jr

A Detailed Look Inside the Peanut's Shell

How It Works . . . What It Can Do . . . And Who It's For

By Gary M. Kaplan and William K. Balthrop

When the IBM PCjr was announced this past November, the event drew all of the pomp and attention of a royal birth. Old Big Blue, King of Greater Computerland, finally showed off his youngest progeny, and christened him PCjr. Inhabitants of the kingdom had speculated about a new arrival ever since rumors (and even doubts) of the royal conception started flying nearly one year before. Now a new round of speculation would start up—about a possible rivalry between two famous royal siblings.

PC, the King's first-born, came into the computer world in July of 1981, in a more peaceful and stable era. The King had turned young PC loose in the corporate lands that lay to the west—lands populated by tribes of businessmen newly aware of potential productivity gains with personal computers. Capitalizing on his inherited aggressiveness, swiftness, and muscle, he quickly occupied this fertile frontier. And by the time his younger brother was born, PC had successfully brought a sizable chunk of the New Businessland Territories under his personal flag.

The King's second son, PCjr, was born into a harsher, more cruel world—a world that saw the First Home Computer War take a devastating toll on corporate balance sheets and consumer trust. The wizened King had carefully observed the persistent march of smaller kingdoms as they pushed into the Home Computer Territories—those vast, mostly uncharted lands that lay to the mysterious east. He saw them succumb to repeated sales famines, plagues of inaccurate delivery schedules, and the chaos of faulty quality control. He saw many of their brave crusaders cut down by fierce attacks from marauding bands of retailing and manufacturing price-slashing brigands. It was a land where only the most hardy could survive.

The old King wisely waited until the dust had settled on these bloody battlefields before he sent out the new boy-Prince, PCjr, into the embroiled Territories. The second son's quest: to advance his banner far and wide and bring home the holy grail of dominant market share . . .
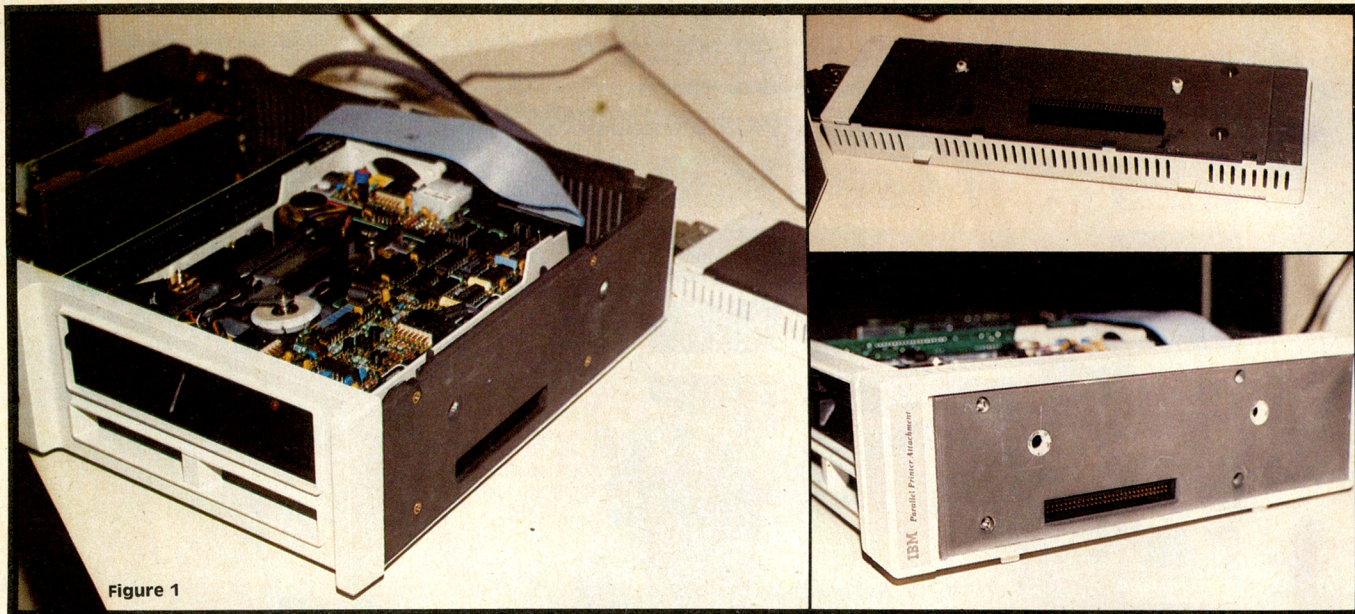
Fig. 1 - A view of the PCjr's right side with the cover panel removed, exposing the I/O expansion bus. Here, the IBM Parallel Printer interface is shown being attached. A feed-through I/O bus connector on each side-mounted peripheral allows additional peripherals to be snapped together on the I/O bus in freight-train style with an "integrated look". The cover panel is then put back in place.

I n a nutshell, the IBM PCjr (code named "Peanut" during its development) is a computing machine with a flexible design architecture. This built-in flexibility allows it to be simultaneously "packaged" as an educational aid, an entertainment device, a home productivity tool, a communications link, and a lower-cost office complement to the IBM PC. It also means that the PCjr can be readily converted into an electronic "black box"—a fully "customizable" machine-servant to humankind.

The architecture of the PCjr is open and straightforward: The machine is constructed of standard, well-proven technology—most of it carried down from its big brother, the PC. And (with the exception of one custom video chip) it is put together with common "off-the-shelf" components and sub-assemblies.

The PCjr is not, however, just a scaled down, smaller version of the PC. In fact, it takes advantage of larger-scale microchip integration that eliminates the need for some adapter cards and improves upon the PC's technical performance and ease of use. For example, the game controller, serial port, light pen interface, enhanced color graphics capabilities, and brand new complex sound generation abilities are located on the computer's main circuit board. In addition, its new (for IBM) capacity for

Fig. 2B — 64K Memory and Display Expansion card required for video graphic screen modes 5 & 6 (including 80-column text); (See Fig. 7)
Fig. 2C — Internal Modem directly connects to phone line; auto-dial, auto-answer, and auto-file updating capability when used with the Personal Communications Manager software package (see Fig. 16).

🥜 IN A NUTSHELL 🥜

System Features of the PCjr:

The Processor & Memory System:
- Intel 8088 Central Processing Unit (CPU) at 4.77 Mhz clock speed—a 16-bit micro-processor with an 8-bit data bus.
- 64K-bytes Read Only Memory (ROM) containing Cassette BASIC, built-in keyboard tutorial, and power-on self-test diagnostics.
- 64K-bytes Random Access Memory (RAM) expandable to 128K-bytes on the system-board; same expansion capability as IBM PC to 640K-bytes RAM via input/output (I/O) expansion bus connector. Memory shared between CPU and video display.

The Sound System:
- 3-channel-plus-noise sound generator with external audio output jack; built-in piezioelectric speaker for time-generated tones, alarm, and keyboard "click"; and audio input capability through cassette port and I/O expansion bus connector.

The Video Graphics System:
- Upward compatible with PC Color/Graphics Adapter running on the IBM PC.
- CRT Page Register with any 16K-byte region of main storage capable of being mapped to the display; updates one page while a different page is being displayed.
- Custom video chip used to read the data and format it for display; 16x4 palette allows quick screen color changes—with only the palette changing, not the data in memory. Includes a separate border-color register.
- 3 video output connectors allow for simultaneous cable hook-up.
  — TV (with RF modulator); color or B/W
  — RGBI direct drive hi-res color video
  — Composite video for color, or monochrome with grey shades.

The Keyboard System:
- 62-key keyboard — detached type, cordless with infrared link and battery operation. Functionally equivalent to 83-key PC keyboard. Color-coded and programmable. Optional keyboard cord ($20). Optional keyboard overlays ($10 for set of 5).

The Input/Output (I/O) System:
- 2 64K-byte ROM cartridge slots.
- 60-pin bus expansion, light pen, serial @ 4800 baud max., plus reserved use.
- Game adapter on the system board for connecting either 2 joysticks or paddles. Optional joysticks ($40 each).
- Cassette Interface for cassette player (optional) — Adapter cable for cassette ($30).

Expansion System Options:
- 64K-bytes Memory and Display Expansion card to increase total system memory to 128K-bytes ($140).
- Parallel Printer attachment, hooks onto side panel ($99).
- Internal Modem card ($199).
- IBM PCjr diskette drive and controller card—360K-bytes, double sided, double density ($480). Operates under DOS 2.1.

Physical System:
- External transformer with 10-foot power cord.
- Weight of system box: less than 6 lbs; less than 9 lbs. with disk drive.
- Dimensions: 13.9" x 11.4" x 3.8"
- Entry Model: keyboard, console with 64K ($669).
- Enhanced Model: keyboard, console with 128K and disk drive; 80-column capability ($1269).
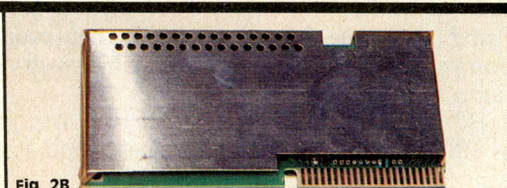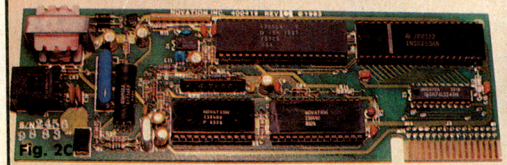

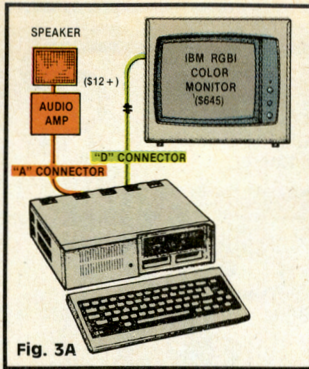**Fig. 2A — IBM Compact Printer**

Fig. 2B

Fig. 2C

Fig. 3A

Notes: Supports all 40/80-column color/monochrome modes; monochrome text has grey shades; compatible RGBI monitor required for 4-color high resolution; no sound without external amp/speaker; "best" for color graphics; "good" for word processing/business. Extras: IBM cable ($20), standard audio cable with RCA plug ($3+).
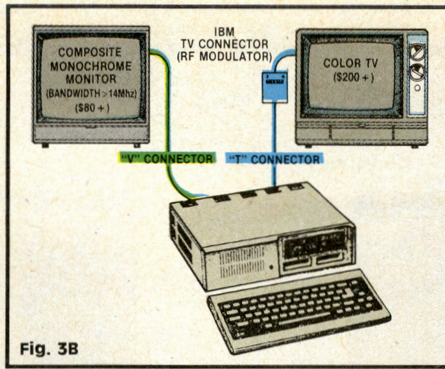
SPEAKER
AUDIO AMP ($12+)
IBM RGBI COLOR MONITOR ($645)
"D" CONNECTOR
"A" CONNECTOR

Fig. 3B

Notes: Different inputs allow simultaneous connections; supports all color/monochrome modes except 4-color at high resolution; "adequate" for color graphics; "best" for word processing/business. Extras: IBM TV connector ($30), standard audio/video cable with RCA plugs ($3+).
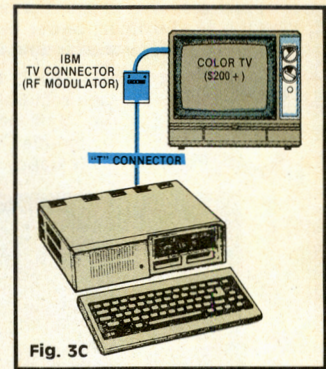
COMPOSITE MONOCHROME MONITOR (BANDWIDTH >14Mhz) ($80+)
IBM TV CONNECTOR (RF MODULATOR)
COLOR TV ($200+)
"V" CONNECTOR   "T" CONNECTOR

Fig. 3C

Notes: 40 columns max; low and medium resolution with 16 colors; "adequate" for color graphics. Extras: IBM TV connector ($30).

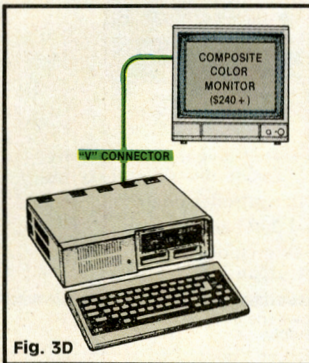IBM TV CONNECTOR (RF MODULATOR)
COLOR TV ($200+)
"T" CONNECTOR

Fig. 3D

Notes: 40 columns max; low and medium resolution with 16 colors; "good" for color graphics; most brands with audio capability — otherwise, separate amp/speaker required (see Fig.3A). Extras: standard audio/video cable with RCA plugs ($3+)
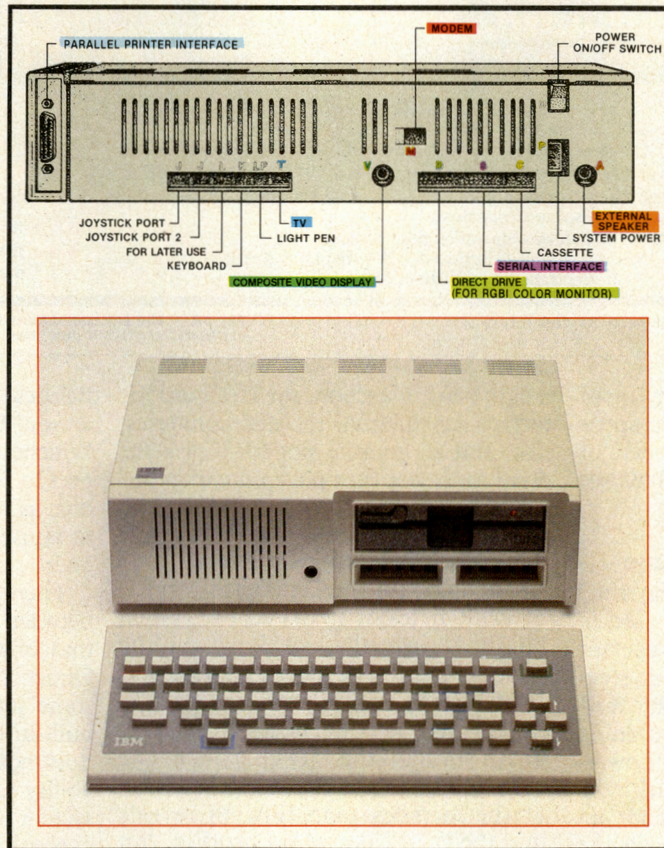
COMPOSITE COLOR MONITOR ($240+)
"V" CONNECTOR

Fig. 3F

Notes: IBM Compact Printer ($175 includes attached cable) operates at 1200-baud; RS232 serial interface supports up to 4800 baud with compatible third-party printers. Extras: IBM Adapter Cable for Serial Devices ($25)

IBM COMPACT PRINTER (THERMAL 1200 BAUD; $175)
OTHER 3RD-PARTY SERIAL PRINTERS ($150+)
"S" CONNECTOR (RS232 SERIAL; UP TO 4800 BAUD)

Fig. 3H

Notes: External modem is practical if already have 300-baud modem and don't need the serial port for printer, or if needs require 1200-baud communication with a higher-speed modem. Extras: IBM Adapter Cable for Serial Devices ($25), standard telephone junction adapter ($3+)

ACOUSTIC COUPLER (MODEM) FOR PHONE HEADSET
OR DIRECT CONNECT MODEM
"S" CONNECTOR (RS232 SERIAL; 300 BAUD OR 1200 BAUD)
TELEPHONE JUNCTION ADAPTER
TELEPHONE LINE IN WALL

PARALLEL PRINTER INTERFACE
MODEM
POWER ON/OFF SWITCH
JOYSTICK PORT
JOYSTICK PORT 2 FOR LATER USE
KEYBOARD
TV
LIGHT PEN
COMPOSITE VIDEO DISPLAY
EXTERNAL SPEAKER
SYSTEM POWER
CASSETTE
SERIAL INTERFACE
DIRECT DRIVE (FOR RGBI COLOR MONITOR)

Figure 3
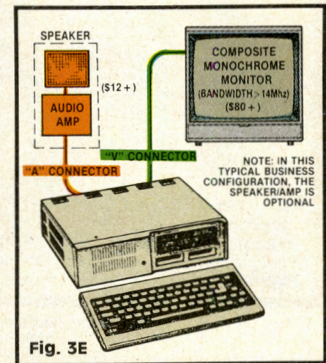**Options for PCjr System Configurations**

Fig. 3E

Notes: 80-column requires band width >14Mhz; grey shades; "best" for word processing, spread sheets, and business applications; most versatile in combination with color TV (see Fig.3B). Extras: Standard audio/video cable with RCA plugs ($3+).
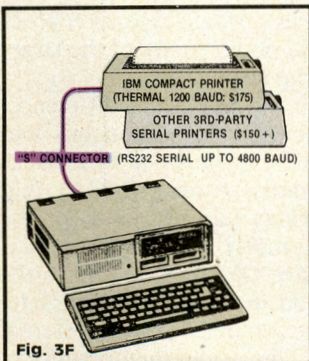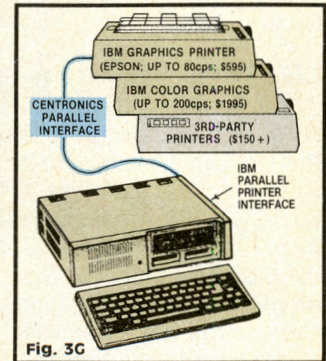
SPEAKER
AUDIO AMP ($12+)
COMPOSITE MONOCHROME MONITOR (BANDWIDTH >14Mhz) ($80+)
"A" CONNECTOR
"V" CONNECTOR
NOTE: IN THIS TYPICAL BUSINESS CONFIGURATION, THE SPEAKER/AMP IS OPTIONAL

Fig. 3G

Notes: Parallel Printer Interface ($99) supports parallel ("Centronics-compatible") printers and plotters and other output devices. Extras: Common parallel cable with DB25 connectors ($25+), or IBM parallel cable ($55).
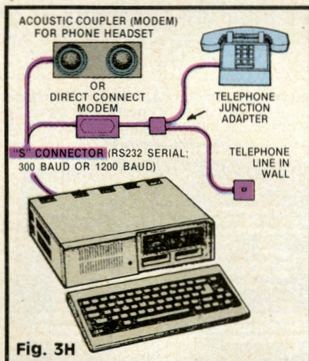
IBM GRAPHICS PRINTER (EPSON; UP TO 80cps; $595)
IBM COLOR GRAPHICS (UP TO 200cps; $1995)
3RD-PARTY PRINTERS ($150+)
CENTRONICS PARALLEL INTERFACE
IBM PARALLEL PRINTER INTERFACE

Fig. 3I

Notes: IBM Internal Modem is practical if serial port is needed for a printer or other peripheral, and if 300 baud is a satisfactory rate of communication. Works with rotary and touch-tone telephones. Extras: Standard telephone junction adapter ($3+).

TELEPHONE LINE IN WALL
TELEPHONE JUNCTION ADAPTER
TELEPHONE LINE IN WALL
"M" CONNECTOR
IBM INTERNAL MODEM (300 BAUD)

How to Buy a PCjr System

As you can see from the diagrams and annotations on this page, it's not just a simple matter of "hooking up" your PCjr right out of the box and starting to compute. Choosing the appropriate monitor(s) and modem/printer combination is a non-trivial matter. Our advice is to read the entire PCjr article, study this page, and give it plenty of thought. Then, you'll be ready to choose wisely.
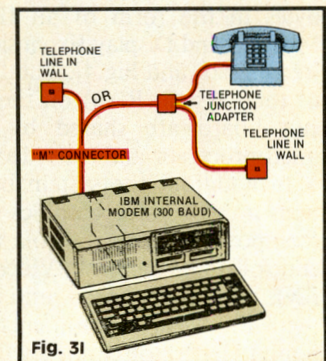
Incoming power from Step-down transformer (16.7 volt AC out   110 volt AC in)

Power Supply Board
Motorola 6845 CRT Controller (produces video signals for TV or monitor)
Mounting Holes for floppy disk drive
Intel 8088 Central Processing Unit (16-bit microprocessor)
Input/Output Bus for expansion (Parallel Printer Adapter & future accessories connect here)

TI Complex Sound Generator (underneath power supply board)

64K ROM cartridge slots (2)
64K system ROM chips (containing power-up Cassette BASIC, self-test diagnostics, & keyboard tutorial)
Receiver for infrared keyboard signal
3 expansion Slots (for disk controller, internal modem, 64K memory & display expansion)
Video Gate Array (Custom chip takes data from memory and formats color/resolution for the display)
64K RAM chips (for program, data and screen memory)

Half-height 5¼ disk drive for double-sided diskettes
Disk controller board
Internal 300-baud modem
IBM 64K memory and display expansion board
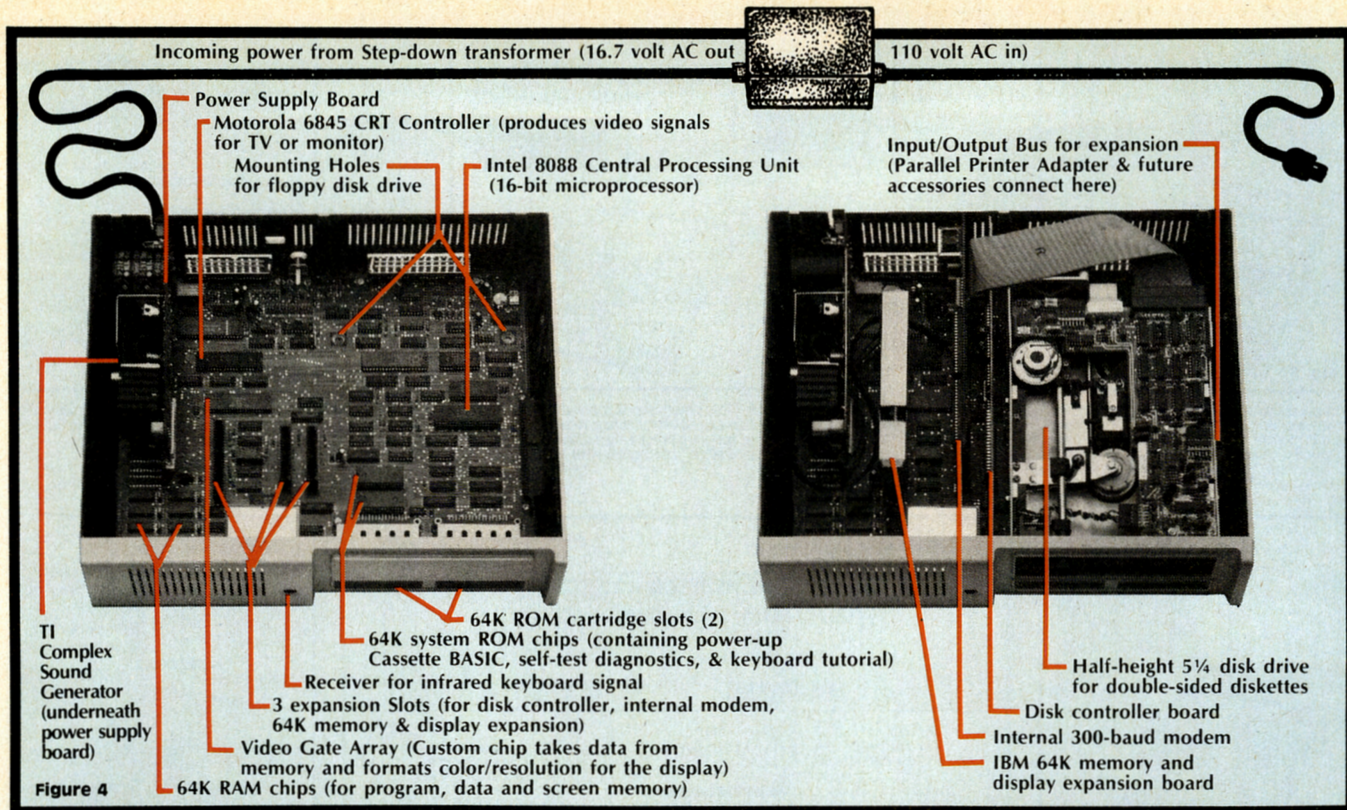
Figure 4

Fig. 4A — The Entry Model PCjr with its connectors and expansion slots clearly visible.

Fig. 4B — The Enhanced Model shows the placement of the 3 expansion cards and disk drive assembly.

accepting and utilizing 128K-bytes of plug-in ROM cartridge software opens the way for an infinite number of machine personalites, as we shall see later.

Like Father, Like Son—Almost

The brain of the PCjr is the Intel 8088, the same microprocessor used in the PC family. It is a 16-bit processor with an 8-bit data bus. The system board [see Fig. 4] also has 64K-bytes of Read-Only Memory (ROM) containing the Basic Input/Output System, power-on diagnostics, user diagnostics, the Cassette BASIC language, and an animated *Keyboard Adventure* on the use of the 62-key keyboard. There are also 64K-bytes of Random Access Memory (RAM) on the system board, plus a connector for an additional 64K-bytes in the form of an IBM 64KB Memory and Display Expansion Option [see Fig. 2B and Fig.4]. The 128K-bytes of total system RAM on the PCjr circuit board are shared by the 8088 microprocessor and the video circuitry.

In addition, the system board contains a color video graphics subsystem (composed of the Motorola 6845 CRT controller and a custom Video Gate Array), a multi-channel sound subsystem (with the Texas Instruments Complex Sound Generator chip), an I/O expansion bus [see also Fig. 1], a 128K-byte ROM cartridge interface, plus six accessory interfaces (a game adapter for joysticks/paddles, an RS232 serial port, a light pen connection, the keyboard interface, an internal modem connector slot, and an internal slot for a diskette drive controller card plus mountings for a half-height 5¼-inch diskette drive).

The Memory Is Not Peanuts

The limit (in the Enhanced Model) of 128K-bytes of RAM on the system board is just that—*a limit on the system board.* The design engineers at IBM have actually provided the I/O expansion bus with most of the same lines found on the I/O channel of the models PC and XT. An examination of the memory map [Fig. 6] reveals that the PCjr, like its big brother, can address up to 640K-bytes of RAM. For such an expansion, the memory chips would be situated on a separate board connected to the PCjr's right side—in the same way that the IBM Parallel Printer Interface is connected [Fig. 1].

It is feasible that just about any feature which can be added to the IBM PC and XT can also be added to the PCjr. Of course, there are restrictions on the size, amount of power required, and manner of implementation, but most of these can be worked around. The signals passing through this I/O channel have sufficient drive to support five expansion adapters (in addition to the internal modem and diskette controller), each with one standard TTL load per attachment. This means that users will see *many* expansion peripherals produced for the PCjr.

Besides extra RAM boards, diskette drives, bubble memory storage, and Winchester fixed-disk drives, we can expect to see hundreds of exotic new add-ons, as well as separate expansion boxes to house and power many of the larger boards at the same time.

There are two important differences between the PCjr expansion bus and that of the PC: The PCjr's bus lacks Direct Memory Access (DMA) and some interrupts (already used for the built-in interfaces). Although the PCjr does not have DMA, it does have the ability to add it (and allow its diskette system to be run under it) with external expansion. This would then permit applications programs to *overlap* diskette I/O operations as is done on its bigger brother, the PC. Having DMA lets a computer accept typewritten input or communicate *while* it is reading from or

Fig. 5 — This master screen appears when the system is "powered up." After the resident memory is checked, the total number of system bytes appears in the window.
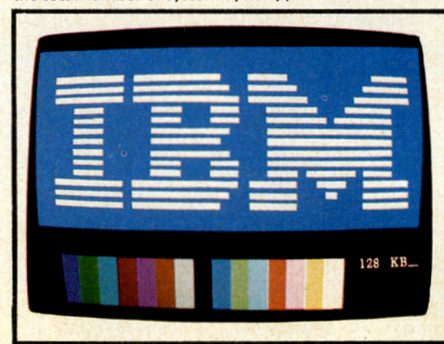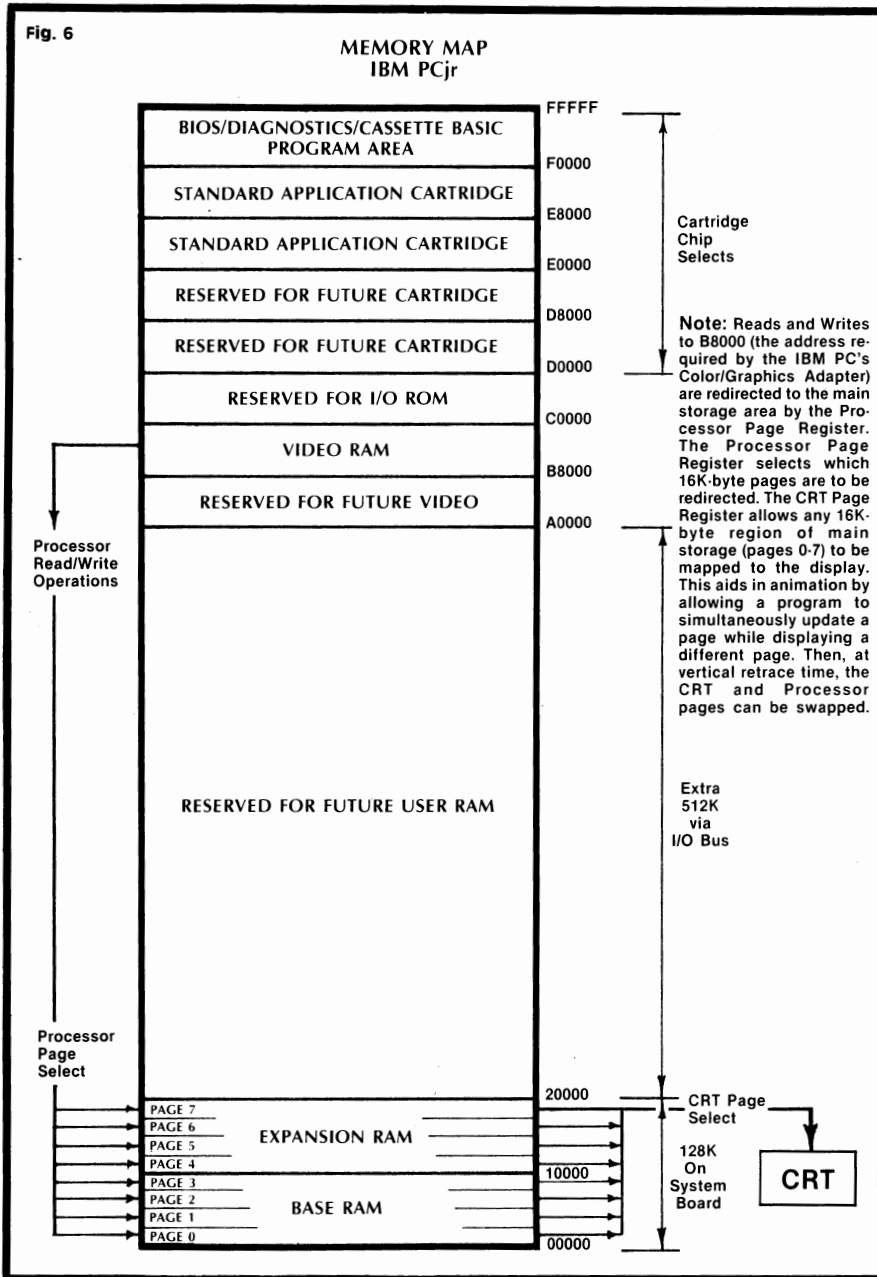
Fig. 6

MEMORY MAP
IBM PCjr

BIOS/DIAGNOSTICS/CASSETTE BASIC PROGRAM AREA	FFFFF
	F0000
STANDARD APPLICATION CARTRIDGE	E8000
STANDARD APPLICATION CARTRIDGE	E0000
RESERVED FOR FUTURE CARTRIDGE	D8000
RESERVED FOR FUTURE CARTRIDGE	D0000
RESERVED FOR I/O ROM	C0000
VIDEO RAM	B8000
RESERVED FOR FUTURE VIDEO	A0000
RESERVED FOR FUTURE USER RAM	
	20000
PAGE 7 / PAGE 6 / PAGE 5 / PAGE 4 — EXPANSION RAM	
PAGE 3 / PAGE 2 / PAGE 1 / PAGE 0 — BASE RAM	10000
	00000

Processor Read/Write Operations

Processor Page Select

Cartridge Chip Selects

Note: Reads and Writes to B8000 (the address required by the IBM PC's Color/Graphics Adapter) are redirected to the main storage area by the Processor Page Register. The Processor Page Register selects which 16K-byte pages are to be redirected. The CRT Page Register allows any 16K-byte region of main storage (pages 0-7) to be mapped to the display. This aids in animation by allowing a program to simultaneously update a page while displaying a different page. Then, at vertical retrace time, the CRT and Processor pages can be swapped.

Extra 512K via I/O Bus

CRT Page Select

128K On System Board

CRT

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cessory as is done with the PC. The graphics implementation is an enhanced version of the PC's Color/Graphics Adapter card. The PCjr differs, however, in that system memory is *shared* between the processor and display. There are two distinct operating modes: (1) alphanumeric and (2) graphic [see Fig. 6]. These are further broken down into seven screen modes (two alphanumeric and five graphic)—each with a unique set of memory requirements, colors, and resolutions. [The resolution of a display is measured in picture elements called "pixels." On the PCjr's screen, each pixel is a small rectangle of light that is either turned on or off, or given one of the 16 unique colors. The resolution of a screen is expressed in dimensions of pixels horizontally by pixels vertically—Ed.]

The microprocessor and video display share the 64K-bytes of RAM on the PCjr system board, accessing the data 8 bits at a time. This supports the 40-column alpha mode and 3 of the graphics modes: 160×200 (low resolution) with 16 colors, 320×200 (medium resolution) with 4 colors, and 640×200 (high resolution) with 2 colors. This means that the Entry Model of the PCjr (for $669) *cannot* display 80 columns of text, medium resolution graphics with more than 4 colors, or high-resolution graphics with more than 2 colors.

If the 64KB Memory and Display Expansion Option (included with the diskette drive and controller board in the Enhanced Model for $1269) is installed on the PCjr, the memory is reconfigured so that all the *even* bytes reside on the system board, and all the *odd* bytes reside on the expansion card. This means that the data is accessed 16 bits at a time instead of just 8. With the PCjr's architecture, this "double fetch" [a discussion of bandwidth constraints is beyond the scope of this article—Ed.] allows it to support 80-column alpha, 320×200 (medium resolution) with 16 colors, and 640×200 (high resolution)

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writing to the diskette—resulting in faster throughput without noticeable "wait states." Although this lack of DMA is probably not too significant for most home users, accessory devices that add the capability will be in demand for more serious, business-oriented applications.

Saying It With Pictures
The color graphics capabilities of the PCjr are built-in, not added as an ac-

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Fig. 7
Video Graphics Modes Available On The PCjr

Screen Mode	Resolution	Video Memory Required	Available Colors	64K Expansion Required	Cartridge BASIC Required	Compatible With IBM PC Color/Graphics Adapter
0	40/80 Column Alpha	2K/4K	16/16	NO/YES	NO/NO	YES/YES
∗ 1	320×200	16K	4	NO	NO	YES
2	640×200	16K	2	NO	NO	YES
3	160×200	16K	16	NO	YES	NO
∗ 4	320×200	16K	4	NO	YES	NO
5	320×200	32K	16	YES	YES	NO
6	640×200	32K	4	YES	YES	NO

∗ **Note:** Mode 4 (only available on PCjr) has a variable palette whereas Mode 1 (compatible with PC) does not.

Screen Mode: the video graphics mode set with the SCREEN command.

Resolution: the screen resolution. The first value on the chart is the number of horizontal pixels, and the second number is the number of vertical pixels.

Video Memory Required: buffer size specifies the amount of memory needed to use the mode specified. Mode 0 is a special case in which two values are given. The first value refers to a 40-column screen and the second to an 80-column screen.

Available Colors: the number in this column indicates the maximum number of colors which can be displayed on the screen at any one time.

64K Expansion Required: some modes require more memory to store the screen contents than others. In these cases (indicated by YES on the chart) the 64k Memory Expansion must be installed.

Cartridge BASIC Required: a YES indicates that this mode is unavailable through Cassette BASIC.

Compatible with IBM Color/Graphics Adapter: YES indicates compatibility with PC equipped with this board.

```
100 REM NEW SCREEN MODES FOR THE PCjr
110 REM
120 REM RESERVE 32K OF MEMORY FOR THE D
    ISPLAY
130 REM
140 CLEAR ,,,32768!
150 REM
160 REM SELECT MEDIUM RESOLUTION (320x2
    00) WITH 16 COLORS
170 REM
180 SCREEN 5
190 REM
200 REM SELECT A RED FOREGROUND ((4)), AN
    D WHITE BACKGROUND ((15))
210 REM
220 COLOR 4,15
230 REM
240 REM SELECT HIGH RESOLUTION (640x200
    ) WITH 4 COLORS
250 REM
260 SCREEN 6
270 REM
280 REM CHANGE PALETTE COLOR #2 TO RED
    ((4))
290 REM
300 PALETTE 2,4
310 END
```

with 4 colors. To see this last high-resolution mode properly (Screen Mode 6) requires a compatible RGBI monitor [see Fig. 3A]. Because most of the mountain of forthcoming third-party educational, entertainment and productivity software will undoubtedly be requiring the versatility of either 16-color medium resolution or 80-column text displays, the 128K-byte Enhanced Model will be the standard in the PCjr world.

The PCjr offers its programmers a rich development environment—especially in 16-color medium-resolution mode (Screen Mode 5). The 320 pixels of horizontal resolution by 200 pixels in the vertical direction allow well-defined graphic images. There is, however, a small price to pay—you must allocate 32K-bytes of your total 128K-bytes of system RAM to the video display. You do this in Cartridge BASIC with the statement:

CLEAR ,,,32768

# A Sound Comparison Between the PCjr and TI-99/4A

Although the TI-99/4A and the IBM PCjr use the same Texas Instruments sound chip, there are major differences in the way each system creates sound or music. TI BASIC uses a single command—CALL SOUND—to create both sound effects and music. IBM PCjr Cartridge BASIC has three different commands—SOUND, NOISE, and PLAY—that control the sound chip.

The PCjr's SOUND command is similar to the TI command CALL SOUND. Both let you specify the frequency, duration, and volume of a tone. The difference is that with the TI command you can specify all three voices plus the noise channel within a single command. All three tones and the noise that are created will have the *same* duration. On the PCjr, *each* of the three voices is activated with a separate SOUND command, and the noise channel is activated with NOISE. This may seem awkward at first, but it has its advantages: Because the individual voices are set up with their own SOUND commands, each voice can have a *different* duration.

PCjr Cartridge BASIC has a third command—PLAY—which is unlike anything found in TI BASIC. The PLAY command lets you set up a string of sub-commands to compose music with the actual notes (instead of by frequency). A program can play three of these command strings at the same time, with each string controlling one of the three voices. The noise channel can't be directly inserted into the PLAY command, but if the music is playing in the background mode (e.g., the program continues while the music buffer plays), then the NOISE command can be used to mix noise with the three voices. The placement of the noise within the music chain of commands can be calculated by testing one of the three voices to determine the number of notes left in the buffer. When the program is creating sounds or playing music in the foreground mode, the statement that is creating the sound must finish executing before the program proceeds to the next statement.

Explanation of the Sample Program

Line No.	Purpose
100	Turns on the sound chip and turns off the internal piezoelectric speaker.
110	Places the sound in background mode. All sounds created with the SOUND command and PLAY command will be placed in the music buffer.
120	Places a tone in the music buffer with a frequency of 110Hz, a duration of 20 clock ticks (each clock tick is 18.5 ms.), and a volume of 15. The output is to voice #0.
130	Places the string of music commands into the default music buffer (voice #0). These notes follow the tone created in line 120 because they are on the same voice channel.
140	Places a tone of 220Hz in the music buffer for voice #0 following the PLAY command string from line 130.
150	Places a tone of 440Hz into the first position of the music buffer for voice #1. This tone will start at the same time that the tone from line 120 starts because they are in the same position in the music buffer.
160	Tests the buffer for the number of remaining unplayed notes.
170	When the number of notes left reaches four, the program branches to line 190. Subroutine returns; program halts.
180	Continues checking the buffer.
190	Places a tone of 440Hz in the music buffer for voice #1. This note will start to play when there are four notes left in the buffer for voice #0.
200	Places a tone of 880Hz into the buffer for voice #2. This tone will play at the same time as the tone from line 190 and the note G from voice #0.
210	Turns on the noise generator at the same time as the tones in lines 190, 200, and the note G in voice #0.
220	Exits the subroutine.

BACKGROUND MUSIC BUFFER
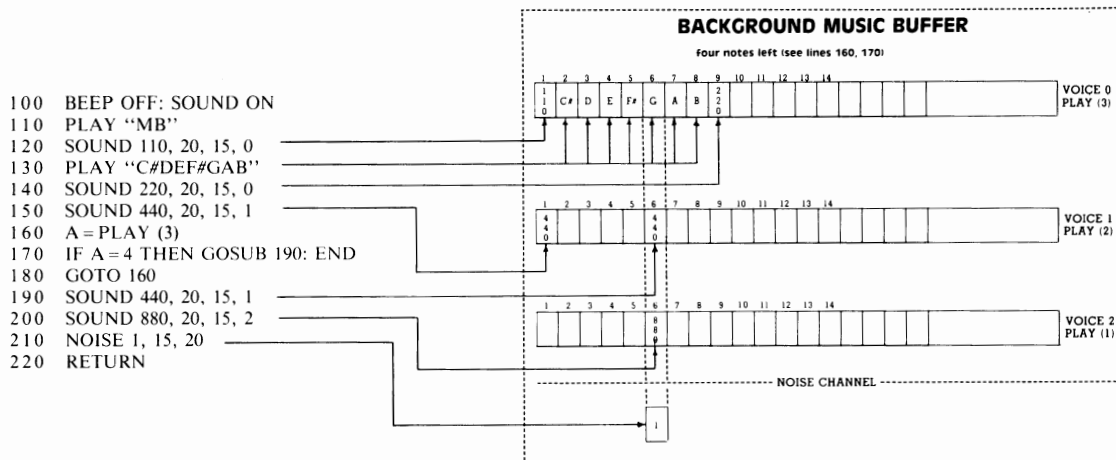
```
100 BEEP OFF: SOUND ON
110 PLAY "MB"
120 SOUND 110, 20, 15, 0
130 PLAY "C#DEF#GAB"
140 SOUND 220, 20, 15, 0
150 SOUND 440, 20, 15, 1
160 A = PLAY (3)
170 IF A = 4 THEN GOSUB 190: END
180 GOTO 160
190 SOUND 440, 20, 15, 1
200 SOUND 880, 20, 15, 2
210 NOISE 1, 15, 20
220 RETURN
```
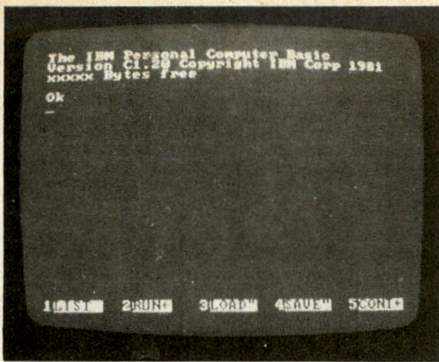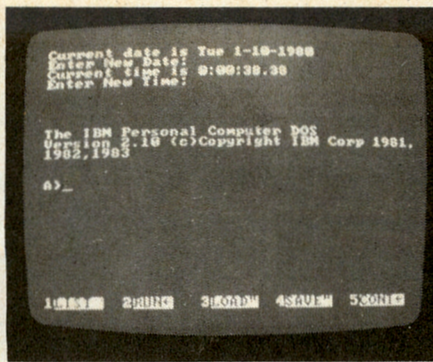
Fig. 10A — Cassette BASIC initial screen

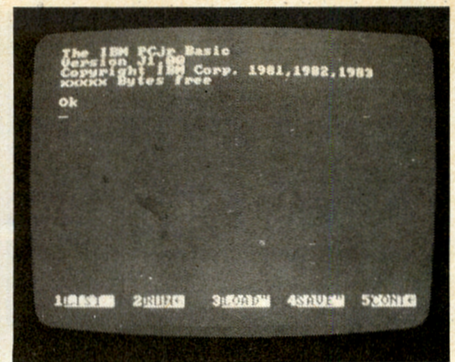**Fig. 10B — DOS 2.1 initial screen**

Fig. 10C — Cartridge BASIC initial screen

The labels across the bottom of each screen correspond to the first five function (FN) key-press sequences—e.g., pressing the FN key together with the number 2 key is the equivalent of typing in the letters R, U, and N, and then pressing the ENTER key. Up to 10 (in 80 column mode) user-defined keystroke sequences may be programmed in to appear in the bottom windows with the KEY command. The number of bytes appearing in screens 10A and 10C depend on system configuration (e.g., with Cartridge BASIC on the standard 64K-byte system, there are 42,210 bytes free and on the 128K-byte system there are 60,130 bytes free).

On the IBM PC, a *separate* bank of memory (16K-bytes) situated on the Color/Graphics Adapter card is used to map the color display. The PC is, however, limited to only 4 colors in medium resolution mode.

Because there is no built-in sprite capability [for smoothly moving graphic shapes that have a color and location anywhere on the screen, and can be set in motion at a variety of speeds—Ed.] as on the TI-99/4A or Commodore 64, programmers must approach the PCjr differently to achieve "spritely" effects. Fortunately, the 16-bit microprocessor offers great speed. This—coupled with the PCjr's CRT Page Register, custom Video Gate Array and an architecture that allows virtually *all* of the system's 128K-bytes of RAM (in 16K byte "pages") to be available for display purposes [see Fig. 6]—permits very impressive color animations to be put on the screen.

IBM's custom microchip, the Video Gate Array, takes the data from memory and formats it for display. It contains a "palette" (16 word × 4 bit) which assigns color to the data. For example, in the 4-color medium-resolution mode, the palette allows the programmer to select any 4 colors out of the 16 possible. It also allows the program to quickly change the colors of the screen image by modifying the palette rather than memory data. [To learn how you can use this technique to create exciting animation, see our next issue—Ed.]

And finally, this versatile Video Gate Array also controls the screen's border color. Its border-color register is independent of the palette, and allows the program to select 1 out of 16 possible colors.

There are 3 types of output on the PCjr to get the video images to a screen: (1) RGBI direct drive video for IBM's Color Monitor or other compatible

RGB monitor, (2) composite video for black/white or color composite monitors, and (3) hook-up to a standard TV via IBM's RF modulator [see Fig. 3].

Big Sound from Small Peanuts

The sound system in the PCjr is built around an "analog multiplexer" which allows one of four different sound sources to be selected, amplified, and sent to the audio outputs. Hiding under the power supply card on the left side of the system board [see Fig. 4A] is the first of the sources, the Complex Sound Generator. This is the small Texas Instruments chip (also found in the TI-99/4A) with the really "big" sound—three programmable frequencies which can be mixed to form chords, plus a white noise generator for special effects. Each of the channel's volume levels may be individually controlled, and each may be given separate durations. There is, however, no Attack, Decay, Sustain, and Release (ADSR)

Fig. 11 — Commands included in the two BASIC dialects (inner rectangle for Cassette BASIC and the *sum* of the three rectangles for Cartridge BASIC) available for the PCjr. The commands found within the two inner "shells" are "sub-sets" of Cartridge BASIC (it being the "super-set"). BASICA is the Advanced BASIC on disk for the IBM PC.

Commands Added to BASICA with IBM Cartridge BASIC

Commands Added to Cassette BASIC Through BASICA on the IBM PC

IBM Cassette BASIC Commands

|							
ABS	DELETE	LEFT$	PEEK	SIN	CHDIR	ON KEY(n)	NOISE
ASC	DIM	LEN	PEN	SOUND	CIRCLE	ON PEN	PALETTE
ATN	EDIT	LET	POINT	SPACE	COM	ON PLAY(n)	PALETTE USING
AUTO	END	LINE	POKE	SPC	COMMON	ON STRIG	PCOPY
BEEP	EOF	LINE INPUT	POS	SQR	CVI	ON TIMER	PLAY OFF
BLOAD	ERASE	LINE INPUT#	PRINT	STICK	CVS	OPEN "COM	PLAY ON
BSAVE	ERR	LIST	PRINT USING	STOP	CVD	PAINT	TERM
CALL	ERL	LLIST	PRINT#	STR$	DATE$	PLAY	
CDBL	ERROR	LOAD	PRINT#USING	STRIG	DRAW	PLAY(n)	
CHAIN	EXP	LOCATE	PSET	STRING$	FIELD	PMAP	
CHR$	FIX	LOG	PRESET	SWAP	FILES	PUT files	
CINT	FOR-NEXT	LPOS	RANDOMIZE	SYSTEM	GET files	PUT graphics	
CLEAR	FRE(0)	LPRINT	READ	TAB	GET graphics	RESET	
CLOSE	GOSUB	LPRINT USING	REM	TAN	KEY(n)	RMDIR	
CLS	GOTO	MERGE	RENUM	TRON	KILL	STRIG(n)	
COLOR	HEX$	MID$	RESTORE	TROFF	LOC	TIME$	
CONT	IF-THEN	MOTOR	RESUME	USR	LOF	TIMER	
COS	INKEY$	NEW	RETURN	VAL	LSET	VARPTR$	
CSNG	INP	OCT$	RIGHT$	VARPTR	MKDIR	VIEW	
CSRLIN	INPUT	ON ERROR	RND	WAIT	MKI$	WINDOW	
DATA	INPUT#	ON GOSUB	RUN	WHILE	MKS$		
DEF FN	INPUT$	ON GOTO	SAVE	WEND	MKD$		
DEF SEG	INSTR	OPEN	SCREEN function	WIDTH	NAME		
DEF type statement	INT	OPTION BASE	SCREEN statement	WRITE	ON COM(n)		
DEF USR	KEY	OUT	SGN	WRITE#			
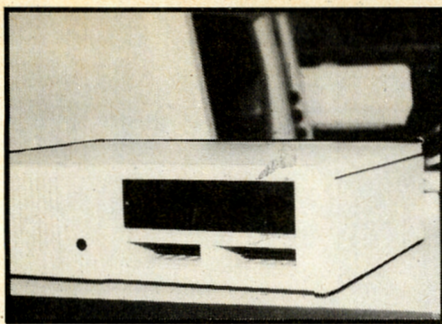
Fig. 12 — View of the two empty 64K ROM cartridge slots and slim-line disk drive. Cartridges may contain applications programs, data files, languages, and even completely new operating systems to "customize" the machine.
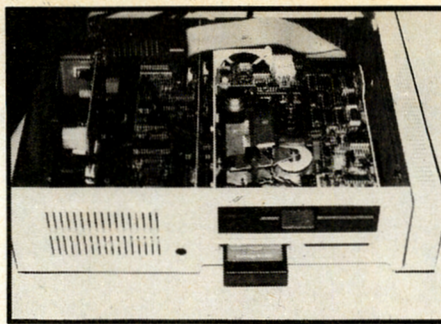

Fig. 13 — Cartridge BASIC in one of the two available 64K slots. With the language residing on a ROM cartridge rather than on disk, a much larger amount in the memory of a 64K Entry Level System is available to the user.

AN IBM PC/PCjr COMPATIBILITY SAMPLER
A LOOK AT WHICH PC SOFTWARE RUNS ON THE PCjr

Program Name/Version	Cartridge BASIC Required
EDUCATION	
Adventures In Math/1.00	YES
Arithmetic Games (Set 1 & 2)/1.00	YES
Note: No Color on composite monitor	
Bumble Games/1.00	YES
Bumble Plot/1.00	YES
Juggles' Butterfly/1.00	YES
LOGO/1.00	NO
Monster Math/1.00	YES
Turtle Power/1.00	NO
ENTERTAINMENT	
Adventure/1.00	NO
Note: Can't set foreground/background colors	
Adventure in Serenia/1.00	NO
Note: Colors may vary from IBM PC	
Casino Games	YES
Strategy Games	YES
PRODUCTIVITY	
Dow Jones Reporter/1.00	YES
Easy Writer/1.15	NO
Note: Requires compatible 80-column display	
Home Budget, jr/1.00	YES
HomeWord/1.00	NO
Multiplan/1.00	NO
PeachText/1.00	NO
Note: Requires compatible 80-column display; not recommended for PCjr	
Personal Communications Manager/1.00	NO
Personal Editor	NO
pfs: FILE/1.05	NO
Note: Requires compatible 80-column display	
pfs: REPORT/1.05	NO
Note: Requires compatible 80-column display	
Professional Editor/1.00	NO
Note: Requires compatible 80-column display	
Time Manager/1.05	NO
VisiCalc/1.20	NO
Word Proof/1.00	NO
UTILITY & LANGUAGE	
Animation Creation/1.00	NO
Note: Runs on 64K-byte PCjr	
Basic Compiler/1.00	NO
Note: Requires sufficient storage for Compile & Link	
BASIC Programming Development System/1.05	NO
Not recommended for PCjr	
Diskette Librarian/1.00	YES
File Command/1.00	NO
Requires compatible 80-column display	
Macro Assembler/1.00	NO

OPERATES ON PCjr — These disk-based programs distributed by IBM for the PC will run on a PCjr with 128K-bytes of memory and a single disk drive.

DOES NOT OPERATE ON PCjr

EDUCATION	*UTILITY & LANGUAGE	
Multiplication Tables/1.00	Asynchronus Communications/2.00	
Private Tutor/1.00	BASIC Primer/1.00	
Typing Tutor/1.00	Learning DOS 2.00/1.00	
	Learning to Program in BASIC/1.00	
PRODUCTIVITY	**ENTERTAINMENT**	
BPI Accounting Software	Decathlon /1.00	
Fact Track/1.00	101 Monochrome Mazes/1.00	
Mail List Manager/1.00		
Peachtree Accounting Software		

* Note: Compiler output from COBOL, FORTRAN, and Pascal Compilers (1.00) will run on PCjr if sufficient storage; p-system products will not operate on PCjr.

envelope generator for "fine tuning" the quality of the sound as is found in the Commodore 64.

The second sound source is a "timer channel." It counts the internal clock "ticks" and can provide single tones to the small piezoelectric speaker found in both the PCjr and PC.

The third sound source is the audio from a cassette player. This allows the audio information from cassette tapes to be routed through to the audio outputs.

The last source is audio input over the I/O channel through a pin in the bus expansion connector (on the right side of the system box). This was put in to accommodate the addition of speech and other audio features.

Plug-In Peanut Power

The use of ROM cartridges as program media for home computers is nothing new. In fact, the practice goes back several years. Texas Instruments was the first to offer them; Commodore and most of the others soon followed suit. The PCjr's cartridge interface is, however, unique in three important aspects. First, it is the *program* in the cartridge that decides where in the memory map [see Fig. 6] the program will place itself. [This is accomplished by wiring the desired "chip select" to the ROM modules inside—Ed.]

Second, the PCjr provides *two* cartridge slots that are able to handle a total of up to 128K-bytes of ROM—enough memory to contain very sophisticated, complex application programs. With two cartridges inserted simultaneously, it becomes feasible to set up large data bases on the PCjr. One cartridge slot can accommodate the program, while the second accepts data from a series of several cartridges. A one-disk system configured this way would be very powerful, indeed—and in many cases would out-perform a conventional twin-disk system. It also should be said that putting programs in ROM cartridge form may be the *only* way some software developers will ever truly be satisfied with the performance of their PCjr implementations. This is because many programs executing out of the 128K-bytes of RAM pay a speed penalty due to the sharing of memory with the display.

The third unique aspect of this cartridge interface is the ability to disable the systems board's own 64K-bytes of ROM and replace it with ROM on a cartridge. This allows the cartridge-based program to gain control of the system at power-on time, and to replace the entire Basic Input/Output System (BIOS), Cassette BASIC, *Keyboard Adventure*, and everything else residing in the pair of 32K-byte system ROMs.

This last feature of the cartridge interface has significant implications. It makes it possible to turn the PCjr into an entirely different computer—from a general-purpose machine into a dedicated device. For example, the right programming (and peripherals) could have the machine taking telephone orders, controlling laboratory instrumentation, or keeping tabs on your home's security and energy efficiency. [This customization ability, used in conjunction with the machine's excellent "interrupt handling" facility, provides this home computer with the power and versatility to finally tackle some non-trivial applications in a home environment. In this regard, the major difference here between the PCjr and its predecessors is that the PCjr supports "event trapping." Its interrupt timer can be programmed (through Cartridge BASIC) to stop a running program at a specific time, prompt for something, branch to a specific routine, then continue. If external devices are connected, they can be ignored until this programmable interrupt occurs. Without event trapping, a program must continuously interrogate the system clock to get an accurate time period—Ed.]

Finally, it should be noted that whenever a cartridge is inserted or removed from a system slot, a momentary grounding of one pin causes the system to reset and go through a warm power-up. Any data in the system RAM will be lost.

Split-Level BASIC

The PCjr BASIC interpreter is structured in two functional levels: (1) Cassette BASIC, and (2) Cartridge BASIC. Cassette BASIC is built into the ROMs on the system board, and is operational when the power is first turned on. It not only handles the tape recorder operation, but also supports the keyboard, display, printer, joysticks and light pen, plus a full load of logic, math, string, and editing functions. [See Fig. 11.]

Cartridge BASIC is optional ($75), and plugs into one of the two cartridge slots on the front of the system unit [see Fig. 12 and Fig. 13]. It is a more powerful version of the disk-based Advanced BASIC (known as BASICA) for the PC. As shown in Figure 11, Cartridge BASIC is the super-set of both Cassette BASIC and BASICA. Most of its language extensions can be used without a diskette system but it also supports the diskette, and its structured directories, date, and time.

As you can see in Figure 7, Cartridge BASIC supports the PCjr's new enhanced screen modes 3 through 6. It also supports: the new statements PALETTE and PALETTE USING; an enhanced CLEAR statement that allows you to increase/decrease your video memory page size (with default at 16K-bytes); the enhanced sound capabilities [see Fig. 9] with SOUND, PLAY, and NOISE commands; and a terminal emulation mode (with the TERM subprogram) for simple RS232 asynchronous communications as well as both internal and external modem support.

In our view, Cartridge BASIC is a *MUST* for all PCjr users. Without it, the only way to get at the machine's rich graphics, sound, communications, and event-trapping capabilities is through assembly language programming—certainly possible, but definitely *not* for the general audience for which this machine is intended. Furthermore, most—if not all— of the commercial software written in BASIC for this machine will require the cartridge version to run.

Examine some of the program listings for the PCjr in this issue of *Home Computer Magazine*, and you will start to see the power and versatility of this new dialect of BASIC.

At Home With DOS

The Disk Operating System (DOS) of the PCjr is IBM's new DOS 2.1, an enhanced release of 2.0 for the PC and XT models. DOS 2.1 is the link between the systems hardware and the disk-based software that you choose to feed in. All DOS commands are supported in the 64K-byte Entry Model environment of PCjr, so the expansion memory is not

Fig. 15 — **Two IBM sales demonstration screens** show some of the graphic special effects possible on the PCjr. These were programmed on a 128K system in screen mode 5.
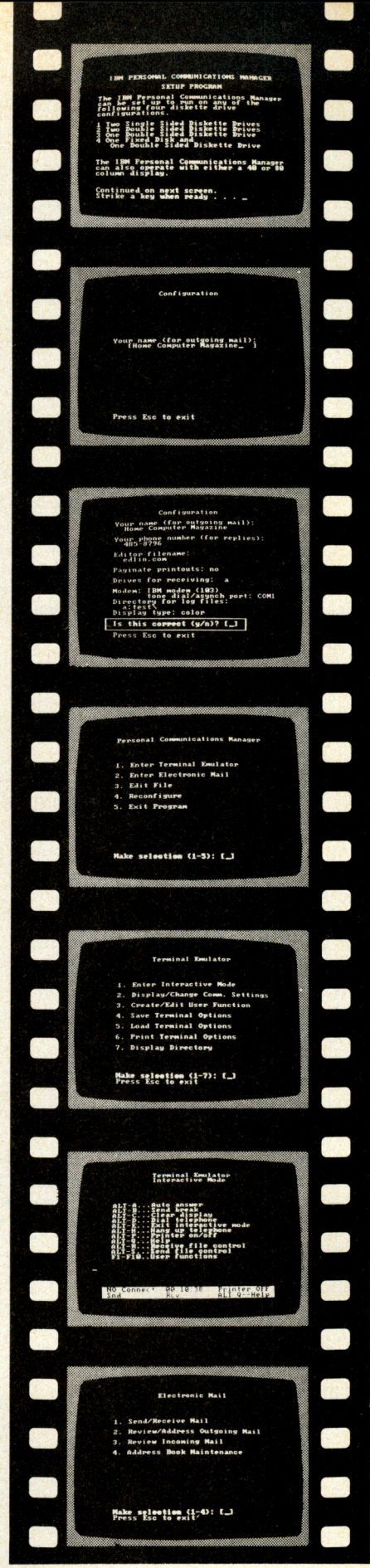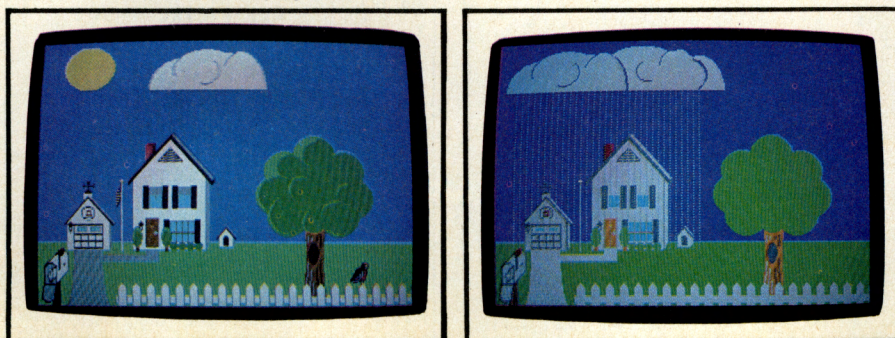

Fig. 16 — **These screens from the IBM Personal Communications Manager** illustrate three functions of the software: Terminal Emulation, Electronic Mail and Word Processor/Editor access. This package enables users to send and receive information via the telephone line. The menu-driven software provides many functions easily modified for use with different modems.

Fig. 17A — The Infrared Keyboard —

The omission of key-face labeling makes this keyboard user-programmable through the use of overlays (see Fig. 20).

CTRL (Control Key) — combined with ALT to achieve PCjr-specific functions and with other keys to emulate all functions available on the larger PC keyboard.

ALT key (Alternate) — used in combination with CTRL for: user diagnostics, shifting the screen image left and right, audio feedback accompanying key-presses, and keyword functions (see Fig. 19B).
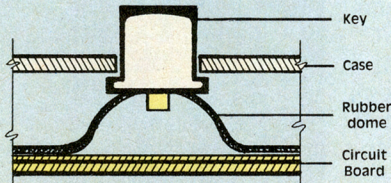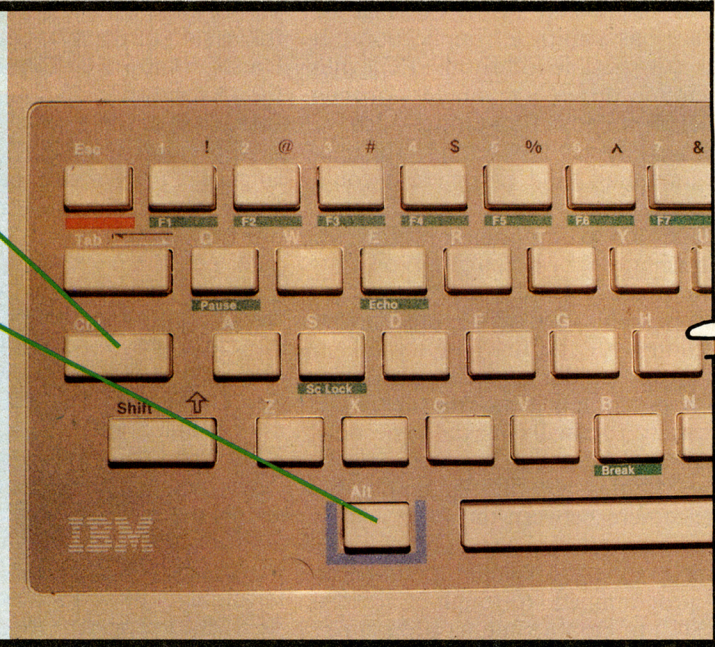
Key
Case
Rubber dome
Circuit Board

Fig. 17B - Keyboard cross section
(see also Fig. 17C)

Figure 17

---

required to use a diskette with this system.

DOS 2.1 contains extensions for supporting the new Cartridge BASIC, IBM PC Compact Printer (See Fig. 3F), and the different diskette drive characteristics of the PCjr 360K-byte slim-line drive. It also comes with documentation that is easier to use than that of its predecessor—a separate User's Guide (for first-time users) that accompanies the standard Reference Manual.

A powerful DOS is a necessity for software developers—and a common one shared with the ubiquitous IBM PC is a boon to rapid software availability. But we can't help but wonder if a somewhat more "transparent" operating system (one that is more "hidden" and less intrusive until requested) wouldn't be better and less intimidating for a typical first-time home user.

Nevertheless, all the instructions are there—they will just take a little getting used to for the neophytes. In subsequent issues of this magazine, we'll be showing you "all the ropes."

Peanuts Can Talk and Write Too

The RS232 serial port on the PCjr system board will support asynchronous (1-way at a time) communications at 4,800 bits per second (baud) for transmitting, 4,800 baud for receiving with no keyboard overlap, and 1,200 baud for receiving with overlapped keyboard operation. This is half the speed of serial ports on other popular home computers, but should be adequate for most uses. If faster printer operation is required, IBM's Parallel Printer Attachment ($99) should be purchased [see Fig. 3G]. The serial port works well with the IBM PC Compact

Printer ($175). This thermal 80-column unit has a top speed of 1,200 baud, so it is not "held back" by the limit of the serial interface [see Fig. 3F].

Of course, serial ports aren't only for printers. Many home users who already own modems will want to hook them up to this interface for telephone communication capabilities [see Fig. 3H and Fig. 3I]. IBM does provide an optional Internal Modem card ($199). Using this auto-dial, auto-answer 300-baud internal modem rather than an external one provides the advantage of leaving the one serial port free for other uses. It also has been designed to perform its wonders with the separate Personal Communications Manager software package ($100). Business users who need the 1,200 baud over-the-telephone communications capability can buy the faster external modems or wait for a third-party hardware firm to offer a PCjr-compatible, 1,200-baud internal modem.

The Personal Communications Manager software [see Fig. 16] has been designed for first-time users. It provides a wide range of functions in terminal emulation and electronic mail, plus allows easy editing (with all IBM PC editors). The modems supported right

---

Fig. 18 — Character and graphics symbols available on the PCjr. There are 16 special characters for games support; 15 for word processing/editing; 96 for standard ASCII/graphics set; 48 for foreign languages; 48 for business block graphics; 16 Greek symbols; and 15 scientific notation characters.

ASCII value	Control character	Character	ASCII value	Character	ASCII value	Character	ASCII value	Character	ASCII value	Character	ASCII value	Character	ASCII value	Character	ASCII value	Character
000	NUL	(null)	032	(space)	064	@	096	`	128	Ç	160	á	192	└	224	α
001	SOH	☺	033	!	065	A	097	a	129	ü	161	í	193	┴	225	β
002	STX	●	034	"	066	B	098	b	130	é	162	ó	194	┬	226	Γ
003	ETX	♥	035	#	067	C	099	c	131	â	163	ú	195	├	227	π
004	EOT	♦	036	$	068	D	100	d	132	ä	164	ñ	196	─	228	Σ
005	ENQ	♣	037	%	069	E	101	e	133	à	165	Ñ	197	┼	229	σ
006	ACK	♠	038	&	070	F	102	f	134	å	166	ª	198	╞	230	µ
007	BEL	(beep)	039	'	071	G	103	g	135	ç	167	º	199	╟	231	τ
008	BS		040	(	072	H	104	h	136	ê	168	¿	200	╚	232	Φ
009	HT	(tab)	041	)	073	I	105	i	137	ë	169	⌐	201	╔	233	Θ
010	LF	(line feed)	042	*	074	J	106	j	138	è	170	¬	202	╩	234	Ω
011	VT	(home)	043	+	075	K	107	k	139	ï	171	½	203	╦	235	δ
012	FF	(form feed)	044	,	076	L	108	l	140	î	172	¼	204	╠	236	∞
013	CR	(carriage return)	045	-	077	M	109	m	141	ì	173	¡	205	═	237	φ
014	SO	♫	046	.	078	N	110	n	142	Ä	174	«	206	╬	238	ε
015	SI	☼	047	/	079	O	111	o	143	Å	175	»	207	╧	239	∩
016	DLE	►	048	0	080	P	112	p	144	É	176	░	208	╨	240	≡
017	DC1	◄	049	1	081	Q	113	q	145	æ	177	▒	209	╤	241	±
018	DC2	↕	050	2	082	R	114	r	146	Æ	178	▓	210	╥	242	≥
019	DC3	‼	051	3	083	S	115	s	147	ô	179	│	211	╙	243	≤
020	DC4	¶	052	4	084	T	116	t	148	ö	180	┤	212	╘	244	⌠
021	NAK	§	053	5	085	U	117	u	149	ò	181	╡	213	╒	245	⌡
022	SYN	▬	054	6	086	V	118	v	150	û	182	╢	214	╓	246	÷
023	ETB	↨	055	7	087	W	119	w	151	ù	183	╖	215	╫	247	≈
024	CAN	↑	056	8	088	X	120	x	152	ÿ	184	╕	216	╪	248	°
025	EM	↓	057	9	089	Y	121	y	153	Ö	185	╣	217	┘	249	∙
026	SUB	→	058	:	090	Z	122	z	154	Ü	186	║	218	┌	250	·
027	ESC	←	059	;	091	[	123	{	155	¢	187	╗	219	█	251	√
028	FS	(cursor right)	060	<	092	\	124			156	£	188	╝	220	▄	252	ⁿ
029	GS	(cursor left)	061	=	093	]	125	}	157	¥	189	╜	221	▌	253	²
030	RS	(cursor up)	062	>	094	^	126	~	158	₧	190	╛	222	▐	254	■
031	US	(cursor down)	063	?	095	_	127	⌂	159	ƒ	191	┐	223	▀	255	(blank 'FF')

Fig. 19A

ALT + CTRL Functions

Available Only on the PCjr (Not on the IBM PC)

Press ALT + CTRL	PCjr Special Functions
+ cursor left	Adjust entire screen image to the left
+ cursor right	Adjust entire screen image to the right
+ Caps Lock	Keys "click" when pressed
+ Ins	User diagnostics
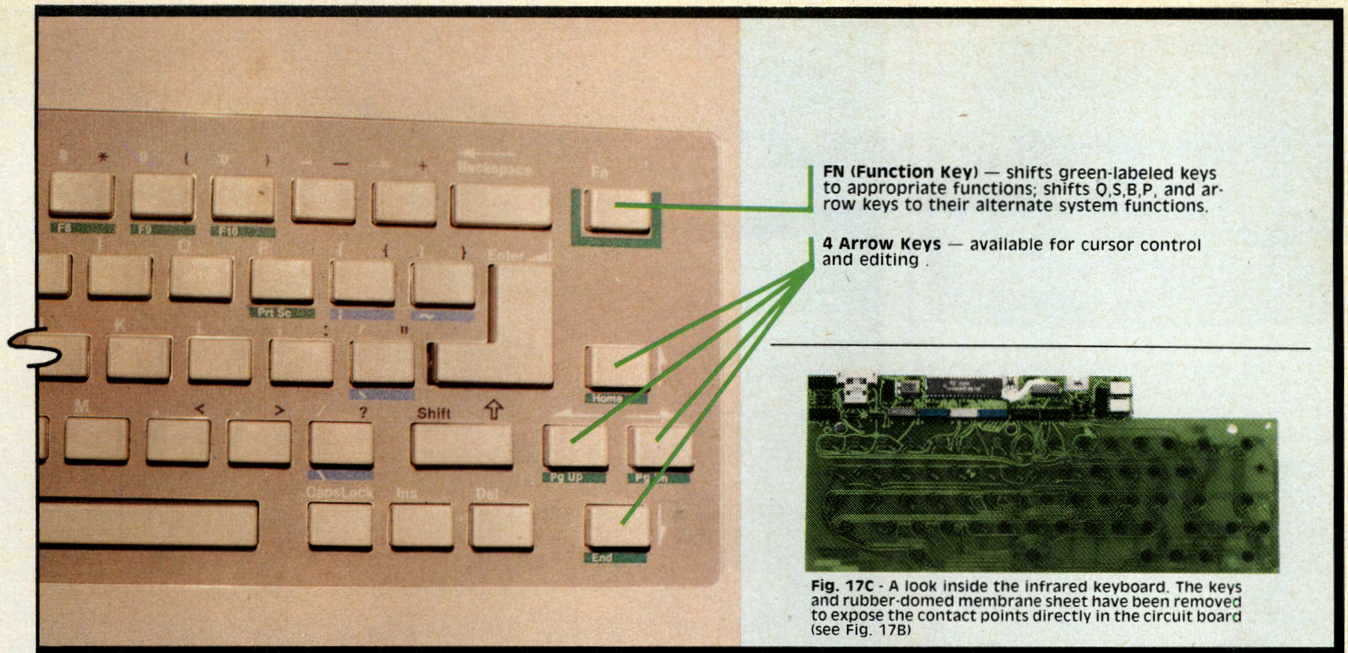
FN (Function Key) — shifts green-labeled keys to appropriate functions; shifts Q,S,B,P, and arrow keys to their alternate system functions.

4 Arrow Keys — available for cursor control and editing .

Fig. 17C - A look inside the infrared keyboard. The keys and rubber-domed membrane sheet have been removed to expose the contact points directly in the circuit board (see Fig. 17B)

off the shelf are the IBM PCjr Internal Modem, the Microcom PCS or RX modems, and the Hayes Smartmodems. Use with other modems requires writing an assembly language program for a "modem driver"—a task best left to the various modem manufacturers. Make sure that one is supplied with any modem you purchase.

A Cordless Peanut in the Home

Probably more has been said about the PCjr keyboard than any of its other features—or in this particular case, liabilities. Before examining the merits of all the criticism, the interface itself should be understood.

The keyboard interface on the system board is a small infrared receiver card mounted at the front of the board behind the circular opening on the front panel [see Fig. 4A]. There's also a small infrared transmitter mounted on this receiver card for diagnostic purposes.

The way it works is simple. When a key is pressed on the detached keyboard, a microprocessor in the keyboard sends the serial data stream to the infrared-emitting diodes. These flash on and off, sending the pulses across the room in the same way as a TV remote control. The receiver card in the PCjr then amplifies and processes the signal ("demodulates" it into an electrical signal) before sending it on to the system board. The 8088 microprocessor then converts the data to obtain the correct keyboard scan codes.

The keyboard itself is a low profile, 62-key detached unit with full-travel keys arranged in standard QWERTY typewriter layout. It has an additional function key and cursor control keys [see Fig. 17]. There are no markings on the keytops—rather, the usual key designations are found printed on the flat panel above the keys. This was done to allow the use of overlays with different markings [see Fig. 20], making the keyboard easy to use for dedicated tasks, without having to commit a lot of special key-press functions to memory.

The PCjr's cordless keyboard—or "free board," as some Madison Avenue types will undoubtedly be calling it—is battery-powered by four AA 1.5 volt cells. There is no on-off switch required because of the low power integrated circuitry (CMOS), and because the unit is normally in the standby, power-down mode until a key is pressed. When an optional cord ($20) is attached, the cord's keyboard connector removes the battery power, and a cable-connect signal disables the infrared receiver circuit on the PCjr system board. This allows other infrared devices to be used without interfering with the computer—a necessity in a school room or office environment with multiple PCjrs.

Unlike other keyboards used by IBM, this one has "phantom-key" detection—occurring when three or more keys are pressed simultaneously. The phantom-key code that is generated instructs the keyboard's microprocessor to ignore all of the keys that were pressed at that time. This feature will undoubtedly be responsible for many complaints of the type: "The keyboard didn't pick up some of the characters I typed."

Figures 17B and 17C will show you how the keyboard is constructed. It's

Fig. 19B

Keyword Functions

Press ALT + keys listed to call up the appropriate keywords.

Key	Keywords	Key	Keywords
A	AUTO	O	OPEN
B	BSAVE	P	PRINT
C	COLOR	Q	(not used)
D	DELETE	R	RUN
E	ELSE	S	SCREEN
F	FOR	T	THEN
G	GOTO	U	USING
H	HEXS	V	VAL
I	INPUT	W	WIDTH
J	(not used)	X	XOR
K	KEY	Y	(not used)
L	LOCATE	Z	(not used)
M	MOTOR		
N	NEXT		

Fig. 20 - Overlays, like this one from Sierra On-Line's HomeWord word processing software allow the keyboard to be programmed to facilitate special applications.
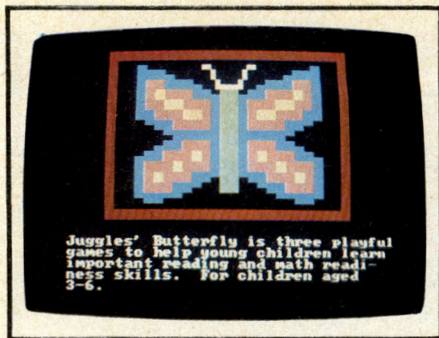
Fig. 21 — Juggles' Butterfly: three game programs to introduce young children (3-6 yrs.) to computers before they can read. Games feature colorful clowns etc. to teach children spatial concepts and math skills.
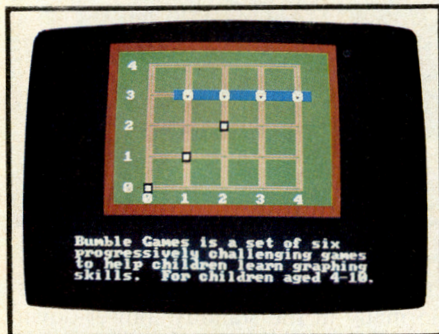

Fig. 22 - Bumble Games: is a set of six animated programs of varying difficulty (ages 4-10 yrs.). Teaches concepts such as "greater than", "less than", and drawing computer pictures and graphs.

Fig. 23 - The initial batch of software for the PCjr includes: *Monster Math, Juggles' Butterfly, Bumble Games, Mine Shaft, Crossfire, Scuba Adventure, Mouser,* and *Animation Creation*. These offerings in their "soap-dish" style packaging (accomodating either cartridge or disk software) are accompanied by colorful booklets. Most initial releases have been disk-based.

really an elegantly simple, peanut-butter-proof design. Protruding through the top cover is a set of 62 "Chiclet-style" keys that sit on a bumpy rubber membrane—each key atop a dome-shaped bump. The membrane provides an effective shield against spilled orange juice and cookie crumbs. The rubber domes provide the pressure and spring-back when keys are pressed. A tiny carbon disk makes connection with the circuit board on each key-press, and sends its corresponding signal code to the keyboard's microprocessor.

The keyboard design offers a new element into the home computer equation—that of being able to use the computer in some capacities while sitting across the room (up to 20 feet away). This feature is obviously not for word processing—you'd need a huge monitor to be able to work from 20 feet away! But it is useful for many educational and entertainment applications. Think about using a large TV in a classroom as a "blackboard" and passing the keyboard around instead of asking students to "come up and write on the board." This remote control ability also lends itself to commanding the PCjr to control household functions: with each task appropriately marked on your custom overlay, you would just point and press. . . The infrared keyboard decoder design also allows for IBM or others to later offer more exotic input devices—wireless joysticks, mice, touch pads, and the like.

For extended bouts of word processing, touch-typists will want a more standard keyboard with a better feel—larger key-tops with key designations *on* the keys (in a lower/upper format instead of the PCjr's slightly disorienting left/right, un-shifted/shifted design), and tactile feedback. Fortunately, third-party keyboard manufacturers will be offering excellent accessory keyboards in the $200 price range, so all is not lost for more professional use of this otherwise versatile machine. It's also possible that IBM might "unbundle" this keyboard from the system price and/or offer its own 83-key PC keyboard separately.

Figures 17, 19A, and 19B reveal some similarities and differences between the keyboard functions of the PCjr and the larger PC. With the right combination/sequences of the PCjr's CTRL, ALT, and FN keys, all the functions of the PC's larger 83-key keyboard can be produced—even the BASIC keyboard functions (so useful in programming) are produced the same easy way. The PCjr also offers four new functions not found on the PC: the ability to adjust the screen image either right or left (useful for centering on different monitors), access to user diagnostics, and the ability to turn on an audible "click" (somewhat muffled) when keys are pressed.

The Shell, Only Just Cracked. . .

According to Philip D. Estridge, president of IBM's Entry Systems Division, "The PCjr's uses are limited only by the imagination of the person using it." In working with the machine, you get the feeling that its wide-open architecture and dormant versatility are begging you to apply your creative potential. It won't be long before users will be able to purchase off-the-shelf hardware and software enhancements for every conceivable application—much as Apple users can choose from the large outpouring of Apple II add-on products.

It's obvious that IBM is focusing primarily on providing "user-friendly" software for home management, family entertainment, and child education. They've made the PCjr suitable for preschoolers as well as adults. In fact, the PCjr will probably fuel an explosion in sophisticated disk-based educational games. We expect to see a prodigious offering of adult self-improvement, strategy, and simulation programs from the third-party software industry—categories heretofore virtually ignored because of memory limitations on other popular home computers.

The business world too, might be the scene of a Peanut invasion. We expect to see the PCjr take on the role of a low-end communications terminal. It would complement its big brother, PC, in the office, and tie into the big IBM mainframes of corporate America.

Is there a PCjr in your future? If IBM has its way, finding one at a local dealer will soon be as easy as Peanut pie. . .

HCM