

### About the Author

*Dan Fylstra is a graduate of Massachusetts Institute of Technology and a second year student in the MBA program of Harvard Business School, concentrating in marketing. His background includes extensive work with high level languages including authorship of the PLM/6800 compiler for Intermetrics Inc, and consulting on the HAL/S language and compilers for NASA and the European Space Agency. His equipment now includes a KIM-1, an OSI system, PET 2001 and Radio Shack TRS-80.*

# User's Report: The PET 2001

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Photography by Dan Comly

About a year ago Commodore Business Machines Inc, a well-known maker of pocket calculators, startled everyone in the personal computer industry by announcing its PET computer, a self-contained unit with keyboard, display, cassette drive and built-in BASIC for \$495. The announcement was greeted with considerable enthusiasm and skepticism, for Commodore obviously was stretching the state of the art in technology, manufacturing and mass distribution.

Now the first PETs have been delivered, and a few computer stores have begun advertising their availability. The PET's price has risen to \$595, and in the meantime other personal computers with comparable price and performance characteristics have come on the market. Many people are wondering which computer represents the best buy in terms of hardware and software capabilities, expandability, availability and delivery, warranty and service, and software support. If you are considering purchase of such an "appliance" computer, this review should help you make your own informed judgments on these issues.

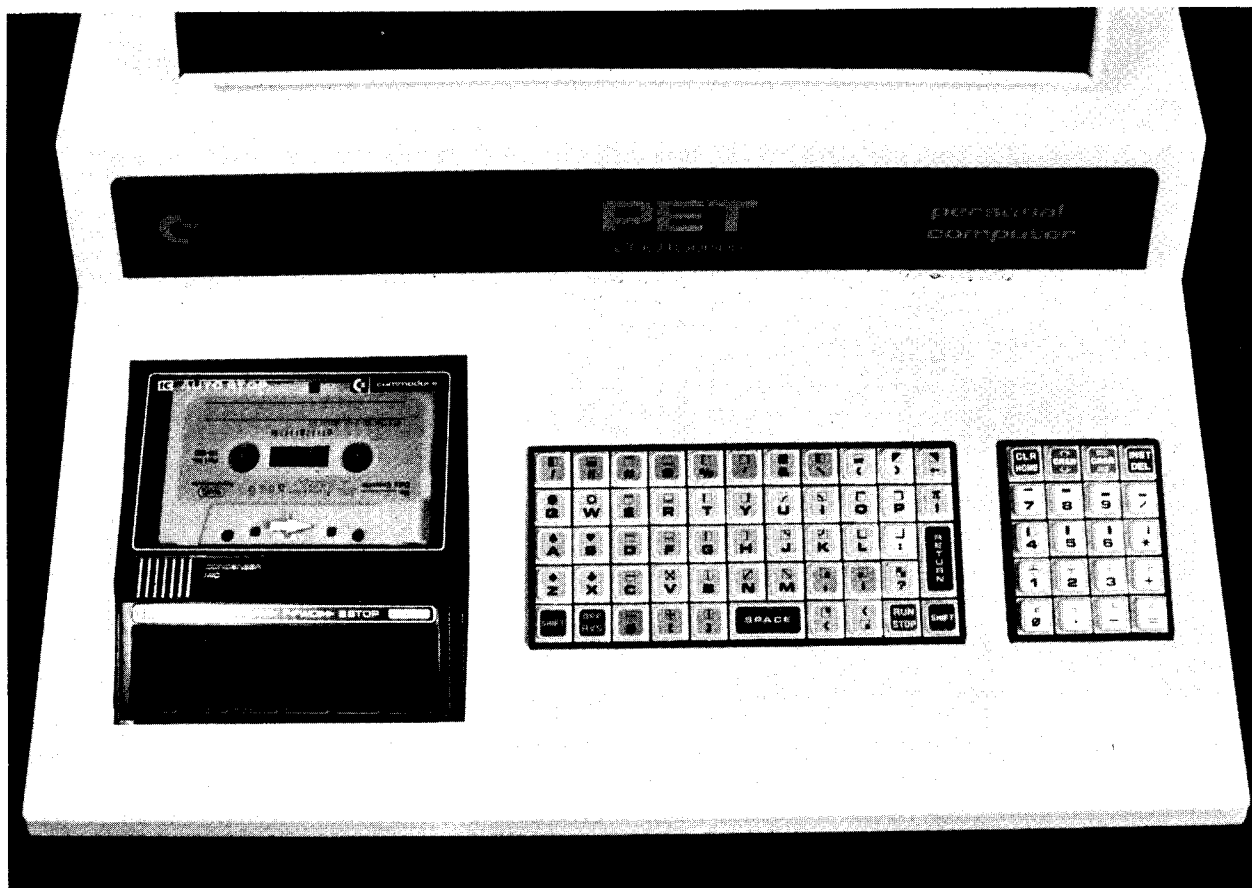
I ordered a PET a few days after the finished product was shown at the National Computer Conference in Dallas TX last June, and hence I received one of the early units (apparently number 17 off the production line) without a complete user manual describing everything the PET can do. By the time this is printed a better user manual should have been published; so bear in mind that this is a preliminary review, written in late October 1977, and based on experience with my PET, conversations with Commodore engineers at trade shows, and precious little documentation. I have not been able to test some of the PET's many features, in particular the expansion options, due to the dearth of information from Commodore. For a more complete picture, talk to your computer dealer and, if possible, to other PET owners before you make a purchase decision.

### General Specifications

Photo 1 illustrates the attractive overall appearance of the Personal Electronic



*Photo 1: A view of the Commodore PET, Model 2001. This personal computer sells for \$595 and includes a keyboard, video display, cassette drive, 4 K bytes of programmable memory, and a BASIC interpreter and operating system in 14 K bytes of read only memory.*



*Photo 2: A close-up of the PET keyboard and cassette drive. The keyboard is a flat, calculator style unit with 73 keys. The upper case shift positions on 64 of the keys are occupied by graphic characters. At the right are the cursor control and insert/delete keys and a numeric keypad.*

Transactor, Model 2001 (as it is fancifully called). Overall it measures 16.5 inches (41.9 cm) wide, 18.5 inches (47 cm) deep and 14 inches (35.6 cm) high, and weighs 44 pounds (20 kg). The PET is a lot more portable than most computers, but you won't have to carry it very far before you'll appreciate how heavy an oddly shaped 44 pound package can be. On the other hand, all the essential peripherals are integrated into the unit, and all you need is a wall socket to power up and start typing in BASIC programs.

A powerful BASIC interpreter and an operating system presently supporting multiple external peripherals are built into the PET's 14 K bytes of read only memory. The basic PET for \$595 includes an additional 4 K bytes of programmable memory, which holds your currently running BASIC program and data. An expanded model for \$795 includes 8 K bytes of user memory (the maximum amount of memory inside the standard cabinet). Thanks to the efficient encoding of BASIC statements (see below), even the basic 4 K unit can hold up to a few hundred lines of program text.

Since Commodore had acquired MOS Technology Inc as a captive source of its

calculator chips and other silicon requirements, the PET is based on the MOS Technology 6502 microprocessor. This may not be of much significance to the casual user since the machine is primarily designed to be programmed in BASIC, but it may make a difference to the experienced hobbyist who intends to write machine or assembly language programs as well.

### Display Screen

The PET includes a 9 inch (22.9 cm) enclosed, black and white, high resolution CRT display which presents 1000 characters, arranged in 25 lines of 40 characters each. The display is memory mapped (ie: continuously read out of a section of programmable memory separate from the BASIC program and data memory), and is easily controlled from BASIC using PRINT and POKE statements. (PET owners who have not already done so may want to experiment with direct access, via POKE statements, to the display memory, which starts at location 32768.)

Built-in software provides a winking cursor and automatic scrolling from the bottom of the display. The cursor can also be moved

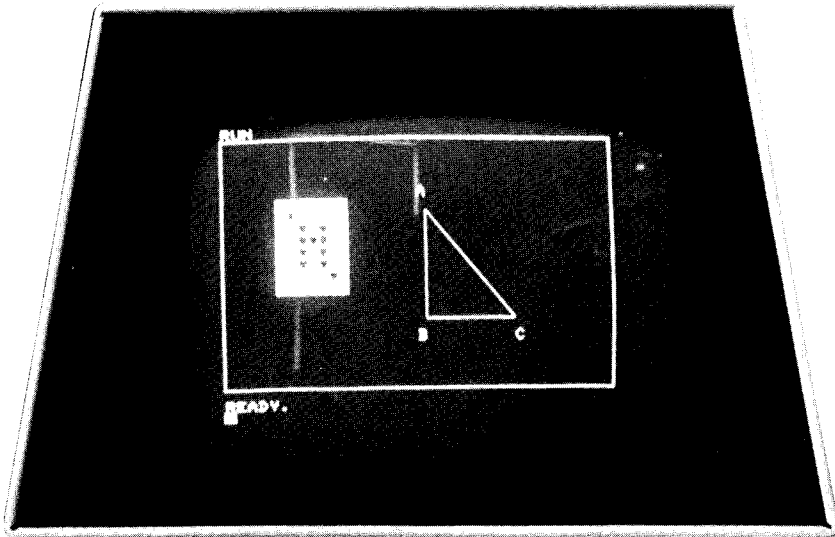


Photo 3: A simple example of the PET's graphic capabilities. This display was created with a series of 23 BASIC PRINT statements. The graphics characters in each character position run together to form the figures. The playing card illustrates the use of the reverse field option.

in any direction using the cursor control keys (see the keyboard layout shown in photo 2), and the insert/delete key can be used to "push apart" characters on a line to make room for changes or to delete characters and "close up" the space which they formerly occupied. These features provide a convenient way to modify a BASIC program without having to retype entire lines: just list the lines on the display, use the cursor control and insert/delete keys to make changes directly on the display, and press the return key after each line is satisfactorily modified. A key is also provided to clear the screen or to send the cursor to the "home" position (upper left-hand corner).

### Character Set

The PET's standard character set includes 64 upper case alphabetic, numeric and special characters, and 64 graphic characters, which are generated by pressing the shift key and one of the regular character keys (see photo 2). Each character is formed on the screen in an 8 by 8 dot matrix, and each character position on the screen is contiguous to those around it, so that graphic characters can be run together to form lines, solid areas and other shapes and figures. Furthermore, a "reverse field" feature, applicable on a character by character basis, changes each white dot to black and each black dot to white. This in effect gives 64 additional graphic characters. Any of these characters, including the reverse field and cursor control characters, can be inserted into a BASIC language PRINT statement, so that interesting graphics effects can be created quite easily. A simple example of the PET's graphics capabilities is shown in photo 3. In general, the PET's graphics capabilities are better adapted for drawing pictures of this sort than for plotting mathematical functions.

For the person who is more interested in alphabetic text than in graphics capabilities, the PET provides an upper and lower case character set with a limited number of graphic characters. The lower case option, which is applicable to the entire screen at once, is enabled by means of a POKE statement which changes the setting of an address line on the character generator read only memory. The effect is to produce a lower case letter in place of the graphic character which normally appears when an alphabetic key is pressed in upper case shift. (Yes, you must press the shift key to get lower case, and omit the shift key to get upper case!) This is illustrated in photo 4.

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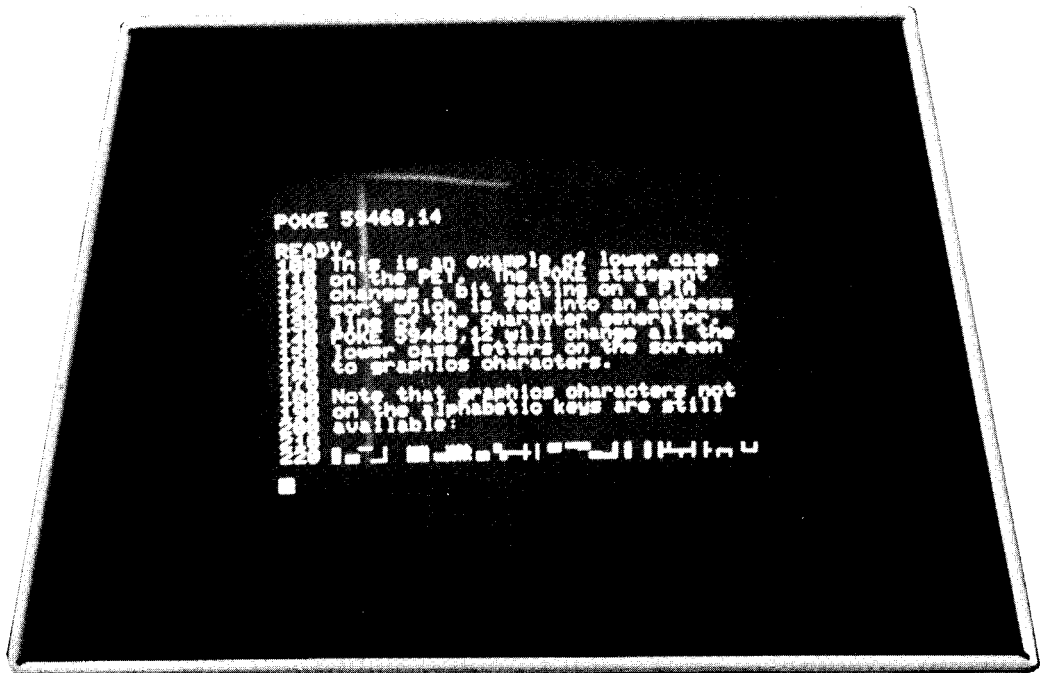


Photo 4: An illustration of upper and lower case letters on the PET. 26 of the 64 graphics characters can be exchanged for lower case letters by altering an address line on the character generator read only memory.

### Keyboard

A much criticized feature of the PET is the design of the keyboard itself. It is a calculator style keyboard rather than a true typewriter keyboard. The keys are small and flat (about a half inch square and a quarter inch deep). They are tightly packed next to each other and are arranged in vertical rows rather than the slanting rows used on a typewriter keyboard. Although the alphabet follows the usual typewriter layout, the PET keyboard really cannot be used for touch typing because of the size, depth and spacing of the keys. The keyboard is said to be reliable and long lasting, but I did find that the space bar would not register correctly unless it was pressed squarely in the middle. Certainly the keyboard lowers the cost of the unit somewhat, and Commodore points out that their keyboard provides a larger number of keys and hence more graphic characters, but it is definitely more difficult to use. As a result many personal computer users may try to interface a separate typewriter style ASCII keyboard to the PET.

A BASIC program can obtain input of numeric quantities and character strings from the keyboard using an INPUT statement. But Commodore BASIC also includes a GET statement, which allows the program to capture each key from the keyboard as it is pressed without the scanning, editing and conversion normally performed by the BASIC system on input. This feature makes it easy to implement interactive keyboard games.

### Cassette Drive

Also built into the PET's cabinet is an audio cassette recorder, which can be used for saving and loading programs and data. This device is hand operated much like an ordinary cassette recorder, but the motor can be started and stopped under software control, and the state of the manual switches can be sensed to a limited extent by software (yet the PET will still try to save a program on cassette if you've pushed PLAY instead of PLAY and RECORD). The cassette drive is said to be "modified by Commodore for much higher reliability of recording and record retention." The exact recording method used by the PET is not yet documented, but it appears to operate at a speed in the range of 1000 to 1400 bits per second. Because all information is recorded redundantly, the effective data transfer rate is about half this much. But the redundant recording enables the PET to detect and correct many recording errors. In my experience, data storage on the PET cassette drive has been remarkably reliable and trouble free.

### Operating System

An elegant cassette operating system in the built-in read only memory supports named tape files of both programs and data, with file names up to 80 characters long. A SAVE command writes a program onto a tape cassette, and the thoughtfully provided VERIFY command can then be used to reread the program from cas-

sette and compare it to the program still in memory to verify that it was written successfully. This is an essential feature when dealing with audio cassettes, if only for the user's peace of mind. A LOAD command will search down the tape for a named program and then load it into memory. Similarly, a data file, written on tape from BASIC by means of OPEN, PRINT# and CLOSE statements, can be searched for and read by another BASIC program using OPEN and INPUT# statements.

With a little care, programs can be chained together: a program segment in memory can automatically load the next program segment from cassette and continue execution. I was able to do this by placing LOAD and GOTO statements (separated by a colon) on the same BASIC line; the old program segment seems to be completely erased and replaced by the newly loaded segment, but data values are preserved.

The PET's built-in operating system is

capable of handling multiple cassette drives and apparently other peripheral devices as well. A second cassette drive interface is in fact included in the basic PET.

## Commodore BASIC

Table 1 summarizes the features of the powerful BASIC interpreter built into the PET Commodore BASIC, developed by the folks at Microsoft who brought you Altair BASIC, features real numbers, integers and strings, multidimensional arrays, a full set of mathematical functions, and a variety of extensions for string handling, input and output on external peripherals and machine language access.

Commodore claims that the PET's BASIC is at least 20 percent faster than other microcomputer BASICs, and the tests which I have run support this claim. In addition, Commodore BASIC is efficient in its use of memory, for it encodes BASIC statements as they are entered so that keywords such as PRINT and INPUT occupy only one byte. Another feature which can save time and memory space, especially when large arrays are involved, is the use of integer variables (which occupy two bytes) in place of real variables (which require five bytes). Programs are also stored on cassette in encoded form. This speeds up the process of saving and loading programs, but makes it more difficult (especially in the absence of documentation) to enter BASIC programs from an external device such as an ASCII keyboard or a paper tape reader, or to write programs, such as macroprocessors, which must manipulate program text as data.

For readers unfamiliar with Altair BASIC, the PET's character string handling functions are worth mentioning. LEFT\$, RIGHT\$ and MID\$ are used to extract a substring of specified length and position from a character string. LEN returns the length of a string, and VAL and STR\$ convert numeric quantities to character string form and vice versa. ASC obtains the internal character code for a given character, and CHR\$ converts a character code into a single character string for handling as such in BASIC.

## Machine Language Access

The PET user is not restricted to working in BASIC, for the PET is designed to support entry and debugging of machine language programs, and even other languages and programming environments. The BASIC user can examine or modify any memory location with the PEEK and POKE statements, or call a machine language subroutine via the USR function. Some nonstandard IO devices can be handled with the aid of the

<b>Data Types:</b>	Real numbers (eg: A), integers (A%) and strings (A\$) of up to 73 characters.		
<b>Arrays:</b>	Any number of arrays of reals, integers or strings with any number of dimensions.		
<b>Precision:</b>	Ten significant digits for real numbers.		
<b>Speed:</b>	Executes the loop 10 FOR I=1 TO 10000, 20 NEXT I in about 15 seconds.		
<b>Statements:</b>	LET READ DATA RESTORE PRINT INPUT GET	GOTO IF ... THEN FOR ... TO ... STEP NEXT GOSUB RETURN ON ... GOTO ON ... GOSUB STOP END	DIM REM DEF FN RUN CONT NEW LIST CLR
<b>Operators:</b>	= + - * / ↑	= <> >= <= > <	AND OR NOT
<b>Built-in Functions:</b>	ABS INT RND SGN	SIN COS TAN ATN LOG EXP	FRE TAB SPC POS TI TIS ST LEFT\$ RIGHT\$ MID\$ CHR\$ ASC LEN VAL STR\$
<b>Other Features:</b>	SAVE LOAD VERIFY	OPEN CLOSE PRINT# INPUT# GET#	PEEK POKE USR SYS WAIT CMD

Table 1: A brief summary of the features and performance of Commodore BASIC. The BASIC interpreter was developed for Commodore by Microsoft Inc, Albuquerque NM, designers of the original Altair BASIC. According to Commodore's engineers, the PET's BASIC actually includes some additional features not documented in the preliminary users' manual, from which this information was taken.

WAIT statement, which repetitively tests a memory location (such as a PIA port) until specified bits are set. Finally, the SYS command can be used to transfer "complete control of the PET" to a machine language subsystem previously loaded into memory.

According to Commodore's engineers, it is possible to save and load machine language programs on cassette, and undoubtedly an assembler in read only memory will be offered some time in the future. A machine language monitor, similar to MOS Technology's TIM, but utilizing the PET's keyboard and video display, has been developed for the PET. It was originally intended to reside in the PET's read only memory, but was squeezed out by other software and is now loadable from cassette, according to the latest word I've heard. As of this writing, Commodore has not released the machine language monitor on cassette, nor any documentation describing its capabilities.

### Expansion

One of the nicest aspects of the PET's design is the degree to which expansion provisions have been built into the basic unit. The main printed circuit board is con-

nected by means of plugs to the keyboard, CRT and built-in cassette. It includes four edge connectors which reach the outside world through openings at the base of the PET's cabinet. These edge connectors provide:

1. A second cassette drive interface with read, write, motor control and sense lines.
2. An 8 bit programmable IO port, actually the unused portion of an MOS Technology MCS6522 Versatile Interface Adapter (VIA).
3. An instrument interface obeying the discipline of the IEEE 488-1975 standard.
4. The microprocessor's address, data and control buses.

Provision for expansion is built into the PET's read only memory operating system as well. The second cassette drive and the IEEE 488 instrument interface appear to be fully supported by BASIC through the OPEN, CLOSE, PRINT#, INPUT#, GET# and CMD statements. Use of the VIA port and the address, data and control buses may require some machine language programming, although much could be done with the PEEK, POKE and WAIT statements

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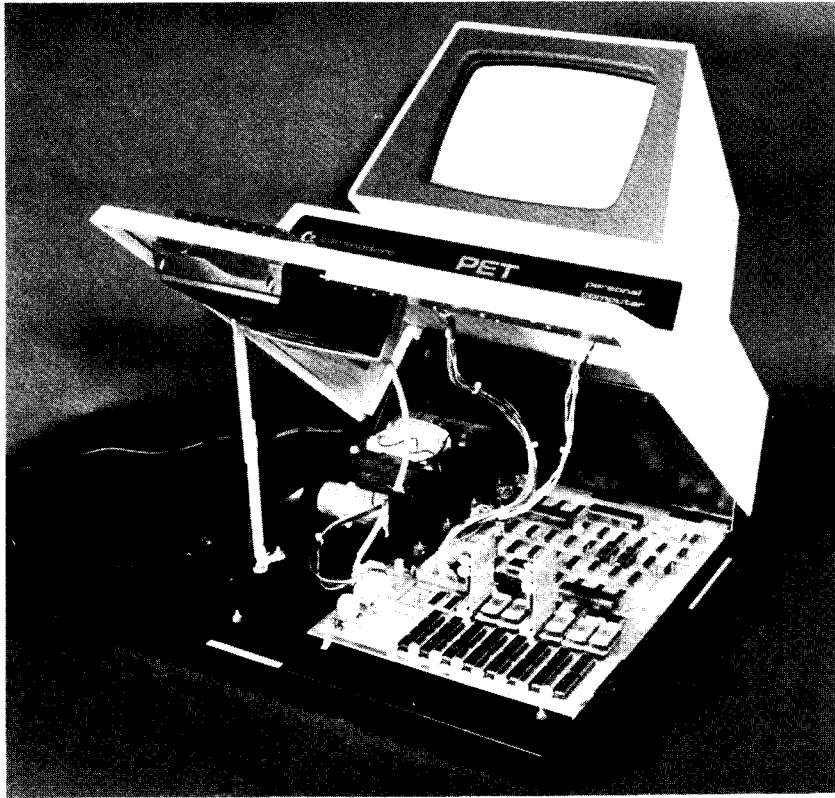
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*Photo 5: The PET props open for easy service access. Besides the main printed circuit board, the unit contains a TV chassis type circuit board and a third board in the cassette recorder.*

in BASIC. Special programming could also take advantage of the VIA's peculiar serial IO capability. And theoretically, one could unplug the built-in keyboard from the main printed circuit board and plug in another keyboard and logic interface. Again, Commodore to date has not provided documentation of any of the expansion options, and I have not been able to test these features. But I did see the PET driving a programmable oscilloscope in a demonstration at a trade show last summer. For those interested, the IEEE 488 interface standard documentation can be obtained from the IEEE Service Center, 445 Hoes Ln, Piscataway NJ 08854, (201) 981-0060.

#### Application Software

No application programs were supplied with the PET I received, not even a demonstration cassette which I had requested. But many of the first PETs off the production line are being delivered to people who have purchased one with the idea of developing generally useful application programs. Commodore plans to reproduce and sell application programs through its dealers, offering royalties to the software developers.

And if the PET follows the pattern of other personal computers, additional systems and application software are likely to be offered by independents as well. Many application programs in BASIC can be found in books and in the files of large scale computer systems. Some of these programs are copyrighted and most will require some modification to fit the features of Commodore BASIC, but far less effort should be required to adapt such existing programs than to write the programs from scratch.

The PET has considerable potential in schools and universities, and it appears that many of the currently active software developers are especially interested in educational applications. I would not be surprised to see the PET show up in classrooms and university computer centers across the country, taking the load off game program burdened timesharing systems, and spurring new courses and educational research projects.

#### Availability and Delivery

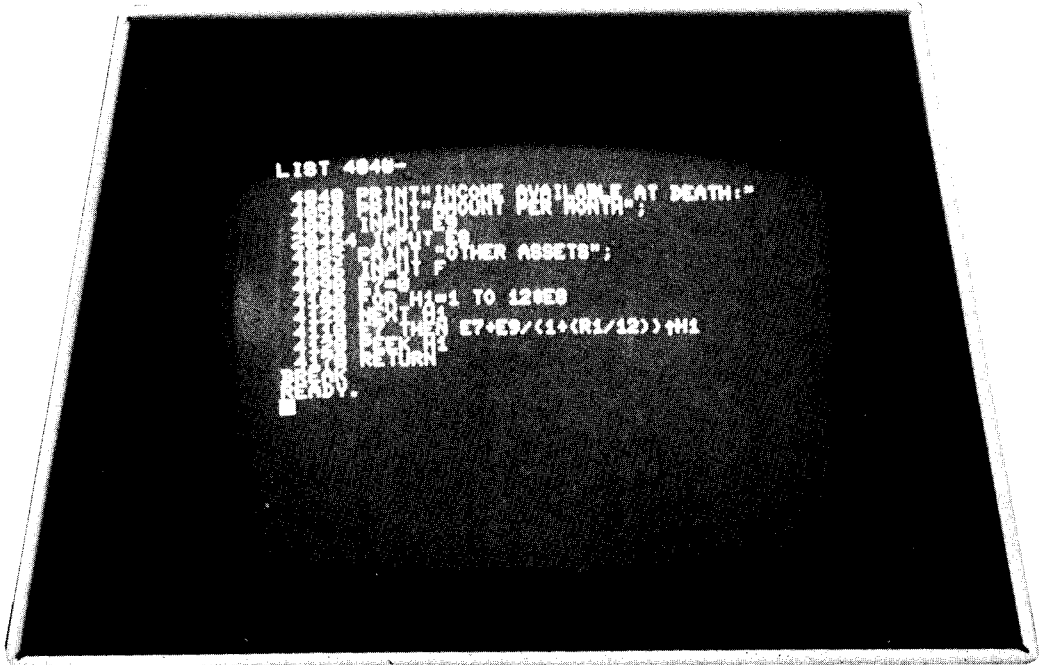
Initially Commodore followed a policy of "cash now, delivery later" which meant, in my case, delivery on October 11 1977 of a PET which I paid for in late June. This was nominally within Commodore's contractual obligation to deliver in 90 days. This situation should change, however, as Commodore builds up its manufacturing volume and works off the backlog of initial orders. As this is written, I have heard that a few dealers have demonstration units on display in their stores, and at least one dealer has begun accepting orders on credit cards. Someday you may be able to buy a PET at your local computer store and carry it home, but until then you should probably base your plans and expectations on "worst case" estimates of delivery time.

#### Warranty and Service

Service has always been a problem in the personal computer industry. It represents an even bigger problem for Commodore, since the PET will be distributed through calculator dealers as well as computer stores, to ordinary consumers as well as to computer hobbyists. Commodore's approach to the problem has been to design the unit to be serviced as easily as possible.

The PET cabinet props open for easy access, as shown in photo 5. The entire unit contains only three individually replaceable printed circuit boards. The main board can be snapped out and returned to the factory or replaced by a Commodore dealer. A 1 K byte diagnostic routine is included in the PET's read only memory,

Photo 6: The PET received by the author was delivered with several faulty memory chips, which led to a variety of strange effects in BASIC as illustrated by this photo. The statement numbered 20464 was not typed by the user, and the statement numbered 4120 was listed twice by the LIST command. After the bad memory chips were replaced, these symptoms disappeared.



so that with special test equipment this board is "self-diagnosing." The second board, for the CRT display, is virtually identical to the same section of a chassis in a conventional TV set. The third board, for the cassette drive, is similar to the circuit board found in an ordinary audio cassette recorder.

Commodore believes that the PET could be serviced by a TV repairman equipped with a brief service manual. It is not yet clear, however, just how or whether TV repairmen might be licensed to repair PETs under warranty. Presumably experienced computer hobbyists could read the service manual and diagnose problems with their own PETs, requesting replacement parts from the factory, but how Commodore might react to this possibility is an open question. Of course, there is always the problem of latent bugs in the read only memory software, which a TV repairman might have some trouble diagnosing. Seriously, the only realistic approach to handling software problems is for hobbyists and PET dealers to document carefully with examples any anomalous behavior of their PETs, referring the information back to the software developers.

At present, however, PETs are being serviced only at Commodore's headquarters in Palo Alto CA. The user must arrange to ship the unit to Palo Alto and must be prepared to wait up to eight weeks for the PET to be fixed.

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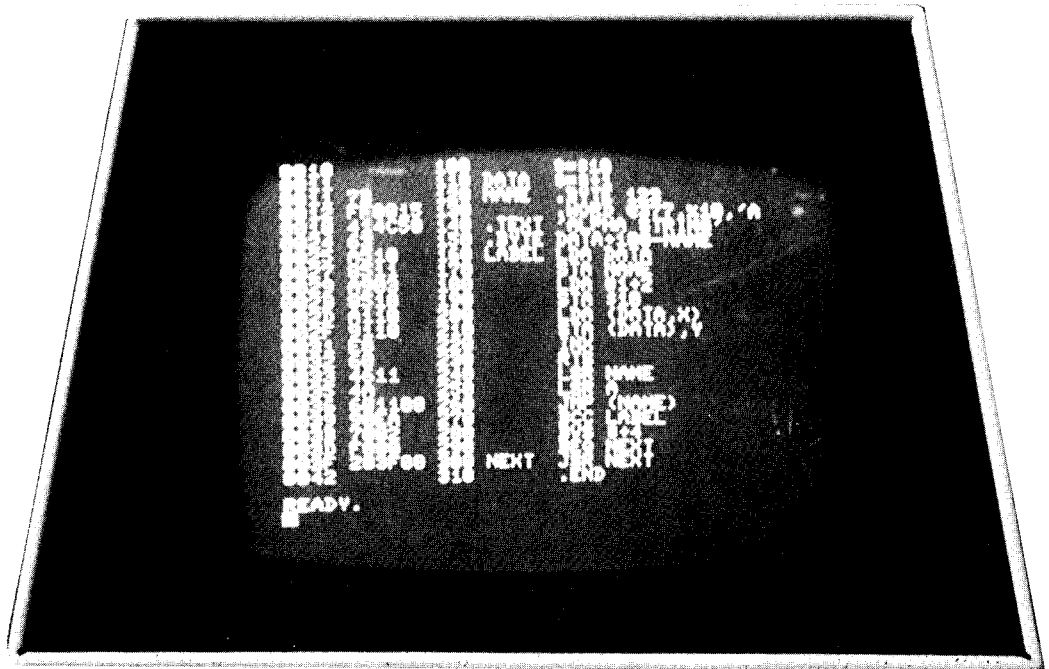

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*Photo 7: The Commodore PET 2001 is an eminently usable machine, as is illustrated by this display of a 6502 assembler written in the machine's version of the BASIC language. This assembler was originally written in FORTRAN for use on large systems, and implementing it in BASIC was a relatively mechanical job of translating statements and typing them into the PET.*



Although eventually Commodore may have a nationwide service network for the PET, my informal service experience with the early unit which I received has been quite similar to that reported by owners of other personal computers. I was unlucky enough to receive a unit with three bad memory chips which caused a variety of strange effects such as those illustrated in photo 6. For several weeks after I received the PET I was unable to get anyone at Commodore on the phone and was left to fend for myself. I suspected a memory problem, but my memory test programs written in BASIC apparently were not exhaustive enough to locate the faults. Finally John Feagans, one of the designers of the PET, called me, quickly diagnosed the problem and mailed me a machine language memory diagnostic program and some replacement memory chips. With these aids I was able to find and replace the defective chips in a couple of hours.

### Conclusion

The PET may well be an "appliance" computer, suitable for the most casual computer user or, with appropriate application software, for the average consumer. But it is also a powerful tool in the hands of an experienced computer hobbyist. The options and flexibility built into the PET, ranging from string handling and machine language access to the second cassette inter-

face and the IEEE 488 bus, make it quite suitable for expansion and enhancement. As a small illustration, despite the problems I have had with my PET, I have been able to debug and put into use several thousand lines worth of BASIC programs. Among these is a 6502 assembler written in BASIC, a program of about 700 lines which I originally wrote in FORTRAN for use on an IBM 360 and a DECsystem 10.

For the casual user, the PET is a very low cost computer which can be programmed easily in BASIC, for use in schools, for playing games and for fairly complex calculations in engineering, statistics and the like. A better keyboard, a disk and a reliable printer would make it suitable for some business applications. In fact, Commodore is said to be considering development of a PET II computer which would incorporate several of these features. Whether the PET evolves into a general-purpose computer with a variety of programming systems and peripherals will depend on Commodore's future moves and on the activity of PET owners.

The PET is far from the only alternative in the marketplace today, but it is a strong contender. If you are contemplating a purchase, you would do well to compare its features against other offerings, talk to owners of the PET and other computers, and think about what you really want from a personal computer. I hope that this review article will help you in your evaluation. ■