealed Lead Acid**—Recharge sealed lead acid batteries whenever they become depleted, and never fully

discharge the battery. Lead acid batteries should always be kept fully charged.

If a lead acid battery becomes fully discharged, it may experience "sulfation." Sulfation occurs when the lead electrodes inside the battery convert to lead sulfate. This destroys the battery, making it unable to hold a charge.

- **Nickel Cadmium**—Recharge nickel cadmium batteries when they become depleted. Apple recommends fully discharging and recharging the battery approximately every 90 days.

  Nickel cadmium batteries are subject to an issue known as "memory effect." If a NiCad battery is only partially discharged, then recharged many times, it will begin to "remember" the level to which it was discharged and won't fully recharge.

  For example, assume your battery has a normal

capacity of 2.5 hours and you use your computer for 1 hour a day, then recharge the battery overnight. After a period of time (approximately 30 to 90 days), you'll discover that your battery now has a capacity of a little more than an hour, instead of 2.5 hours.

The only way to recover the battery's full capacity is to fully discharge it, then fully recharge it.

- **Nickel Metal Hydride**—Recharge nickel metal hydride batteries when they become depleted. Fully discharge and recharge the battery approximately every 30 days. Nickel metal hydride batteries are also subject to "memory effect" and should be treated like nickel cadmium batteries.

  The best way to fully discharge NiCad or NiMH PowerBook batteries is to use your computer normally, and ignore the low-power messages that appear on the screen. Be sure, however, to save your work

frequently. When the computer goes to sleep automatically, recharge the battery completely before using that battery again.

Verifying the Battery and Recharger

While servicing a PowerBook computer, you may need to verify the operation of a battery or the battery recharger. Refer to the appropriate manual for verification procedures.

Power-Management Tips and Guidelines

- Keep screen dimming turned on in the PowerBook Display control panel. This setting dims the screen automatically if you haven't used the computer for a few minutes.
- Keep virtual memory turned off in the Memory control panel.
- If your computer has 6 MB of memory or more, you can use a RAM disk as your startup disk to minimize hard drive use.
- Quit any program that uses a modem, unless you're using the program for telecommunications. As long as the program is open, your modem is consuming power (not applicable when you have an Express Modem).
- If you're near an electrical outlet, plug in the power adapter.

- Apple recommends that you use and/or store PowerBook computers with the main battery in place to prevent the backup batteries from becoming drained and to prevent dirt from entering the battery compartment.
- Leave the Battery desk accessory or Control Strip open on the desktop so that you can track the battery charge while you work.
- Set Battery Conservation to a "conservation" setting on the PowerBook control panel.
- Set the backlight dimming time lower on the PowerBook Display control panel (System 7.1).
- Set Processor Cycling to Allow Cycling unless you are using a program that seems to be performing very slowly.
- Set Processor Speed for Reduced speed (more battery savings) in the PowerBook control panel, or, on some versions of system software, in the "Portable" control panel.

- To maintain battery charge, use the power adapter whenever possible. Verify that the power adapter is plugged into an operating electrical outlet.
- Connect only low-power ADB devices to the ADB port.
- Dispose of spent batteries in accordance with the guidelines on Service Source and in accordance with local ordinances.
- Quit from telecommunications programs when finished to reduce modem power consumption (not necessary when you have an Express Modem).
- Turn off AppleTalk in the Chooser accessory. When AppleTalk is activated, and the computer is connected to the power adapter, the computer will not automatically initiate sleep mode.
- Avoid using disk-intensive applications (HyperCard, database programs, QuickTime) while running off the battery.

- Keep files and/or programs in memory if you have enough RAM and software that supports this feature.
- Simultaneously open files you will work on so that the disk spins up a single time.

PowerBook 100 Series

This section reviews the PowerBook 100 Series computer components and their functions. The PowerBook 100 is the first PowerBook to be introduced by Apple Computer. Since the introduction of the PowerBook 100 computer, additional members have been added to this family of computers.

External Components

External components of PowerBook 100 Series computers differ from each other by the type of display used and by the configuration of ports, connectors, and switches. Three external components not found on all PowerBook 100 Series computers are an HDI-20 floppy adapter port, a storage switch, and a power button.

HDI-20 Floppy Adapter Port

The HDI-20 floppy adapter port allows for the connection of an external floppy drive, using a special floppy drive adapter cable. While the HDI-30 SCSI port is found on all PowerBook 100 Series computers, the HDI-20 floppy adapter port is found only on the PowerBook 100 computer, as this computer does not contain an internal floppy drive.

Storage Switch

The storage switch is found only on the PowerBook 100 computer—all other PowerBook 100 Series computers have a power button, discussed later. Located on the back of the computer, the storage switch is used to disconnect all battery power (both main and backup) when the computer is unused for a week or longer. When the switch is in the down position, batteries are not discharged to potentially damaging levels. Place the switch in the up position before starting up the computer.

Caution: Using this switch does not put the computer into sleep mode. The contents of all RAM will be lost when moving the storage switch to the down position. The storage switch must be moved to the up position before the computer can be started up.

Power Button

All PowerBook 100 Series computers have a power button, except the PowerBook 100 computer (which has a storage switch). Located on the back of the computer, the power button starts up and shuts down the computer. If the system freezes, press the power button twice to reboot the system, or press and hold the button for five seconds to shut down the system.

Caution: Pressing the power button shuts down the computer and does not place it in to sleep mode. Except with PowerBook 160, 180, and 180c computers, pressing the power button to shut down the computer (instead of using the Shut Down command in the Special menu) erases information stored in RAM and shuts down the system without first properly closing open applications and system files. To be safe, choose the Shut Down command from the

Special menu.

Internal Components

When examining internal components, the PowerBook 100 Series generally can be divided into two groups, with the PowerBook 100 and 150 computers in one group and all other PowerBook 100 Series computers in another group. Within each group, the computers have the same dimensions and general physical design.

Internal Components Likenesses

PowerBook 100 Series computers have the following internal components:
- Display
- Motherboard
- Daughterboard (with the exception of the PowerBook 150 computer)
- Inverter board

- Interconnect board
- Hard drive
- Trackball
- Keyboard
- Modem card
- Cousin card (PowerBook 165c and 180c computers only)
- Converter board (PowerBook 165c and 180c computers only)

Internal Components Differences

PowerBook 100 Series Computers have differences in the following internal components:
- Internal floppy drive
- Backup battery
- Display and display cable
- Board functionality
- Power adapters

- Interconnect board
- Battery thermistor

Internal Floppy Drive

All PowerBook 100 Series computers, with the exception of
the PowerBook 100 computer, have an internal floppy
drive.

Backup Battery

The PowerBook 100 computer backup batteries are user-
replaceable through the backup battery door on the back of
the computer. The backup battery for all other PowerBook
100 Series computers is located on the interconnect board,
and must be replaced by a service technician.

Display and Display Cable

Most computers in the PowerBook 100 Series have their own unique display, display cable, and inverter board. Refer to the appropriate manual for display, display cable, and inverter board specifications, descriptions, and part numbers.

Board Functionality

Board functionality varies among PowerBook 100 Series computers.
- The PowerBook 150 computer doesn't have a daughterboard or cousin card. All functionality is located on the motherboard.
- The display driver, keyboard processor, and RAM and modem expansion card connectors in the PowerBook 100 and 150 computers are on the motherboard, whereas

they are on the daughterboard on all other PowerBook
100 Series computers.

- The ROM and system RAM in PowerBook 165c and
  PowerBook 180c computers are on the cousin card,
  whereas they are on the motherboard of the PowerBook
  150 computer and on the daughterboard of all other
  PowerBook 100 Series computers.

- The PowerBook 165c and PowerBook 180c computers
  are the only computers in this series that have a
  converter board.

Power Adapters

Power adapters are backward-compatible. Use only the power adapter that came with the computer, or one that came with a later release of the PowerBook 100 Series computer.

Caution: Using the wrong power adapter may cause severe damage to the computer.

Interconnect Board

The interconnect board contains the backup battery, except on the Powerbook 100 computer, which contains user-replaceable backup batteries accessed through a door on the back of the computer.

Battery Thermistor

Unique to the PowerBook 100 Series motherboard is the battery thermistor and cable. The battery thermistor is physically attached to the battery bay, and electrically attached to the motherboard through the battery thermistor cable.

This component senses excessive heat in the main battery. The main battery will become warm when recharging, but it should not get hot. An excessively hot battery could mean that the battery has somehow shorted out internally, which could be a dangerous condition if the battery continued to receive a charge. If an over-temperature condition occurs, the thermistor carries this signal to the motherboard, where the power manager interprets this condition and turns off the charging circuitry to prevent further heating.

PowerBook 200 Series

This section reviews PowerBook 200 Series computers, Duo Dock, Duo Dock II, Duo MiniDock, and Duo Floppy Adapter components and features, and their functions. For ease of reading, Duo Dock, Duo Dock II, Duo MiniDock, and Duo Floppy Adapter are referred to as "docking and adapter options."

The PowerBook 200 Series computers are designed to be used with or without the accompanying Duo Dock, Duo Dock II, Duo MiniDock, or Duo Floppy Adapter. Many of the ports, switches and buttons normally found on a PowerBook I/O panel are absent from the computer and located on the docking and adapter options.

External Components

The PowerBook 200 Series external components differ from each other by the type of display and power adapter used. The configuration of ports, switches, and buttons are the same on all PowerBook 200 Series computers.

The expansion connector is a 152-pin processor direct slot (PDS) that connects the PowerBook to the docking and adapter options.

Internal Components

All PowerBook 200 Series computers, not including the
docking and adapter options, have the same types of internal
components, and support a DRAM expansion card, modem
card, and an on/off PCB. All computer functions (with the
exception of expansion DRAM, an optional modem card, and
an on/off PCB) are provided by the logic board
(motherboard).

Unlike other PowerBook families, the PowerBook 200
Series computers do not have daughterboard, cousin card, or
interconnect board. Only the PowerBook 270c and 280c
computers have an inverter board, which is located on the
display housing. The functionality normally provided by
daughterboard, cousin card, and interconnect board is
provided by the logic board.

On/Off PCB

The on/off PCB is connected to the modem connector on the motherboard and contains the power button accessed on the back of the computer, and the power-on button located on the top of the computer near the back of the keyboard. These two power buttons are also found on modem cards. PowerBook 200 Series computers require that either an internal modem card or an on/off PCB be installed in order for the computer to function. If neither an on/off PCB or a modem card is installed, the circuitry needed to start up and shut down the computer will be missing.

CPU Stiffener and EMI Clip Assembly

To increase structural strength, PowerBook 200 Series computers have an internal frame called the "CPU stiffener." This frame also provides electromagnetic interference (EMI) shielding to components through contact with the EMI clips.

Main Battery

PowerBook Duo computers use Nickel Metal Hydride (NiMH) batteries and come in three types: I, II, and III. Type I batteries are used in Duo 210 and 230 systems. Type II batteries are used in Duo 250, 270c, and 280 systems. Type III batteries are used in Duo 280c. It is possible to use both Type II and Type III batteries in Duo 210 and 230 systems with the addition of appropriate battery-management software. Type I batteries can be used in newer Duo systems, but battery life will be much shorter. Unless the battery is fully charged, it may not start up the unit.

Each succeeding battery type offers improved battery life performance over the other. The Type I battery provides two to three hours use before recharging is required. The Type II battery provides two to four hours use before recharging, as much as 50 percent longer life than Type I batteries. The

Type III battery provides two to four hours use before recharging and offers up to 15 percent longer life than the Type II battery. Type II and Type III batteries can be recharged in as little as three hours, depending upon the charging method used.

Type II and Type III batteries have the same model number, but are marked differently. Each will have either a "Type 2" or "Type 3" logo printed on it. Type I batteries do not have a logo. In addition, the battery release button is shorter and wider on the Type II and Type III batteries.

Battery Reconditioning

Battery reconditioning is a deep discharge of a battery to avoid "memory effect," which, over time, can erode the battery's power capacity.

The PowerBook 270c, 280, and 280c computers have a modified power system that can recondition the battery. This allows the computer to draw power exclusively from either the AC source or the main batteries. When you recondition the battery, the computer temporarily disconnects external power to avoid recharging, draws power from the internal battery only, and ignores all low power-level alerts (including hardware shutdown). The computer then senses when the battery is completely exhausted and fully recharges it. The entire process should take a few hours.

During battery reconditioning, you cannot use the computer for any other purpose. While the computer is reconditioning

its battery, it goes into a screen-saver mode, displaying a black-and-white battery icon moving around the screen.

Note: The power adapter must be plugged into the computer and to a known-good power source for reconditioning to work.

You should recondition your battery no more than once a month. The battery reconditioning software (located on the Disk Tools disk) keeps track of the last reconditioning performed by checking the battery's serial number. PowerBook computers introduced prior to the PowerBook 270c, 280, and 280c cannot use the battery reconditioning software.

Duo Dock/Duo Dock II, Duo MiniDock, and Duo Floppy Adapter Components

The docking and adapter options allow connection of expansion devices to PowerBook 200 Series computers. The docking and adapter options differ considerably from each other in physical dimension, components, and functionality.

External Components Differences

Of the external components found on the docking and adapter options, seven differences should be noted:

- **Expansion Connector—**The 152-pin PDS expansion connector is used to connect the docking and adapter options to the matching connector on PowerBook 200 Series computers.
- **HDI-20 Floppy Adapter Port—**The HDI-20 floppy adapter

port allows for the connection of an external floppy drive. This connector is found on the Duo MiniDock and Duo Floppy Adapter, as these expansion products do not contain an internal floppy drive. The Duo Dock and Duo Dock II contain an internal floppy drive and, therefore, do not include this port. The HDI-20 port requires the use of a special floppy adapter cable.

- **HDI-30 SCSI Port—**This port is used to connect SCSI devices to the docking options. It is found on the Duo Dock/Duo Dock II and the Duo MiniDock, but is not found on the Duo Floppy Adapter.

- **RJ-11 Modem Connector—**The RJ-11 modem connector on the Duo Dock, Duo Dock II, and Duo MiniDock is a pass-through telephone jack for optional (PowerBook internal) modems.

- **Eject Switch and Security Lock—**The Duo Dock and Duo Dock II have an eject switch that activates the motorized eject mechanism (discussed later), and a security lock

that secures the PowerBook computer to the dock.

- **Video Output Port—**The video output port (found on the Duo Dock, Duo Dock II, and Duo MiniDock) supports Macintosh and some VGA monitors. VGA monitors require a 15-pin-to-VGA adapter. The Duo Dock supports Apple monitors up to 16 inches, the Duo Dock II supports Apple monitors up to 20 inches, and the Duo MiniDock supports Apple monitors up to 14 inches.
- **Duo Dock/Duo Dock II Covers—**Three different covers are used with the Duo Dock and Duo Dock II. The first was used on the Duo Dock when the PowerBook 210 and 230 computers were released. The second cover, used on the Duo Dock II, has a wider opening (needed to accommodate newer computers), and has an access door. The third cover is identical to the second with the name Duo Dock II added.

Duo Dock/Duo Dock II Operation

The following are important guidelines for using the Duo Dock and Duo Dock II:

- With the access door open, partially insert the Duo (PowerBook 200 Series computer) into the Dock (Duo Dock/Duo Dock II), and the Dock will automatically pull the Duo into the Dock. Press the eject switch to eject and remove the computer from the Dock.
- When you insert a Duo into the Dock, both the Duo and the Dock must be turned off.
- The Duo must be off and not in sleep mode. If the Duo is in sleep mode, the Dock will eject the Duo. Since the Dock automatically charges the Duo, you may insert the Duo into the Dock to recharge the batteries.
- Once inserted, use the power on key on the Dock's keyboard to start up the Duo and the Dock.
- While inserted in the Dock, the Duo will not go to sleep.

- Use the normal Shut Down command to shut down the Duo and Dock. If you press the eject switch while the system is on, you will see the normal Shut Down commands, and the system will shut down as normal before it is ejected.
- If you are unable to use the eject switch, use the manual eject button located on the side. You must first unlock the Dock and then insert the key into the manual eject access to activate the manual eject mechanism.

Duo MiniDock Operation

The following are important guidelines for using the Duo MiniDock:

• The computer must be shut down or in sleep mode when you install the Duo MiniDock. If it is on, the computer will automatically shut down and you'll lose the contents of RAM.

• Connect any external devices before waking up or starting the computer.

• The computer must be in sleep mode or shut down before you disconnect external devices. The computer must be shut down before you disconnect SCSI devices or an external monitor.

Duo Floppy Drive Adapter

The following are important guidelines for using the Duo Floppy Drive Adapter:

- The computer must be shut down or in sleep mode when you install the Duo Floppy Drive Adapter. If it is on, the computer will automatically shut down and you'll lose the contents of RAM.
- Connect the floppy drive using the special floppy drive adapter cable and/or low-power ADB device.
- Wake up or start the computer after the external devices are connected.
- The computer must be in sleep mode or shut down before you remove the Duo Floppy Drive Adapter.

Internal Components

Internal components vary among the docking and adapter options. Only the Duo Dock and Duo Dock II have an internal floppy drive. The Duo MiniDock and the Duo Floppy Adapter include an HDI-20 connector, which allows the connection of an external floppy drive.

Internal Components Differences

Five of the docking and adapter option components differ from the components found in PowerBook computers. Each differing component is discussed here.

• **Duo Dock/Duo Dock II Logic Board—**The Duo Dock logic board allows the addition of an internal hard drive, two Nubus cards, additional VRAM, and an optional FPU math coprocessor.

The Duo Dock II logic board allows the addition of an internal hard drive, and two Nubus cards with 1 MB of VRAM installed. No additional VRAM can be added. The FPU math coprocessor is standard.

- **Duo Dock/Duo Dock II Release Mechanism—**This power-driven mechanism automatically draws the PowerBook 200 Series computer fully into the Duo Dock or Duo Dock II when it is partially inserted by the user. This mechanism also automatically ejects the PowerBook computer when the eject switch on the front right side of the unit is activated.

- **Duo Dock/Duo Dock II Nubus Adapter Card—**The NuBus adapter card allows the installation of up to two NuBus cards.

- **Duo MiniDock Logic Board—**The Duo MiniDock logic board provides the ports, connectors and switches (discussed earlier in this module), but does not provide any processing or other functionality.

- **Duo MiniDock Latch Assembly—**This non-powered assembly allows the Duo MiniDock to be connected to the PDS expansion connector on PowerBook 200 Series computers.

PowerBook 500 Series

This section describes how to identify PowerBook 500 Series computer components. You learn which components were introduced with the PowerBook 500 Series computers. You will also be able to identify procedures for using multiple batteries.

External Components

The following are external components of the PowerBook 500 Series computers:

- **Audiovisual Display—**All PowerBook 500 Series computers use the same standard-sized display bezel, which includes all critical-display electronics. The display bezel has a single interface to the CPU, making upgrades and new displays easy to offer. The display bezel includes built-in stereo speakers and a microphone, which are tuned to support full-duplex telephony.

- **Power Adapter—**The PowerBook 500 Series computers use an external 40 W AC adapter with a size optimal for travel. This adapter works only with the PowerBook 500 Series computers, and is not backward-compatible.

- **Trackpad—**The trackpad replaces the trackball, and is used to move the cursor. The trackpad is less expensive,

more reliable, and uses less energy than a trackball.

To move the cursor, move your finger across the 400-dpi trackpad until the pointer is in the desired position. Then press the trackpad actuator (below the trackpad) as you would when using a trackball. The trackpad responds to the capacitance in your finger and doesn't require pressure to operate. Use the Trackpad control panel to make the trackpad more or less responsive to your touch.

- **Sleep Switch —**Located next to the trackpad, the sleep switch is activated by the sleep switch actuator when the display is closed. When the sleep switch is activated, the PowerBook is automatically placed in sleep mode. Use the display release to open the display.
- **Dual Battery Bays—**The PowerBook 500 Series computers can be powered by one or two intelligent nickel-metal-hydride (NiMH) battery packs. The smart

processors contained within each pack help to ensure that users receive the maximum runtime possible per pack. The PowerBook 500 Series also provides dual battery charging. To aid future functionality, the left battery bay contains a processor direct slot (PDS) connector.

When using two battery packs to power the computer, increase battery life by changing the location of the batteries (right battery to left bay, and left battery to right bay) once each month. When using one battery pack, the battery pack must be installed in the right battery bay. This ensures consistent charging and discharging of both batteries.

- **Full Keyboard—**The PowerBook 500 Series computers use a full keyboard that includes a row of function keys and a power-on switch.
- **Sleep Mode LED—**This LED, located on the top edge of the

display assembly, lights when the PowerBook 500
Series computers are in sleep mode. The location of this
LED makes it possible to determine if the PowerBook is
in sleep mode without having to open the computer.

- **Ports and Connectors**—The PowerBook 500 Series
  computers include the following ports and connectors:
  - Power adapter port
  - Ethernet port
  - Apple Desktop Bus (ADB) port
  - Video port
  - Sound-in/Sound-out ports
  - SCSI port
  - Modem/printer port
  - Optional modem port

  The PowerBook 500 Series computers include an
  Ethernet port, which is new with this series of
  computers, but they do not include an interrupt or

reset switch.

The PowerBook 500 Series of computers does not have a power button on the back of the computer, as do other PowerBook computers. To shut down the computer when the system tries to start up but never boots, hold the Command, Option, and Control keys while pressing the power-on key on the keyboard.

Internal Components

Each of the following internal components is new or functions differently from similar components on other PowerBook computers:

- **Audiovisual Display Assembly—**The audiovisual display assembly contains the display bezel, LCD panel, EMI shield, inverter PCB, interconnect PCB, microphone, and display rear housing. The inverter PCB alternates low-voltage DC to high-voltage AC, and controls display bulb voltages and currents. The interconnect PCB interfaces between the logic board (motherboard) and the display, inverter PCB, microphone, and speakers. The bezel assembly also contains the brightness and contrast controls, display access cover, latch assembly, and stereo speakers.
- **Motherboard—**The motherboard contains the connector for the trackpad assembly and modem DAA PCB

(described later), and the processor direct slot (PDS).

- **Daughterboard—**The daughterboard contains 4 MB of RAM, 2 MB of ROM, the microprocessor, and the connector for the RAM card. With the addition of a third-party RAM card, RAM can be expanded to 36 MB. The PowerBook 500 Series computers can be upgraded to PowerPC (when upgrade boards are available) by replacing the daughterboard with one having a PowerPC microprocessor.

- **DAA PCB—**The optional internal modem requires a separate DAA PCB that ensures proper timing of data transmission over telephone equipment. A different modem card and DAA PCB are required for international use of the PowerBook 500 Series computers. The DAA PCB connector is on the motherboard.

Power Management

The PowerBook 500 Series computers introduce several new power features, as well as several new procedures for maximizing power usage. This section discusses each of these features.

Battery Configurations

The PowerBook 500 Series computers are designed to use one or two internal, rechargeable nickel-metal-hydride battery packs. The runtime for each battery pack is estimated to be 3.5 hours, on average. When two battery packs are used, the total run time doubles to approximately 8 hours. The exact time depends on a variety of factors such as the brightness of the screen and how often you use the hard disk.

The PowerBook 500 Series computers have two battery bays. If only one battery pack is used, it must be installed in the right bay. For a one-battery configuration, install a battery blank in the empty left battery bay.

Since the PowerBook 500 Series computers require only one battery, the left battery bay can be used for a second battery pack, or for an optional PCMCIA (Personal Computer Memory Card International Association) expansion module. The PDS connector, which is accessed through the left battery bay, connects the PCMCIA expansion module to the motherboard. A more detailed discussion of the PCMCIA expansion option is presented later.

Battery Charging

The PowerBook 500 Series computers use an external 40 W AC adapter. The adapter's small size is optimized for travel (approximately the same size as the Duo AC adapter). This power adapter can be used only with the PowerBook 500 Series computers and is not backward-compatible.

The PowerBook 500 Series computers support the use of two batteries with dual built-in battery charging. Two depleted batteries charge in approximately two hours when the computer is sleeping or shut down, and in approximately four hours when the computer is in use.

To maximize battery life, recondition the battery by discharging and then completely recharging it once every 30 days (refer to the PowerBook 500 Series user manual for instructions on reconditioning the battery). With a two-battery configuration, you can also maximize battery life by

swapping the left and right batteries once every month.
Swapping batteries ensures a consistent charging and
discharging of both batteries. With proper care, you can
expect your batteries to last at least a year.

PCMCIA Technology

The following are commonly asked questions about PCMCIA
technology. For additional information, refer to the
Technical Information Library.

Q: Can I plug in PC Cards on-the-fly?

A: Yes, individual cards can be plugged in at any time the
PowerBook is started up and they will be recognized. If,
however, the actual expansion module is inserted or
removed while the unit is started up or in sleep mode, the
unit will shut down.

Q: How do I eject a PC Card?

A: For mass-storage cards, when the card icon is dragged to the Trash, the eject command is invoked from the PCMCIA Eject control panel, or the eject command is selected from the PowerBook Control Strip, the card is ejected. Also, the Put-Away command (Command Y) will eject mass-storage cards. Additionally, modem (and mass storage) cards can be ejected by way of the control panel or control strip.

Q: How many insertions/ejections is the expansion module rated for?

A: The PowerBook PCMCIA Expansion Module has been certified for 10,000 insert/eject cycles, but has gone beyond that in testing without a failure.

Smart Batteries

The battery packs used by PowerBook 500 Series computers are called "smart batteries," because they contain a microprocessor. The microprocessor provides more accurate and detailed charge status information to the CPU, when compared to other types of batteries, ensuring that customers receive the maximum runtime possible.