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PE COMPARES NEW HANDHELD COMPUTERS

Author discusses results of his "hands on" experience with Sharp, Quasar, and H-P handhelds

BY FORREST M. MIMS

TEN years ago, Hewlett-Packard introduced the HP-35, the world's first scientific calculator. Though some "experts" said its $395 price tag would hold little appeal for consumers, the company sold more than 300,000 units in the first three years. The HP-35 was certainly revolutionary for its time, but it was just another step in the evolution of handheld electronic calculating devices that still continues today.

The most recent (and most impressive) products of this evolutionary process are a new generation of handheld *computers*. These new machines are not merely upgraded calculators. They are sophisticated, fully programmable computers with alphanumeric keyboards and displays. Their memory circuits retain data and programs even when the computer's CPU is powered down. They can be expanded with additional memory modules, and can be connected to peripherals such as printers and cassette-tape storage units.

Handheld computers are much more "personal" than desktop personal computers owing to their small size and battery-powered portability. But are the new handheld computers practical? Are their prices, which can approach those of some desktop machines, justified? To answer these questions, a substantial amount of time was spent working with a handful of these units: Quasar's HHC (same as Panasonic's RLH-1000), Sharp's PC-1500 (same as Radio Shack's TRS-80 Pocket Computer Model PC-2), and Hewlett-Packard's HP-41 Programmable Calculator.

Each of these computers is unique. Here is a close look at their features, capabilities, idiosynchrasies, and peripherals.

Quasar HHC

The Quasar HHC (Hand Held Computer) is a sophisticated portable computer with advanced programming features. A product of the Matsushita Electric Corp. of Japan, the HHC (as well as a Panasonic twin model) is compatible with a wide assortment of peripherals. The computer and its peripherals are distributed in the United States by the Quasar Co. (9401 W. Grand Ave., Franklin Park, IL 60131).

The operating-system language is SNAP (derived from FORTH) or BASIC. The latter's thumb-size plug-in capsules give a choice of 8K Microsoft and 16K Level II BASIC. Moreover, CP/M software is said to be handled in conjunction with an HHC disk system.

The HHC's microprocessor is a 6502 that operates at a clock speed of 1 MHz. The machine's internal ROM capacity is 16K bytes. In addition, a receptacle on the back side of the computer can accept up to three 16K-byte ROM modules. Each module is a plastic carrier containing a 22-pin, dual-in-line ROM.

Information in ROMs cannot be altered or erased, of course, so storage is needed to allow the user to store programs and data. The HHC's internal RAM is either 2K or 4K bytes (depending on the model). This can be expanded with as many as six 8K-byte nonvolatile (continuous storage), external memory units.

The HHC has a typewriter-style (QWERTY) keyboard with 65 keys and two-key rollover. There is no numeric keypad; but an array of a dozen or so function keys, including a handy HELP key, are at the right side of the keyboard.

The keyboard provides an automatic repeat mode and full (up, down, left, right and stop) cursor control. Three keys are user definable. The individual keytops, all of which are colored gray, are *not* marked. Instead, their function or functions are printed in white and orange above each key.

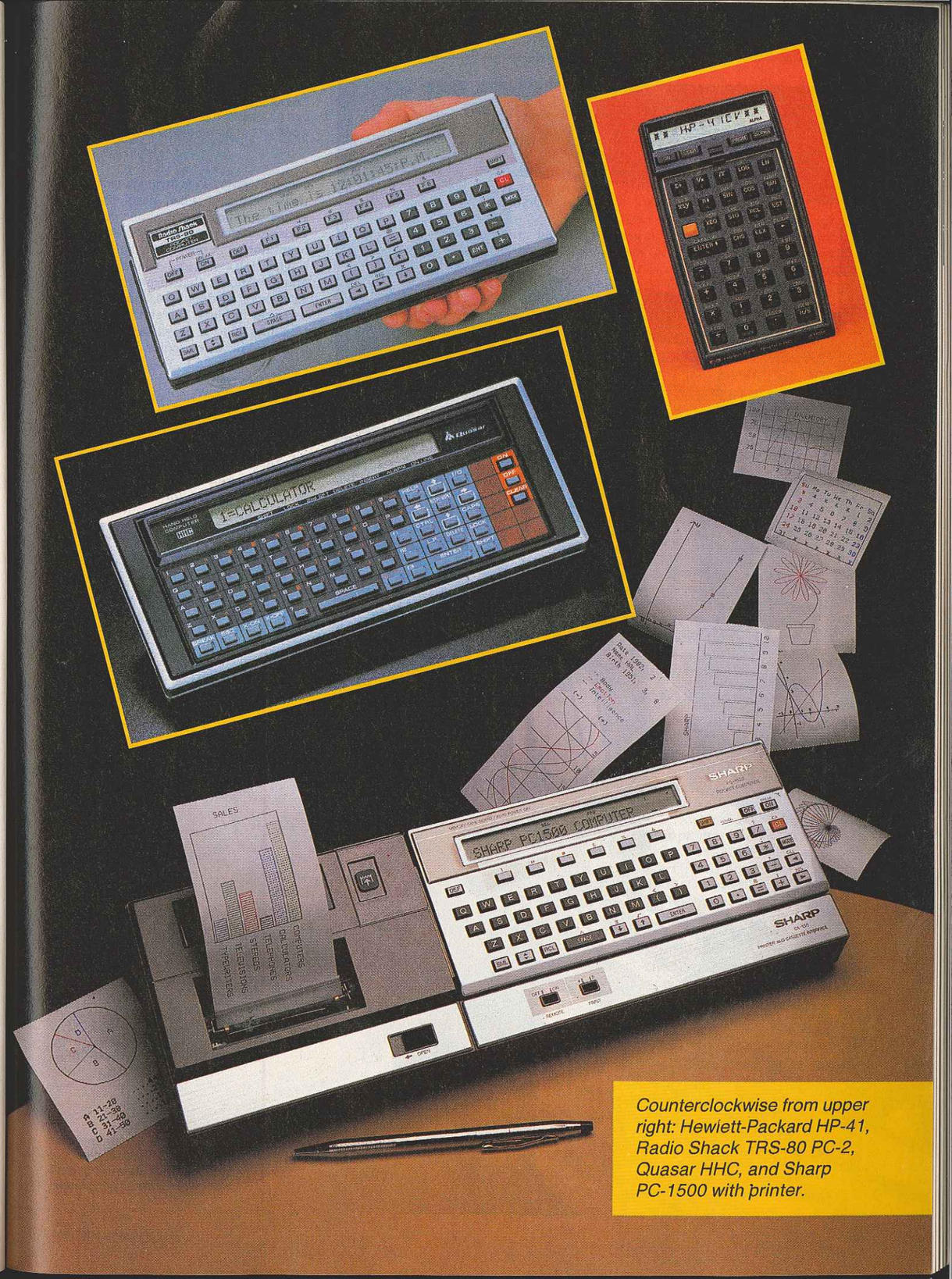
The display is a 26-character (8 × 159 dot matrix) liquid-crystal readout. Status indicators (SHIFT, LOCK, DELETE, etc.) are printed in a row under the display and, when selected, are indicated by a small triangle. The machine is powered by a built-in nickel-cadmium rechargeable power pack. The dimensions of the unit are $8^{15}/_{16}$" × $3^{3}/_{4}$" × $1^{3}/_{16}$".

An important feature of the HHC is its user-accessible bus. Access to the bus is provided by a double-sided edge connector recessed into the left side of the case and containing 22 contacts on each side. A spring-loaded dust cover protects the connector when it is not in use.

A wide range of compact peripherals can be connected to the HHC by means of its bus. Though it can function alone, the HHC can also act as the processor for a powerful computer system that fits in a slim-line attache case. The fully expanded attache-case system is a highly portable personal computing system that can be operated in a car, plane, or hotel room.

For example, the Quasar handheld system reviewed here included the HHC, TV adapter, telephone modem, micro printer, RS-232 interface, and a programmable memory module. All these peripherals and the HHC slide into modular plastic trays attached to each side of the HHC's I/O (input/output) adapter unit. Up to six peripherals can be connected at a single time.

The HHC can be connected via the TV adapter to an external color or B&W tele-



Counterclockwise from upper right: Hewlett-Packard HP-41, Radio Shack TRS-80 PC-2, Quasar HHC, and Sharp PC-1500 with printer.

The Quasar HHC telephone modem can be used in the field to access a network or home-based computer.

vision receiver. This arrangement is particularly handy when developing programs or using the telephone modem to access another computer or one of the computer services.

The HHC provides two video color-graphics modes that display 64 dots by 32 lines or 64 dots by 48 lines in an assortment of black and eight colors. Sixteen lines up to 32 characters each can be displayed in various color combinations.

Using the HHC. Turn on most personal computers and the display typically shows READY, followed, perhaps, by a cursor. The HHC, however, provides an interactive series of nested menus that allow the user to select any of its various operating modes. When the machine is *initially* turned on, for example, the display scrolls through the HHC's primary menu:

1 = CALCULATOR
2 = CLOCK/CONTROLLER
3 = FILE SYSTEM
4 = RUN SNAP PROGRAMS
5 = MICROSOFT BASIC

Pressing 1 converts the HHC into a low-grade, four-function calculator with a fully addressable memory. To return to the primary menu, the CLEAR key is pressed *twice*.

Pressing 2 causes the nested menus for the clock/controller to be scrolled through the display:

1 = SET ALARM
2 = REVIEW
3 = ACKNOWLEDGE
4 = TIME
5 = SET TIME

If the time and date have already been set, select 4; the display will read something like:

A
MON 11:05:21 M JUN 12 1982

The rate at which the HHC scrolls through the selections in its various menus can be controlled by means of the STP/SPD (stop/speed) key. Simply press STP/SPD, followed by any digit from 1 (very slow) to 0 (very fast).

To load a BASIC program into the HHC, press 5 while the primary menu is scrolling through the display. This selects Microsoft BASIC. The display will then present a menu of programs already loaded in the HHC. If none are present, the display will show:

1 = NEW FILE
NO FILES

To enter a new program, press 1. The display will read PROGRAM NAME, followed by a blinking cursor. Type in a name, press ENTER, and the cursor alone will be displayed to indicate that program entry can proceed.

Your program name has now become part of the Microsoft BASIC menu and you need not assign it to a line number in your program. It is also listed in the file menu selection (key 3 of the primary menu).

After you enter the program, type BYE to load it into the HHC. Should you make a mistake or wish to modify the program, the HHC has a very versatile array of edit functions. If you expand your filed programs to a point where less than 80 characters of storage remain, the display will warn:

ONLY *** BYTES LEFT!

A word of advice to first-time HHC users who know BASIC: The HHC requires an orientation period to fully understand its operation. Be sure to read through the owner's manual and Volume I of the Microsoft BASIC manual to learn the idiosyncrasies of this machine. If you don't, you may have considerable difficulty loading programs.

For example, suppose you've figured out how to title a program, enter the title in the file menu, and write the actual program. Fine, but how do you return to the primary menu to select some other option—or load another program?

Pressing CLEAR seems to be the logical move since this returns the primary menu to the display. But when you try to load a new program, the computer beeps and displays:

NO ROOM, DELETE FILE

Pressing the I/O key will probably reveal a few thousand bytes of free internal RAM, so what went wrong?

I attacked this problem without success until returning to Volume I of the Microsoft BASIC manual. Page 4-8 warns ". . . you may be tempted to return from your program to the BASIC menu by pressing CLEAR, as you would do in most other HHC programs. Resist this temptation at all costs!" Later, on page 7-2, a way to recover from this keyboard gaffe is explained.

So how *should* you return to the BASIC menu? As I noted earlier, just type BYE. Then press CLEAR to return to the primary menu. The lesson, then, is that when the cursor is blinking while the HHC is in program mode, *never* press CLEAR!

First-time users may also run into problems when attempting to use the HHC in its direct-execution or manual mode. The machine does provide a very limited four-function calculator mode, but more advanced operations involving more than simple arithmetic require BASIC. This means naming of a new program file or going to an existing program and using the computer in its direct-execution mode (that is, entering BASIC

A

```
>list
10 FOR I=1 TO
10
20 PRINT "THE
SQUARE OF
";I;"IS";I*I
30 NEXT I
>
>
>run
THE SQUARE OF
1 IS 1
THE SQUARE OF
2 IS 4
THE SQUARE OF
3 IS 9
THE SQUARE OF
4 IS 16
THE SQUARE OF
5 IS 25
THE SQUARE OF
6 IS 36
THE SQUARE OF
7 IS 49
THE SQUARE OF
8 IS 64
THE SQUARE OF
9 IS 81
THE SQUARE OF
10 IS 100
```

B

```
1000:FOR N=1TO 10
1010:LPRINT N;" S
     QUARED IS ";
     N*N
1020:NEXT N
1030:END



 1 SQUARED IS  1
 2 SQUARED IS  4
 3 SQUARED IS  9
 4 SQUARED IS  16
 5 SQUARED IS  25
 6 SQUARED IS  36
 7 SQUARED IS  49
 8 SQUARED IS  64
 9 SQUARED IS  81
 10 SQUARED IS  10
0
```

C

```
01♦LBL "SQR"
02 0.01001
03 STO 01
04♦LBL 01
05 CLA
06 RCL 01
07 INT
08 ARCL X
09 ACA
10 " SQUARED IS "
11 ACA
12 CLA
13 X↑2
14 ARCL X
15 ACA
16 ADV
17 ISG 01
18 GTO 01
19 END

    0.0 SQUARED IS 0.0
    1.0 SQUARED IS 1.0
    2.0 SQUARED IS 4.0
    3.0 SQUARED IS 9.0
    4.0 SQUARED IS 16.0
    5.0 SQUARED IS 25.0
    6.0 SQUARED IS 36.0
    7.0 SQUARED IS 49.0
    8.0 SQUARED IS 64.0
    9.0 SQUARED IS 81.0
   10.0 SQUARED IS 100.0
```

Shown above, and on the opposite page, are reproductions of tapes from the printers that are peripheral components for the computers: (A) Quasar HHC; (B) Sharp PC-1500; and (C) Hewlett-Packard HP-41.

commands without line numbers). The existing program will be unaffected by what you enter.

I much prefer the former method since it's easy to create (and thereafter select) a programless file named MANUAL MODE. Then you must learn how to enter commands.

Suppose you want to know the square root of 743. You *must* place parentheses around the numerical value and enter PRINT SQR (743). PRINT can be abbreviated?. If you enter ? SQR 743, however, the HHC will beep and display SN ERROR to remind you to insert the missing parentheses.

After figuring out this procedure, which is explained on page 2-2 of Volume II of Microsoft BASIC, I tried to find the sine of 37° by entering ? SIN (37). A beep and a BS error promptly informed me something was wrong. This time the problem was more fundamental. BS is the error code for *bad subscript*, meaning an array element outside the dimensions of an array has been entered.

Since the sine of 37° has nothing to do with arrays, I turned to the section on trigonometric functions in Volume II of Microsoft BASIC and read: "Microsoft Basic on the HHC does not have built-in trigonometric functions." Neither does the HHC have many other functions common to virtually all scientific calculators. Fortunately, appropropriate subroutines for sin, cos, tan, cotan and arctan are provided.

These idiosyncrasies should not be considered deficiencies, for the HHC is apparently designed more as an information processor than as a high-powered mathematical machine. Of course, future ROM modules may add many more BASIC functions to the HHC.

The HHC Micro Printer. Accessing the HHC's peripherals can be both awkward and tricky. For example, to use the miniature thermal printer, press the I/O key to check the printer's status. If *no* peripherals are connected to the bus, the display will show the available number of bytes in internal RAM. Otherwise, the display will identify, in turn, the name and status of each peripheral, as well as the amount of available RAM remaining in the HHC and the programmable memory module (if connected).

If the printer is in place, its status line may intially read:

1 = PRINTER OUT, OFF, SLOT = 3

OUT means the printer is an output peripheral, and OFF means the printer is now off. SLOT = 3 means the printer is plugged into slot 3 of the I/O adapter. (SLOT = 0 means the printer is plugged directly into the HHC's bus socket.)

The printer is turned on by pressing the digit key corresponding to its menu selection number (in this case, 1). The printer status line will then read:

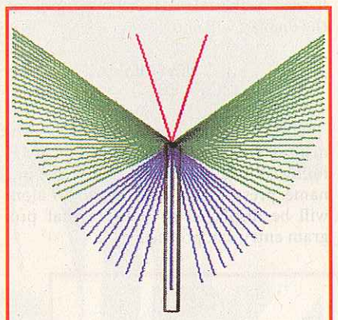
1 = PRINTER OUT, ON, SLOT = 3

Using the printer requires the assignment of a logical unit number—LUN, for short—between the PRINT statement and the data to be printed. For example, in the statement PRINT #2; 123456, #2 is the LUN. Before this statement can be executed, the printer must be referenced via its identification number (68) to LUN #2 with the ATTACH statement ATTACH 68 to #2. Now the printer will operate in response to the instruction PRINT #2; 123456 by printing 123456.

ATTACH is a clumsy barrier to gaining access to the printer. However, it does provide an important advantage in program writing since programs can be peripheral independent. In other words, the same program can be used *without modification* to operate a printer or access some other output device. ATTACH defines which peripheral is accessed.

This advantage notwithstanding, the HHC printer itself is the least sophisticated of the printer models reviewed here. Besides its rather noisy, raspy sound, printed lines are not visible by the user until the paper tape has advanced three or four lines.

Quasar recognizes some of the limitations of the small HHC printer. The manual points out that a serial printer with an 80-character line width can be connected to the HHC by means of a serial-interface adapter.



THE BUTTERFLY"

```
 1:REM  BUTTERFLY
 2:REM  F. MIMS
 3:REM  MARCH 3,
   1982
 5:LPRINT "  THE
   BUTTERFLY"
 7:COLOR 03
10:GRAPH
14:GLCURSOR (110,
   100)
16:SORGN
17:LINE (0,100)-(
   25,175)
18:LINE (0,100)-(
   -25,175)
19:COLOR 00
20:LINE (5,100)-(
   -5,-15),,,B
21:COLOR 01
22:FOR A=0TO 50
   STEP 5
25:N=-10*SQR A
26:COLOR 01
30:LINE (0,100)-(
   N,A)
40:NEXT A
42:FOR A=60TO 200
   STEP 5
43:N=-10*SQR A
44:COLOR 02
45:LINE (0,100)-(
   N,A)
46:NEXT A
49:COLOR 01
50:FOR B=0TO 50
   STEP 5
60:O=10*SQR B
70:LINE (0,100)-(
   0,B)
80:NEXT B
82:FOR B=60TO 200
   STEP 5
83:O=10*SQR B
84:COLOR 02
85:LINE (0,100)-(
   0,B)
86:NEXT B
90:TEXT
100:END
```

Program and color graphics developed by the author for Sharp PC-1500.

HHC Memory Modules. The plug-in memory modules contain either 8K or 16K of RAM, and batteries to keep the memory alive during power-off periods. There is one main slot for the memory module, though additional memory modules could be plugged into any of the other slots of the bus connector. In fact, an additional bus module could be connected by a cable and an additional six memory modules could be connected. However, the HHC can only address one memory module at a time (either 8K or 16K.) The other memory modules can be used to store programs or data that can be switched into use as required. Total memory capacity of the computer cannot be considered as contiguous blocks of addressable memory. Outside of one 8K or 16K block, the memory is the mass storage of this computer.

Modem Module. The HHC Modem Module looks like any other coupler, but it is an unusual peripheral controlled by a replaceable ROM module. There are two such modules available for the modem unit. The first has a ROM called Telecommunications 1. It controls all of the protocol used in accessing public information networks like The Source or Compuserve. In use, all you have to do is make contact with one of these services and the modem provides all of the answers except your User Number and password. The other ROM is Telecommunications 2, and it contains programs to permit you to download or upload files from the host computer. Either of these ROMS enables a person with little experience to engage in network operation from his home.

Sharp PC-1500

THE Sharp PC-1500, which uses BASIC language, is the successor to the company's PC-1211 Pocket Computer. Manufactured by the Sharp Corp. of Osaka, Japan, the PC-1500 will be distributed in the United States by the Sharp Electronics Corp. (10 Sharp Plaza, P.O. Box 588, Paramus, NJ 07652). Like the PC-1211, the PC-1500 will be available from Radio Shack (TRS-80 Model PC-2) with a slightly modified keyboard layout.

The PC-1500 uses a custom 8-bit microprocessor instead of the two 4-bit CMOS microprocessors used in the PC-1211. The new chip, which is also a CMOS device, is installed in a miniature flatpack having 76 connection pins—enough to handle keyboard, display, and other I/O signals without multiplexing. Its 1.3-MHz clock speed makes for fast, efficient program execution.

Dimensions of the PC-1500 are $7^{11}/_{16}" \times 3^{3}/_{8}" \times 1^{1}/_{16}"$, and it weighs 0.83 pounds. The unit is smaller than its more sophisticated cousin, the HHC.

The PC-1500 includes 2.64K bytes of RAM and 16K bytes of ROM. The internal RAM can be expanded an additional 4K by inserting a CE-151 Memory Module in a receptacle on the back of the computer. Higher-capacity RAM and RAM/ROM modules are expected to be announced in coming months.

Other features of this computer are a 26-character display, a 65-key typewriter-like (QWERTY) keyboard, and upper- and lower-case capability. (Note that the PC-1500 will run any programs written for the PC-1211.)

You can develop your own graphics and special characters with the PC-1500 by using the GPRINT command. This permits you to treat the display as a 7×156 dot matrix in which any combination of individual dots can be activated. The POINT command allows you to sense dots in any of the 156 columns.

The PC-1500 also provides a very versatile audio output in the form of a self-contained programmable tone generator. The command BEEP n_1, n_2, n_3 specifies a tone sequence having the following characteristics; n_1 specifies the number of beeps (from 0 to 65,535); n_2 specifies the tone frequency (use 0 to 255); and n_3 assigns the duration of each tone (use 0 to 65,279).

These capabilities can be used to create highly specialized tone combinations and even tunes. Let the results of calculations or the machine's random number function be applied to the BEEP command and the PC-1500 makes its own "music."

Using the PC-1500. Unlike the Quasar HHC, the PC-1500 is well suited for calculator-style, direct execution of a wide range of mathematical expressions. Its ten-key numeric pad is particularly handy. Though functions other than square root, pi, and the four basics (+ , − , * and /) must be typed into the keyboard, they can also be entered into one of the six multi-purpose, user-definable, reserve keys.

Normally the reserve keys, which form a row directly under the display, coincide with !, ", #, $, % and &. Up to three functions, program lines, or even complete programs can be assigned to each key with the help of the RESERVE SELECT key.

The reserve keys are made even more versatile by identifying them with labels which can be displayed by pressing RCL. Three strings of characters called *templates*, one for each batch of reserve key assignments, can be stored. A typical identification template for the trigonometric functions might be:

TAN SIN COS ATN ASN ACS

Each of these keys could be assigned two additional functions.

While the PC-1500 has more built-in functions than the HHC, it lacks several useful BASIC commands (such as PEEK and POKE). Its edit capability is slightly less sophisticated than the HHC's and its clock mode is not nearly as versatile. Furthermore, it totally lacks the HHC's sophisticated system of nested menus and files.

The PC-1500 user must keep track of the starting address of each of the programs and always make sure line numbers within the range of existing programs are not used in new programs. Likewise, END commands at the end of each program are imperative if the computer is to avoid inadvertently executing a series of programs when only one was intended to be run.

The PC-1500's array of reserve keys helps to compensate for the lack of a file system. Up to 18 separate programs can be assigned for one- or two-key execution. A typical reserve-key assignment might be RUN 220. When the newly assigned key is pressed, the PC-1500 will run the program beginning at line 220 just as if RUN 220 had been entered.

Editing PC-1500 programs with the aide of the delete, insert and cursor-movement keys is simple and direct. The 46 error codes are a major asset. It's particularly helpful to clear an error code, return to program mode, and immediately see the line with the problem. Often, depending upon the nature of the error, the cursor will be blinking directly over the problem.

Sharp's CE-150 Printer and Cassette Interface. Thus far only a single PC-1500 peripheral is available—the CE-150 Printer and Cassette Interface.

The HP-IL Interface Loop enables the HP-41 to be used with a number of peripherals. Shown are Cassette Drive and Printer.

The cassette interface permits the attachment of two cassette recorders, one for data and programs and the other for their recall.

The CE-150 printer is by far the most sophisticated of the three reviewed here. Since this printer, which is made for Sharp by Alps, is so unusual, let's examine it in some detail.

First, the CE-150 printer is *not* a conventional thermal or impact printer. Instead, it is a four-color, highly miniaturized pen plotter/printer. Four miniature ballpoint pens (black, blue, green and red) are installed in a revolving cylinder that slides back and forth across the paper tape. A small magnet between the black and red pens tells the computer, via a magnet-actuated switch at the left side of the carriage, which pen has been selected for printing or plotting. Pens are selected by the command COLOR n, where n is 0, 1, 2, or 3 (0 = black, 1 = blue, 2 = green and 3 = red).

Printing takes place when the selected pen is pressed against the paper tape by a miniature solenoid. Forward and reverse rotation of the roller causes the paper to move up and down to provide vertical inking. Back-and-forth movements of the pen holder provide horizontal inking. Diagonals are formed by simultaneous movements of the roller (paper) and pen.

The plotter-like operation of the CE-150 gives it amazing versatility. It can, for example, print characters in nine sizes ranging from a tiny 1.2×0.8 mm to a huge 10.8×7.2 mm ($^{1}/_{16}" \times {}^{1}/_{32}"$ to $^{7}/_{16}" \times {}^{9}/_{32}"$). The print size is selected by the command CSIZE n, where n is a digit from 1 (smallest) to 9 (largest). When CSIZE 1 is selected, the printing speed is an impressive eleven characters per second.

The CE-150 can generate high-quality, four-color graphics with a resolution of 0.2 mm ($^{1}/_{64}"$)! Thanks to a paper-gripping mechanism, even complex graphics requiring many movements of the paper tape are produced with a very high degree of accuracy.

The fully expanded Quasar HHC computer system fits in an attache case and can be operated in a car, plane, or hotel room.

When the computer is placed in GRAPH mode, the command LINE (0,0)-(100,100) draws a 45°-diagonal, solid line from the leftmost pen position to a point halfway across the tape. The pen color and line format can be changed by adding two additional terms. For example, the command LINE (0,0)-(100,100),4,2, will cause the printer to form a dashed (4), blue (2), diagonal line. The dash width can be varied from 0.4 mm (n = 1) to 1.8 mm (n = 8).

Add ,B to the command and the printer/plotter will form a box or rectangle defined by the diagonal. This provides a handy way of forming borders around graphs, graphic characters, and data. You can even make game boards and calendar grids!

Several other commands simplify the production of graphics. For example, ROTATE n, where n is a digit from 0 to 3, causes the printer to print sideways or upside down. The paper tape can be scrolled forward and backward up to about four inches by the line feed command LF ±n. Since there is no paper detector, the tape can actually be expelled from the roller by an LF command. Should this occur, the printer keeps right on printing, but on the roller instead of the tape.

The set origin command, SORGN, sets as the origin for subsequent x-y pen movements the current pen position. The

COMPARISON OF HANDHELD COMPUTERS

Specification	Quasar HHC	Sharp PC-1500 Radio Shack PC-2	Hewlett-Packard HP-41C/CV
Microprocessor	6502	Custom CMOS	Custom
Clock speed	1 MHz	1.3 MHz	Slow
Internal RAM (bytes)			
Initial	2K	2.6K	448 (HP-41C)
Fully expanded	4K	7.5K	6.4K (HP-41CV)
Internal ROM (bytes)			
Initial	16K	16K	Unknown
Fully expanded	64K	32K	Varies
Display	8 × 159 dot	7 × 156 dot	24 × 14-Segment
Language	BASIC & SNAP	BASIC	RPN/HP-41
Program files?	Yes	No	Yes (Label Names)
Auto line numbering?	No	No	Yes
User definable keys	4/62	6 × 3	34 × 2
Internal clock?	Yes	Yes	Plug-in module
Peripheral bus	44-pin edge con.	60-pin socket	12-pin edge con.
Power	Rechargeable	4 × AA cells	4 × N cells or rechargeable
Dimensions (in.)	$8^{15}/_{16} \times 3^{3}/_{4} \times 1^{3}/_{16}$	$7^{11}/_{16} \times 3^{3}/_{8} \times 1^{1}/_{16}$	5.7 × 3.0 × 1.3
Weight (ounces)	20	13.2	7.4
***Price**	$525	$300 (PC-1500) $280 (PC-2)	$250 (HP-41C) $325 (HP-41CV)

*Suggested retail prices. Actual prices may be lower.

GLCURSOR command moves the pen to any specified x-y coordinate *without* drawing a line. There's even a TEST command that causes the printer/plotter to draw four small boxes in each of its four colors.

First-time users of the PC-1500 should be forewarned that developing original graphics programs can become an entertaining, though time-consuming addiction. The printer's only shortcoming is the time it requires to print long program listings and to form complex graphics.

It took me a couple of hours to develop a program that draws a stylized butterfly in four colors. *Most* of that time was taken by the plotter as it methodically drew various wing configurations until I was satisfied. The actual programming required comparatively little time.

Hewlett-Packard HP-41

THE HP-41 is the oldest of the handheld computers reviewed here. The only domestic handheld machine currently available, it is manufactured by Hewlett-Packard (1000 N.E. Circle Blvd., Corvalis, OR 97330).

When it was first introduced a few years ago, the HP-41 was described by Hewlett-Packard as an alphanumeric, programmable, scientific calculator. But I've owned an HP-41 for nearly two years and am convinced that its programming power and versatility qualify it for designation as a handheld computer.

There are two versions of the HP-41: the HP-41C and the HP-41CV. The self-contained program/data memory (RAM) in the HP-41C can store up to 400 program lines or 63 data registers. The HP-41CV is functionally identical to the HP-41C but has five times the RAM storage capacity (2000 program lines or 319 data registers). The memory for program lines and data registers can be allocated in any desired format by using the SIZE instruction.

The RAM capacity of the HP-41C can be expanded to that of the HP-41CV by inserting a single quad RAM module into one of the four ports on the upper end of the computer. Since both computers are otherwise identical, we will simply use the designation HP-41.

The HP-41 has 58 keyboard functions and a total of some 130 internal functions that can be addressed by typing in the appropriate alphabetic name. Forget a function name not on the keyboard? Just press CATALOG 3 and every internal function will be scrolled through the 12-character position display. Press CATALOG 2 to see the functions provided by plug-in ROM modules. The titles (labels) of user programs are displayed in sequence when CATALOG 1 is pressed.

Programs stored in the HP-41 are run by pressing XEQ (execute) and then typing in the program name. Programs can be keyed in by the user from his own or published software; or factory-programmed ROM modules that plug into the ports above the display can be used.

Why compare the HP-41 to newer machines like the HHC and PC-1500 when it can be operated like a calculator and doesn't have a higher-language capability like BASIC? First, though its keyboard "language" is sometimes clumsy and often more complicated than BASIC, it provides many capabilities not ordinarily found in BASIC. For example, programs are stored and called by names or *labels*. Line numbers are automatically inserted and, during editing, revised. Loops and subroutines can be referenced to a permanent label instead of a line number that might be hard to remember and subject to change. Also many instructions, commands, and functions can be implemented by pressing a single key. The HP-41 is also smaller and lighter than the HHC and the PC-1500. Moreover, it is supported by excellent software, a dynamic users club, and a manufacturer that interacts well with its customers and continues to introduce a growing number of versatile peripherals.

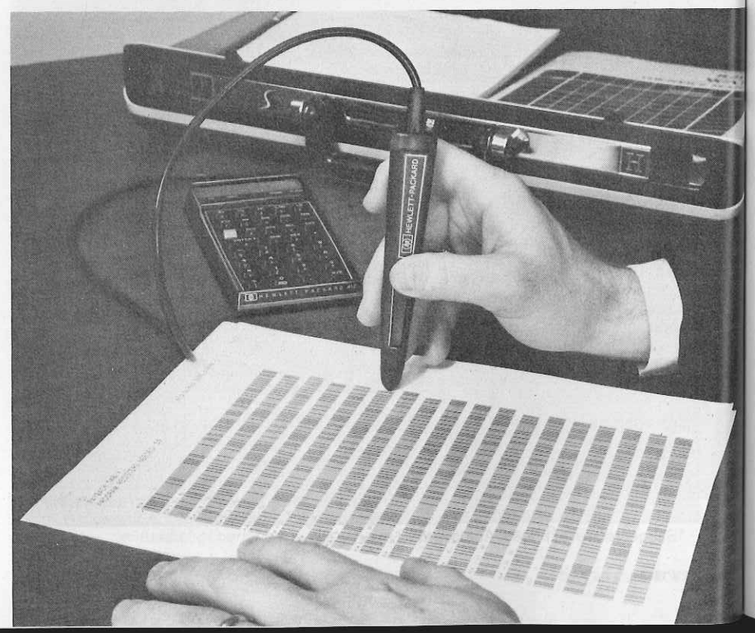
HP-41 Peripherals. In the fast-moving world of computer technology, it's not uncommon for companies to abandon older computer products as they introduce newer ones to take their place. Whether planned or unplanned, this form of technology obsolescence is detrimental and sometimes disastrous to owners of the older systems.

Hewlett-Packard has demonstrated a high degree of product loyalty by continuing to introduce software and peripherals for the HP-41. So far they have made available more than two-dozen solution books and sixteen application pacs. The application pacs include plug-in ROM modules that contain programs in such diverse topics as surveying, engineering, circuit analysis, statistics, mathematics, etc. The modules are accompanied by excellent documentation and, when appropriate, a customized keyboard overlay.

Numerous hardware peripherals are available for the HP-41. The 82180A Extended Functions/Memory Module is a plug-in RAM/ROM cartridge that adds 47 new keyboard functions *and* 889 bytes of continuous memory. This module gives the HP-41 the ability to store programs and data in files and to access an additional 1666 bytes of continuous storage in each of one or two 82181A Extended Memory Modules. These modules give the HP-41 up to 6454 bytes of RAM storage space.

The 82182A Time Module adds a quartz-controlled clock, stopwatch, and calendar capability to the HP-41. The Time Module allows the HP-41 to be programmed to execute a program, signal an alarm, actuate an external device or peripheral, or function as a versatile data logger.

Hewlett-Packard's bar code-reading Optical Wand (HP-82153A) plugs into the HP-41C computer.



Programs and data can be loaded into the HP-41 via the keyboard or with the help of a handheld wand that reads bar code. The wand permits lengthy listings to be loaded quickly and *error free*. Bar-code listings are supplied with HP-41 software. A service for converting commonly used programs into bar code is available.

Programs and data may also be loaded into the HP-41 with the 82104 Magnetic Card Reader, a plug-in attachment that mounts atop the computer. A single card holds up to 224 bytes. Long programs can be stored on multiple cards. An interesting feature of this "smart" card reader is that it can be instructed to disallow alterations of on-card programs or even prevent unauthorized viewing. This provides an important degree of security for programs or data which may have required considerable development time.

Fast, quiet, alphanumeric printing of program listings and data is provided by the 82143A thermal printer. The printer, which has its own rechargeable battery pack and connects to the HP-41 via a short cable, includes built-in firmware that adds 25 new printer instructions.

A 44-register print buffer is included to allow combinations of alpha and numeric characters to be printed in any desired format. With patience, you can design your own graphics and special characters using the BLDSPEC (build special) instruction. There's even a built-in interactive plotting routine, PRPLOT, that prompts you for information about what to plot and then proceeds to graph the results on an x-y axis.

The latest HP-41 peripheral development is the Hewlett-Packard Interface Loop (HP-IL). This is a closed-loop, two-wire link that allows an HP-41 or other compatible computer to access and control any device in a string of up to 96 series-connected peripherals. The cable length between devices can reach 100 meters.

Implementing the HP-IL requires an HP-IL module that plugs into the HP-41. So far, Hewlett-Packard has introduced two HP-41 peripherals that are HP-IL compatible. The 82161A Digital Cassette Drive is a compact, mass-storage unit with a storage capacity of 131,072 bytes per tape—more than fifty times the maximum RAM capacity of the HP-41CV.

All the programs in every HP-41 software book can be stored on about 75% of a single tape! The average file access time is a reasonable 13 seconds, and the total contents of a fully expanded HP-41 can be copied from or written onto tape in under 40 seconds. Program files are easily copied from tape into the HP41's RAM by entering the name of the file and executing the command READP.

The second HP-IL peripheral is the 82162A Thermal Printer/Plotter. Functionally similar to the 82143A, the original HP-41 printer, this new printer includes several new features and an expanded buffer. The 82183A Extended I/O Module permits the new printer to print bar codes.

Hewlett-Packard has also introduced the 3468A Multimeter, the first HP-IL compatible instrument designed to interface with the HP-41. Many sophisticated applications for this new multimeter are possible because its operation can be controlled by the HP-41.

For example, a suitable light detector can be connected to its input to cause it to function as a solar-power meter. With the help of a Time Module, an HP-41 can sample the solar-power level at any desired time interval during the day and resume sampling the next day. The 82162A printer can then produce a plot of available solar power versus time.

While some companies wait to see what Hewlett-Packard will do next, Hand Held Products (6201 Fair Valley Drive, Charlotte, NC 28211) has introduced an HP-41 add-on memory peripheral, the HHP-16K™. This compact unit connects to the HP-41 via a short cable and provides a storage capacity of 4K, 8K, or 16K bytes. Ultraviolet-erasable EPROMs are used in the unit.

HHP provides full customer service for the loading of programs into its memory unit. The introductory cost is $241, with EPROM loading available for an additional fee.

Using the HP-41. The HP-41 has multiple operating modes. Normally it functions as a sophisticated scientific calculator. Placed in USER mode, the keys execute any functions or even complete programs previously assigned to them by the user. In ALPHA mode the keys become letters of the alphabet.

The HP-41 that I own is presently configured as a specialized optical radar and communications calculator when it is in USER mode. One of the programs I've loaded into the machine is called Range R. This program is assigned to a key which has been given the name "R" with the help of a keyboard overlay. Range R can be executed by pressing this R key (in USER mode) or the XEQ (execute) key. In the latter instance, the display will show XEQ____. The program name is typed into the keyboard (in ALPHA mode), and the display then prompts "XMTR POW-

The HP-41C shown here is generating the function sine x. The output, with the curve, is shown on the printer.

ER?" After the transmitter power is entered, a series of prompts for additional information flashes into the display. Finally, the display shows "RANGE = " followed by the range in meters.

The HP-41 utilizes reverse Polish notation (RPN), a highly efficient and logical problem-solving procedure wherein numerical data are processed immediately after they have been entered into the display. This eliminates the traditional equal key found on algebraic-type calculators. Thus, the keystrokes required to add two and three (2/ + /3/ =) becomes 2/ENTER/3/ +.

Developing simple programs for the HP-41 is easy, direct and fast. The program is first assigned a name or *label*, and the steps are then keyed in. There's no need to assign line numbers since they are automatically included by the HP-41. Editing is straightforward, though certainly not as convenient as with the HHC or PC-1500.

Here's a simple timer program that decrements (counts down) in units of one from any positive number initially in the display:

```
01 LBL "TIMER"
02 VIEW X
03 1
04 -
05 X≠0?
06 GTO "TIMER"
07 BEEP
08 END
```

The beeper sounds when the count reaches 1.

This program is straightforward. After the number is decremented (steps 3-4), the program compares it with 0 (step 5). If it does *not* equal 0, then the number is again decremented (step 6). Otherwise the beeper sounds.

While this program is very obvious, it is not elegant. An experienced HP-41 user would simplify it by the apparent contradiction of *adding* an extra step and revising the loop instruction (GTO "TIMER"):

```
01 LBL "TIMER"
02 LBL 01
03 VIEW X
04 1
05 -
06 X≠0?
07 GTO 01
08 BEEP
09 END
```

This program is simpler since the HP-41 need not perform a *global search* through its files to find the program named "TIMER" each time it runs the loop. Instead, it searches for the *local* label 01 *within* the program. This approach is more efficient and it speeds up program execution. Therefore, a larger number must be initially entered into the display to obtain the same time delay.

The most important benefit of adding the extra label is the saving of four bytes: The new GTO instruction is simply GTO 01, not GTO TIMER.

This short example illustrates but one of the many fine points of HP-41 programming. Complicated HP-41 programs can be difficult to develop, but the HP-41 provides a highly versatile, almost assembly-language approach that appeals to some programmers.

HP-41 owners should know about PPC, an international, independent users' club for HP-41 devotees. You can receive information about PPC and a sample issue of its journal by sending a self-addressed 9" by 12" envelope with first-class postage for two ounces to PPC Calculator Journal, 2545 W. Camden Place, Santa Ana, CA 92704.

Conclusion

IN comparison, Quasar's HHC and Sharp's PC-1500 are both considerably faster than the HP-41. When a printed output is required, however, the HP-41 can often hold its own.

To simplify comparisons, I matched the PC-1500 against the slower HP-41 on a time-trial basis. For the first test, both machines were programmed to count from 0 to 1000 and sound their beeper when complete. Both computers were programmed from the keyboard in minutes with little or no editing. The PC-1500 finished in a very fast 1.5 seconds versus a dismal 14 seconds for the HP-41.

For a second test, both machines were programmed to print the square of each digit from 1 to 10 in identical formats (for example, '1 SQUARED IS 1', etc.). The PC-1500 program was composed in a minute or so at the keyboard. The HP-41 program, however, required considerably more time. Though the bulk of the program was trivial, having everything printed on the same line was not. (I was unfamiliar with the use of the accumulator buffer in the 82143A printer and its instruction, ACA.)

Now it was Sharp's turn to eat dust. The PC-1500 needed 45 seconds to print what the HP-41 printer spewed out in 15 seconds. When the PC-1500 printed its smallest character size, it improved its speed to 23 seconds, still 50% slower than the HP-41. (Of course, the PC-1500 could have easily beaten the HP-41 if hard copy were not required.)

My tests can hardly be considered worthy of benchmark status. But at the very least, they illustrate the need to carefully compare *all* the parameters of a handheld computer system before making judgments about which machine is faster than another.

Summing Up. Now that I've had the opportunity to use and evaluate three of the new handheld computers, which represent five brands in the marketplace, I'm convinced they are indeed practical, priced right, and destined to thrive in the highly competitive personal computer market.

But which of the handheld computers examined here is best? Since each of the machines has special characteristics, there is no clear answer. Here are some capsule comments about each model's attributes to help you determine which one best fits *your* applications and requirements.

The Quasar HHC (or Panasonic equivalent) is well-suited for file-structured programming. It has several very useful peripherals and can interface with color-TV receivers and video monitors, as well as other computers, via its optional modem. Of the three machines reviewed here, the HHC most closely resembles what one might expect if a desktop personal computer were reduced to a handheld format.

The Sharp PC-1500 (or Radio Shack equivalent) has a drawback in its lack of a file system, but it has more mathematic and logic functions than the HHC. Though it lacks the HHC's wide range of peripherals, its optional printer/plotter is by far the most impressive and versatile of the three we looked at. Furthermore, its color print provisions give one an added benefit.

The Hewlett-Packard HP-41 has neither the programming ease of BASIC, nor a keyboard that is familiar to typists. It has many single-key functions that speed up program entry, however. Nearly all of its keys are redefinable, and its keyboard "language" generates its own line numbers and automatically files programs by alphanumeric labels. Numerous peripherals are widely available for the HP-41, though given time, the others, which are recent entries on the market, could well catch up. With the HP-41, one cannot interface with other general-purpose computers or use a common high-level language.

The HHC and PC-1500 are further set apart from the HP-41 by their somewhat larger size, which allows for more display characters and a standard keyboard layout. However, the HP-41 is easier to hold in one hand, and its keyboard is simpler to customize.

If you are interested in acquiring a handheld computer, your purchase decision also will be influenced by price and availability of peripherals. You should arrange for a firsthand demonstration and inspection of each machine, of course, and determine which meets your needs best. No matter which you select, you will be impressed by any one of them. ◇

SIMPLE AUDIO GATE EXPANDS DYNAMIC RANGE

Obtain effective noise reduction with this under-$30 circuit

BY JOHN H. DAVIS

SINGLE-ENDED noise reduction may be all you need to strip background noise from on-location voice recordings, dub "clean" home-movie soundtracks, mute public-address microphones, and improve the audio from video tape recorders. The simple audio gate described here can handle any of these tasks. No encoding is required of the signal source, and with a little practice you should find the gate quite satisfactory for most nonprofessional applications. An investment of less than $30 can buy you a cost-effective alternative to the more sophisticated noise-reduction devices currently available.

Audio gates have been used by professionals for many years—recording studio engineers often refer to them as "noise gates." An audio gate does not constrict and expand the bandwidth of the reproducing system. Instead, it is simply a voltage-controlled attenuator with two states. When a normal signal level is present, the gate operates at unity gain. Below this level, the gain automatically drops, quieting background noises—and the residual signal. This action is comparable to dynamic range expansion, except that the gain reduction is fixed and occurs at a definite, preset threshold.

Circuit Description. In the circuit (Fig. 1), input *IC1A* can be operated as a buffer or a gain stage, depending on input level. Its output is coupled through *C1* to the voltage-controlled attenuator (*R3, R4, Q1*) and the input of a level comparator (*IC1C*). The level comparator is biased with a threshold voltage from *R10*. As long as no signal peaks exceed this threshold voltage, the output of *IC1C* will be positive and no charge will be applied to *C3*. This means the channel resistance of *Q1* will be low, allowing voltage divider *R3-R4* to attenuate the signal applied to the output buffer (*IC1B*).

When positive signal peaks rise above the threshold, the output of *IC1C* will switch negative for a fraction of each cycle, charging *C3* through *D1*. Now the channel resistance of *Q1* rises to several times that of *R3*, effectively disabling the *R3-R4* voltage divider. Attenuation is thus removed from the audio path.

With the component values given, the threshold may be adjusted to begin anywhere from 160 mV rms to less than