Apple's Enhanced Computer, the Apple IIe

It's like having an Apple II with all the extras built in.

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It all began in the summer of 1977 at the West Coast Computer Faire. A fledgling computer company with an unusual name—Apple Computer—introduced a new hobby computer called the Apple II. The new Apple II was an impressive machine. It had BASIC in ROM (read-only memory), a built-in Teletype-style keyboard, high-resolution color graphics, and, once the new 16K-bit semiconductor memory devices became available, its memory could be expanded all the way up to 48K bytes. One of the first true home computers, it was completely self-contained, needing only a TV set for a display and a common cassette recorder for data storage.

Today, almost everyone is familiar with the Apple II. It can be found in homes, schools, laboratories, and businesses, and is being used in a wide variety of ways. During the past five years, an entire subindustry has sprung up around it that has, in turn, stimulated further Apple II sales.

It had been obvious for a while at Apple Computer that a replacement for the Apple II was needed. The Teletype-style keyboard, uppercase only 40-column display, and the

maximum of 64K bytes of memory were becoming limitations as the marketplace changed and software became more sophisticated. The design was getting old and technology had changed enough to allow a redesign with significantly fewer parts. A new design could also address foreign requirements for special keyboards, displays, and video signals better than the Apple II. Although the Apple II was a tremendous success, it was clearly time to design a successor.

Enter the Apple IIe

For about the same price as the Apple II, the Apple IIe (e for enhanced) provides a variety of exciting new features and capabilities. Rather than start from scratch and design an entirely new machine, Apple Computer Inc. chose to make a very careful series of enhancements and improvements while keeping the flavor and style of the Apple II. Although completely redesigned internally, the Apple IIe is clearly a member of the Apple II family.

Even though it looks almost the same as the Apple II, the Apple IIe (see photo 1) gives you a great deal more for your money. The base-priced machine includes 64K bytes of memory (expandable to 128K bytes), Applesoft BASIC in ROM, a 63-key keyboard that produces both upper-

case and lowercase characters and has special-function keys, seven expansion slots for I/O (input/output) devices, and a video interface that can display 24 lines in a 40-column-wide format with both uppercase and lowercase characters (this can be easily and inexpensively expanded to 80 columns). In addition to the standard Apple II I/O expansion slots, the main circuit board also holds a special auxiliary connector that is used primarily for various video- and memory-expansion options. Along with Applesoft BASIC, the internal 16K bytes of ROM hold an improved monitor, built-in self-test routines, extended memory-management routines, and an 80-column firmware package with extended editing features that can be used with the 40-column display.

The quality of the product is highly

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Rob Moore is a design engineering manager who also maintains a strong interest in FORTH, graphics, and computer music.
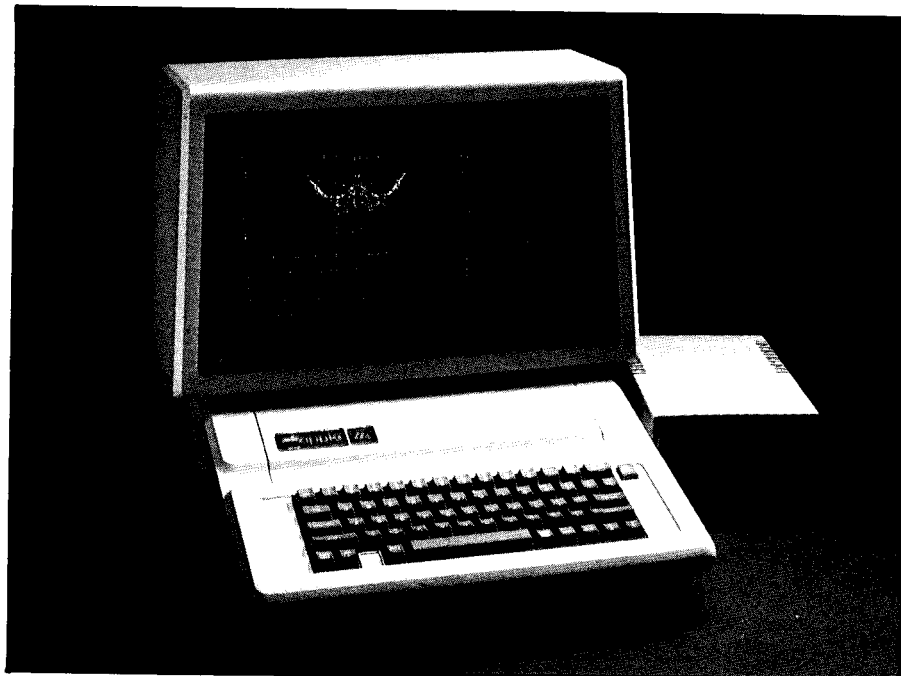

Design Credits

Although it is impossible to give credit to all the people involved, three people deserve special mention. Peter Quinn, the POS Hardware Section Manager, was responsible for the team that designed the Apple IIe. Walt Broedner designed the Apple IIe hardware, including its two custom integrated circuits. Rick Auricchio is Broedner's software counterpart—he modified the original Apple II Plus firmware and added all the new code that is in the Apple IIe firmware.
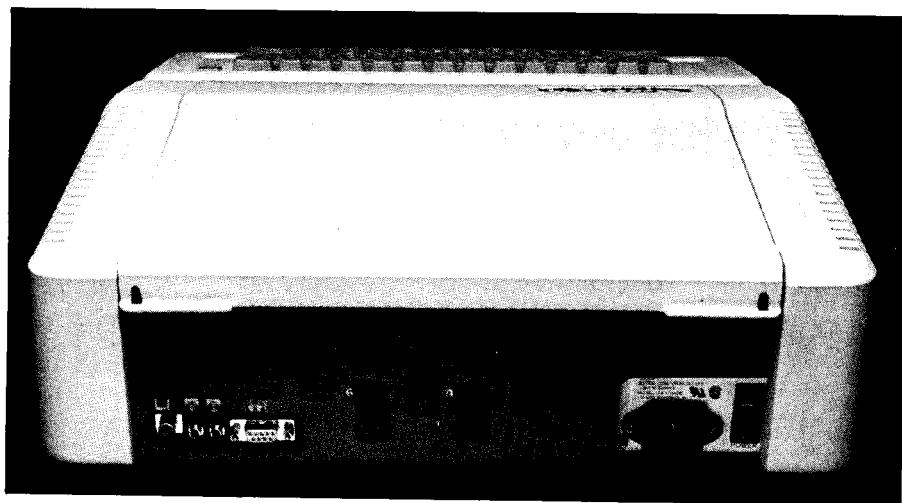

Photo 1: *An Apple IIe system made up of the Apple Monitor III, the Apple IIe computer, and a Disk II 5¼-inch floppy-disk drive.*

Photo 2: *The rear panel of the Apple IIe. Instead of the plastic slots found in the Apple II, the Apple IIe's metal back panel is designed to mount 9-pin, 19-pin, and 25-pin D-type connectors in precut recesses, providing more reliable connections and reduced RF interference. The built-in game-paddle connector has also been changed to a 9-pin D-type; however, the older-style connector is still available inside the case to accommodate existing devices.*

evident. The case is rugged structural foam, the keyboard has a nice touch and dished keytops, and the back panel (see photo 2) has an array of openings that fit the 9-pin, 19-pin, and 25-pin D-type connectors commonly used for serial I/O devices. It appears obvious that the Apple IIe was designed from the ground up to meet the new FCC (Federal Communications Commission) RFI (radio-frequency interference) regulations.

The computer has a metal bottom pan, a metal back panel (rather than plastic as in the present model), and the removable cover is shielded with conductive paint and grounded with metal gaskets at the front and back edges. Some other nice touches include: the "D" and "K" keys (the ones that the middle fingers of a touch-typist's hands fall on) have small bumps on their surfaces; the connector openings on the back panel come

with plastic caps to cover them if connectors aren't installed; the top cover has tabs in the rear to help lift it open, and screw holes to help keep it shut when desired (schools should like this feature).

The Keyboard

The keyboard is the most obvious difference between the Apple II and the Apple IIe. It is essentially an enhanced version of the Apple III's keyboard without the numeric pad; the keyboard on the Apple IIe (see photo 3) has 63 keys, while the Apple II has 53, and the layout is slightly different. Although the changes seem minor, they make the new keyboard significantly easier to use, especially in word-processing or screen-editing applications.

One of the most significant changes is indicated only by the Caps Lock key. The Apple IIe keyboard provides full uppercase and lowercase operation. When Caps Lock is latched down, however, it operates much like the original Apple II keyboard and produces only uppercase characters. If the two solder pads on the main board labeled X6 are connected, programs can check to see if the Shift keys are pressed by reading the PB2 input in the game-paddle port. (This supports a common Apple II modification and many existing word-processing programs.)

To correct a limitation of the old Apple II keyboard, the new keyboard can produce all 128 ASCII (American National Standard Code for Information Interchange) character codes. This was accomplished in the Apple IIe by adding some new character keys, along with Tab and Delete keys, to improve its word-processing capability. (The added keys, with different keycaps, will be used in European versions to provide an ISO [International Organization for Standardization] standard keyboard layout.)

Two interesting additions are the Open-Apple and Solid-Apple keys, which are positioned one on each side of the space bar. If you press Control, Open-Apple, and Reset simultaneously, the Apple IIe will write some arbitrary data into each page of memory and then simulate a power-up

cold start. This eliminates the need to turn the Apple off and then on again to exit a protected program (a definite annoyance), but prevents people from making unauthorized copies of protected software.

Pressing Reset while holding Control and Solid-Apple invokes the built-in self-test software, which responds with "KERNEL OK" if the memory and circuitry pass the tests. Open-Apple and Solid-Apple may also be read individually and used as special-purpose keys by various programs—they are internally connected to the game-paddle port inputs PB0 and PB1. Other improvements include a full set of cursor-control keys positioned to the right of the space bar, auto-repeat on all keys after a 0.9-second delay, and a relocated Reset key. (The Reset key is placed apart from the main keyboard to keep it from being pressed accidentally. In addition, the Control key must be pressed simultaneously with the Reset key to have an effect; this behavior, standard on the Apple IIe, was an option on later models of the Apple II Plus.)

Internally, the keyboard is completely different from that on the Apple II. The Apple IIe keyboard is a simple array of switches—the keyboard-scanning circuitry has been moved to the main printed-circuit board, which also holds a special numeric pad connector. A ROM on the main board maps the keyboard-switch closures into the appropriate ASCII codes and can be changed to provide foreign or special keyboards. (Incidentally, the American version of the ROM is only half used. The other half holds a Dvorak keyboard map that can be accessed with a few jumpers and etch cuts.) For programmers, the keyboard provides an additional "Any key down" flag; it can be read by examining location C010 hexadecimal. This will allow pro-

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At a Glance

Product
The Apple IIe computer

Manufacturer
Apple Computer Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Components
System Unit

Size:	width 15.2 inches (38.6 cm); depth 18 inches (45.7 cm); height 4.5 inches (11.4 cm)
Power Required:	107 to 132 VAC, 60 Hz, 60-80 watts maximum
Processor:	1-MHz 6502 8-bit microprocessor
Memory:	64K bytes of memory; 16K bytes of monitor in ROM (includes self-test, Applesoft BASIC, and 80-column routines)
Standard:	keyboard for text and data entry; internal and external video connectors; 1-bit programmable audible speaker; audio cassette recorder input and output connectors; seven I/O expansion slots to hold peripheral devices and interfaces; external game control connector with four analog inputs and three TTL or switch inputs (similar internal connector includes three TTL-level outputs)
Video Display:	Two Uppercase/lowercase Text Modes •24v by 40h standard •24v by 80h optional •character set stored in ROM Two Standard Graphics Modes •40h by 48v sixteen-color graphics (40 by 40 with four text lines) •280h by 192v bit-mapped array with half-dot-shift logic (280 by 160 with four text lines)—with appropriate software this can provide: 560 by 192 monochrome graphics with some limitations 280 by 192 monochrome graphics 140 by 192 six-color graphics with some limitations 140 by 192 four-color graphics
Video Outputs:	Both outputs provide NTSC-compatible video, negative sync, 2-V peak-to-peak
Keyboard:	63 keys for text and data entry; N-key rollover; auto-repeat on all keys (15 Hz) after 0.9 seconds; four cursor-control keys; Caps Lock; two special-function keys; keyboard allows input of all 128 ASCII characters
Disk Drives:	System supports up to six 140K-byte 5¼-inch floppy-disk drives; data is stored using Apple Computer's 6/8 GCR (group-coded-recording) encoding

Operating System
Apple's DOS 3.3 single-user, single-task, program-driven operating system provides multiple file types, random-access and sequential text files, random disk allocation, individual file protection, and slot-based I/O

Options
Standard options include 80-column text card; extended 80-column text card with 64K bytes of additional bank-switched memory; Apple Disk II floppy-disk drives and controllers

Available Software
Includes almost all existing Apple II software. New software includes Applewriter IIe word processor ($195) and Quickfile IIe database system ($100)

Hardware Prices
|	
Apple IIe main unit	$1395
Apple IIe system with main unit, Disk II and controller, Monitor III, monitor stand, and 80-column text card	$1995
Apple Monitor III (green screen)	$249
Apple Disk II (with controller/without controller)	($545/$395)
80-Column Cards (standard/Extended card with 64 K memory)	($125/$295)

Optional Documentation
Apple IIe Owner's Manual	$20*
Applesoft Reference Manual (two volumes)	$30
Applesoft Tutorial	$25
Applesoft package (both books plus disk of software)	$50
BASIC Programming Manual (Integer BASIC)	$7
The DOS Manual (DOS 3.3)	$10* **
DOS Programmer's Manual (available March, 1983)	n/a
DOS User's Manual with Tutorial (March, 1983)	n/a
Apple IIe Reference Manual	$30
Apple IIe 80-Column Text Card Manual	$20*
Apple IIe Extended 80-Column Text Card Supplement	$15*

* included with associated Apple product, available optionally
** one-page errata sheet available free from dealers
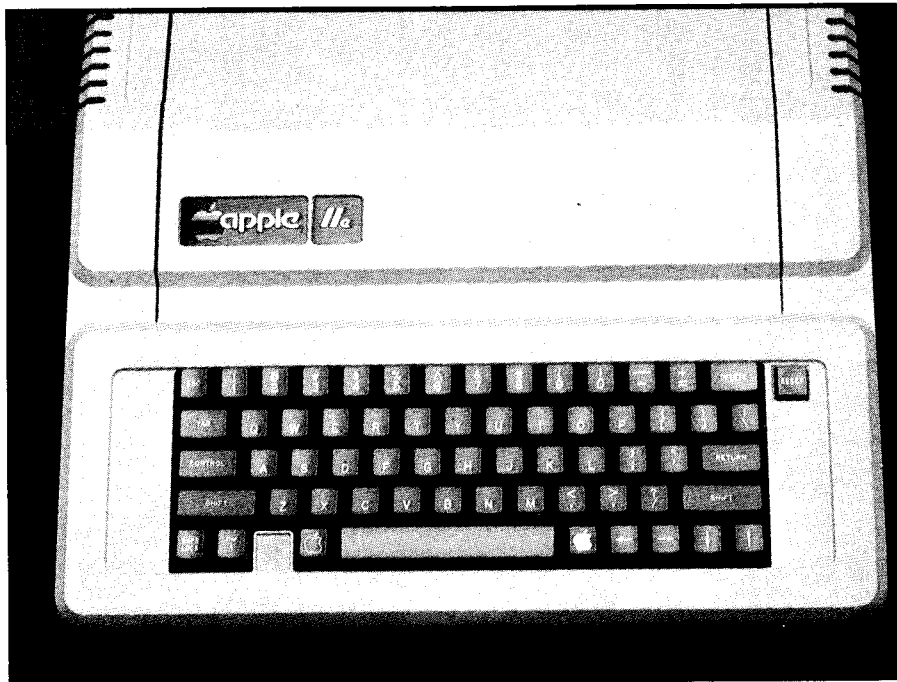
Photo 3: *The Apple IIe keyboard. With uppercase and lowercase characters, N-key rollover, auto-repeat on all keys, and special-function keys, it provides a mix of functions found on both typewriter-style and computer keyboards. Unfortunately, the left-arrow key is inconveniently placed for its use as a backspace key while using BASIC. The special Open-Apple and Solid-Apple keys are used to invoke the self-test routines, simulate a power-up cold start, and may be read as paddle push buttons 0 and 1.*
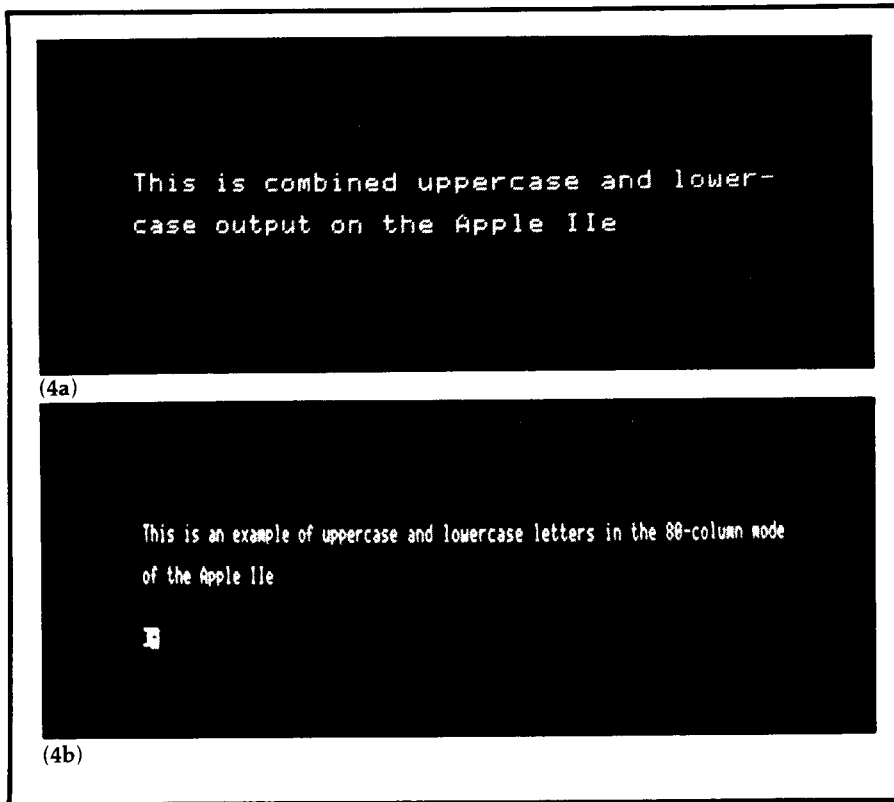
Photo 4: *The Apple IIe video display. Photo 4a is an example of the 40-column text display showing both uppercase and lowercase characters available. Photo 4b shows the Apple IIe 80-column display. The plus sign within the cursor shows that you are in Escape mode, which provides expanded editing and cursor-control functions.*

grams to provide their own auto-repeat or special pause functions, overriding the auto-repeat built into the keyboard.

Text-Display Modes

The standard Apple IIe displays 24 rows of 40 characters (see photo 4a). It provides normal (white on black) and inverse-video (black on white) modes for all characters, and a flashing mode for the uppercase characters and special symbols. If you try to display a lowercase character in flashing mode, the display shows a flashing special character instead. Although this may seem strange, it emulates exactly what is displayed by Apple IIs that have been modified with added lowercase adapters, and is done this way for compatibility with those machines. The Apple IIe also provides an alternate character set where there are only two modes—normal and inverse—but the characters are always displayed correctly.

Although the ability to display both uppercase and lowercase characters is a definite improvement, I suspect that few users will stay with the 40-column display. The two 80-column options are just too useful—and too inexpensive—to be ignored.

The 80-Column Display Options

To accommodate users who need a display wider than 40 columns, the Apple IIe offers two 80-column option cards: the 80-column text card and the extended memory 80-column card, which includes 64K bytes of additional memory. Either of these cards can be plugged into the auxiliary connector, and they are both just memory cards. Photo 4b shows an example of the 80-column text display.

The actual 80-column display circuitry and firmware are already built into the Apple IIe. In fact, by setting the appropriate soft switches, you can see an 80-column display on any Apple IIe—every character in the normal 40-column display will be displayed twice. Both of the 80-column cards (see photo 5) provide the additional display memory required for 80-column operation; however, the 80-column text card is inexpensive
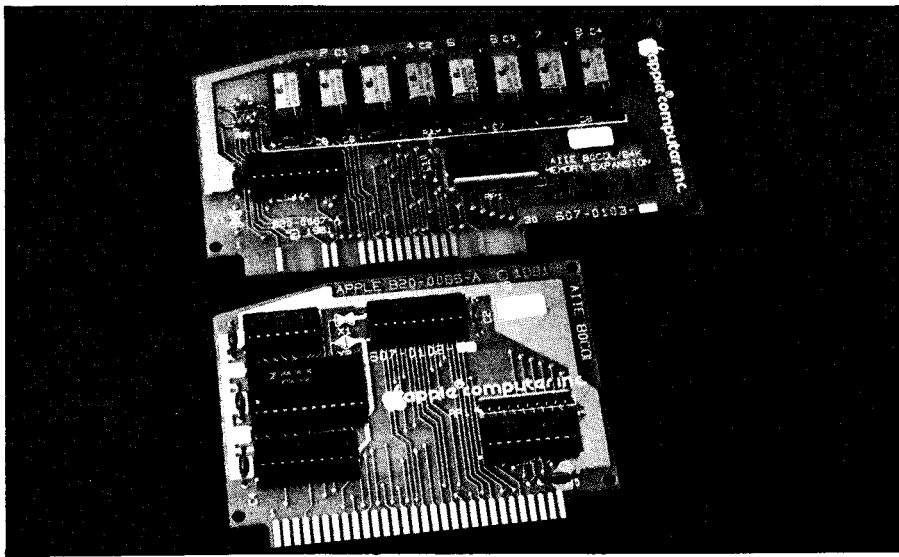
Photo 5: *The Apple IIe 80-column text card (bottom) and extended memory 80-column card (top). The 80-column text card provides an additional 1K-byte text/low-resolution graphics display page, while the extended memory 80-column card duplicates the entire Apple IIe 64K-byte address space.*

Photo 6: *Apple IIe graphics. See the text for a full explanation of the modes available.*

because it is simply a 1K-byte memory card.

The extra (separate) display memory is needed because the 80-column circuitry displays twice as many characters in the same period of time as the 40-column circuitry. This doubles the rate at which the display accesses memory; if the Apple's main memory was used, this wouldn't allow the processor any memory cycles. The designers found an ingenious solution to this dilemma. The Apple IIe's dis-play always accesses memory at the 40-column rate, allowing the processor all the memory cycles needed. When in 80-column mode, however, the display circuitry reads both the main memory and auxiliary display memory simultaneously, saving the character that is read from the auxiliary memory and displaying it after the character read from the main memory. This allows the display to operate twice as fast but doesn't affect the operation of the processor.

One of the nicest things about the Apple IIe 80-column option is that it is compatible with all other Apple IIe display modes. In the old Apple II, people often used two monitors with 80-column cards—one for the 80-column display and one for 40-column text and graphics—because the available 80-column cards had separate video outputs for the 80-column text.

The 80-Column Firmware

The 80-column routines built into the Apple IIe ROMs provide a number of advanced cursor-control and editing features. One of the most interesting is the lowercase restrict mode. If you type a Control-R when the 80-column firmware is active, the keyboard input is restricted to upper-case only (just as if Caps Lock was pressed) unless you are between quotes. This mode is handy because Applesoft BASIC and DOS 3.3 won't accept lowercase commands—it locks you into uppercase except when typing in BASIC string constants (which can accept lowercase).

To maximize its compatibility with existing software, the Apple IIe 80-column firmware emulates an 80-column card installed in I/O slot 3 (the standard location). If one of the two 80-column option cards is installed, typing PR#3 will activate the internal 80-column routines and disable any firmware installed in slot 3. Once activated, the 80-column firmware and its extended editing features can be used in either 40-column or 80-column mode. In fact, by setting one of the soft switches, you can use the 80-column firmware even if you don't have the 80-column card installed.

To help you keep track of which display software is active, the Apple IIe displays three different types of cursors. A small checkerboard cursor indicates that the 80-column firmware is inactive. A larger block cursor is displayed when the firmware is on, and a + (plus sign) within the block indicates that the firmware is in "Escape mode" and is waiting for another keystroke, which will be interpreted as a cursor-movement command.

The 80-column software is also

compatible with other languages. If you have Apple's Pascal 1.1 or one of the Apple II CP/M systems, these both can load in 80-column mode and operate correctly without any additional patches or modifications.

Graphics

Like the Apple II, the Apple IIe offers two standard graphics modes. The low-resolution mode produces 16-color graphics, with either 40 by 48 pixels (picture elements) or 40 by 40 pixels and four lines of text. The standard high-resolution mode provides a 280 by 192 bit-mapped pixel array with half-dot-shift logic (see photo 6). Depending upon the software used, this mode can be used to provide limited 560 by 192 monochrome graphics, 280 by 192 monochrome graphics with no limitations, 140 by 192 six-color graphics with limitations, or 140 by 192 four-color graphics. (The vertical dimension is reduced to 160 pixels if you want four lines of text at the bottom.)

The 80-column options are the keys to the new Apple IIe graphics features. With the proper software, the Apple IIe can provide double-density graphics in both low-resolution and high-resolution modes. Either of the 80-column cards will support the double-density low-resolution graphics, but you will need the extended memory 80-column card if you want to use the double-density high-resolution mode, which can also provide 140 by 192 graphics with 16 colors! At the time this article was written (November 1982), no software was available to support these new graphics modes; however, it will undoubtedly be available soon, either from commercial vendors or user's groups.

The double-density graphics modes are provided by the 80-column display circuitry. Instead of simply displaying bytes sequentially from the main memory, it displays bytes alternately from the main memory and the auxiliary memory, at twice the normal rate. Although this capability was designed to provide an 80-column text display, the designers soon realized that it could also be used to provide additional graphics modes.

Use of the double-density graphics has three requirements. First, you need a Revision "B" main circuit board; this will probably be the only type shipped after the first month of production. Second, you must connect two pins on your 80-column card; this is explained in the *Apple IIe Reference Manual*. Third, you must turn on the AN3 output to the game-paddle connector; this can be used to switch between normal and double-density mode. (Unfortunately, the Apple IIe sent to BYTE for review had a Revision "A" main board. Thus, there is no photo of the new graphics modes included with this article.)

Inside the Box

The most significant differences between the Apple II and the Apple IIe are internal. The main printed-circuit board has been totally redesigned and incorporates many new features and options unavailable in the Apple II.

The power supply is unchanged, but there are now seven I/O expansion slots instead of the eight found in the Apple II. Part of the Apple IIe memory emulates a 16K-byte RAM (random-access read/write memory) card (commonly installed in Apple IIs), and the card's former location, I/O slot 0, is no longer present.

The most obvious change is a reduction in the number of ICs (integrated circuits). Where an Apple II with a keyboard enhancer, a 16K-byte memory card, and an 80-column card included about 120 ICs, the Apple IIe provides the same features with just 31 ICs. A large part of this reduction is due to the use of 64K-bit dynamic memories, rather than 16K-bit ones. The entire 64K-byte memory of the Apple IIe occupies just 8 ICs.

Another significant reduction in IC count is provided by two custom-designed MOS (metal-oxide semiconductor) ICs—the IOU (input/output unit) and MMU (memory-management unit)—that manage memory
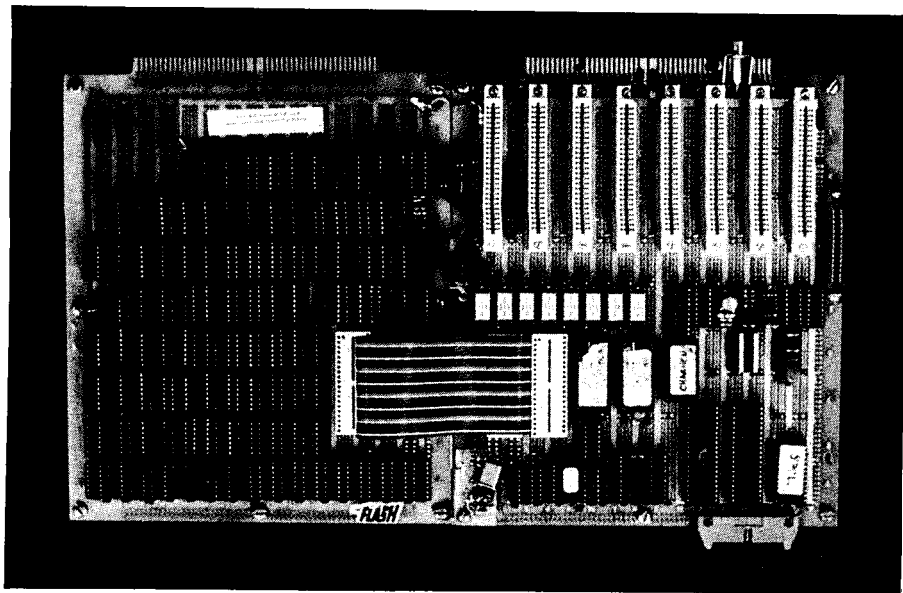
Photo 7: *The Apple IIe engineering prototype wire-wrap boards. The custom MOS IOU and MMU ICs are emulated with discrete logic on the board to the left, while the Apple IIe main board prototype is on the right.*

and I/O decoding and provide many of the new internal features. Photo 7 shows the engineering breadboard of the Apple IIe main board and a second board that emulates the IOU and MMU with standard 7400-series ICs, so that the designs could be completely tested before committing them to silicon. The IOU and MMU emulations required about 50 and 60 ICs
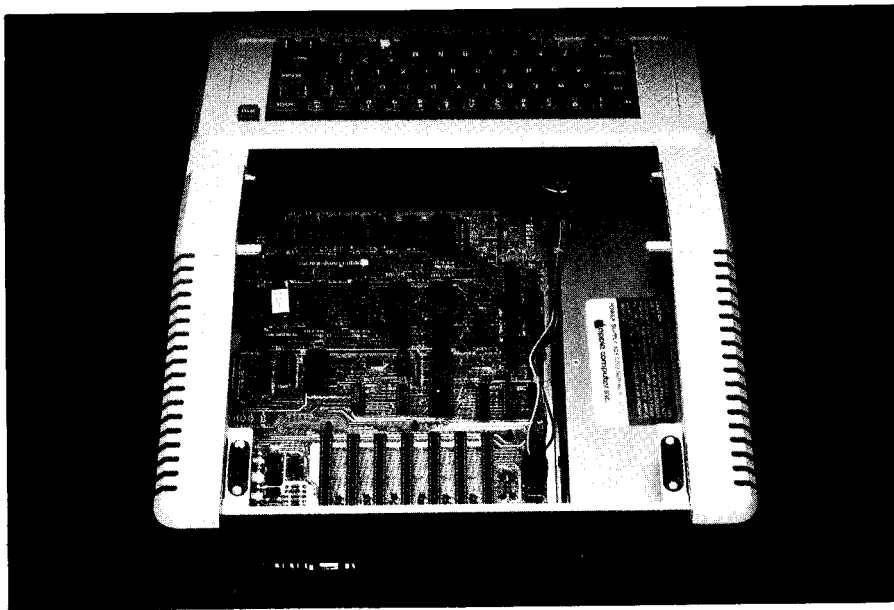
Photo 8: *The Apple IIe main circuit board. The 31 ICs on this board replace the 120 ICs found in a standard Apple II, including a memory card, 80-column card, and keyboard enhancer, as well as providing a number of new features not available in the Apple II.*

switching, and converts the address to the multiplexed form required by the dynamic memories. The IOU provides similar functions for the video display. It also includes the video-timing logic, keyboard control, and other miscellaneous functions. To support foreign versions of the Apple IIe, the IOU includes video circuitry to provide both the American-standard NTSC (National Television System Committee) signals and European-standard PAL signals. The IOU ICs are customized during assembly by the manufacturer by connecting the internal bonding wires to the appropriate set of pads on the IC chip inside the package.

The Auxiliary Connector

Although I/O slot 0 is no longer present, a new "auxiliary connector" can be used in a variety of ways. In the factory, the auxiliary connector is used to connect special test equipment to the Apple IIe. With this equipment and the signals available at the auxiliary connector, problems

respectively. In the final board (shown in photo 8), these 110 ICs are replaced with just two components.

Working together, the IOU and MMU generate all memory-address-

ing and I/O-decoding signals. The MMU is primarily responsible for supporting the 6502 processor. It accepts addresses from the processor, does any necessary memory-bank

can be localized to one or two ICs.

Once in the customer's hands, the auxiliary connector is used to hold various video and memory options. Its set of signals provides access to a number of areas in the Apple IIe and can, in fact, be used to totally disable the internal video-generation circuitry, so that an alternate video generator can be installed. Currently, the only options supplied by Apple Computer Inc. for the auxiliary slot are the two 80-column cards. However, other devices should soon be available from Apple and other manufacturers.

The Extended Memory 80-Column Card

Besides an 80-column display, the extended memory 80-column card provides an additional 64K bytes of memory. Rather than switching blocks of auxiliary memory into a fixed address range, the designers chose to replicate the entire 64K-byte addressing space on the auxiliary card and provide a series of soft switches that enable either the main memory or auxiliary memory in various address ranges. The documentation points out that "even though an Apple IIe with an extended memory 80-column card has a total of 128K bytes of programmable memory in it, it is not appropriate to call it a 128K-byte system. Rather, there are 64K bytes of auxiliary memory that can be swapped for main memory under program control."

To help programmers use the auxiliary memory, the Apple IIe 80-column firmware provides two special routines: AUXMOVE and XFER. Using these two routines, you can store and retrieve data in the auxiliary memory or transfer control to a program that resides there.

AUXMOVE is used to copy data from main memory to auxiliary memory or vice versa. You simply store the data's starting address, ending address, and destination address in memory locations; set or clear the processor's carry flag to indicate direction; and call AUXMOVE. XFER is used in a similar fashion in order to jump from programs in main memory to others in auxiliary memory (or vice versa). XFER may also be used to switch stacks and zero pages as you transfer from one section of memory to the other.

These two routines, and the auxiliary memory, open up some interesting possibilities. It appears to be possible, for example, to have an entire Pascal system residing in main memory, while a DOS 3.3/BASIC system is in auxiliary memory, and be able to transfer control between the two systems at will.
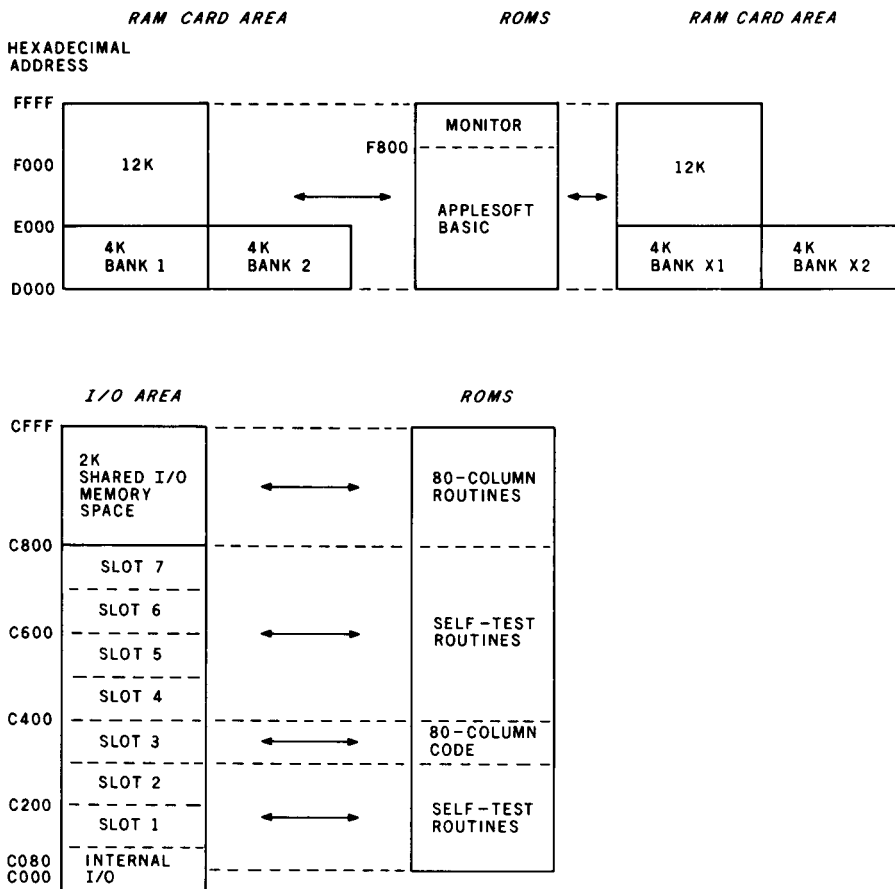
Soft Switches

To support the auxiliary memory and 80-column display software, the Apple IIe provides a number of new soft switches and adds a few new features to the old ones. (A soft switch, in an Apple II or Apple IIe, is a memory location that can be accessed to cause some hardware change to take place.)

Existing soft switches in the Apple II were used to select various video

APPLE II● MAIN MEMORY

EXTENDED 80-COLUMN
TEXT CARD AUXILIARY
MEMORY

RAM CARD AREA   ROMS   RAM CARD AREA

HEXADECIMAL
ADDRESS

```
FFFF  ┌─────────┬─────────┐ ─ ─ ─ ┌─────────────┐ ─ ─ ─ ┌─────────┬─────────┐
      │         │         │       │   MONITOR   │       │         │         │
      │   12K   │  F800   │       ├ ─ ─ ─ ─ ─ ─ ┤       │   12K   │         │
F000  │         │         │       │             │       │         │         │
      │         │  ←───→  │       │  APPLESOFT  │ ←──→  │         │         │
E000  ├─────────┼─────────┤       │    BASIC    │       ├─────────┼─────────┤
      │  4K     │  4K     │       │             │       │  4K     │  4K     │
      │ BANK 1  │ BANK 2  │       │             │       │ BANK X1 │ BANK X2 │
D000  └─────────┴─────────┘ ─ ─ ─ └─────────────┘ ─ ─ ─ └─────────┴─────────┘
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I/O AREA   ROMS

```
CFFF  ┌──────────────┐ ─ ─ ─ ─ ─ ─ ┌──────────────┐
      │ 2K           │             │              │
      │ SHARED I/O   │  ←───────→  │  80-COLUMN   │
      │ MEMORY       │             │  ROUTINES    │
      │ SPACE        │             │              │
C800  ├──────────────┤ ─ ─ ─ ─ ─ ─ ├ ─ ─ ─ ─ ─ ─ ┤
      │   SLOT 7     │             │              │
      ├ ─ ─ ─ ─ ─ ─ ─┤             │              │
      │   SLOT 6     │             │  SELF-TEST   │
C600  ├ ─ ─ ─ ─ ─ ─ ─┤  ←───────→  │  ROUTINES    │
      │   SLOT 5     │             │              │
      ├ ─ ─ ─ ─ ─ ─ ─┤             │              │
      │   SLOT 4     │             │              │
C400  ├ ─ ─ ─ ─ ─ ─ ─┤ ─ ─ ─ ─ ─ ─ ├ ─ ─ ─ ─ ─ ─ ┤
      │   SLOT 3     │  ←───────→  │  80-COLUMN   │
      ├ ─ ─ ─ ─ ─ ─ ─┤             │  CODE        │
      │   SLOT 2     │             ├ ─ ─ ─ ─ ─ ─ ┤
C200  ├ ─ ─ ─ ─ ─ ─ ─┤  ←───────→  │  SELF-TEST   │
      │   SLOT 1     │             │  ROUTINES    │
C080  ├──────────────┤ ─ ─ ─ ─ ─ ─ │              │
C000  │ INTERNAL I/O │             └──────────────┘
      └──────────────┘
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Figure 1: *Apple IIe memory maps. Within the Apple IIe's main memory, ROM can be switched to replace RAM in various address ranges. When the extended 80-column text card is used, it adds 64K bytes of switched memory. Areas of RAM and ROM that can be switched are indicated with arrows. In the 80-column text and double-wide graphics modes, the computer's main memory and the auxiliary memory on the card are accessed simultaneously to double the display density. Figure 1a (above) shows the language-card RAM and I/O areas, while figure 1b (on page 82) shows the main RAM and display areas of memory. The 80-column text card includes the alternate text page x1 only.*

modes and control the internal I/O devices (keyboard, game paddles, speaker port, and cassette port). If a 16K-byte memory card was added, it included additional switches to disable the card or to enable areas on the card as read-only or read-write memory. When using the switches, however, the programmer had to keep track of them. There was no way to read them back.

The Apple IIe makes many of the existing soft switches, and all the new ones, readable. Specifically, you can read back the states of the video-mode switches, the 16K-byte memory-card-area switches, and all the new auxiliary-memory switches by examining locations between hexa-

decimal C010 and C01F. To help provide better graphics animation, you can also read the "vertical blanking" from the video display, thus allowing you to change the contents of memory while it is not being used to create the video display.

The auxiliary memory is supported by several new switches that change the display from main to auxiliary memory, enable display areas in both memories at once for 80-column text or double-density graphics, and control reads and writes to the auxiliary memory. Other switches allow you to overlay portions of the I/O-slot memory space with the internal ROM 80-column firmware or self-test routines, and select either the standard or
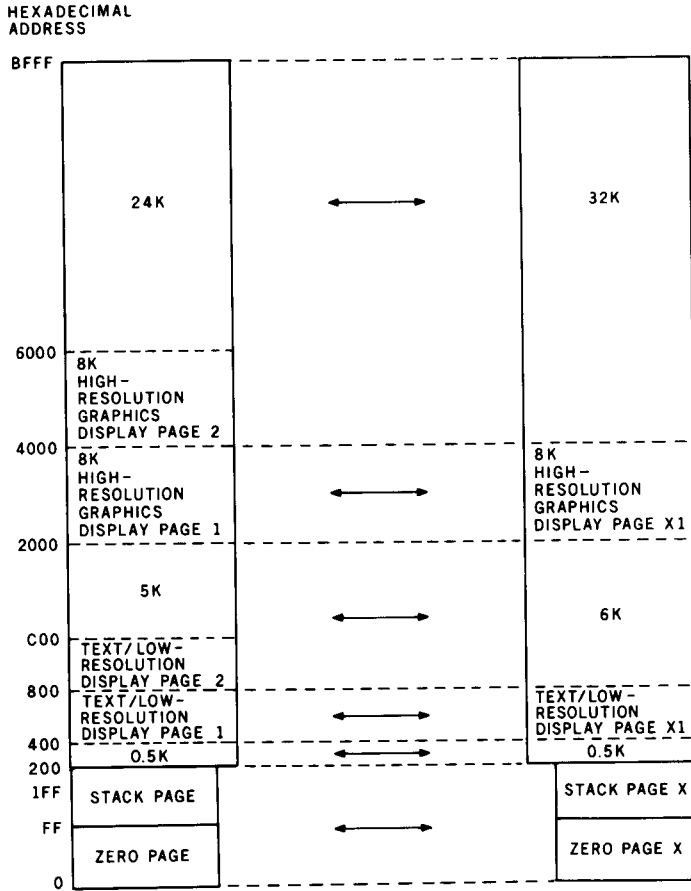
alternate display character sets. (Figures 1a and 1b provide memory-switching maps for the Apple IIe.)

Apple II Compatibility

One of the major concerns during the design of the Apple IIe was its level of compatibility with the Apple II. Literally thousands of programs are written for the Apple II, and numerous hardware products are designed to plug into Apple II I/O slots. User surveys had shown that the volume of available software was a prime consideration among purchasers. It was therefore obvious that the new machine had to be compatible with virtually all existing Apple II hardware and software products, while still including the desired new features and design improvements.

The designers succeeded admirably. The Apple IIe is physically a complete redesign; logically, however, it is compatible with almost all existing Apple II software and hardware add-ons. This goal was not met simply—more than 150 software products and numerous peripheral devices were tested for compatibility during the Apple IIe development process.

Unfortunately, a few Apple II-based products from other manufacturers won't work properly in an Apple IIe—primarily because their designers did not follow Apple's interface guidelines. In general, accessory cards that occupy one of the I/O slots and do not connect directly to an IC socket will operate correctly. Others that connect directly to the main circuit board or to the keyboard will not be compatible without redesign.

Examples of cards that *will* work in an Apple IIe include 80-column cards, serial and parallel interfaces, graphics tablets, disk controllers, and memory cards that do not connect to an IC socket. To maximize compatibility, Apple II-style video- and game-paddle connectors are provided inside the case, even though the new-style connectors are now on the back panel. This allows existing video switches, joysticks, and game controls to be used with the Apple IIe (although they may cause excessive

HEXADECIMAL
ADDRESS

BFFF			
	24K	⟷	32K
6000	8K HIGH-RESOLUTION GRAPHICS DISPLAY PAGE 2		
4000	8K HIGH-RESOLUTION GRAPHICS DISPLAY PAGE 1	⟷	8K HIGH-RESOLUTION GRAPHICS DISPLAY PAGE X1
2000	5K	⟷	6K
C00	TEXT/LOW-RESOLUTION DISPLAY PAGE 2		
800	TEXT/LOW-RESOLUTION DISPLAY PAGE 1	⟷	TEXT/LOW-RESOLUTION DISPLAY PAGE X1
400	0.5K	⟷	0.5K
200			
1FF	STACK PAGE		STACK PAGE X
FF	ZERO PAGE	⟷	ZERO PAGE X
0			

Figure 1: (continued)

RF interference).

Devices that won't work in an Apple IIe include keyboard enhancers, lowercase display adapters, numeric pads (existing designs), and memory cards that connect to an IC socket with a small flat cable. Fortunately, the capabilities of most of these devices are already included in the Apple IIe.

It is much harder to quantify which Apple II software products will or will not work in an Apple IIe. To support the new hardware features, certain changes had to be made to the ROM monitor routines, and these changes may affect programs that use the monitor. Approximately 40 standard entry points and routines in the monitor have been documented by Apple Computer, and all these have been left intact and operate correctly, even though the actual code may have changed somewhat. However, some programs use undocumented entry points and these may or may not run properly.

It seems safe to assume that all programs written in higher-level languages will work. Thus, software written in Integer or Applesoft BASIC, FORTRAN, PILOT, Logo, and Pascal should run correctly (providing that no strange monitor CALLs were made), along with CP/M programs that use the standard BIOS (basic input/output system) CALLs. Also, any software sold by Apple Computer will be compatible with the Apple IIe. In addition, a great deal of commercial software has been tested at Apple Computer, and your local dealer should know which products are compatible with the new machine. (If in doubt, you should ask the dealer to demonstrate the program on an Apple IIe before purchase.)

Software

As with most new computers, a great deal of software isn't available yet specifically for the Apple IIe, but the machine doesn't require it. Most of its new features can be applied to make existing Apple II software easier to use. At least initially, the Apple IIe will use the same DOS 3.3 disk operating system that is currently used in the Apple II, although it will probably be repackaged on a new master disk.

Apple Computer Inc. has done a great deal to make writing programs for the Apple IIe as easy as possible. The *Apple IIe Reference Manual* provides precise technical descriptions of every area of the machine, and the built-in memory-management routines will encourage programmers to take advantage of the extended memory option. Because the 80-column firmware acts like a conventional 80-column card in I/O slot 3, programs that use 80-column displays can easily be compatible with both the Apple IIe and the Apple II.

To help programmers identify the type of machine and which options are present, the *Apple IIe Extended 80-Column Text Card Supplement* to the reference manual provides an identification routine, with examples in assembly language, BASIC, and Pascal. To aid outside developers (Apple considers them extremely valuable), 120 Apple IIes were lent to various vendors during the eight months prior to the product introduction. This allowed a large number of software and hardware suppliers to prepare a variety of new products—eighteen programs from ten companies are scheduled for introduction coincidentally with the Apple IIe.

One interesting new program for the Apple IIe is simply called "Apple presents Apple IIe." Primarily a keyboard tutorial, it uses humorous text and excellent graphics to guide you in a friendly fashion through the features of the Apple IIe keyboard. The section that teaches the cursor keys includes two simple but well-designed maze games where you guide a rabbit or gnome through a maze with the cursor-control keys. These made an immediate hit with our 3-year-old, who within 15 minutes was guiding the rabbit through the maze and laughing at its antics when it hit the walls.

Applewriter and Quickfile

Applewriter IIe and Quickfile IIe are Apple Computer's first two major software products that are designed to use all the new Apple IIe features. Both are enhanced versions of the same programs for the Apple III, and both are characterized by being extremely friendly to the user—they provide clear, simple prompts, multiple menus to select options, and numerous "help" screens to guide you through the program operations. Although at the time this article was written (with Applewriter) the documentation was preliminary, it appears to follow the format of the other Apple IIe manuals—clear and friendly.

Applewriter IIe is a document-oriented word processor with numerous editing and print-formatting features. It will run with or without the 80-column display and extended memory options, but will use them if they're present. One of the more interesting features of Applewriter IIe is called WPL (word-processing language). WPL allows you to compose and execute a series of Applewriter commands that are stored in a disk file. It provides looping, conditional execution, and subroutine calls, effectively allowing you to automate the production of form letters, invoices, or other repetitive tasks. WPL also provides a turnkey capability that can be used to automatically execute a WPL program after you load the Applewriter IIe disk.

To get familiar with Applewriter IIe, I used it to prepare this article. I was particularly impressed with the print-formatting capabilities. It was very easy to set up a standard manuscript page—double-spaced, one-inch margins, with headers and footers—and I could preview the actual appearance of the result by printing to the display rather than the printer. It did, however, take me a while to get used to some of the editing features. When you delete characters, words, or paragraphs, Applewriter deletes from right to left. This is fine if you are correcting a mistyped character immediately but seems a little awkward otherwise. On the whole, I liked Applewriter and recommend that you look it over if you are considering purchasing a word processor for your Apple IIe.

Quickfile IIe is an information-filing system (or database manager) that allows you to store and retrieve information, search and sort your files, and print reports in formats that you define. It also has math capability—you could set it up, for example, to file a list of checks and their amounts, and it could also balance your checkbook for you.

Quickfile IIe is also compatible with Applewriter IIe. Quickfile reports can be included in Applewriter documents, and Quickfile files can guide the production of Applewriter form letters. I didn't get a chance to spend much time with Quickfile, but it appears to be very well done, as is most of Apple's software.

Documentation

The new Apple IIe manuals are so good they must be seen to be believed. In a spiral-bound format, slightly larger than the Apple II manuals, they are extremely clear and readable—presenting their information in an easy step-by-step manner. It is obvious that Apple spared no effort or expense when designing them.

The *Apple IIe Owner's Manual* is an excellent example of the right way to introduce a beginner to a first computer. Using clearly written text and numerous color photos, it starts out by telling you how to unpack and set up the computer and then explains the various parts of the system in layman's terms. As you read through the manual, points of special interest and warnings are clearly noted and possible error messages are explained. Nine pages are devoted to the keyboard alone—they describe how to use each of the functions available and how they are commonly used in programs. Further chapters introduce you to the system hardware, the DOS 3.3 disk operating system, the display features, and various computer applications. Other chapters describe

Photo 9: *A look at the* Apple IIe Owner's Manual. *The manuals provided with the Apple IIe set new standards of quality by being comprehensive, very friendly, and by containing numerous color photos to illustrate the text.*

the various computer languages, how to add components to your system, and what to do when you have problems.

This is clearly the first manual a new owner should read, and is also the only manual that is included with the Apple IIe. The new owner picks up the only manual in the box and it tells exactly what to do to get the system up and running. To avoid confusion, all other manuals are optional, and many manuals included with products are available separately. (The *Apple IIe Owner's Manual* is shown in photo 9.)

The *Apple IIe Reference Manual* is an optional manual worth noting. It provides a complete technical description of the machine, and its operation, in detail sufficient to satisfy almost anyone. It provides descriptions of the hardware and special features, instructions for using the monitor, timing diagrams and pinouts of the custom ICs and ROMs, and a complete set of schematics. No self-respecting programmer or experimenter should be without this manual. Apple also provides other manuals, including rewritten Applesoft and DOS manuals and reference

manuals for the Apple IIe and the 80-column boards; see the "At a Glance" text box on page 70.

Conclusions

As you can probably tell, I was impressed with the Apple IIe. The people at Apple Computer had their act together when they designed this machine and it really shows.

I am disappointed that the 80-column cards are not as inexpensive as they were rumored to be; other vendors will probably design less expensive ones. However, with the new keyboard and 80-column display, the Apple IIe can handle just about any task.

The manuals with the system are superb. They are friendly, easy to read, and comprehensive, setting a new standard for the industry to meet.

Applewriter IIe and Quickfile IIe are well-written, useful programs that will find favor with people who wish to use their Apple IIe for word processing and information filing. With these two programs and a spreadsheet (like Visicalc), you could satisfy virtually all your computing needs.

I was most impressed with the balance struck between compatibility and new features, and the obvious care that went into the design. Congratulations, Apple Computer, you've produced another winner. ∎