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BYTE

the small systems journal

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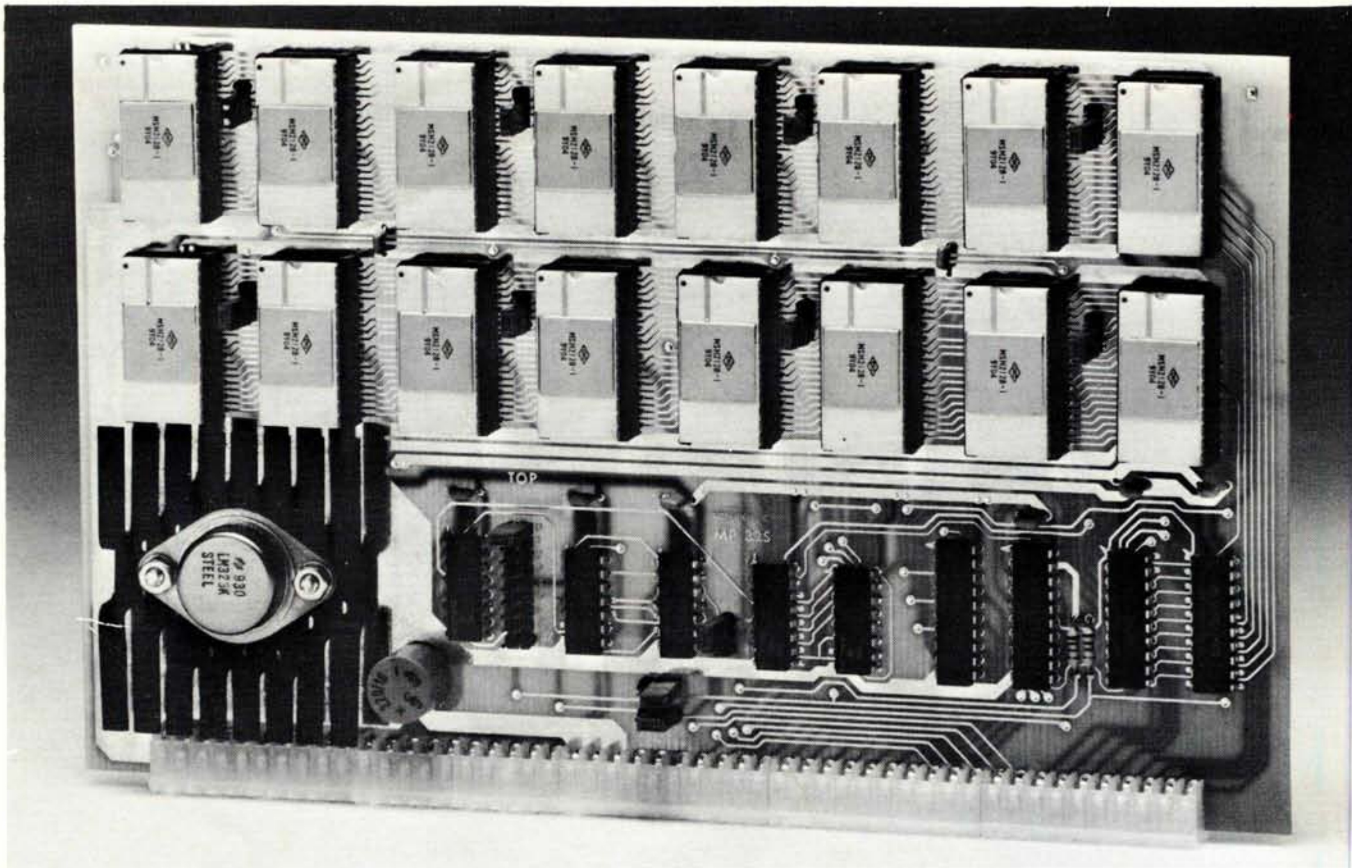

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In The Queue

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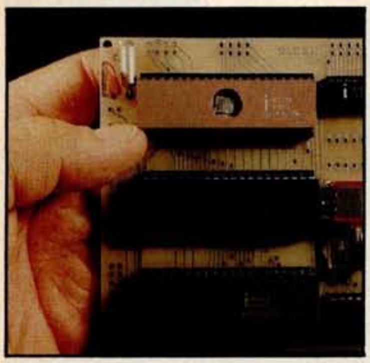

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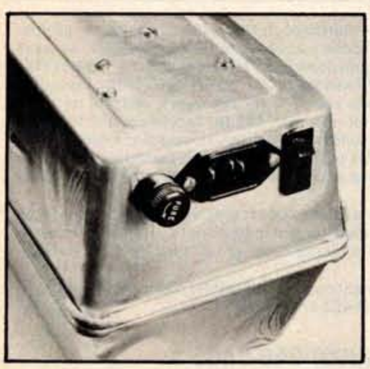

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Background

Nucleus

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ON THE COVER

This month's cover features Hewlett-Packard's new bar code loader. The unit is described in detail in Carl Helmers' editorial on page 6. Bar codes, have been around for several years, in one form or another, but the HEDS-3000 Digital Wand is the first serious attempt to make bar codes a part of personal computing. Bar code readers will soon be used to enter recipe information into your microwave oven, read the bar codes on groceries, and enter programs into your computer.

Also in this issue are several articles dealing with computer music. A lot has happened since our last special issue on music in September, 1977. Many of the new computers feature sound effects as a matter of course, such as the Atari and Texas Instruments models. This month Hal Chamberlin talks about recent developments in digital-to-analog (D/A) techniques for multiple-voice music generation; Jef Raskin describes a musical "amanuensis" or computerized music stenographer (the first of two parts); and Randolph Nelson reveals the details of how to enter and modify musical information into a computer quickly and efficiently.

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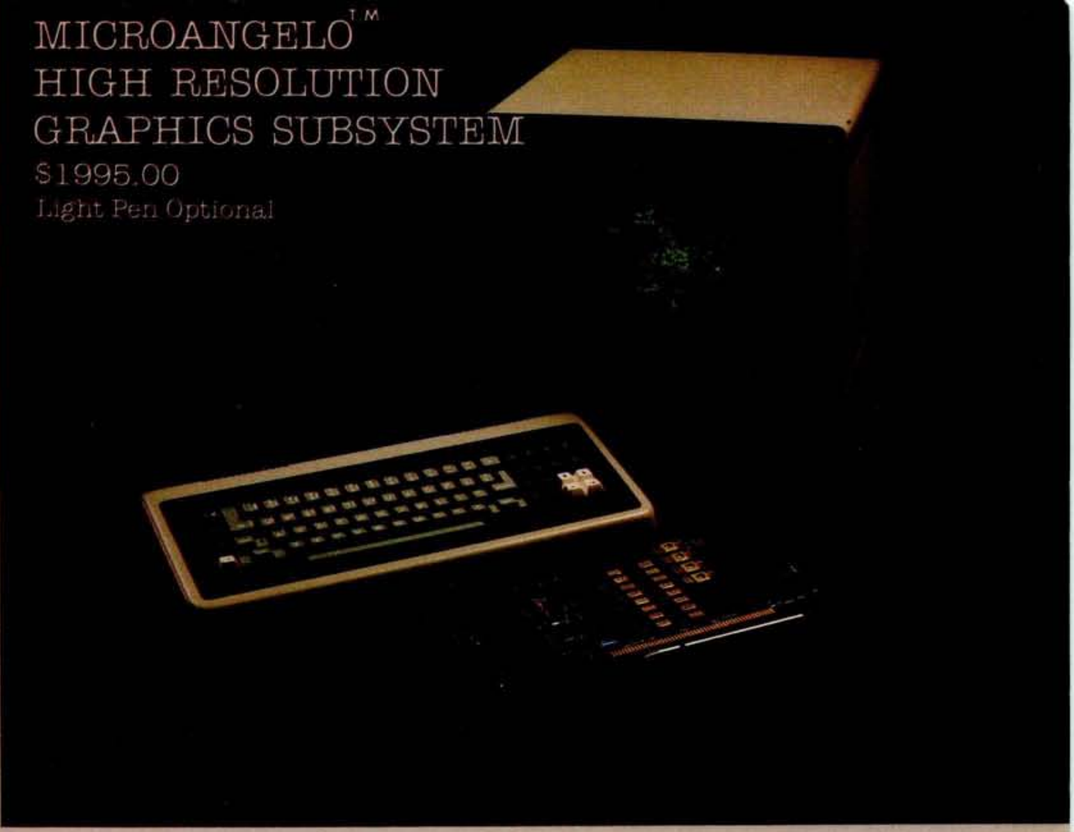

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Editorial

Bar Codes, Revisited . . .

Carl Helmers

It was with great excitement that I opened a package which recently arrived from Hewlett-Packard's Optoelectronics people in Palo Alto, California. This package contained one of the first production versions of the model HEDS-3000 bar-code data-entry wand. A photo of the wand as it came to us was prepared by Ed Crabtree as a cover for this April 1980 issue of BYTE. The bar-code reader opens the way to a whole new field of applications of small intelligent processors.

As long-time readers of BYTE will recall, we have in the past presented no small amount of information on the concept of printing digital information in bar-coded form as a method of economically distributing data or programs for use in a personal computer or other local processors. (See page 10 for "A History of Bar Code Information Published in BYTE.") The idea is to treat the printed medium as a means of distributing data. With five centuries or so of technological progress since Johann Gutenberg's day, the techniques of making a good image on paper have been fairly well debugged.

In the winter of 1976, I had first thought about this subject, then filed it away as an impractical scheme. My first thinking had been to try and use the direct output of a typewriter to record binary 1s and 0s. But 1s and 0s are not the ideal printed images to decode. They vary from typewriter to typewriter and have fairly low tolerance for variation in the position of a simple photosensor's scan. After putting aside this idea at that time, I expected to go no further with it.

But then in the summer of 1976 I was approached by Walter Banks, who, at the time, was associated with the University of Waterloo's Computer Communications Network Group. Walter proposed to transform the printing scheme into a true bar code, rather than to use my original idea of employing a type font. He commented that the University of Waterloo had an old Photon phototypesetter that communicated directly to several of his computers, so that it would be a relatively trivial task to create bar-code images for various data sets. This gave us a representation which was realizable.

But there was the problem of scanners. The technique would never become practical until a scanner that could be marketed for our target price, $50 in 1976 dollars. (Four years later, at an order of magnitude of 10% per annum inflation, our 1980 target is about $73.) The arbitrary figure of $50 (1976) was chosen so that the incremental cost would be small compared to the cost of a system which might use the technique. During the course of 1977, 1978, and 1979, we have from time to time printed texts containing data encoded in a bar-code format in order to experiment with the technique, even if no scanners were available which met the price criterion. The thought here was that among our readers would be individuals who might wish to experiment with methods of reading the form.

We also published a book written by Ken Budnick, about loaders and algorithms for decoding bar codes with several popular microprocessors. (This book, entitled *Bar Code Loader*, is available at a price of $2 plus postage of $0.60. It may be ordered from BYTE Books, 70 Main St, Peterborough NH 03458.)

But there remained the key requirement of an inexpensive mass-produced sensor for the bars. It would do little good to have a neat method of entry for mass-produced data unless the entry method were at a mass-produced price level (ie: not expensive relative to the total cost of the computer system). At the time Walter suggested this idea to me in the summer of 1976, the typical price of a commercially available bar-code sensor wand was $300 and up. We needed to excite enough interest in the concept to get a manufacturer interested in the technique for a number of purposes.

"My 8 to 5 minifloppy™ now works nights and weekends."

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Shugart Associates

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See opposite page for list of manufacturers featuring Shugart's minifloppy in their systems.

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As a result of the interest expressed in the magazine, Walter and I were contacted by John Sien of Hewlett-Packard's Optoelectronics Division in the spring of 1978. That year we stopped by at Hewlett-Packard after the National Computer Conference, which was held in Anaheim, California, as it will be again in May of this year.

Walter and I spent a solid day of activity with John and several of his product engineering and development people going over the functional specifications of what we wanted to see in a bar-code reader that was to be suitable for use with printed software. We were, of course, not told about specific details of any product they might have had under development at that time. Our purpose was to convey the functional specifications and an idea about the potential markets for such a product in the personal-computing area. But, as recent events have confirmed, Hewlett-Packard has decided to market just such a product.

The product is the Model HEDS-3000 bar-code reader wand, which is found on this month's cover. The wand can be purchased off the shelf from any Hewlett-Packard distributor around the world. The list price for a single unit is $99.50 from the distributor. Technical information about the digital wand can be obtained by contacting Hewlett-Packard directly at 640 Page Mill Rd, Palo Alto CA 94304; Attention: John Sien. The technical information that comes with the prototype reader kit includes the *Digital Wand User's Manual* for the HEDS-3000 and the detailed six-page engineering specifications for the device, dated October 1979 in the case of our copy.

The wand's price in production quantities will of course be significantly lower than the single-unit price of $99.50, depending on volume and details of the transaction like custom molding. John reports that Hewlett-Packard will supply this product in volume with numerous optional specifications. For example, there are 193 different combinations of case colors. The wand can be had in quantity with or without the manual push-to-read switch, with or without a custom label, and with or without the nine-pin D-type connector found in the prototype version.

John also reports that there is considerable interest from appliance manufacturers in use of this product to enter user-variable data. Thus, we can, for example, foresee microwave ovens that have scanning wands for entry of cooking instructions, kitchen computers that use scanning wands for entry of nutritional data used in managing various kinds of special diets, and other such appliances. To such a manufacturer of appliances, the bar-code option is very real and usable now, because of the existence of this product.

Other applications suggested by some of the Hewlett-Packard literature on the wand include file-folder tracking in offices, ticket verification, identifying assemblies in an electronics-service environment, security checkpoint verification, and the "classical" application of inventory control. This bar-code wand is the same one which is used to distribute user-library programs in an attachment for the HP-41C calculator, although it has a special interface and a different model number in that application.

For experimenters and systems designers interested in trying the wand, its interface is a model of simplicity and ease. Three wires are all that are required, as seen in figure 1. This figure is reproduced from page 9 of the excellent fifteen-page user's manual which accompanies the prototype kit for the HEDS-3000.

One wire supplies power, which is specified to be from 3.6 to 5.75 V. The reader attachment consumes a nominal, but fairly trivial, 50 mA worst-case current. A second wire is ground. The third wire is a signal connection, which represents an open-collector output similar to that of a typical opto-isolator. In the transistor-transistor logic (TTL) interface of figure 1a, this signal line is pulled up to the supply voltage with a 2.2 K ohm resistor. The recommended TTL-level interface also obtains hysteresis by using a Schmitt trigger integrated circuit, such as the 74LS13. Figure 1b shows a somewhat more complicated complementary metal-oxide semiconductor (CMOS) logic interface.

As of this writing, I have not yet connected the wand and experimented with it. Nearly any computer will do for those who wish to try this circuit. An obvious connection, for example, is to the game-paddle port of an Apple II computer, which has the necessary power and signal lines. A similar arrangement could be made with a parallel data port for the typical S-100-based computer such as the North Star or Cromemco machines. For complete low-level, assembly-language software needed to read bar codes published as a PAPERBYTE® , see Ken Budnick's book mentioned earlier. In it readers will find 8080/Z80, 6502, and 6800 versions of routines needed to scan our PAPERBYTE® format. These routines may also be used as a model for similar programming of other formats such as the HP-41C calculator format.

How about printing bar-code formats? It turns out that our original use of a phototypesetter is far more elaborate than is really required. Any software house can begin to supply variations of their products in bar-coded form

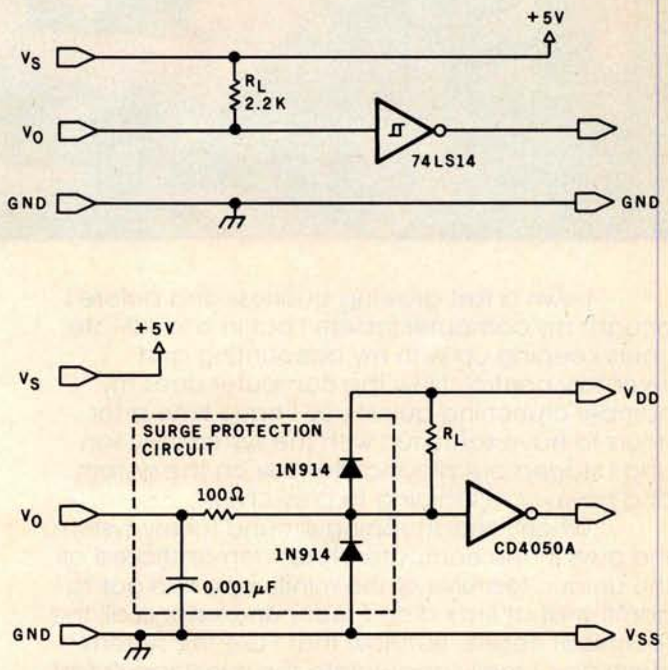


Figure 1: *A pair of schematics showing (1a) the TTL interface for the HEDS-3000 bar-code reader, and (1b) the CMOS-logic interface. This diagram is reproduced from page 9 of the HEDS-3000* Digital Wand User's Manual, *which accompanies the reader in a prototyping kit.*

using a relatively inexpensive piece of equipment added to a typical small-computer system, namely a high-resolution, hard-copy printer with relatively small incremental-spacing intervals.

For example, Tom McNeal of Hewlett-Packard's Corvallis Division (manufacturers of the HP-41C calculator) reports that he uses an impact printer with carbon-film ribbon to produce bar codes in the format shown in figure 2. Printers with similar characteristics of high-resolution placement of vertical bar characters are manufactured by companies such as Diablo, Qume, and NEC. In preparing an output of digital information, the precise spacing of the vertical bar characters is used to create a wide- or narrow-width imprint depending on the details of the format used.

Let us conclude this commentary with some critique on the potential uses of the bar-code format in publishing programs or data. The first and most important comment is that the technique is not intended to be useful with large files of data. When the bulk of information to be transferred by a user is in excess of ten to twenty thousand bytes, the bar-code method is not at all appropriate. It is best used for chunks of data that are on the order of hundreds of bytes rather than tens of thousands.

The reason for this comment is that in our previous experiments with homebrew prototype wands, we found that the practical data-rate-equivalent for the manually guided input of data is about 10 characters per second. The benchmark was taken using input from bar-coded program texts published in BYTE's various PAPERBYTE® software books. This data rate compares favorably with the paper-tape reader on an ASR33 Teletype, but is not at all desirable for repeatedly loading a 10,000-byte file.

But, when the data to be loaded has a high semantic content per byte of coded information, bar codes are quite appropriate. This is especially true when the system in which the bar code is used must deal with a great variety of such detailed specifications. An example of such semantically dense coding is the typical electronic calculator program, which might have several hundred bytes of information representing a very high level of function in each byte. Another example might be evidenced by instructions for some hypothetical kitchen cooking appliance, which are printed as perhaps a hundred bytes of data on a food package. Another classic example often used in the past is use of bar codes as an inventory-control technique in fields as diverse as libraries and factories. And of course, the Universal Product Code (UPC) information found on many standardized supermarket products can be read by this wand, thus allowing home and kitchen applications impossible for personal computers before this price breakthrough.

So, I will close my present commentary about bar codes by noting that we can expect further lively applications articles to appear in future issues of BYTE. This is a natural prediction based on the fact that readers now can get their hands on the necessary hardware at a very reasonable price. The clever designers and marketeers of Hewlett-Packard have made the bar-code technology quite practical and useful in numerous new applications of the small computer. ■

ROOT FINDER

PROGRAM REGISTERS NEEDED: 21

ROW 1 (1 - 2)

ROW 2 (2 - 5)

ROW 3 (6 - 8)

ROW 4 (9 - 13)

ROW 5 (14 - 24)

ROW 6 (25 - 36)

ROW 7 (37 - 45)

ROW 8 (45 - 55)

ROW 9 (56 - 65)

ROW 10 (66 - 71)

ROW 11 (71 - 75)

Figure 2: *A sample of bar codes in the format used by the Hewlett-Packard HP-41C calculator. This sample consists of binary code for the HP-41C program called Root Finder, found in the HP-41C Standard Pac library. This image was prepared by Tom McNeal, who is a development engineer with the Corvallis Division of Hewlett-Packard.*

The format specifies that 2 start bits (both binary 0) be used, followed by three 8-bit header words, up to 13 data bytes, and then 2 stop bits (the first set to binary 1, the second to 0). The wide bars, which represent binary 1s, should be twice the width of the narrow bars, which represent binary 0s. The spaces serve as a gauge for the width of the narrow bars.

The original image was printed on an 8½ by 11 inch sheet of paper, but in reproducing it for use in the magazine we have reduced it in size to fit our layout.

A History of Bar-Code Information Published in BYTE

1. *Banks, W, C Helmers, and R Sanderson, "A Proposed Standard for Publishing Binary Data in Machine Readable Form," November 1976 BYTE, page 10.*
2. *Banks, W, "Samples of Machine Readable Printed Software," December 1976 BYTE, page 12.*
3. *Farnell, C, and Seeds, G, "A Novel Bar Code Reader," October 1978 BYTE, page 162.*
4. *Helmers, C, "Further Notes on Bar Codes," February 1977 BYTE, page 121.*
5. *Helmers, C, "Another PAPERBYTES Test," March 1977 BYTE, page 130.*
6. *Helmers, C, and S S Loomis, "PAPERBYTES Forum," July 1977 BYTE, page 128.*
7. *Merkowitz, F L, "Signal Processing for Optical Bar Code Scanning," December 1976 BYTE, page 77.*
8. *Merkowitz, F L, "Micro-Scan Corporation Bar Code Scanner" (Product Review), October 1978 BYTE, page 166.*
9. *Regli, K, "Software for Reading Bar Codes," December 1976 BYTE, page 18.*
10. *Shuford R, "A Proposal for a Kitchen Inventory System, or Don't Byte the Wand That Feeds You" (Technical Forum), December 1978 BYTE, page 184.*

Letters

Disputed Analysis of Frequency

The article "Frequency Analysis of Data Using a Microcomputer" (December 1979 BYTE, page 10) by Dr F R Ruckdeschel would have been very useful, if he had not made one disastrous error: he did not realize that Fourier coefficients for discrete, equally spaced data points can be validly calculated *only* at certain discrete frequencies. This error caused the wide smearing of the frequency plots shown in the article. These plots should have shown very sharp maxima, with little or no amplitude at other frequencies.

I devised a version of his program that now gives the correct results. My program shows that his figure 2 (page 18) was correct, but that figure 3 was incorrect. In figure 3, essentially all of the energy was actually in the first frequency, as would be expected. The only energy present in the other frequencies was due to the inexact input data, and to round-off errors during calculation.

My analysis of a square wave (his figures 5, 6, and 7) differs. A square wave should contain only odd frequency components. My analysis of a sixty-five-point, eight-period sine wave (his figures 10 and 11) also differs. My plot shows that essentially all of the energy is in frequency number 8, as would be expected.

My analysis of a sixty-five-point, eight-period sine wave with random noise added shows that there is now some energy distributed among other frequencies, due to the noise component.

The major changes to the program include:

1) It now calculates only the discrete frequencies that are valid. These valid frequencies correspond to sine (or cosine) waves with one complete cycle, two complete cycles, three complete cycles, etc, in the data. This can be visualized most easily by setting the data end to end, to form a complete loop; then the only valid frequencies are those that can fit around the loop without having any discontinuity.
2) Lanczos' method is used to prepare the data; this reduces the amount of calculation by one half (for longer problems) and also reduces the round-off error. (See Lanczos, C, *Discourse on Fourier Series,* Hafner Publishing Co, New York, 1966, page 119.) The data is folded at the center, and the sums and differences are calculated to make two new series of numbers, each set one-half as long as the original data set. The trend is also removed, to allow analysis of data that has a straight-line, up or down trend. Calculation of thirty-two frequencies for sixty-five data points now takes just over 2 minutes.
3) The amplitude and phase are calculated for each frequency. Note that frequency 0 is the base level of the data, frequency 1 is for one cycle in the data, frequency 2 is for two cycles in the data, etc. The phase is given in degrees, and is checked for a 0 sine-coefficient (which would give a divide-by-zero error), and is adjusted to the proper quadrant (in the 0 to ±180 degrees convention). The number of valid sine and cosine coefficients that can be calculated for a set of data are equal in number to the number of data points. (The 0 and $(N-1)/2$ frequencies have only a cosine coefficient.) Beyond this point, the absolute values of the sine and cosine coefficients repeat (this is called *aliasing*). A message is printed on the table at this point.
4) In the frequency plots, the amplitude tends to decline sharply at first, then more slowly. To compensate for this, I plot energy for each frequency instead of amplitude. Energy will tend to remain constant for all frequencies, making higher levels stand out more clearly. I also plot bar graphs instead of only the maximum level, and for clarity label each bar. The 0 frequency is not plotted, as it has no bearing on the frequency spectrum, and only valid frequencies are plotted.

With my revised program, meaningful frequency analysis of data is much easier.

Delmer D Hinrichs
2116 SE 377th Ave
Washougal WA 98671

Reply from the Author

I received several interesting letters regarding my article "Frequency Analysis of Data Using a Microcomputer," December 1979 BYTE, page 10. Most of the letters were in reference to errors on

pages 3 and 4 of the magazine, the "In the Queue" and "In This BYTE" sections. My program was referred to as a Fast Fourier Transform, or FFT. It obviously is not, and that choice was intentional (as you will see later). I assume someone on the editorial staff scanned the article, saw a reference to FFT, and made a simple mistake.

One particularly long communication was that of Delmer Hinrichs. He states that there is a "disastrous error" in the analysis, and goes on to provide a revised program which, in one case, shows the energy in the eight-period sine wave to be concentrated at one frequency, and not the "wide smearing" my figures showed. I am afraid Mr Hinrichs fell into a trap which I intentionally avoided.

The exact solution for the spectrum of an eight-period sine wave is well known. It is simply a "sinc" function centered on the continuous sine-wave frequency, W_0 (in radians):

$$F(W) = \frac{\sin[(W-W_0)\times 8\pi]}{(W-W_0)\times 8\pi}$$

A comparison of a plot of this expression with figure 10 (page 28) will show my results to be in very good agreement with theory in the vicinity of the fundamental sine-wave frequency (the discrepancy near $W=0$ will be discussed shortly).

The sinc function has many zeros and small peaks, as can be seen from figure 10. Mr Hinrichs's program calculates the values for the central peak and the zeros. His program misses all *the small peaks. It is no wonder that he concludes that all the energy is at one frequency! If all the energy* were *at one frequency, how would an eight-period sine wave, preceded and followed by zero signal, be distinguished from a continuous sine wave?*

The problem Mr Hinrichs experienced is typical of the subtleties embedded in many discrete Fourier transform (DFT) and FFT algorithms. Often the calculation, by the way the algorithm is economized, implicitly assumes that the signal repeats *outside the "window" over which the integral approximation is to be performed. A repeating eight-period sine wave is just a continuous sine wave, which is what Mr Hinrichs's calculation told him. I avoided these algorithms and just performed a simple approximation of the Fourier integral.*

I am just as guilty of believing the computer as Mr Hinrichs is. There is *an error in the program of listing 1 (page 14), and this was kindly pointed out by Mr H L Cunningham. For the sake of plotting, I shifted up the data, thus adding a DC component. The Fourier transform of the shifted data was calculated, and the DC component was subtracted out. However, the same sinc function effect caused some energy spread into the frequencies near DC, and I did* not *correct for that. When you spend much time looking at frequency plots, you see what is expected. I saw the zero DC term and the smear near the fundamental frequency, and not the fairly obvious anomaly near DC. The program corrections Mr Cunningham has provided are shown below:*

```
Add: 681 REMOVE DC SHIFT
     682 FOR I = 1 TO N
     683 D(I) = D(I)-B
     684 NEXT I
```

Remove line 810 and lines 1250 thru 1280. The last statement should be:

```
1240 RETURN
```

These changes do not affect the discussion of the frequency-shift keying (FSK) technique used in cassette recording.

I wish to thank the readers who have written to me, and I apologize for any inconvenience.

F R Ruckdeschel
773 John Glenn Blvd
Webster NY 14580

BYTE Replies

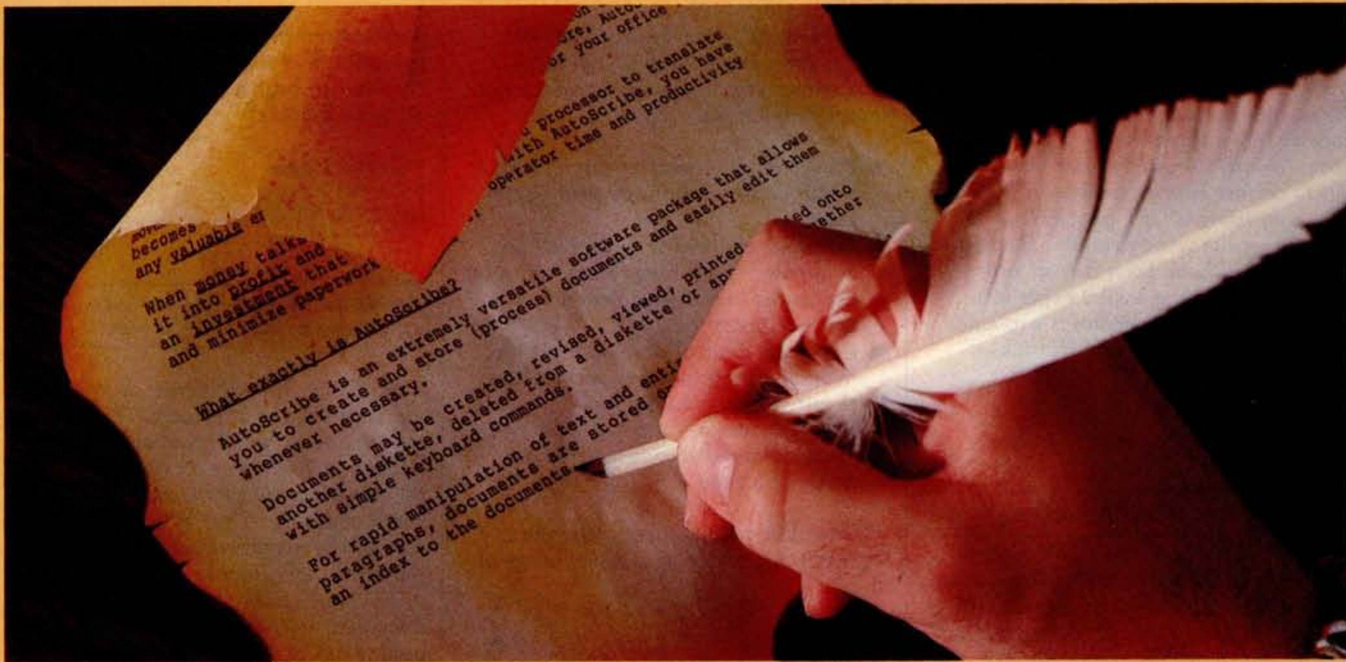
The description of Dr Ruckdeschel's article as being principally about the fast Fourier transform was indeed a mistake made by a member of the BYTE editorial staff. We apologize to those readers who may have suffered confusion due to this error.

A Dead Transformation?

Baron Jean Baptiste Joseph Fourier arose from his grave to award the Golden Bomb Award to F R Ruckdeschel and BYTE magazine for generating and publishing such "gross" frequency specta in the name of Fourier (in Ruckdeschel's article in the December 1979 BYTE).

A quick glance indicates that line 300 in listing 1 should use $2\pi(6.2831)$, and line 710 should read TO K1 where $K1=(N+1)/2$. Even worse is the lame explanation for the "unexpected" result rather than finding the "bug." Since I am sure BYTE will receive many letters on this, 'nuff said.

Sid Gear
72 Heritage Dr
Rochester NY 14615



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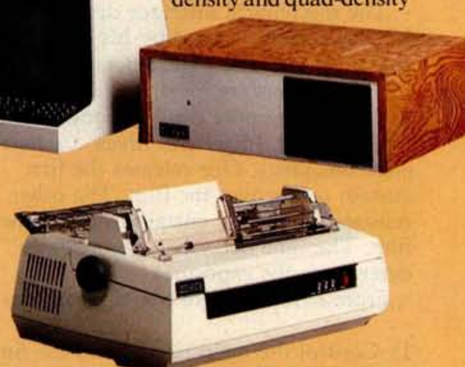

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Further Reply from the Author

Mr Gear's "quick glance" was a quick error. He failed to observe (as others) that a numerical approximation to the Fourier Integral was being performed, not *a formal discrete Fourier transform (DFT) or fast Fourier transform (FFT). In this case, using a DFT (or FFT) would have given the* wrong *results. His comments would have been correct otherwise. The only bug which exists in the program (as far as I know) is explained in the response to Delmer Hinrichs's letter (see above).*

F R Ruckdeschel

Information Requested

Are any of my fellow BYTE readers willing to share information with me on interfacing microcomputer systems to the IBM Models 50 or 60 electronic typewriters? I would like to use my Model 60 as an output printer, and I would appreciate some advice, if any is to be had.

Thanks very much.

Michael Pinneo
3757 Vienna Dr
Aptos CA 95003

Eclipsing Mechanical Pipe Dreams

In looking through back issues of BYTE, I came across an editorial by Carl Helmers regarding the control of a camera with a computer. ("Computers and Eclipses," July 1979 BYTE). Though this is probably too late to help Mr Helmers with the February 16 event, it may be of interest to others.

The mechanical interface described by Mr Helmers is dictated by his choice of camera body. The new generation of 35mm cameras are mostly electronic, and therefore more directly controllable by computer. In general, there are two electromagnets. One releases the first curtain to uncover the film. The other releases the second curtain to cover the film. The time delay between releases determines the exposure.

From here there are two approaches:

1) Control the main release and the time delay circuit (this requires a speed-select code and a trip signal).
2) Control each curtain directly, timing done by the computer (this requires only an open and close signal).

To keep the hardware as simple as possible, I would recommend the second method. Detailed information and schematics for a particular camera can be found in a service manual. (Available from National Camera Inc, 2000 W Union Ave, Englewood CO 80110.)

A completely electronic interface has several advantages:

- Power requirements are simplified; a major consideration for field equipment.
- Solenoid and motor vibrations are eliminated; with long lenses and long exposures they would seriously degrade image quality.
- Complete control of exposure time, including long timed exposures and in-between standard speeds.
- Random access shutter speeds; you are not limited to one step up or down at a time.

These last two features make the instrument applicable to a wider range of tasks.

William Earl
363 Joe McCarthy Dr
Tonawanda NY 14150

*See the Editorial in the March 1980 issue. . . .***CH**

Nose It All

My comment concerns the smell (yes, literally the smell) of BYTE. When the December 1979 issue arrived, I sensed the same odor that one sometimes encounters in large discount chain stores, associated with plastic foot-gear and, no doubt, a rampage of other products as well. As this substance, the one responsible for the odor, has brought on attacks of asthma, I gave the issue a wide berth, reading it only in well-ventilated surroundings for brief periods of time. I escaped without any obvious damage to my health.

I assumed that, somehow, the issue had come too close to some offensive item while enroute to me, or that a not-to-be-repeated mistake had occurred during the production of the magazine. Alas, I was wrong, for the issue which just arrived, January 1980, exudes the same noxious particles/vapor.

Perhaps I, alone among your readers, am overly sensitive to whatever new manufacturing process is producing this "air pollutant." In that case, the solution to the problem is simple and is up to me. However, I write in case there are others who are similarly affected by it, in which case the substance might be considered at fault. In fact, my reaction might be likened to that of the miner's canary, warning others of a potential threat.

If you choose to, you are welcome to publish this as a letter to find out if enough others have been bothered to warrant removing the cause. It would certainly be a shame if BYTE were required to bear a legend devised by the Surgeon General.

Philip K Hooper
5 Elm St
Northfield VT 05663

Warning: The Surgeon Corporal May Yet Determine That BYTE Reading Is Dangerous to Your Health.

*Seriously, the difference in smell is due to a change in printers that became effective with the December 1979 BYTE. Readers will observe an improvement in the magazine that took place simultaneously. The "What's New?" section of the magazine is now printed on the same glossy-paper stock as the rest of the issue, rather than on the uncoated, buff-colored stock previously used. . . .***CH**

Reform = Neologism

In language usage it often happens that one person's sensible reform is another's unjustified neologism. I was reminded of this by Philip Bacon's letter in the December 1979 BYTE, "Problems 1 Thru Ten," page 78. He objects to using numerals to represent small numbers within English text. His claim to have to mentally translate such numbers into words in order to recognize them seems amazing to me, having never experienced any such difficulty myself. Nevertheless, if BYTE doesn't mind using a little extra space to spell out numbers for Mr Bacon's benefit, then I have no objection either.

As a matter of fact, I would like to direct your attention to the far more abominable abbreviations recently coming into use for designating the fifty states. By the principle of ironic symmetry I can expect that Philip Bacon has no problem with them. When I, however, encounter an address in the state of "MN" it is my turn to go through a kind of mental stuttering: "Maine? Montana? Michigan? Where the devil is that ZIP code directory?"

It is obvious that the post office is pushing these state codes so that computerized records need allocate only two characters to name a state, whether two characters suffice for human intelligibility or not. This is the most blatantly dehumanizing misuse of computer technology that I have yet seen.

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Using the Computer as a Musician's Amanuensis

Part 1: Fundamental Problems

Jef Raskin
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It is the dream of many amateur and some professional composers to have a machine that relieves the tedium of writing down musical ideas. The notation of music is not terribly difficult to write, but it takes a number of years of practice before you can do it quickly and legibly. Unfortunately, many composers never attain the goal of readability.

There are several kinds of systems that might appeal to a composer who wants good-looking scores. One might be a display-based music editor. Picture the composer seated before the display, light pen or graphic tablet in hand, writing on the display much as he now writes on paper. The computer's editing power would just make the process easier and more efficient. This is fine for the composer who does not use a musical instrument as he composes, but who sits at a desk with pencil and paper and is able to write down musical thoughts without having to play them.

Other composers actively use an instrument as they write, much as some people write prose more effectively by dictation rather than with a typewriter or a pen. It is this kind of keyboard-based system that is discussed here.

Most modern musicians never learn to write musical notation at all. Many never even learn to *read* music (for example, at least nine out of ten guitarists are musically illiterate — however well they might play). I am always amazed at this lack of literacy, not only among guitarists, but also among other performers. For some reason, music teachers rarely expect their students to be fluent at writing one of the most widely adopted notations that mankind has invented. Once you learn to read music, then printed music from almost anywhere in the world is open to you.

The notation of music has changed little since the seventeenth century, and it takes relatively little additional study to play from many musical scores written 500 years ago. The same is not nearly as true for certain spoken languages.

(However, this is not to say that music notation has not changed at all. I have heard many pathetic performances of Baroque and earlier music put on by singers and instrumentalists who did not realize that today's notation of music, while maintaining much the same *appearance* as Baroque notation, has often changed in *meaning*. The notation of rhythm in French Baroque music in particular is radically different from what it appears to mean to a person trained only in twentieth century notation. This problem is delightfully documented in Thurston Dart's book, *The Interpretation of Music*, Harper Colophon Books, 1963.)

There is an interesting parallel with computer languages here: when I receive a piece of music for the piano, written in Japan, I can read and play the music even if I cannot read the title and dedication. Similarly, when I have a BASIC program for my APPLE II computer, written in Japan, I can follow the program and "play" it on my computer, even though I cannot read the title or REM (remark) lines. I somehow suspect that BASIC will not last 500 years, but who knows?

Why Use Computers in Music at All?

Most people expect at least one of four musical benefits from their computer:

1. The computer as instrument: the system will create sounds and give the user new sonic effects and musical control far beyond the abilities of synthesizers now available — or do the same things simpler and more cheaply.
2. The computer as virtuoso: it will be programmable so that it can play pieces that people are technically incapable of performing.
3. The computer as piano roll: the computer will capture the performances of musicians much as a good player piano can, and will enable the recreation of their exact performance upon demand. Being able to do some editing is usually part of the deal.
4. The computer as amanuensis: the computer will listen to a person hum or play a tune (or be attached to their instrument) and write down what he is playing.

There are many other applications of computers in music, but these are the four dreams that most people confess

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About the Author

Jef Raskin's credentials in music include his years as a professional musician and music teacher. He is presently the manager of Advanced Systems at Apple Computer, Inc. His personal music and computer equipment includes a piano, a harpsichord, an organ, a Digital Equipment PDP-11, and three Apple II computers.

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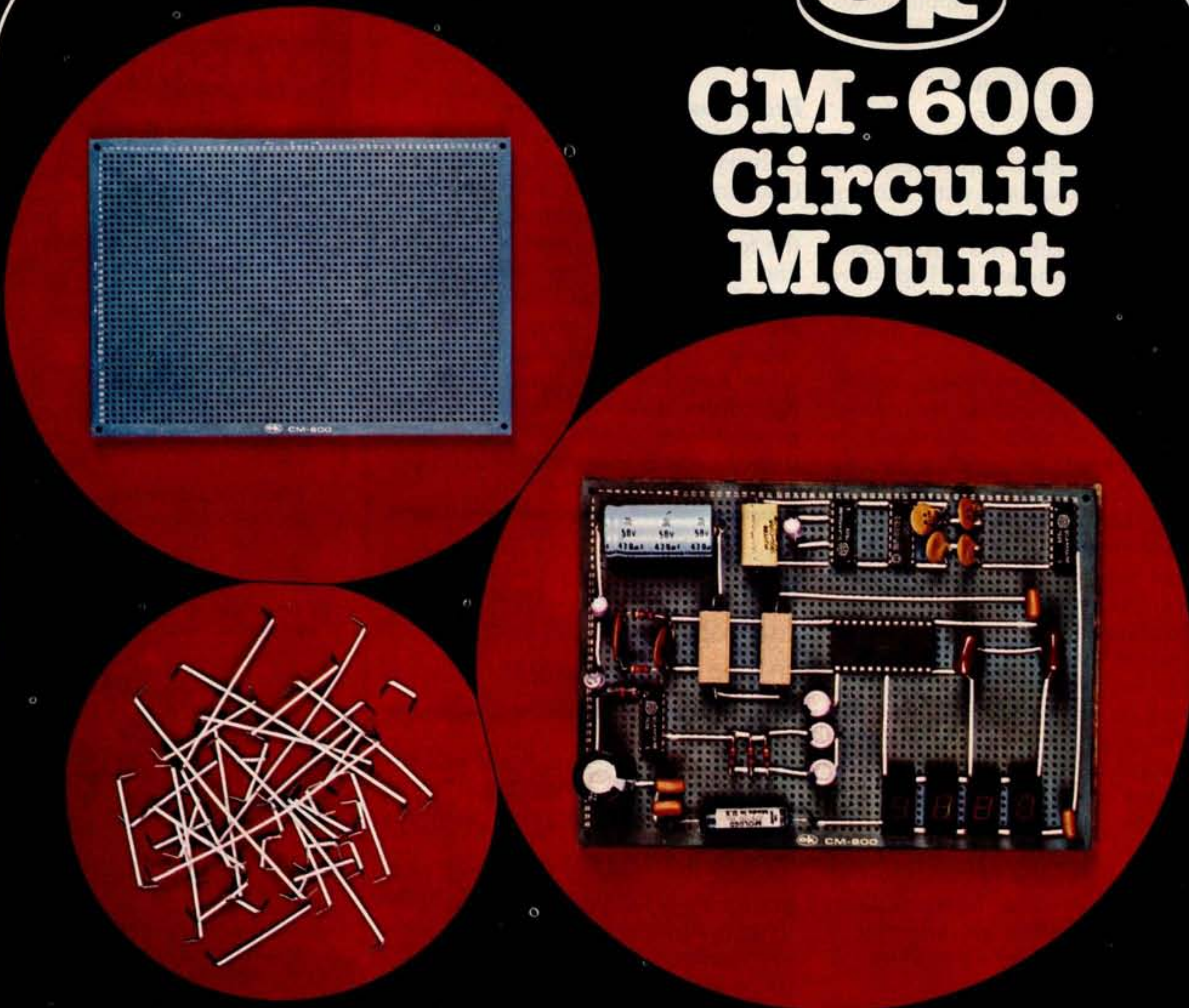

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to me. Most of the other applications fall into musicological, physiological, psychological, or acoustical studies. None of these applications will be discussed in this article.

Item 1 (using computers as synthesizers or as their components) is being done all the time, with varying degrees of success. Popular music's use of synthesizers has often been quite effective, whereas the highbrow use of computers in music has more often had results that are merely bizarre.

Item 2, using the computer to play conventional instruments, is coming along nicely — at least as nicely as can be expected. It has an interesting problem: a true virtuoso performer plays a bit differently each time. Different virtuosi play quite differently from one another. These differences are called *interpretation*.

Interpretation is one of the things that makes listening to live performances much more interesting than listening to recordings which do not vary from one playing to the next. Few people have even thought about, much less attempted to write algorithms to solve, the problems inherent in getting a computer to "understand" a piece of music so that it can create a viable interpretation. Without the ability to interpret a piece, the virtuoso computer is trivialized to item 3, a piano roll.

Some people have set up the computer to be an automatic recorder-player, in the tradition of the Welte Vorsetzer (roughly translated: that which sits in front) system of the last century. Player pianos effectively became extinct, and history will probably repeat itself with this idea. Who wants to have to maintain, for example, a piano, when a simple record player can reproduce the sound of not only the piano, but of every other instrument ever invented? Besides, the record player is cheaper and does not go out of tune as easily.

But of all the dreamers mentioned here, among those least prepared to turn their dream into reality are those whose dreams turn to item 4, transforming played music to the written form. They are the composers of the future, whose musical ideas need but the invention of the automated amanuensis for them to become rich, famous, or both. They well may be right, but they are usually unaware of the subtle problems that lie across their path.

Problems in Building the Composer's Aid

Every now and then, I read about a company that has begun to manufacture such a device, normally found in the form of a piano with a computer and a plotter as peripherals. The trouble is, you will usually read about them but once. They are seldom heard from again, except when they announce some "technical difficulties" that will delay the mass production of their device until next year. I suspect that some of them put the correct hardware together, announce the product, leaving only the writing of a few programs to finish the job.

> Musical notation contains both more and less information than is contained in the performance.

Well, dear reader, that bit of programming *is* the job. I have no doubt that a successful device is or will eventually become available. Its existence will mean that someone has come up with some heuristic solutions to the rather interesting and difficult problems involved. As you will see, these problems cannot be solved in the sense that certain equations can be solved to give a definite, fixed answer. All that a solution to the computer-generated score problem can be is a more or less useful approximation, which will require human editing in most cases. The rest of the article explains why this is the case.

Three Parts of the Problem

First let us look at some of the technical difficulties. One portion of the job is quite easy, and another is not considered to be difficult. The third portion is nearly as difficult as climbing Mount Everest on roller skates.

Assume, for the time being, that the input will be via a piano-style keyboard. Getting this arrangement to work is the very easy portion of

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Figure 1: *A section of Beethoven's "Variations on 'God Save the King'" done on the computer. When done correctly, computer-drawn music is indistinguishable from printed music. Only the time signature reveals the computer origin of this sample. The author programmed the music system that produced this in 1967.*

the problem. It is no great feat to be able to attach a keyboard to a computer — there is even an integrated circuit that does it for you (Intel's 8279, for example).

The minimally difficult part of the job lies in getting the computer to produce what looks like printed musical output of acceptable appearance (for an example, see figure 1). It will take an experienced programmer a year or so to write programs that can achieve a good-looking music output from a computer system, unless he has a powerful graphics system to use. For minimally readable music notation, you should figure a month or two for the programming job. I am not talking about drawing just a single melodic line, but drawing full scores with all the slurs, beams, and other complex notations that composers use.

The *very* difficult portion of the problem is to go from the computer's internal representation of the keypresses to standard musical notation. The processes at the two ends are readily accomplished; it is the transformation from one to the other that is very difficult.

It is difficult enough to go the other way, from standard musical notation to a reasonable performance: musicians find that it takes years of training even to do that apparently straightforward task. But we will concentrate for now on the problem of going from the keyboard input on a piano-style keyboard to graphic output in standard musical notation.

The first obstacle that deters many a hopeful attempt is the fact that musical notation contains both more and less information than is contained in the performance. To see this clearly, let's simplify the problem slightly. If we cannot solve the simplified problem satisfactorily, it is unlikely that we will be able to solve the whole problem.

A Musical Instrument to Keep in Mind

One of the simplest instruments to computerize is the pipe organ. Its keys are in either an on or off (down or up) state, unlike a piano, where the manner in which the keys are struck makes a difference in the sound. (Note to organists: in this instance I am not talking about tracker-action organs; rather, I am talking about the usual electromechanical pipe organ, which is operated electrically from simple contact closures in the keys.)

Another important simplification: real pipe organs often have the ability to produce a number of different timbres or sound qualities. We will limit the organ modeled here to what organists call a single *registration*,

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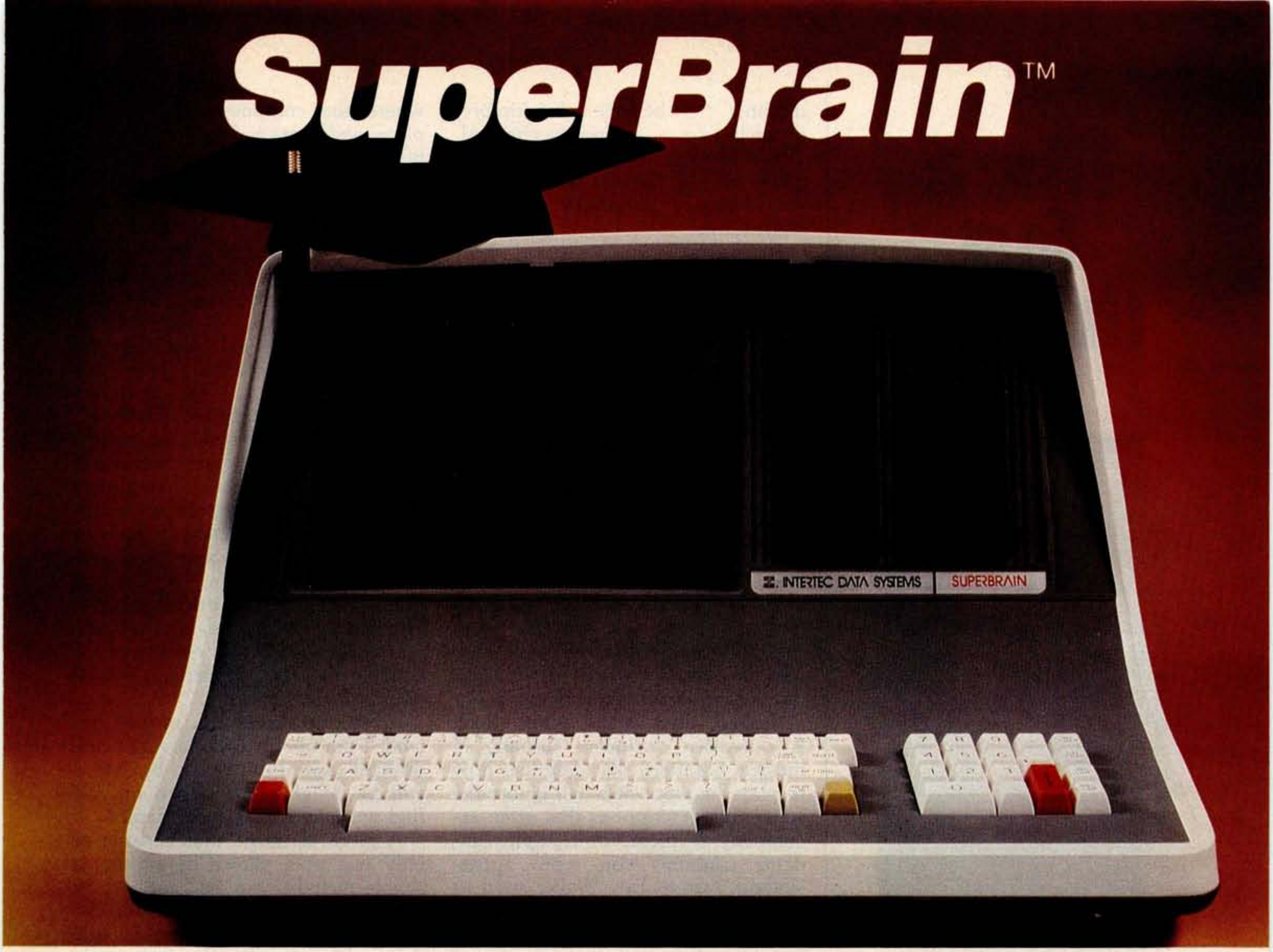

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meaning that the tone color (timbre) of the instrument cannot be changed. This is not too severe a limitation, as much of J S Bach's music can be played very beautifully with only one registration.

For the rest of this discussion, then, this simple pipe organ will be a useful model of a musical instrument to keep in mind.

Four Views of a Piece of Music

Before proceeding with the musical and technical details of the most difficult portions of the Composer's Aid, it might be a good idea to make sure that you and I are using the same terms in the same way.

A piece of music, for this discussion, has four major embodiments. First, there is the *musical idea*, which exists in the mind of the composer. It may evolve as it is performed, as in improvisation; it may never be realized, or it may be written down. This last activity is termed *composing*.

Second, there is the *score*, which is a written document (usually in musical notation) that describes how to play the piece. We will ignore the suggestive descriptions that often accompany the piece, for example: "andante cantabile con moto appassionato," or as Fats Waller used to write, "Tempo Basement De Luxe." The only portion of the score that will interest us for now is the collection of splotches of ink that, by their shape and position on the page, indicate the action to be taken by a human or mechanical performer.

The third embodiment consists of a sequence of switch closures or *keypresses* on the keyboard. Such an embodiment is represented by a piano roll. On the organ, this embodiment can be represented mathematically as a sequence of ordered pairs, the first of which states at what time the key was pressed, and the second stating for how long an interval the key was held before being released. In practice, these times need not be more accurate than to the nearest hundredth of a second (so long as errors do not accumulate).

The fourth embodiment is the *sound* of the piece. This is what the composer primarily seeks. Many computer hobbyists overlook the fact that the score, the performer, and the instrument are just means to an end. Perhaps the ideal world would be one where the composer thinks up a piece, and some gadgetry attached to his head picks up these mental emanations and realizes them as sound — or perhaps disseminates them directly into the audience's brains. For the time being, though, we prefer to go through this last embodiment and hear the piece through our ears. Direct mind-to-mind music we will leave to the science fiction writers.

Getting Tripped Up by Rhythm

Now that we have our corner of the computer-music world carefully delineated, our model instrument chosen, and the stipulation made that it is not difficult to have a computer read a keyboard and produce musical notation, let's look at some of the more difficult aspects. One such aspect is having the computer proceed from its reading of the keyboard to the production of written musical notation.

If, due to someone's inspiration, what I am about to declare as being difficult to do turns out to be easy, I will be delighted. But read on and find out *why* it may be difficult.

A piece of music that consists of only one note played at a time (a simple melody) can be captured by the computer by simply storing the time at which the note begins, and then storing the length of the time interval that the note continues to sound. It is convenient to measure these times in hundredths of a second. It is also convenient to say, by convention, that the time the first note begins is called time 0.

For example, if the first note lasts 1 second, we say that it starts at time 0, and has a length of 100. If the second note starts half a second after the first note stops and is half a second in duration, then we say that it starts at time 150 and has a length of 50.

The rate of playing a musical piece, its *tempo*,is given in terms of Maelzel's metronome markings: the number of notes of a given metrical type (such as quarter or eighth notes) that are to be played in 1 minute. Incidentally, since the metronome was not available until after 1816, tempi of pieces composed before that date can rarely be ascertained with any assured accuracy.

Figure 2 presents the notation that tells us to play exactly 120 quarter

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notes in 1 minute. Each quarter note will have a length of 50/100 of a second.

The first significant problem occurs right here. Have a person using a metronome play on some instrument six quarter notes, in succession, at this tempo. There is no difficulty in having the computer find when and for how long each note is played. The resulting data might well look like the data in table 1, which came from an experiment conducted with a push-button switch attached to my Apple II computer.

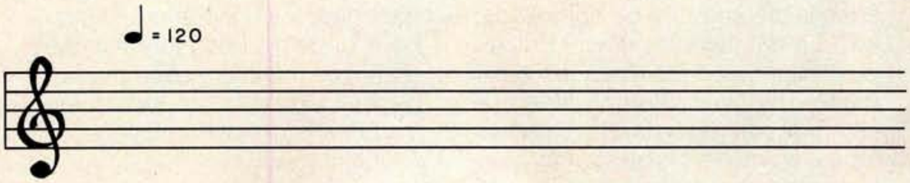

Figure 2: *Markings for tempo. The notation above and to the right of the treble clef tells us to play this musical passage at a rate such that 120 quarter notes can be played in 1 minute.*

Figure 3: *Music notation for six equal quarter notes. When a human player tries to play these notes, the results, as strictly interpreted by an unsophisticated computer program, may be interpreted differently. See figure 4.*

Figure 4: *Possible computer interpretation of six quarter notes. When the keystrokes entered by a human attempting to play six notes of equal duration are interpreted, even a fairly good computer program might interpret them as something quite different. The notes here are: a dotted eighth and a sixteenth rest (two times); a eighth note and an eighth rest; a dotted sixteenth note, a thirty-second rest, and an eighth rest; an eighth note, a thirty-second rest, and an eighth rest; a dotted eighth note, a sixteenth rest, and a thirty-second rest.*

Note	Starting Time (1/100s)	Note Length (1/100s)	Comments
1	0	32	The first note started at time 0 and lasted 32/100 seconds.
2	53	34	The second note started 53/100 seconds after the first.
3	101	37	The third note's starting time and length, etc.
4	167	22	
5	210	28	
6	268	30	

Table 1: *Results of an attempt to play six notes of equal length. The starting times and note lengths, each measured in hundredths of a second, were derived from a computer program written for the author's Apple II. The program recorded the times a push-button switch was pressed and released. Any computer program that has the task of converting these keypresses to standard music notation will have to decide from the note length values whether or not certain notes are meant to be equal.*

The data was produced from the playing of an experienced musician and yet is irregular. There are two reasons the results from this very simple piece seem so ragged. First, so that several notes played consecutively at the same pitch may be heard as distinctly separate events, the actual duration of each note must be shorter than the indicated length in order leave a short period of silence between each instance of the note. Thus the length of a note will not be exactly half a second (50/100 of a second) nor will it average this length, but something less. In this case the duration averages to 30.5 hundredths of a second.

Another reason the note inceptions are not as regular as we might hope lies in the normal variations in human motion. The average time between the notes is 53.6 hundredths of a second.

Now that we have the starting times and lengths, how would we notate the piece *as played*? The player was thinking of six equal notes, filling a measure as shown in figure 3. But the computer heard nothing of the sort. It received a sequence of rather irregular numbers. It would require some clever programming to determine that all of those notes were intended to be the same length. A moderately clever program might produce the music notation shown in figure 4.

The program seems to be struggling to accurately fit the notes it "hears" into the pattern of 120 beats to the minute, and losing the struggle.

Another Rhythmic Difficulty

Matters become worse if the computer has to determine what the intended tempo is, just by hearing it. Even if the notes are played by a precise mechanism, no program can tell the difference between the notes in figure 5a and the notes in figure 5b, since they both sound the same, albeit at different tempi. Nonetheless, a human player may interpret those two notations differently. In fact, if we rewrite the six equal notes in 6/4 time (as in figure 3) so that it is in 3/4 time, the result is the notation given in figure 6.

Figure 5: *The difficulty of determining tempo from context. Without some kind of external reference (such as the tempo notation in figure 2), musical notation becomes somewhat arbitrary. Hearing only the note sequences in figures 5a and 5b, a computer program could not differentiate between the two.*

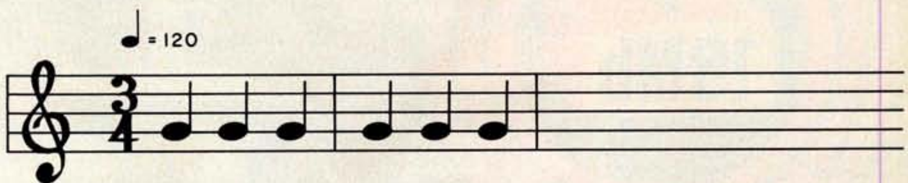

Figure 6: *Example of agogic accent. Although the notes here are equivalent to the notes in figure 3, a human player will likely accent the first and fourth notes (the first note of each measure); this is called an agogic accent.*

The human player is likely to make the first and the fourth notes from figure 6 *longer* than any of the others. This is done to emphasize them. The technique is called an *agogic accent* and is frequently used — especially on our organ, which has few other means for putting emphasis on a note.

How is the computer to know that this phenomenon is accenting and not accident? And how is it to know that it should *not* notate the first quarter note in each bar differently than the others? Clearly then a program must have some information about the metrical structure of the music. I leave it to you to determine just how this is to be accomplished. If you require human intervention too often, you might begin to abandon the computer altogether.

If our organ is located in a resonant cathedral, the organist might play the notes even shorter, perhaps for only a quarter of their indicated time, and let the resonance of the hall fill in the rest of the note. In another instance, the organist might feel inspired to play a passage staccato for other reasons. (*Staccato* means playing the notes briefly, leaving silence to make up the time between notes.) This is well within the accepted limitations of a performer's rights to interpretation.

What is the poor computer to do? Try to notate in minute and scrupulous detail the exact performance? This might be interesting if we are studying human performance. But it is not useful here, for our goal is to create a score, which we hope will be playable by a human performer, and therefore it must not be encrusted with the myriad details of a particular performance.

The more successful programs (such as Moorer's work at the Stanford Artificial Intelligence Laboratories) are adaptive and quite clever about imagining what the player must "mean" by the apparently strange sequence of timings that come into the computer in digital form. It would be a notable accomplishment for a programmer to get a computer to merely notate all *rhythms* correctly, let alone to solve the problems caused by details of harmony as well.

Next month in Part 2, I will examine more problems that arise in using the computer as a musician's amanuensis. ■

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BYTE's Bits

Stop, Thief!

On Friday, February 2, 1980, a burglary was committed at the Cambridge, Massachusetts, apartment where David Mitton, secretary of the New England Computer Society, lives. Among the items stolen was the computer system that had been used to operate the Cambridge Computerized Bulletin Board System (CBBS). The following equipment was stolen:

- Processor Technology Sol-20 Terminal Computer;
- SD Systems ExpandoRam memory board populated with 48 K bytes of memory;
- Potomac Micro Magic MM-103 modem board and telephone interface, serial number 1-1155;
- North Star Minifloppy disk-controller board;
- Two Shugart SA-400-3 Minifloppy 5-inch floppy-disk drives, serial numbers A40096 and A93222 (drives were open and screwed onto a ¾-inch piece of plywood);
- Motorola video monitor.

Readers of BYTE that have any information concerning the whereabouts of this equipment are asked to contact David Mitton by telephone at work (617) 493-3154 or at home (617) 876-8718.

Personal belongings also stolen included an Advent 300 stereo receiver (serial number JO-23821), a Sanyo 625 turntable (serial number 66119191), and a Raleigh Super Course ten-speed bicycle (serial number 250525, brown with handlebar gear shifters).

T C F Rides Again

The Trenton Computer Festival (TCF) (the original Personal Computer show) will take place on April 19 and 20 1980.

The fifth annual Festival will last for two full days, with a 5-acre outdoor flea market and indoor commercial exhibitor area for up to ninety booths. There will be thirty speakers, user group sessions, and demonstrations, as well as hundreds of door prizes.

Computer conference sessions and forums will be held on microcomputers in the home, education, medicine, amateur radio, music and the arts. There will be user group sessions on Saturday and special tutorial sessions for the general public and novice on Sunday.

It is expected that attendance will exceed 9000, up from 6000 last year. There is free parking for 5000 cars. There will be a Saturday night banquet with noted guest speakers.

TCF-80 will be held at Trenton State College, just outside of Trenton, New Jersey, convenient to New York City, Philadelphia, and Baltimore.

Admission is $5 for the two days ($2 for students). The Saturday night banquet is $10. Flea Market spots are $5 per day.

TCF-80 is a nonprofit undertaking and is sponsored by: the Amateur Computer Group of New Jersey, the Philadelphia Area Computer Society, the Trenton State College Computer Society, the Institute of Electrical and Electronics Engineers—Princeton Section, and the Department of Engineering Technology, Trenton State College.

The $300 Hand-Held Coconut

A little-known fact about Hewlett-Packard is that most of its computer products visible to the average person have come from the same division. This branch of Hewlett-Packard began in Cupertino, California, under the name of the Advanced Products Division (APD). In mid-1976, APD changed its name to the Corvallis Division, when it moved to its current location in Corvallis, Oregon.

In 1972, APD started the calculator boom with the introduction of the HP-35, which was the first hand-held calculator that could entirely replace the (then) common engineer's slide rule. In 1974, APD surprised an increasingly calculator-oriented world with the introduction of the HP-65, the first user-programmable calculator with magnetic card storage.

The Corvallis Division has continued its orientation toward the personal user since its name and location change in 1976. Even before the move to Corvallis was made (some three years before the introduction of the first product), Hewlett-Packard had already devised the code names of two already-planned products, known internally as Capricorn and Coconut.

The Capricorn, Hewlett-Packard's desktop computer (officially named the HP-85), has become a popular name by which the product is known. (For a review of the computer, see Christopher Morgan's article in the March 1980 BYTE, "Hewlett-Packard's New Personal Computer, The HP-85.") However, it was only recently discovered that the other name, "Coconut," referred to the HP-41C, the extended-function hand-held programmable calculator introduced by the Corvallis Division last July.

Hewlett-Packard has a large semiconductor production line at the Corvallis plant; this facility is largely being used to produce custom integrated circuits and liquid-crystal displays (LCDs) used in the HP-41C. The Corvallis plant also manufactures a number of parts for the HP-85 computer.

Computer Camp

Children can sign up for an overnight camp in Moodus, Connecticut, where this summer's main activity will be computers. This recreational and educational experience is directed by Fairfield University professor Dr Michael Zabinski. One week is planned from June 29 to July 4. The campers, ages ten to seventeen, will have small group instruction along with minicomputers and microcomputers for hands-on experience. The camp is for children of all levels of experience. In addition to computers, the campers will have the facilities of the Grand View Lodge including swimming and tennis. For further information, contact Dr Michael Zabinski PhD, (203) 795-9069, or write, Computer Camp, Grand View Lodge, POB 22, Moodus CT 06469.

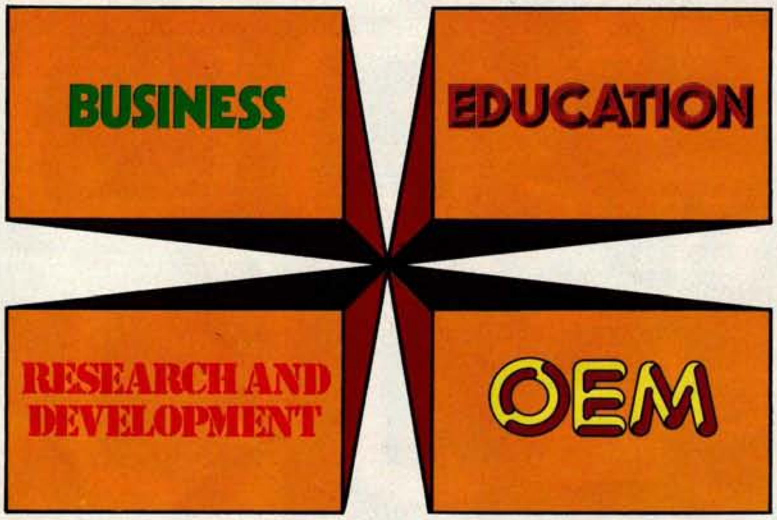
Drive Through Order Verification Screen

If you have ever ordered a hamburger and french fries at a drive-through restaurant, then waited patiently only to receive a jar of horseradish and a pound of onions, you now have the ability to stop the problem before it begins. Scan-Data Corp, 800 E Main St, Norristown PA 19401, has developed the Positran Fast Food System which eliminates mistakes by allowing customers to view their order on a video screen as it is being placed. The system has been tested at restaurants around the country. ■

OHIO SCIENTIFIC
Professional Computers
The Challenger Line

Ohio Scientific Microcomputers for all reasons

Ohio Scientific has been building microcomputers longer than any company currently in the personal computer and small business computer marketplace. The company features a uniquely broad line of computer systems and interchangeable accessories. Ohio Scientific computer models range from the $279 Superboard II which is the lowest cost complete computer on the market to the world's most powerful microcomputer; the C3-B GT which features a 74 million byte, 10 millisecond access disk and a 300 nanosecond instruction cycle processor. Ohio Scientific computer products are sold and supported by a world-wide network of over 350 computer dealers. The product line featured in this brochure is Ohio Scientific's professional series computers, software and accessories. All machines in this brochure incorporate dual 8″ floppy disk drives and utilize the OSI 48 line BUS architecture of modular interchangeable PC cards. This architecture allows easy servicing, modification and upgrading. All machines in this brochure have internal firmware for instant disk loading and diagnostic testing and come complete with connecting cables, operating manuals and OS-65D disk operating system with extended BASIC so they can be utilized immediately when delivered by connection to a standard RS-232 terminal.



Business

The most popular use of Ohio Scientific professional computers is in small business accounting. The minimum configuration of each computer has dual 8″ floppies, 48K bytes of RAM and an RS-232 port making each computer usable in business applications as delivered. All Ohio Scientific machines can operate as single-user, stand alone computers, but by simply adding one PC board, they can also be used as intelligent terminals in a distributed processing network. Business software includes an advanced BASIC operating system; OS-65U which features end user operating ease and security as well as highly advanced file structures and communications protocols. OS-65U is unique in that programs written in this operating language are immediately upward compatible from single-user floppy systems to multi-user timeshare and/or distributed processing networks with hundreds of megabytes of hard disk. Specific business applications software include a complete word processor for use on any professional series computer (WP-2), a family of conventional fully integrated accounting systems (OS-AMCAP) and a highly advanced data base manager and information management system (OS-DMS). DMS based applications modules range from simple general accounting packages to Construction Quotation, Medical and Legal billing systems in stand alone and/or integrated single-user, multi-user and network compatible configurations. The data base structure of these packages allows a high degree of end user customization without programming through use of powerful general purpose report writers, mathematical packages and an on-line query facility.

Education

Ohio Scientific personal computers are very popular in general education. The professional series offers capabilities for advanced educational use. Ohio Scientific's C1P and C4P series computers can be connected to a C2 or C3 computer to utilize its floppy disk and printer, and to allow teacher monitoring and communications under OS-65U Level 1 operating system.
The Challenger III's unique three-processor architecture provides opportunities for students to compare architecture, machine code, assemblers and upper level languages for three types of processors on one machine. OS-CP/M further provides a wide range of language capabilities including BASIC, FORTRAN, COBOL, PASCAL, APL, FORTH, ALGOL and others. Ohio Scientific's broad range of compatible accessories include a solderless interface prototyping board, a high speed analog I/O module and a PROM blaster for use in hardware labs. OSI's home security and control I/O, unique voice I/O, and new telephone interface coupled with the fast access high capacity CD-74 hard disk provide unique opportunities for advanced computer science investigations on an educational budget.

Research and Development

The C2 and C3 series computers feature the most advanced 6500 family operating system and architecture complemented by a fast resident interactive assembler/editor, on-line debugger and optional PROM blaster capability. The C3 extends this development system capabilities to the 6800 and Z80 family by nature of its three-processor architecture. Ohio Scientific's broad range of plug compatible accessories include a unique voice recognition breadboard, a powerful Votrax® based voice output system, a general purpose telephone interface, a fast analog I/O module, very fast high storage capacity hard disks, and computer network capabilities. These leading edge technology products provide opportunities for advanced architectural investigations and development without extensive hardware modifications. To further enhance the C3's usefulness in R/D applications, the company is currently developing a 68000/Z8000 CPU expander board which is designed to plug-in to existing C3 series computer systems.

OEM

Ohio Scientific's broad line of plug-compatible products and mass production economies provide a tremendous cost/performance benefit to both original equipment manufacturers and "systems houses".
Contact your local dealer or the factory for OEM contract details on computers, accessories, complete systems and/or subassemblies.

C2-OEM

Ohio Scientific's new C2-OEM is designed to be the cost effective solution to business and industrial applications which can effectively utilize typical microcomputer execution speed. The C2-OEM benefits from Ohio Scientific's years of volume microcomputer production experience yielding an extremely competitively priced medium performance microcomputer.

The C2-OEM utilizes the popular 6502 microprocessor operated at 1MHz clock speed in conjunction with 48K or 450 NS Dynamic RAM memory.

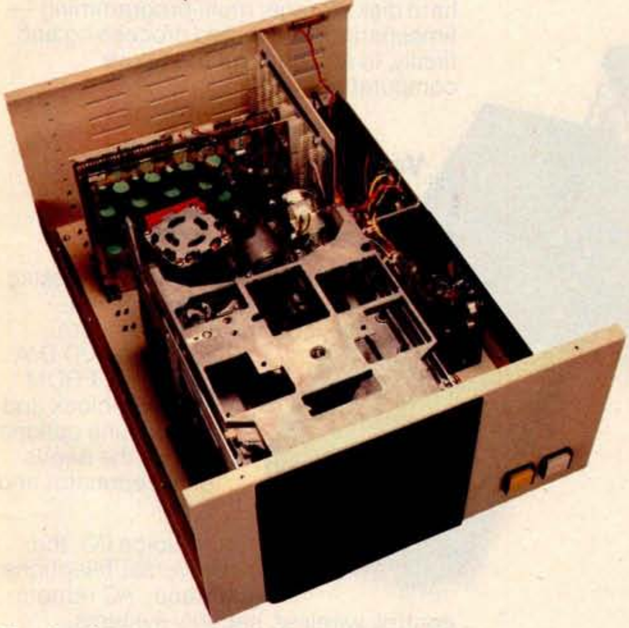
This hardware configuration when used in conjunction with Ohio Scientific's ultra fast BASIC by Microsoft yields Business environment performance equal to or better than competitive microcomputer systems.

The C2-OEM is housed in a versatile table top cabinet which can also be rack mounted or incorporated in a matching desk which also accommodates a CRT terminal and printer.

The system features very simple physical construction and the use of industry standard parts for reliable operation and simple servicing. All circuitry is on two 8 x 10″ OSI BUS compatible PC cards, one for the 48K memory and the other which contains the CPU, Firmware, RS-232 port and floppy controller.

The cards are plugged into an 8 slot back plane which provides tremendous expansion capability. The unit features two industry standard 8″ Floppy disk drives and is powered by two standard UL recognized open frame power supplies.

The C2-OEM's low cost, simple construction, standard performance, and factory configuration make it the logical choice when a simple, rugged "no problems" computer is desired.



The C2-OEM with cover off showing the placement of floppy drives, UL recognized power supplies and 8-slot OSI 48 BUS backplane.

Features:

Simplest, most cost-effective computer when typical microcomputer execution speed is acceptable.

- Full business configuration standard • 48K dynamic RAM
- .35 MIPS 6502 CPU • RS-232 port at 300 to 19,200 baud
- Dual 8″ floppies store 600 Kbytes
- OSI BUS oriented for modular expansion
- Fast low overhead disk operating system standard
- Microsoft BASIC with random and sequential access files
- Instant load disk bootstrap and front panel emulator in ROM

Prices

C2-OEM	As specified above	**$2799**

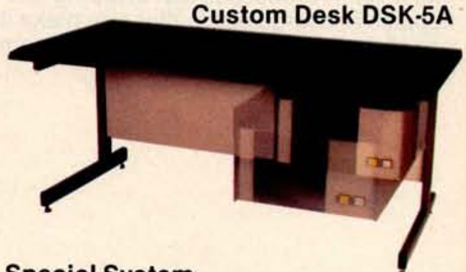
Options

-01	Double-sided disks doubles capacity to 1.2 Mbythes.	**800**
-02	Internal video board and keyboard with numeric pad provide complete terminal function with upper/lower case and graphics within the computer (a low cost alternative to conventional CRT terminals). Just add a TV monitor for a complete low cost system.	**299**
-03	Conversion to static RAM uses one more slot (2-24K boards) and adds 4.5 amps additional power.	**600**
-04	Double cases—uses separate cases for computer and floppies. Identical in appearance to the C3-S1.	**200**
-05	OS-AMCAP package provides AMCAP V1.5 and OS-65U at a $300 savings when purchased with the computer.	**$875**

Notable Accessories

AC-3P	12″ TV monitor for use with the 02 option	**129**
CA-17	Plug-in board adds intelligent terminal capability under Level 3 NET.	**298**
DSK-5A	5 foot matching desk with slide-in mounting for C2-OEM, C3-OEM or C2-NET.	**300**

Custom Desk DSK-5A



Special System

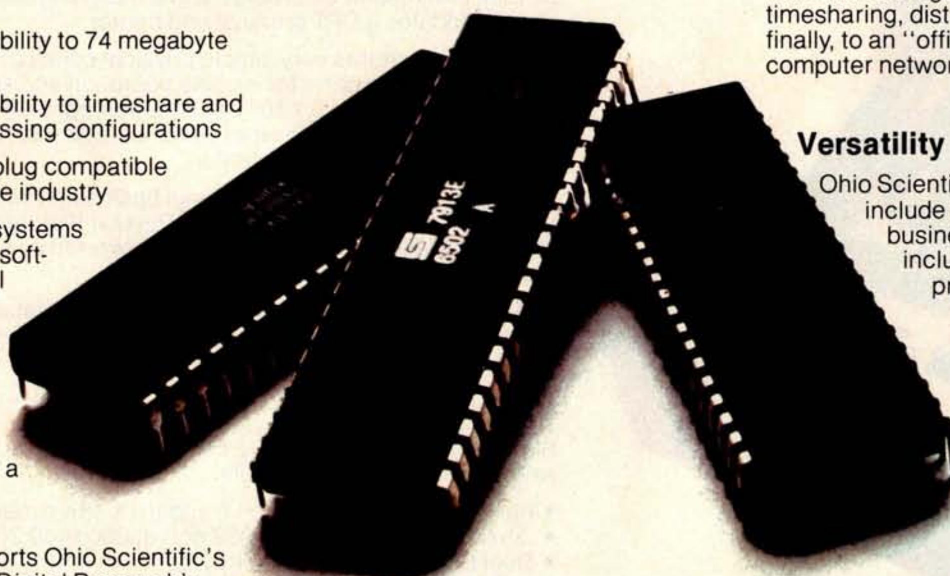
C2-NET	C2-OEM-04 with a CA-17 but without the floppy disk drives. Unit has special "down load" bootstrap ROM which loads the operating system from a network data base on power up. Just add on RS-232 terminal for the lowest cost intelligent terminal configuration.	**$1499**

Ohio Scientific Microcomputers for all reasons

The Premium Performance C3 Series

The Challenger III family of computers is one of the most popular small computers in existence with tens of thousands of units installed to date. The C3 series provides several unique features including:

- 3 processors — the 6502A, 68B00 and Z80A
- User programmable interrupt vectors on all three processors
- OSI 48 line BUS architecture with 16 data lines and 20 address bits (1024K address space)
- Upward expandability to 74 megabyte disk drives
- Upward expandability to timeshare and distributed processing configurations
- Broadest line of plug compatible accessories in the industry
- Broadest line of systems and applications software of any small computer (three processors is unbeatable here)
- Fastest instruction execution speed commercially available in a microcomputer (with GT option)



The C3's Z80 supports Ohio Scientific's implementation of Digital Research's CP/M® operating system. This very popular operating system supports nearly a dozen upper level languages and hundreds of business, scientific and educational packages from several independent suppliers. The Challenger III's 4MHz Z80A processor, fast stepping rate floppies and large disk buffer size make it one of the fastest CP/M operating system compatible computers available.

CP/M's excellent performance is overshadowed by the C3's 6502A ultra-high performance processor which executes Ohio Scientific's OS-65D developmental operating system and OS-65U, a highly advanced business BASIC operating system with multi-user and distributed processing capabilities. The 6502A performs a memory to accumulator ADD in 1.0 μs. and a jump extended in 1.5 μs. with an overall average of .7 Million Instructions per Second (M.I.P.S.) making it far faster than any other widely used microprocessor (including the new 16-bit versions).

The GT option further extends Challenger III performance by utilizing the 6502C processor and high speed static RAM (150 ns. access) to achieve memory to accumulator ADD of 600 ns. and 1.2 MIPS average operation. This performance level places the C3 GT models comparable to mid-range minicomputers ($50,000 to $100,000 price range) in typical business and other information intensive applications. Such computers are much faster in arithmatic operations because of their wider wordwidth but this performance advantage is not cost effective in all but the most demanding number crunching applications.

Upward Expandability

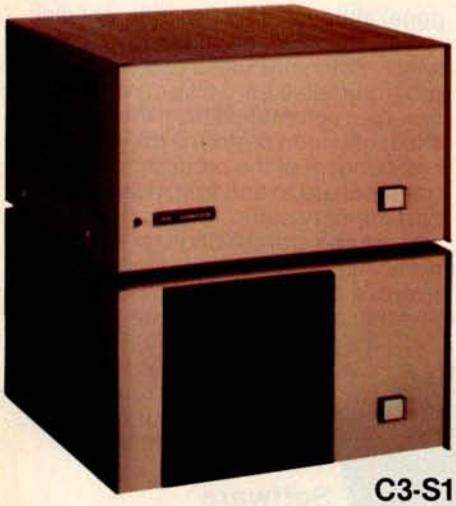
Users can start with a relatively modest C3-OEM table-top computer and transport all of their software and most, if not all, of their hardware upward in simple plug-together expansion steps to hard disk storage, multi-programming — timesharing, distributed processing and finally, to an "office of the future" computer network.

Versatility

Ohio Scientific's plug-in options include the full scope of business accessories including a word processing printer, modem and matching furniture. Parallel I/0, A/D D/A capability, PROM blaster, clock and prototyping options satisfy the needs of the educator and OEM.

Voice I/O, the Universal Telephone Interface, AC remote control, wireless security systems, affordable ultra-fast execution speed, network capability and huge storage capacity challenge the most creative innovators to develop the applications of tomorrow.

The Challenger III Series


C3-S1


C3-OEM


C3-A

Family Features

Premium performance 3-processor computer systems.

- Full business configuration standard
- 3-processors 6502A, 68B00, Z80A
- 6502A operation at .7 MIPS standard
- Z80A operation 4MHz, 68B00 operation 2MHz
- 48K high speed static RAM standard
- 20 address bits with memory pager addresses 768K
- User programmable interrupt vectors
- 8-bit parallel I/O port
- Instant loading floppy disk bootstrap/hard disk bootstrap/front panel emulator in ROM
- RS-232 port strappable from 300 to 19,200 baud
- Dual 8″ floppies store 600K bytes
- OSI 48 line BUS oriented for modular expansion
- OS-65D fast low overhead development operating system with ultra-fast BASIC standard
- OS-65U advanced business operating system standard
- Largest accessory family in the microcomputer industry
- Largest software library in microcomputing (due to its unique 3-processor architecture)

C3-S1, C3-OEM

These two computers are table-top versions of the C3 system with a total of eight OSI BUS slots. They are ideally suited to applications which do not require hard disk drives and/or multiple users. Both systems can be enhanced by adding the GT option and/or dual-sided drives. They support OS-CP/M by expansion to 56K RAM and can be networked by expansion to 56K and a network I/O port. (The CA-17 provides network and CP/M compatibility.) The C3-OEM is a single-case table-top unit similar to the C2-OEM except for larger power supplies and can be mounted in the DSK-5A. The C3-S1 is in two cases which can be shipped via U.P.S. (the C3-OEM must be shipped by freight). The C3-S1's floppies can be independently turned off; a useful feature for process control and security applications.

Prices

C3-S1	As specified above with 48K	**$4095**
C3-OEM	As specified above with 48K	**3995**
-GT Option	Increases 6502 execution speed to 1.2 MIPS average (150 ns main memory)	**1500**

C3-A

The C3-A system is a 17-slot version of the C3 series in a stylish free-standing equipment rack. Although the standard machine has the same circuit boards and hence the same functional specifications as the C3-OEM or C3-S1, the system can be directly expanded to 8 users, hard disk operation and a network data base node configuration by simple plug-in operations. The rack also accommodates the PDS-1 system power sequencer and Alloy Engineering cartridge tape back-up units.

The C3-A features rack slide-mounted CPU and floppies as well as removable side panels and locking back door for convenient servicing and upgrading.

Prices

C3-A	As specified above with 48K	**$5995**
-GT Option	Increases 6502 execution speed to 1.2 MIPS average (150 ns main memory) and adds heavy duty switching power supplies.	**1950**

C3 Family Options

-01	Double-sided drives, doubles capacity to 1.2 Mbytes	**$800**
-06	OS-AMCAP package provides AMCAP 1.5 at a $200 savings when purchased with the computer (65U is standard with C3's)	**775**
-07	CP/M package requires CM-10 or CA-17 for operation. Provides OS-CP/M, Z80 Assembler/Editor, Microsoft Z80 BASIC, FORTRAN and COBOL at a $250 savings over individual prices when purchased with the computer.	**400**
-08	Real time clock option	**100**

Ohio Scientific Microcomputers for all reasons

Winchester Technology Disks

Floppy disks store from 250K bytes to 500K bytes per surface in a series of concentric circles called tracks which each store 2.5K to 7K bytes. To access specific information a head must be mechanically positioned over the track, then the computer must wait for the information to rotate under the head. On an 8″ floppy accessing a specific piece of information this can take as long as 1.2 seconds even though the computer could have processed the informaion in a few microseconds. (The access time of mini-floppies is much worse.) Furthermore, in most business applications, it is impossible to store all necessary information on one floppy disk; thus requiring several diskettes and frequent disk changes.

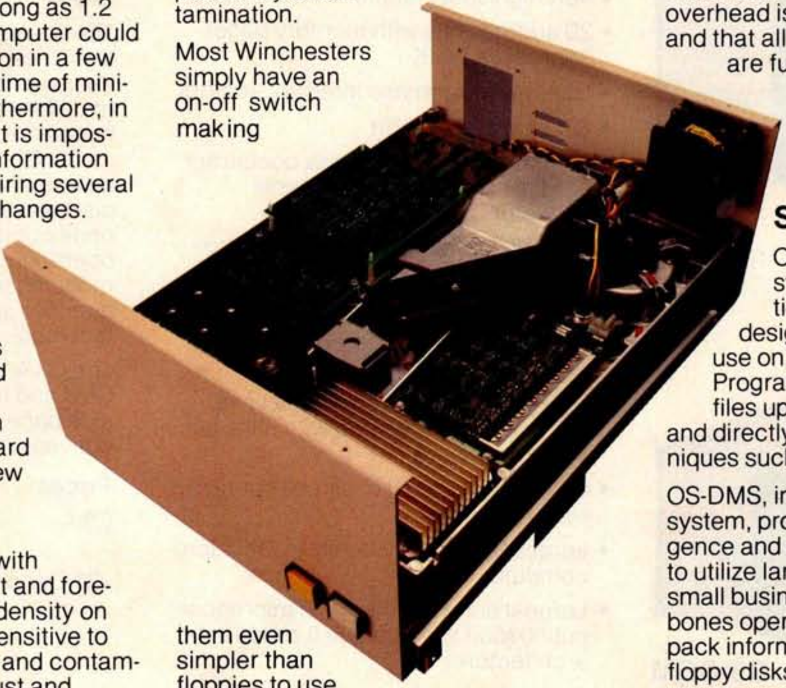
The traditional solution to these problems is the conventional removable platter hard disk. These disks rotate ten times faster than floppies and use more elaborate head positioners to move from track to track as much as ten times faster than floppies. Hard disk storage ranges from a few megabytes to a few hundred megabytes.

There are several problems with conventional hard disks. First and foremost, the extremely high bit density on the disks makes them very sensitive to mechanical misadjustments and contamination such as vibrations, dust and temperature differences of a few degrees, etc. Attempts to use removable hard disks in any other than a big computer, air conditioned, clean room environment by other than experienced computer operators can result in expensive head crashes and the complete loss of a disk pack. The second problem with these drives is that since they require close mechanical tolerances for bit density, disk removability and interchangeability, they are very complex mechanical devices. This results in large physical size, high power requirements and, most of all, high initial cost and high maintenance cost.

Enter the Winchester:

In the mid-70's a new disk technology was developed which eliminates most of the undesirable features of hard disks for small computer users; the Winchester hard disk. Winchesters utilize fast rotating high density disks and medium to high speed head positioners to achieve performance comparable to the most expensive hard disks. However, to minimize mechanical complexity and difficulty of use, they use fixed or non-removable media. Because the media is factory installed, the critical head-disk tolerances can be maintained with relatively simple mechanics. The fixed nature of the drive allows the disk chamber to be sealed eliminating the possibility of contamination.

Most Winchesters simply have an on-off switch making



them even simpler than floppies to use from an operator viewpoint. In high storage capacity models they achieve the lowest cost per bit of any Random Access Memory technology now available.

The Winchester disk solves all the problems of floppies and conventional hard disks but creates one big new one! Back Up. Ohio Scientific has effectively solved this problem with three approaches depending on the specific application, see the box below.

Ohio Scientific Winchesters

OSI pioneered the use of Winchesters with microcomputers in 1977. Since then, we have installed more units than anyone else and have developed the most sophisticated Winchester hardware and software products for microcomputer use.

Hardware

Ohio Scientific offers two Winchester disks; the CD-23 and CD-74 (see next page) although they use different disk drives, the basic architecture is the same. Both units use a dedicated but programmable hard disk controller which receives commands from the host processor and then performs disk transfers independent of the processor. Data transfers are to and from a large dual port memory buffer. The dual port architecture and stand alone disk controller mean that virtually no processor overhead is required for disk transfers and that all segments of disk transfers are fully interruptable. Thus, disk operation does not degrade terminal interrupt response time in multi-user systems, a very important feature.

Software

OS-65U business operating systems and OS-DMS information management systems were designed from the "ground up" for use on Winchester based computers. Programs in 65U can directly access files up to 100 megabytes in length and directly support fast access techniques such as multi-key ISAM.

OS-DMS, information management system, provides a high degree of intelligence and end user versatility by its ability to utilize large disk files whereas most small business computers offer bare bones operation because of the need to pack information as tightly as possible on floppy disks.

Ohio Scientific Winchester disk based computer offer business users a dramatic improvement in total performance over floppy based micro and minicomputers at a relatively modest cost.

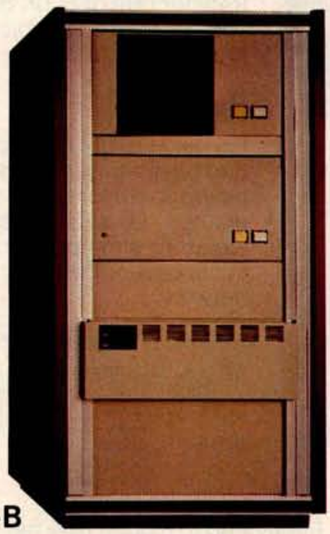
You now have three backup options for use with the C3-B and C3-C Winchester disk based computers:

1. Fast floppy dumper under OS-HDM for small files (5 Mbytes or less). Daily to weekly backup.
2. 3M tape backup unit from Alloy Engineering. About 11 Mbytes per tape, cost about $3500. For medium files (Under 11 Mbytes). Weekly backup.
3. Networked C3-B's and/or C3-C's. Ultrafast backup of files up to disk capacity for Large files (over 11 Mbytes) and/or frequent backup requirements.

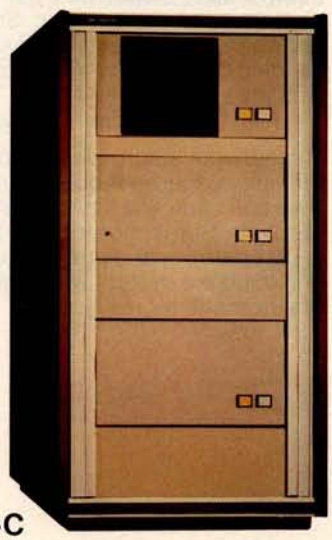
(Prices and specs subject to change without notice)

Hard Disk Computers

C3-A



C3-B



C3-C

Family Features

All standard C3 features including:

- 3-processor CPU
- .7 MIPS 6502A
- 48K static RAM
- Dual 8″ floppies
- Free standing rack for direct expansion capabilities
- 17-slot OSI 48 line BUS architecture for large system expansion
- Directly accepts up to 8 users with currently available memory boards, more with higher density boards in the future
- Directly expandable for use as Network data bases
- Slide-mounted subassemblies, removable side panels and locking rear door for easy expansions and service

C3-A

The floppy only rack based C3 for users who anticipate expansion to hard disk, multi-user and/or networking in the future. Additional specs are on the preceding pages.

C3-A	$5995
CD-74 expands C3-A to C3-B	7500
CD-23 expands C3-A to C3-C	4500
CA-16 heavy duty cooling pack (specify B or C)	150

C3-B

The world's most powerful microcomputer (when GT equipped). Features the highly advanced and extensively field proven OKIDATA 3306 Winchester disk. Some 3306 drives have operated since 1977 without a single failure.

Features

- System boots from floppies or hard disk on power up
- 74 megabytes end user workspace under OS-65U, 80 megabytes unformatted
- Ultra-high performance disk

  74 millisec worst case access
  38 millisec average

  10 millisec access on cylinder
  (215K user workspace)
  8 megabits per second transfer rate
- Simple on/off disk operation with elaborate internal protection from improper temperature, line voltage and controller failures
- Features spindle brake and designated head landing areas for much longer operational life than the newer low-cost Winchesters
- Highly advanced OS-65U operating system:

  Multiple level pass word security

  Multiple operating systems on disk

  Ultra-high speed "FIND" command for high speed string searches (Associative Access)

  Upward compatible with multi-user and network systems with full file, peripheral and communications arbitration between users
- Expandable to CP/M operation by adding 4K (CM-2 memory)
- Available factory configured for up to 8 users and network data base operation
- Comes standard with real time clock and heavy duty cooling package

C3-B	$12,995
GT Option (as per C3-A) add	1,950

C3-C

A medium performance Winchester disk based system which provides the ideal cost/performance ratio in typical small business applications. The C3-C uses the Shugart SA4008 29 megabyte Winchester disk.

Performance specifications, hardware configuration and software is identical to the C3-B with the following exceptions:

- 23 megabytes of end user workspace under OS-65U
- 29 megabytes unformatted capacity
- Medium performance Winchester

  240 millisec worst case access

  87 millisec average access

  10 millisec access on cylinder
  (110K user workspace)
- Simple on/off disk operation

C3-C	$9,995
GT Option (as per C3-A) add	1,950

Ohio Scientific Microcomputers for all reasons

Multiple User Systems

In applications where several terminals are desired, but most of which will be utilized for entry and editing (such as order entry systems), multiple user microcomputers are feasible. In environments where it is commonplace for more than one user to be processing information at a time, a single microcomputer may become annoyingly slow. A better configuration for such applications is distributed processing as discussed later.

All C3 series computers will support up to 16 timeshare users under OS-65U Level 3 providing that the computer has a real time clock, sufficient memory and the appropriate communications ports.

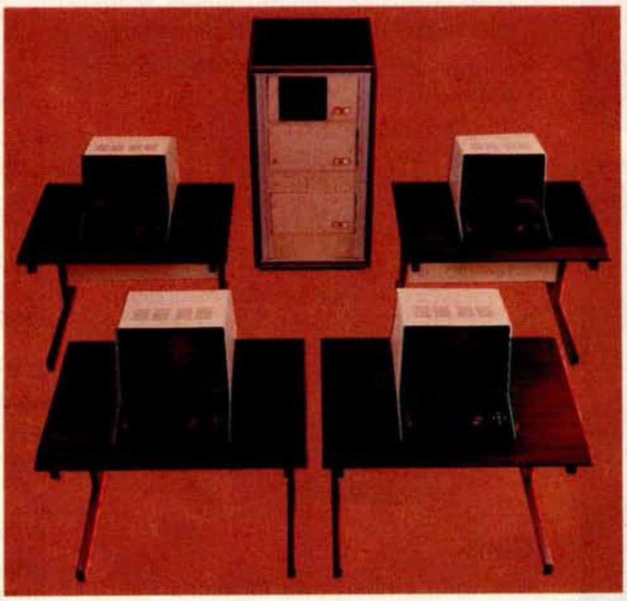
C3 computers utilize bank switching for multiple users. Each user must have 32K to 48K RAM and an RS-232 port. The host machine must also have 4K RAM for the multi-tasking executive. The computer timeshares individuals by interrupting a user after a set time (approximately 100 milliseconds) and bank switches to the next user in a "round robin" fashion. Bank switching architecture is not as memory efficient as techniques which use re-entrant code or swapping disks but is by far the fastest technique, requiring only a few microseconds of processor overhead per switch, a feature which is most important in multiple user systems.

Although OS-65U Level 3 will support timesharing on any C3, it is only recommended on C3-B and C3-C computers. This is because of the desirability of 17 BUS slots for multiple user memory partitions and the dramatic performance advantages of Winchester disks over floppies.

Networking

In a distributed processing system using OSI microcomputers as intelligent terminals (local systems) most of the work load is handled locally. Overall system performance does not degrade under heavy job loads. Each local system performs entry, editing and execution while utilizing a central data base for disk storage, printer output, and other shared resources.

For more demanding applications it is desirable to have several data bases, each with its own collection of local systems. Such an inter-connected set of data bases is called a network. Each data base and its local intelligent and dumb terminals is called a cluster.



Level 3 NET

OS-65U Level 3 NET supports this advanced networking and distributed processing capability as well as conventional single user operation and timesharing. Level 3 NET supports local clusters of intelligent microcomputer systems as well as dumb terminals for the purpose of utilizing a central Winchester disk data base and other shared resources. The system also has full communications capability with other Level 3 data bases providing full network capability.

Level 3 resides in each network data base. A subset system resides in each intelligent terminal. Each data base supports up to 16 intelligent systems and up to 16 dumb terminals. Level 3 also supports a real time clock, printer management, and other shared peripherals.

Data Base Requirements

Minimal requirements for a Level 3 network data base are a C3-C or C3-B computer system with 23 or 74 megabytes respectively, console terminal, 88K bytes RAM and a CA-10X 16 port I/O board for network and cluster communications.

Intelligent Terminal Requirements

Any Ohio Scientific 8" floppy based computer with 56K RAM and one data base communications port.

Connections

Intelligent terminals and networked data bases are connected by low-cost cabling. Each link can be up to 10,000 feet long at a transfer rate of 500K bits per second, and will cost typically 30¢ a foot (plus installation).

Syntax

Existing OS-65U based software can be directly installed on the network with only one statement change! Level 3 has the most elegantly simple programming syntax ever offered on a computer network.

File syntax is as follows:

DEV A,B, C,D	Local Floppies	unchanged from single user and timeshare system
DEV E	Local Hard disks	
DEV K-Z	Specific network Data Bases	

Each of up to 8 open files per user can be from 8 separate origins. Specific file and shared peripheral contentions are handled by 256 network semaphores with the syntax Waite N
Waite N, close

The network automatically prioritizes multiple resource requests and each user can specify a timeout on resource requests. Semaphores are automatically reset on errors and program completion providing the system with a high degree of automatic recovery.

Time Sharing/Networking

One Step at a Time

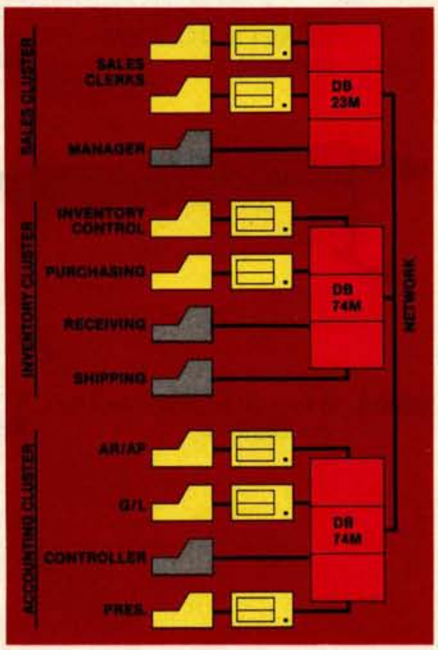
Best of all, Ohio Scientific users can develop distributed processing systems economically one step at a time. A user can start with a single user floppy system, add a hard disk, then timesharing, then a second Winchester data base for backup and, finally, cluster intelligent terminals to achieve a full network configuration.

Level 3 Support Group Factory Configured Systems

Prices include OS-65U Level 1 but do not include 65U Level 3 or Level 3 NET. Machines with NET prefix have the specified number of users plus NETWORK data base node capability. The NETWORK partition can be used as an extra user through its diagnostic RS-232 port.

For example, a 4-user system with networking can be used as a 5-user system without networking.

Network systems have ports for 4 intelligent terminals (cluster ports) and 1 NET port.



Time-share Users	C3-C .35 MIPS	C3-C .7 MIPS	C3-C .7 MIPS + NET	C3-B .35 MIPS	C3-B .7 MIPS	C3-B .7 MIPS + NET
1	NA	$9995 C3-C	$11,995 C3-C-N1	NA	$12,995 C3-B	$14,995 C3-B-N1
2	$10,900 C3-C-12	11,400 C3-C-22	12,995 C3-C-N2	$13,900 C3-B-12	14,400 C3-B-22	15,995 C3-B-N2
3	11,700 C3C-13	12,400 C3-C-33	13,995 C3-C-N3	14,700 C3-B-13	15,400 C3-B-33	16,995 C3-B-N3
4	12,400 C3-C-14	13,400 C3-C-44	15,200[1] C3-C-N4	15,400 C3-B-14	16,400 C3-B-44	18,200[1] C3-B-N4
5	13,100 C3-C-15	NA	NA	16,100 C3-B-15	NA	NA
6	13,800 C3-C-16	NA	NA	16,800 C3-B-16	NA	NA
7	14,500 C3-C-17	NA	NA	17,500 C3-B-17	NA	NA
8	15,200 C3-C-18	NA	NA	18,200 C3-B-18	NA	NA

Note 1. Uses 16-slots, 1 open, comes with printer and word processing ports installed.

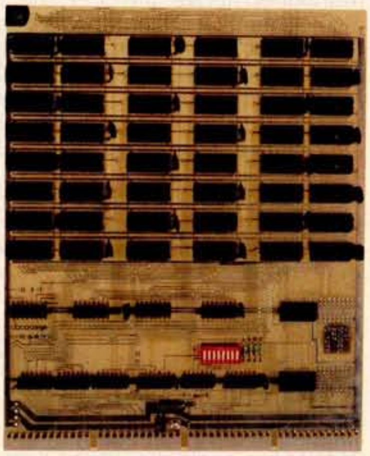
Microcomputer Components

OSI Power Sequencers Turn Entire Systems On/Off From One Keyswitch.

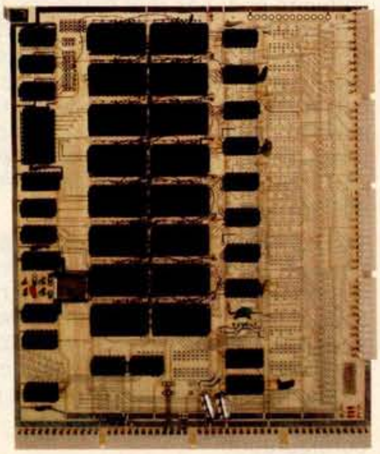
PDS-1 Switch panel for C3-A, B, C. Sequences CPU, floppies, hard disk, CRTs, printer and other accessories. **$350**

PDS-3 Switch panel for DKS-5A desk. Sequences CPU, floppies, CRT, printer and other accessories. **$200**

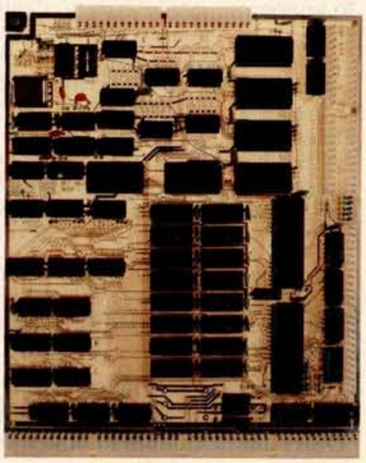
CM-9



CA-10-16



CA-18A



Memories

CM-2 4K 2MHz static for expanding C3-B, C3-C to 56K for CP/M and/or networking. **$129**

CM-3A 16K 2MHz low power static standard C3 memory. **$399**

CM-6 48K 1MHz dynamic for C2-OEM and some timeshare systems. **$549**

CM-9 24K 2MHz medium power statics usable in computer with booster supplies or high current switchers. **$450**

CM-10 8K 2MHz static for expanding C2 and C3 computers to networking or CP/M. (C3 only) **$198**

General I/O

CA-9 Centronics parallel printer interface with cable. **$175**

CA-10X 1 to 16 RS-232 port I/O board. 300-19200 baud plus synchronous operation at 250K and 500K baud. 1 port standard. **$125**

Each additional port. **$ 50**

CA-10-N5 CA-10X port board configured for four cluster communications ports and one network communications port all at 500K baud for use in data bases. **$349**

Combinational I/O

CA-17 8K 2MHz RAM and 1 cluster port plus 1 auxiliary RS-232 port. (Converts any C2 or C3 to networking.) **$298**

CA-18 1 Centronics parallel printer port with cable, 1 parallel word processing printer port with cable, 2 RS-232 ports and 1 cluster port. **$398**

CA-18A As above with 8K 2MHz RAM and 2 additional RS-232 ports (4 total), i.e., fully populated 555. **$598**

See the OEM and R/D section for more accessory boards.

Ohio Scientific Software for all reasons

OS-AMCAP (Level 1.5)

OS-AMCAP is a fully integrated small business accounting system. The software package runs on any Ohio Scientific dual-floppy, double-sided dual-floppy or hard disk based 6502 system with at least 48K RAM. OS-AMCAP contains the following integrated modules using a common data base:

General Ledger, including a complete user defined chart of accounts, cash receipts, cash receipts journal, cash disbursements, cash disbursements journal, journal entries, editing, balance sheet, trial balance and statement of earnings with complete editing for all of the above.

Accounts Receivable with and without aging, aged monthly statements.

Accounts Payable with and without aging.

Inventory, including inventory analysis, inventory by vendor, inventory overdue, inventory on order, inventory re-order, and detailed reports.

Billing/Invoicing and order entry for the inventory which will optionally support customer files with bill to, ship to, credit and customer mailing and monthly statements.

Payroll

For easy installation, the AMCAP system includes the AMCAP configuration program which automatically creates all necessary disk files based on the user's requirements. An AMCAP training disk which is pre-loaded with information for a hypothetical company is also included for demonstration and training purposes. A 250-page AMCAP Level II manual is included that describes Levels 1.5 and II.

OS-AMCAP is designated by Ohio Scientific to be a small concise easy-to-use "turnkey" business software package. OS-AMCAP has been in use at hundreds of locations for over two years.

OS-AMCAP $975

OS-AMCAP Level II

OS-AMCAP Level II contains all of the features included in Level 1.5 in addition to many other significant and valuable expansions that are a direct result of many end user requests.

- Divisionalization and departmentalization in the general ledger, inventory and payroll and all accounting journals such as C/R, C/D, A/R, A/P, JE and aging reports, balance sheet and the statement of earnings.
- Multiple cash in bank accounts, multiple accounts receivable/payable accounts by division or department.
- Listing of general ledger journals by from-date-to-date.
- Enhanced order entry to include temporary inventory items, special discounts and special list price considerations in addition to credit memos and quotations.
- Enhanced payroll which allows for up to ten miscellaneous deductions and multi-state payroll withholding tax includes payroll 941 form, W2 forms and check registers plus an advanced employee file editor.
- Monthly statements contain inclusion of automatic overdue charges as a service charge on each statement which is ready for window envelope mailing.
- Preset IBM compatible system 32 and IBM system 34 forms for monthly statements, invoices and payroll checks that are available locally.
- OS-AMCAP Level II is available only as an upgrade to AMCAP Level 1.5.

AMCAP 1.5 to AMCAP II upgrade $995

(AMCAP is a trademark of American Intelligent Machines)

OS-HDM Hard Disk Manager

General

The Hard Disk Manager is an end user oriented software package designed to allow multiple independent systems to reside on the hard disk at the same time. Each system can contain over 150 program or file entries in its separate directory. Each system can be of any length from 600K bytes to several million bytes long.

Any AMCAP, DMS or other BASIC programs that operate under OS-65U can occupy any system area of any length within the Hard Disk Manager. Provisions are included to easily transfer an existing floppy based system to any system within the Hard Disk Manager.

Fast Floppy Dumper

With the Fast Floppy Dumper back-up feature a user can easily and conveniently back up on removable floppies any or all systems (programs and files) residing on the hard with the standard hardware.

It takes approximately 1.3 minutes for each 250K of memory to automatically be placed on a floppy diskette and the HDM automatically prompts when one floppy is full and another should be inserted.

Cartridge Tape Back-Up

As with the Fast Floppy Dumper feature mentioned above, the OS-HDM package also contains a Cartridge Tape Back-Up feature. While this Cartridge Tape Back-Up is somewhat slower than the Fast Floppy Dumper it does not necessitate the operator inserting another floppy each time one becomes filled unless the size of a system on the hard disk exceeds the limit of the large capacity cartridge tape medium (approximately 11 megabytes). As with the Fast Floppy Dumper, the Cartridge Tape Back-Up is self-identifying and easily used by inexperienced personnel.

OS-HDM $675

OS-TMUM Timesharing Multi-User Manager

TMUM is a sophisticated and advanced software package that manages the timesharing features available with hard disk based C3 computers and offers the user true large computer timesharing capability with Log-On, Log-Off features, account number tracking, connect time usage by account number and system plus many other inherent timesharing system characteristics.

TMUM is designated to be used either in-house or with auto-answer modems and is thoroughly secure with non-echoing account number entry, system name, and classified password protection. The TMUM package is capable of accommodating up to 16 users and one console user depending upon machine configuration.

To accommodate a variety of different systems on the hard disk TMUM utilizes some of the multiple system techniques used with and explained in the Hard Disk Manager (HDM) package. This includes the ability to automatically back up any system of any size onto floppy diskettes. It also includes the ability to back up systems on the hard disk with the cartridge tape hardware now available.

The TMUM package is capable of running OS-AMCAP, DMS and all other programs including BASIC programs written in OS-65U.

OS-TMUM is available only as an upgrade to the Hard Disk Manager (HDM).

OS-HDM to OS-TMUM upgrade $1095

OS-DMS

The OS-DMS Nucleus and supporting business packages make up an extremely powerful Data Base Management System and Inquiry System that lend themselves to a wide range of small business applications. Generally, any collection of information of primary importance to a business can be placed in this system. To clarify the application of OS-DMS an explanation is necessary of a Data Base Management System and an Inquiry System.

Fundamentally, a data base is a collection of data. The data can be any information that is of value to a person, business or agency using the system. The data may be as varied as real estate files, inventories, personnel files, or automotive sales. Typically, data is usually kept in filing cabinets, card files, desk drawers, etc. Information in these categories are prime targets for a data base management system.

The operator has the ability to access the information of the data base in a manner which makes the data useful. The user has the ability to enter, remove, or edit information in the files to keep it current with present activities. The user also may change the order of information in a file to suit a particular application.

When the operator needs information, or a decision based on information in the file, a report of some kind will be generated.

The user, in some cases, may set specific conditions related to the report. Examples of conditions are inventory items over a certain amount, age analysis of accounts receivable or payable, or houses costing between two dollar amounts.

The emergence of OS-DMS makes computers immediately usable for the untrained small businessman. The system finally brings the use of microcomputers down to the level of non-programmers. It means that virtually untrained computer users can take advantage of the speed and efficiency of a computer in their daily activities.

OS-DMS Modules

OS-DMS Nucleus

OS-DMS Nucleus — provides the data base manager and information management system for DMS compatible files. Can be used to "computerize" any collection of information. Since it is written primarily in BASIC it can be easily customized for specific applications. It is also a useful maintenance tool to complement other DMS modules. **$300**

DMS modules—specialized applications packages based on the OS-DMS information management system.

OS-DMS — Inventory I and II

Inventory I is designed to be primarily a finished goods inventory for manufacturers, wholesalers and retailers. The system incorporates an inventory file, an order entry system, receiving program and shipping program. **$300**

Inventory II is primarily a manufacturing inventory system which can be integrated with Purchasing system and Bills of Material system. These three packages collectively provide small manufacturing businesses with capabilities comparable to those found in MRP system, but with a higher degree of personal control. The Inventory system maintains an inventory with average weekly usage, weeks on hand, weeks on order with a shipping and receiving (or stock room control) program. **$300**

OS-DMS Purchasing System

The Purchasing System complements Inventory II by maintaining a file of open purchase orders and deliveries against those purchase orders. **$300**

OS-DMS Bills of Material

The Bills of Material System interfaces with Inventory II and the Purchasing System and will provide bills of material for several levels of subassemblies. This program maintains bills of material with cost accounting and allows the user to break down any assembly to its subsequent subassemblies, and ultimately to raw parts. This inventory explosion is highly useful for forecasting raw parts usage based on finished goods sales. It can also be used for inventory control applications to update raw parts and subassemblies inventories by the subassemblies and finished goods shipped out of a department. **$300**

OS-DMS A/R, A/P

Accounts Receivable and Accounts Payable system maintains accounts receivable and payables aging, detailed reports and customer statements. **$300**

OS-DMS General Ledger

DMS General Ledger System maintains a detailed general ledger based on a user specified chart of accounts. Also produces monthly statements including balance sheet and profit and loss statements. **$300**

OS-DMS Personnel Payroll

The Personnel Payroll system provides payrolls for a several hundred employee company including check generation and quarterly reports. The Personnel Payroll system maintains detailed personnel files for each employee. It contains general purpose report writing capabilities which can generate a broad range of management requested reports. **$300**

OS-DMS Query

The Query System allows the computer operator to make queries about data stored in DMS compatible data bases. The result of this inquiry can be a simple answer or the generation of a report. Additionally the Query system allows end users to specify fairly complex report formats and store these report formats under user assigned names so that they can be recalled quickly for future use. DMS Query system effectively allows high-level utilization of the computer's resources by non-programmers. **$300**

OS-DMS Quotation Estimation

The Quotation Estimation package is useful for providing quotations and estimations on tasks which are comprised of many well defined and often used sub-tasks and components, such as those found in the construction industry. **$300**

OS-DMS Educational System

DMS Educational system allows teachers to generate drills, quizzes and tests without programming. The system allows several forms of student interaction. Grades and responses can be stored for teacher examination. Grades for an entire period can be automatically tabulated. **$300**

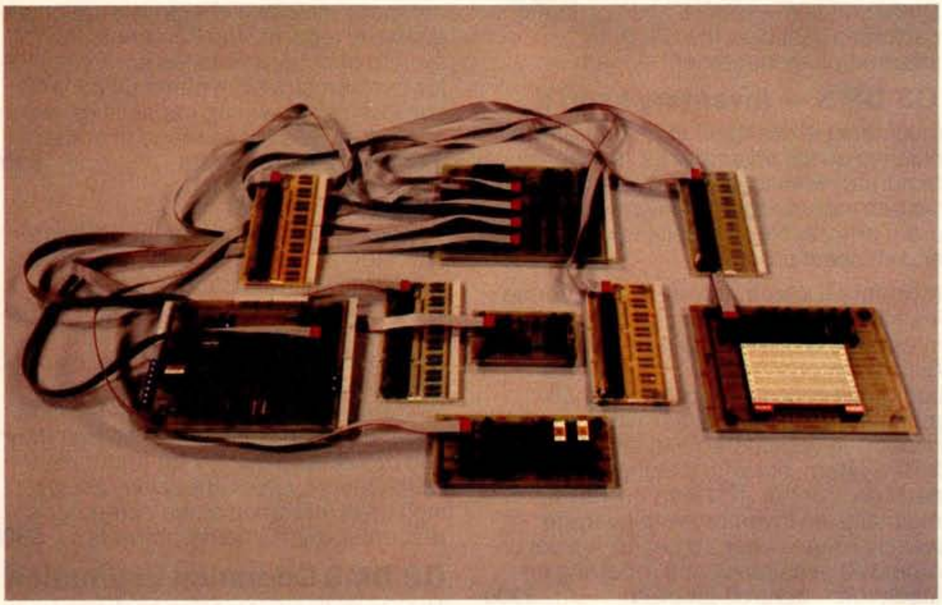
Customized Fully Integrated Systems

Customized fully integrated systems in the area of accounting, manufacturing, wholesaling, retailing and other services are available for multi-user timeshare and distributed processing based Ohio Scientific computer systems. These services are available through your local dealer as well as through the company's **Level 3 Support Group.** Contact your dealer for details.

Specialty Applications

Dozens of specialized applications have been generated by Ohio Scientific dealers and systems houses under OS-DMS including fully integrated Construction packages, Medical Billing systems, Legal Billing systems and a broad range of specialized information systems. Contact your dealer for the latest information concerning your specific application.

Ohio Scientific Accessories for all reasons



Ohio Scientific's Revolutionary New 16 Pin I/O BUS

Modern technology has made it possible to pack far more I/O functions on a computer board than one can practically connect to. Ohio Scientific has solved this problem with a series of remote "head end cards" which feature tremendous I/O capability and connect to the computer via single inexpensive 16 pin DIP ribbon cables. Thus I/O connection can be made away from the computer's card cage.

CA-20
8-port I/O BUS interface and calendar clock provides interfaces for 8 head end cards and a battery back up clock with hours, minutes, seconds, 1/10 second, day, and date. The automatically recharged batteries will power the clock for months. **$175**

CA-20A
As above without clock **$95**

Head End Cards

CA-21
48 Line Parallel I/O card features 3 PIA's and prototyping area **$45**

CA-22
High speed analog I/O module. Two 12-bit D/A converters, 1 12-bit/8-bit A/D converter with 16 channel input multiplexer. Factory configured for ± 10V offset binary, user jumperable for other configurations. Max error ± 2 LSB. 28,000 12-bit conversions per second. 66,000 8-bit conversions per second, drift. -50 ppm per °C. Note, the CA-22 can also be directly plugged into the computer without a CA-20, thus occupying one slot. **$598**

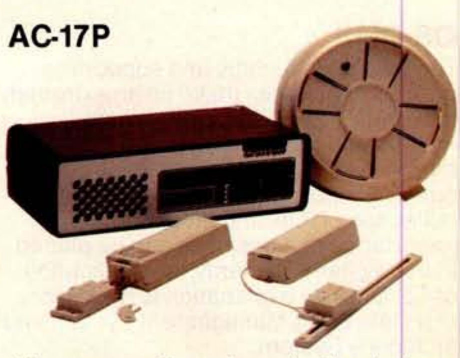
CA-23
PROM Blaster. Programs 2758, 2716, 2732 and 2764. 8 through 65K EPROMS. Programs and verifys from memory or other EPROM. **$195**

CA-24
Solderless interface prototyping board features a PIA and TTL I/O as well as provisions for direct user connection of devices such as the 6850 ACIA. Board also features 16 switches and 16 LED's. Has a large solderless breadboard for prototyping or educational lab exercises. **$175**

CA-25
Security and AC remote interface connects the AC-17P home security system and AC-12P wireless remote control system to C2 and C3 computers. **$45**

> 16 pin BUS family boards should be powered by external means where possible, however, a few modules can be supported by the host computer's supply if necessary.

AC-17P



A home security system, that's wireless and includes a control console, a fire detector, two window protection devices and one door unit. Additional protection devices are commercially available. **$249**

AC-12P

Wireless AC remote control. AC Remote Control Starter Set includes control console and modules to operate two lamps and two appliances via remote control with home control software on disk. Additional appliance and lamp modules are commercially available. **$175**

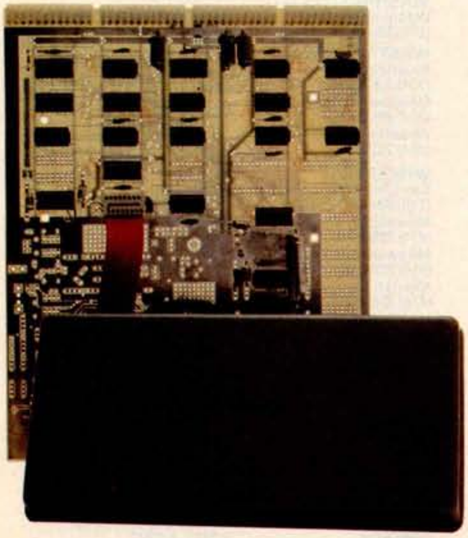
Process Control BASIC

A modified 9-digit BASIC under 65D with commands that support the real time clock, time of day clock (CA-20), 48 line parallel I/O (CA-21) analog I/O model (CA-22), AC remote (AC-12P) and to a limited extent the UTI (AC-15V) and security system (AC-17P). **$250**

Security BASIC — Use your computer for business accounting during the day and office and plant security at night!

A modified BASIC under 65D with commands which support the real time clock, AC-remote (AC-12P), security system (AC-17P) and universal telephone interface (AC-15V). Comes complete with a library of security program demonstrations. **$95**

OEM and R/D Accessories



CA-14A Votrax Voice I/O System

This Votrax Voice Synthesizer module has the capability of generating English speech phonetically. The supporting software simply feeds the phonetic spelling of English words to the module which generates medium quality spoken words. This advanced Votrax system is capable of generating all English phonemes as well as four levels of inflection on each phoneme. CA-14A also includes a voice recognition experimentation area which must be user populated. This experimentation board contains a five filter feature extractor with zero crossing detectors and envelope filters. The CA-14A in conjunction with the CA-22 high speed analog I/O module provide a complete voice recognition lab. **$399**

Voice Output Software

OS-Vocalizer I

"Generation by Rules System". Runs under OS-65D or OS-65U. Accepts conventional English spelling and outputs the phonetic spelling to the Votrax module in real time. Also, will print phonetic spellings for use by other programs. **$150**

OS-Vocalizer II

Runs in one partition of a 65U Level 3 system. Accepts normal print statements from other partitions (users) and vocalizes them in real time. Uses disk look up for the 3000 most common words and generation by rules for words not on file. End user can add approximately 1500 additional words to file. Generates the most legible speech now attainable via totally synthetic means (i.e. not recorded human speech). Operates on a C3-B or C3-C with at least two partitions. **$975**

CA-15 Universal Telephone Interface

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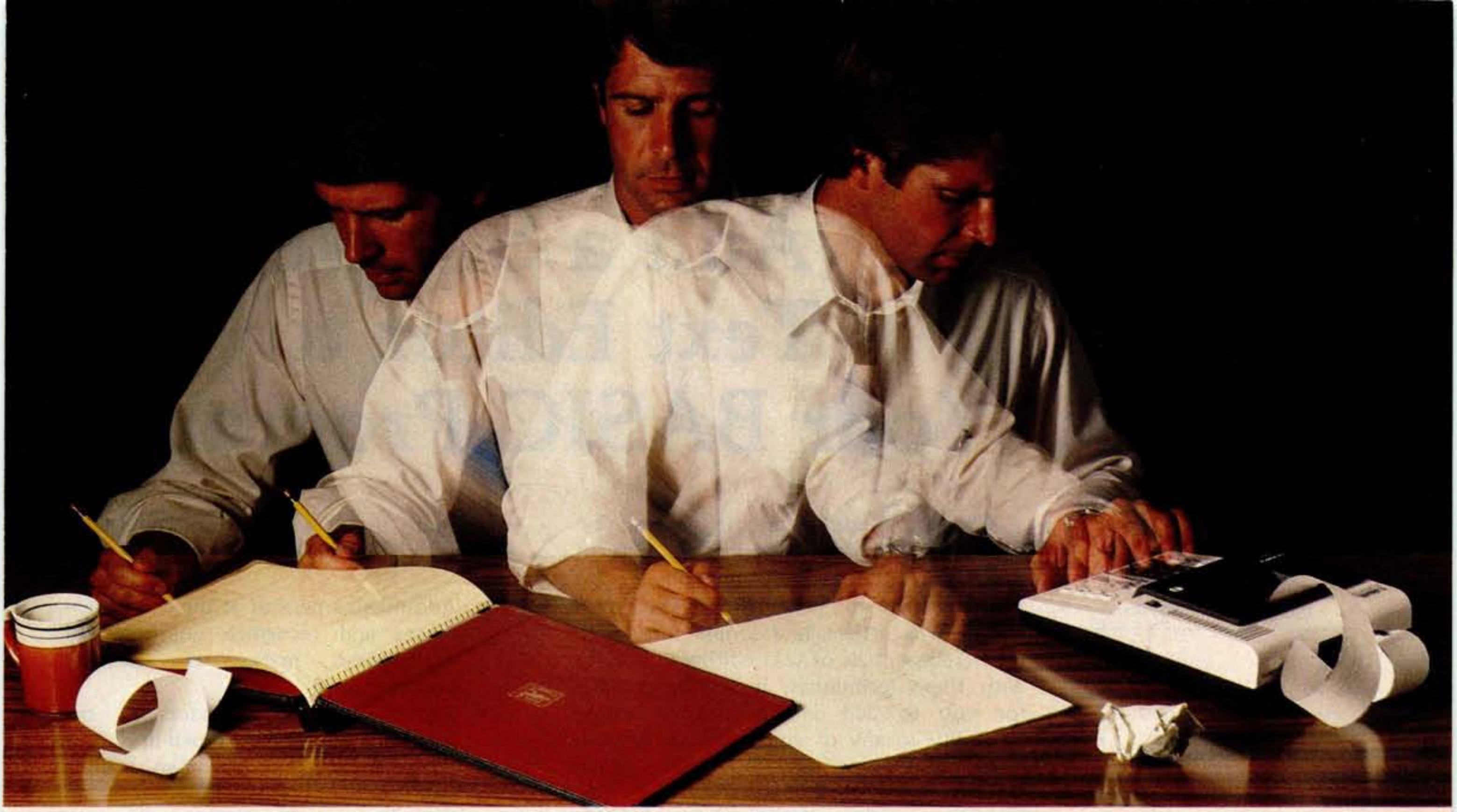

Add a Simple Text Editor to Your BASIC Programs

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While text editors are, in general, extremely useful for preparing all sorts of paperwork, it is usually not possible to append them to your own BASIC programs. This article is a simple tutorial in the bare essentials of text editing in BASIC. With these techniques, it will be possible for you to add simple text processing capability to any of your personal or business programs written in BASIC, which require paragraphed textual output. The program is written in North Star BASIC, version 6, release 3. It may be stored, as is, in 3186 bytes; it executes in a total of 4746 bytes. Deleting the remark statements reduces the program length to 1410 bytes enabling it to execute in 2956 bytes. While listing 1 is fairly self-explanatory, I'll discuss each of the steps in detail.

Text Editing

There are several tasks which text editors must accomplish. Most of these fall under the general category of producing a hard copy of text in an acceptable format. The barest definition of "an acceptable format" is one in which words are not randomly truncated at the end of a line of print. With this single requirement met, the text will be readable. But even this single text editing function requires that there be some ways to:

- Access the text string from memory or input.
- Determine line length to be printed.
- Distinguish between words and spaces.
- Alter what is to be printed on a given line based on the three criteria above.
- Link the sentences together in the proper order.

Such a text editor assumes that the user has made certain that each sentence is punctuated, and that each sentence string ends with the two trailing spaces needed to separate consecutive sentences.

A more useful text editor would also possess the following capabilities:

- Add missing periods at the end of sentences and recognize question and exclamation marks as adequate punctuation.
- Remove extraneous spaces at the beginning of each new typed line.
- Automatically add the two trailing spaces between sentences.
- Indent paragraphs when desired.
- Translate numeric data fetched from memory or input into the corresponding string characters for inclusion within a sentence.
- Allow input of line length for printing.

Text editors used solely for input and composition of text, such as Michael Shrayer's *"Electric Pencil,"* possess one other powerful set of characteristics: the ability to make radical modifications to the text after input and prior to printing. Because of this capability, this type of text editor does not need to compensate for the user's input errors noted above. As useful as full capability text editors are (I used *Electric Pencil* to compose the manuscript of this article) they are of no use within a BASIC program written for some other application, since most commercially available text editors are written in machine language.

Accessing Text

Text must be manipulated as strings of characters, whether letters, numbers, or symbols. In North Star BASIC, string variables may have names consisting of a letter, A thru Z, optionally followed by a number, 0 thru 9, allowing 260 unique string names. This number is quite enough for most applications, since if more than 260 strings are manipulated, several strings may be linked (concatenated), then renamed as a single string, and the variables thus freed reused for new strings. Strings of over 10 characters must be dimensioned at the start of the program, and may have dimensions limited only by your computer's memory. A portion of a string may be accessed using North Star BASIC by appending to the string name the character positions of the first and last characters in the desired substring:

```
10 DIM A3$(8)
20 A3$="ABCDabcd"
30 PRINT A3$(3,6)
```

This causes the printing of "CDab." The BASIC line 30 PRINT A3$(5) causes the printing of "abcd."

In other versions of BASIC, substrings may be named differently. One such method (used in Microsoft BASIC) looks like this:

```
LEFT$(A$,3)   is the same as  A$(1,3)
MID$(A$,3,6)  is the same as  A$(3,6)
RIGHT$(A$,6)  is the same as  A$(6)
```

Strings may be stored in memory and accessed as individual variables. They may also be included in a data line of the program and read from there, or they may be entered during program execution.

Determining Line Length

Let us make L the number of characters to be printed per line. Now, any line to be printed will begin with character number B of the string and end with character number E. For the first line of print, B is set equal to 1 and E is set equal to L. To compute the range of the second line, set B equal to E+1 and E equal to E+L, and so forth, for the entire text. These line printing parameters are used to define the *line string* F$, by using B and E as the substring parameters. Thus, if the text string to be printed is E$, we set F$ equal to E$(B,E), and print F$. We increment B and E, then again set F$ equal to E$(B,E).

The one difficulty with this method occurs when any line of text to be printed is shorter than the line length. In setting F$ to E$(B,E), E will be greater than the length of E$, and will generate an out-of-bounds error. To prevent this situation, the length of E$ must be compared to the value of E using the function LEN(E$), which returns a number equal to the number of characters actually contained in the named string (E$). If E is greater than LEN(E$), the program lines which calculate and print F$ must be skipped; all that is left is to print E$(B), which will print from

Listing 1: *BASIC source program and a sample run of TXTEDIT2. This text editor is word oriented rather than line oriented. The normal editor, supplied with BASIC, works line by line in edit mode. This BASIC program allows changes of single words without having to retype an entire line. The program accepts four sentences of up to 97 characters each. A period is added to the end of each sentence if it is missing, as well as two trailing spaces. (The program recognizes the characters ? and ! as sufficient punctuation.) When printing the four sentences, the program removes any leading spaces at the beginning of a new line; line length may be adjusted by the user. The total number of characters entered plus any necessary punctuation and trailing spaces are calculated, changed into a string, and printed in the final sentence obtained by the program. The program is written in Release 3 of North Star BASIC. If you are using Release 4, delete the comma after PRINT # Z.*

```
220 REM *** #Z,=OUTPUT DEVICE (#1,=PRINTER, #0,=CRT)
230 INPUT#Z,'for printer, type 1, for CRT type 0 ',Z
240 IF Z=1 THEN FILL 51206,1\REM *** SET INPUT TO PRINTER
250 DIM A$(100),B$(100),C$(100),D$(100),E$(466),F$(466),G$(100)
260 INPUT#Z,'1st ',G$
270 GOSUB 800
280 A$=G$
290 INPUT#Z,'2nd ',G$
300 GOSUB 800
310 B$=G$
320 INPUT#Z,'3rd ',G$
330 GOSUB 800
340 C$=G$
350 INPUT#Z,'4th ',G$
360 GOSUB 800
370 D$=G$
380 PRINT#Z,'THE SENTENCES WITH PUNCTUATION,IF NEEDED, AND BLANKS'
390 PRINT#Z,'FOLLOWED IMMEDIATELY BY * TO SHOW SUBSTRING LENGTH'
400 PRINT#Z, A$,'*'
410 PRINT#Z, B$,'*'
420 PRINT#Z, C$,'*'
430 PRINT#Z, D$,'*'
440 PRINT#Z,\PRINT#Z,\PRINT#Z,
450 E$=A$+B$+C$+D$\REM ***CONCATENATE STRINGS INTO PARAGRAPH
460 I=LEN(E$)\REM *** 'I' WILL DEMONSTRATE DATA INSERTION
470 G$='Your sentences, with punctuation and spacing,'
480 G$=G$(1,45)+' total      characters.'
490 G$(52,55)=STR$(I)\REM *** CHANGE 'I' TO ITS STRING EQUIVALENT
500 REM *** AND INSERT IT INTO G$
510 E$=E$(1,I)+G$
520 D=1\REM *** START OF PRINT LINE
530 INPUT#Z,'Line length (number of characters)? ',L
540 E=L-4\REM *** L=LINE LENGTH
550 PRINT#Z,'THE CONCATENATED SENTENCES, PRINTED BY THE LINE'
560 PRINT#Z,\PRINT#Z,'     ',\REM *** INDENT PARAGRAPH
570 IF E>LEN(E$) THEN 670
580 F$=E$(D,E-1)\REM *** F$=LINE TO BE PRINTED
590 IF E$(D,D)=' ' THEN GOTO 760
600 IF E$(E,E)=' ' THEN 630\REM *** TEST FOR END OF WORD
610 E=E-1\REM *** SHORTEN LINE UNTIL END OF WORD IS FOUND
620 GOTO 580
630 PRINT#Z,F$
640 D=E\REM *** START OF NEXT LINE
650 E=E+L-1\REM *** SET LENGTH OF NEXT LINE
660 GOTO 570
670 IF E$(D,D)=' ' THEN GOSUB 760
680 PRINT#Z,E$(D)
690 PRINT#Z,\PRINT#Z,\PRINT#Z,
700 INPUT#Z,'Do you want to print this paragraph again? ',H$
710 IF H$(1,1)='Y' THEN 520
720 IF H$(1,1)='y' THEN 520
730 IF H$(1,1)='N' THEN END
740 IF H$(1,1)='n' THEN END
750 PRINT#Z,'YES or NO please'\GOTO 700
760 D=D+1
770 E=E+1
780 IF E$(D,D)=' ' THEN 760
790 GOTO 570
800 G=LEN(G$)
810 REM *** REMOVE TRAILING BLANKS
820 IF G$(G,G)=' ' THEN G=G-1 ELSE GOTO 860
830 REM *** RETURN TO CHECK FOR MORE TRAILING BLANKS
840 GOTO 820
850 REM *** CHECK FOR PUNCTUATION (ASCII .=46, !=33, ?=63)
860 IF(ASC(G$(G))=46 OR ASC(G$(G))=33) OR ASC(G$(G))=63 THEN 910
870 REM *** ADD PERIOD TO END OF SENTENCE
880 G$=G$(1,G)+'.'
890 G=G+1
900 REM *** ADD TRAILING SPACES
910 G$=G$(1,G)+'  '
920 RETURN
```

Listing 1 continued on page 36

Listing 1 continued:

```
RUN

for printer, type 1, for CRT type 0 1
1st The first sentence is properly punctuated.
2nd The second sentence is not punctuated
3rd What will the editor do with these 9 trailing spaces?
4th Such a quick job this makes of text material in your programs!
THE SENTENCES WITH PUNCTUATION,IF NEEDED, AND BLANKS
FOLLOWED IMMEDIATELY BY * TO SHOW SUBSTRING LENGTH
The first sentence is properly punctuated.  *
The second sentence is not punctuated.  *
What will the editor do with these 9 trailing spaces?  *
Such a quick job this makes of text material in your programs!  *


Line length (number of characters)? 72
THE CONCATENATED SENTENCES, PRINTED BY THE LINE

     The first sentence is properly punctuated.  The second sentence is
not punctuated.  What will the editor do with these 9 trailing spaces?
Such a quick job this makes of text material in your programs!  Your
sentences, with punctuation and spacing, total 203 characters.


Do you want to print this paragraph again? y
Line length (number of characters)? 13
THE CONCATENATED SENTENCES, PRINTED BY THE LINE

     The
first
sentence is
properly
punctuated.
The second
sentence is
not
punctuated.
What will
the editor
do with
these 9
trailing
spaces?
Such a quick
job this
makes of
text
material in
your
programs!
Your
sentences,
with
punctuation
and spacing,
total 203
characters.
```

character number B to the end of the string. *[This method also assumes that strings can have arbitrary lengths; Some BASIC interpreters limit strings to 256 characters in length . . .* **CH***]*

To indent a paragraph, initialize B to 6 and E to (L–5). Then, prior to printing the text, simply print five blanks, followed by a comma to keep the printing line open. The following program prints the entire string E$ in lines that are L characters long.

```
50 INPUT "What is line length?", L
60 B=6
70 E=L–5
80 IF E>LEN(E$) THEN 140
90 F$=E$(B,E)
100 PRINT F$
110 B=E+1
120 E=E+L
130 GOTO 80
140 PRINT E$(B)
```

Any words that cross the boundary between one printed line and the next would be arbitrarily broken to fit the line length, when using this program. To avoid this, it is necessary to scan the text for the last space before the end of each line to be printed, and shorten each line so that no partial word is left at the end. This is done by testing the first character following the proposed line of print. If it is a space, no word would be broken by printing the line as is. If on the other hand the first character following a proposed line of print is not a space, the end character of the print line must be either a space or an arbitrary character. So the print line is shortened by one character (E=E–1), and retested in the same way until a space is found as the next character following the proposed line of print. The line is then printed, and we go on to process the second line in a similar fashion. In the listing of TXTEDIT2, E is initially set equal to the line length plus one, and then, in line 600, character E of the proposed line of print is tested. If it is a space, E$(B,E–1) is printed. If not, the line is shortened by one character in line 610.

Linking Sentences

Strings that must be linked together, or concatenated, are placed in a string equation such as:

```
50 E$=A$+B$+C$
```

This will concatenate the strings in the order specified in the equation. With string variables, North Star BASIC does not allow many equation formats that would be perfectly acceptable if used for numeric variables. For example:

```
50 E$=E$+B$
```

will generate an out of bounds error, since the first E$ will be greater than the second E$. Because of this and other peculiarities of North Star BASIC string functions, intermediate variables must often be used to concatenate strings. (The example above will function properly in North Star BASIC Release 4.) As an example, if your program contains 11 strings that must be concatenated in a sequence determined by the program, you may either concatenate each of them by name (all in the same equation) or accumulate them one by one. If the latter method is chosen, an intermediate variable is necessary. If E$ is the paragraph to be printed, then:

```
50 F$=E$
60 E$=F$+A$
70 F$=E$
80 E$=F$+B$
90 F$=E$
```

with F$ being the intermediate variable, and A$ and B$ being new strings to accumulate in E$. F$ must be dimensioned equal to E$.

There is one other way of accumulating strings without obtaining an out-of-bounds error message: by specifying the length of the currently accumulated string and then concatenating literal text. That is:

```
50 G=LEN(G$)
60 G$=G$(1,G)+
     "This is the text to be added."
```

A peculiarity of North Star BASIC is that the statements:

```
50 G=LEN(G$)
60 G$=G$(1,G)+A$
```

will generate an out-of-bounds error message. Actually, the problem is that once a string has been defined, and in spite of its dimension, its length cannot be increased without redefining it in a concatenation equation that doesn't concatenate itself. Nevertheless, this rule can be violated when concatenating a string with itself and literal text. That is, the added string is presented in its entirety in the equation, enclosed within quotes.

Just as an aside, strings may be alphabetized by their first character by using the relationals > or <. Strings can be used in conjunction with LET, READ, DATA, INPUT, IF, and PRINT. In most versions of BASIC strings may be read from data intermingled with numeric variables as long as the proper sequence is maintained.

Inserting Numeric Data

Even though numeric values appear the same as number characters, they cannot be manipulated in the same way. A number cannot be inserted into a text string. First, it must be converted to its character equivalent. Then it may be inserted. This is understandable when you consider that, for example, in BASIC with 8 digit precision for numeric computations, a number (regardless of the number of digits) is stored in five bytes, whereas number characters within a string are stored as one byte (representing that particular print character) per digit.

This conversion is made by the STR$(expr) function, in which expr stands for the numeric value which must be converted into its string counterpart. In TXTEDIT2, this is used in line 490 to convert the numeric value of the length of E$ (represented by 'I' from line 460) into the equivalent string characters and insert them into the blank of string G$. The opposite conversion — from string number characters into a numeric value that can be manipulated algebraically — is performed by the function VAL(expr), with expr being the number characters of a string.

Punctuating Sentences

When strings are to be input by the user of a program in response to some question, the user will not always remember to add the period at the end of each sentence. This is no problem if the printed output is not in paragraph form. If the output is to be a paragraphed letter or document, however, then regardless of the input, the sentences must be closed with some form of punctuation. It is therefore necessary to check the input string to see if there is a period, question mark or exclamation point present. If not, a period should be added. In TXTEDIT2, as each sentence is entered, it is sent to line 800 where any extraneous trailing blanks are deleted, and the last character of the string is tested to see if it is one of the three possible punctuation marks. If not, a period is added.

One difficulty in comparing several string characters is that the Boolean operators AND, OR, and NOT cannot be used. There are two ways around this: the first and most cumbersome is to use one program line for each comparison to be made. The

Text continued on page 39

Figure 1: *Bar code representation of the shortened version of listing 1. In this version all the remarks and demonstration print statements have been removed to conserve memory. The bar codes represent textually coded data as described in the book* Bar Code Loader *(available for $2 plus $0.60 postage from BYTE Books, 70 Main St, Peterborough NH 03458, or from local computer stores).*

000 001 002 003 004 005 006 007 008 009 010 011 012 013 014 015 016 017 018 019 020 021 022 023 024 025 026 027 028 029 030 031 032 033 034 035 036 037 038 039 040 041 042 043 044

000 001 002 003 004 005 006 007 008 009 010 011 012 013 014 015 016 017 018 019 020 021 022 023 024 025 026 027 028 029 030 031 032 033 034 035 036 037 038 039 040 041 042 043 044

Text continued from page 37:

second is to convert the string characters into numbers that can be compared using the Boolean operators. Since VAL(expr) may be used only for string characters that represent numbers, it may not be used for converting alphabetic characters into numbers. Instead, the characters can be converted to the ASCII code decimal value by using the function ASC(string name), which will return the decimal ASCII value of the first character in the named string. This is demonstrated in lines 850 and 860 of TXTEDIT2.

Trailing Spaces

Sentences that are concatenated into a paragraph must be separated by two spaces. This is done by finding the last character of the string which is not a space, and then simply adding two spaces beyond that last character. This is done in line 910 of TXTEDIT2.

Leading Spaces

The last task for our text editor is to make certain that no line of print begins with a space. If the preceding sentence ends exactly at the end of the last print line, the next two characters to be printed will be the trailing spaces of the last sentence. Prior to printing each line, we must therefore test to see if the first character of that line is a space. If it is, it is skipped and the line retested for another leading blank. When the first character is finally not a space, we retest the length of the line to be printed, since after incrementing E while skipping the leading blanks, E may have grown larger than the length of E$. This sequence starts in line 590 of TXTEDIT2.

More Sophistication

Though not demonstrated in TXTEDIT2, there are other text editing techniques you might like to try. The right margin may be justified by determining the length of a line as it will be finally printed, subtracting that from the requested line length, and thereby calculating the number of additional blanks that must be inserted in the line to make it equal the requested length. Starting at the last character and moving backwards, test for a blank and insert one of the extra blanks in that space; then on to the next blank. An intermediate string variable must be set up in which all the characters from the end to the first space encountered from the end will be renumbered from the requested line length L, on down. The extra space may be added, and then the next word (heading backwards) is added to the intermediated string variable, etc, until the required number of spaces have been added. If the line is exhausted before all the needed spaces have been added, run through the string again, adding more.

Form feeding at the end of a page to the top of the next page may be implemented by adding a counting variable to the loop that prints each line of text. When the counter reaches the requested page length (in lines), the program jumps to a subroutine which issues the number of PRINTs specified to reach the top of the next page. If the page length and page spacing are entered as variables, the page size may be varied from address labels to poster size sheets.

A line oriented text editor allowing modification of the text after input could be implemented by displaying several lines at a time, each with a number. Then, by asking the user if there are any changes to be made to any of the lines, and requesting the particular line number, the program may redefine the string variable containing that line to contain a newly entered line. A little cleverness with the use of the INP(expr) instruction might allow the user to space over the unchanged portions of the line, and change only the part typed over.

A Note About TXTEDIT2

In North Star BASIC, the PRINT, INPUT, LIST, and LINE instructions allow an optional specification of the input/output (IO) device to be used with the instruction. By using PRINT#1, the serial IO port is selected. By writing a program with a variable in place of the device select number, it may be user selected to run on any of the available devices. This was done in TXTEDIT2 and may be changed to the usual PRINT and INPUT instructions for use with other BASICs.

Conclusions

While TXTEDIT2 cannot be merely appended to your BASIC programs, the techniques discussed in this article and demonstrated in TXTEDIT2 will enable you to select the text editing functions you need and synthesize them into an efficient part of your own programs. Any suggestions you may have regarding this material or other text editing functions will be welcomed.■

Ease Into 16-Bit Computing

Part 2: Examining a Small Multi-User System

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In computer club meetings, in software-development groups, and among hardware designers, the terms multiprogramming, multiprocessing, and multitasking are often heard. Now that we have a few years of experience in microprocessing, the prefix *multi* has become prevalent. I define multi as an indication of the ability of a system to seemingly process more than one function at a time.

Multiprogramming, as I refer to it, is a form of program execution that allows more than one user to access the resources of a computer system at (apparently) the same time. Rather than denoting the execution of multiple programs simultaneously, which requires the use of more than one processor, multiprogramming implies a division of a single processor's time and resources. A computer executes commands faster than any single human user can enter data or instructions. A user in such a situation may never realize that there are other users connected to the same computer.

Because the input and output are being performed by the operator at human speed (which is extremely slow relative to the speed of the microprocessor), most of the processor's time in a single-user system is spent waiting for the operator to enter information, or for an output device to display the information being sent by the processor. The ratio of time the computer spends in useful activity to time the computer spends waiting is very small. Multiprogramming takes advantage of this relatively large amount of wait time by using it to execute a request from one of the other concurrent users. Of course, as the number of users on the system increases, the operator response time

Surprisingly little hardware is required to support a multi-user system running Tiny BASIC.

(ie: the amount of time it takes for the computer to respond to a specific request from an operator) will become longer and longer until it reaches some unacceptable limit. In order to maximize the number of users that may use the system concurrently with acceptable response time, the operating system may be tailored to a particular type of application.

Your first question may be, "How much hardware is required to support a multi-user system running a high-level language such as BASIC?" The answer: surprisingly little. Because of the 16-bit processing features of the Intel 8088, which I outlined last month, a multi-user operating system can be provided with a computer consisting of as few as five integrated circuits.

It is beyond the scope of this article to discuss and list the entire assembly code of the Tiny BASIC system written for the 8088. The assembly listing of the 2 K-byte interpreter is thirty-one pages long.

Readers who are interested in using the 8088 for a similar application are advised to contact the manufacturer directly. Intel is publishing an application note describing a small (seven integrated circuits) multi-user Tiny BASIC system that uses the 8088. There was discussion at the time of this writing (January 1980) that a printed-circuit board of the expanded circuit would be available for sale as well.

For this information contact:

Tom Cantrell
Marketing Communications
Intel Corporation
3065 Bowers Ave
Santa Clara CA 95051

Minimum System Hardware

The five integrated circuits required to build a workable system include the 8088 microprocessor; the 8284 clock generator; the 8155 memory, input/output (I/O), and timer device; and the 8185 erasable programmable read-only memory

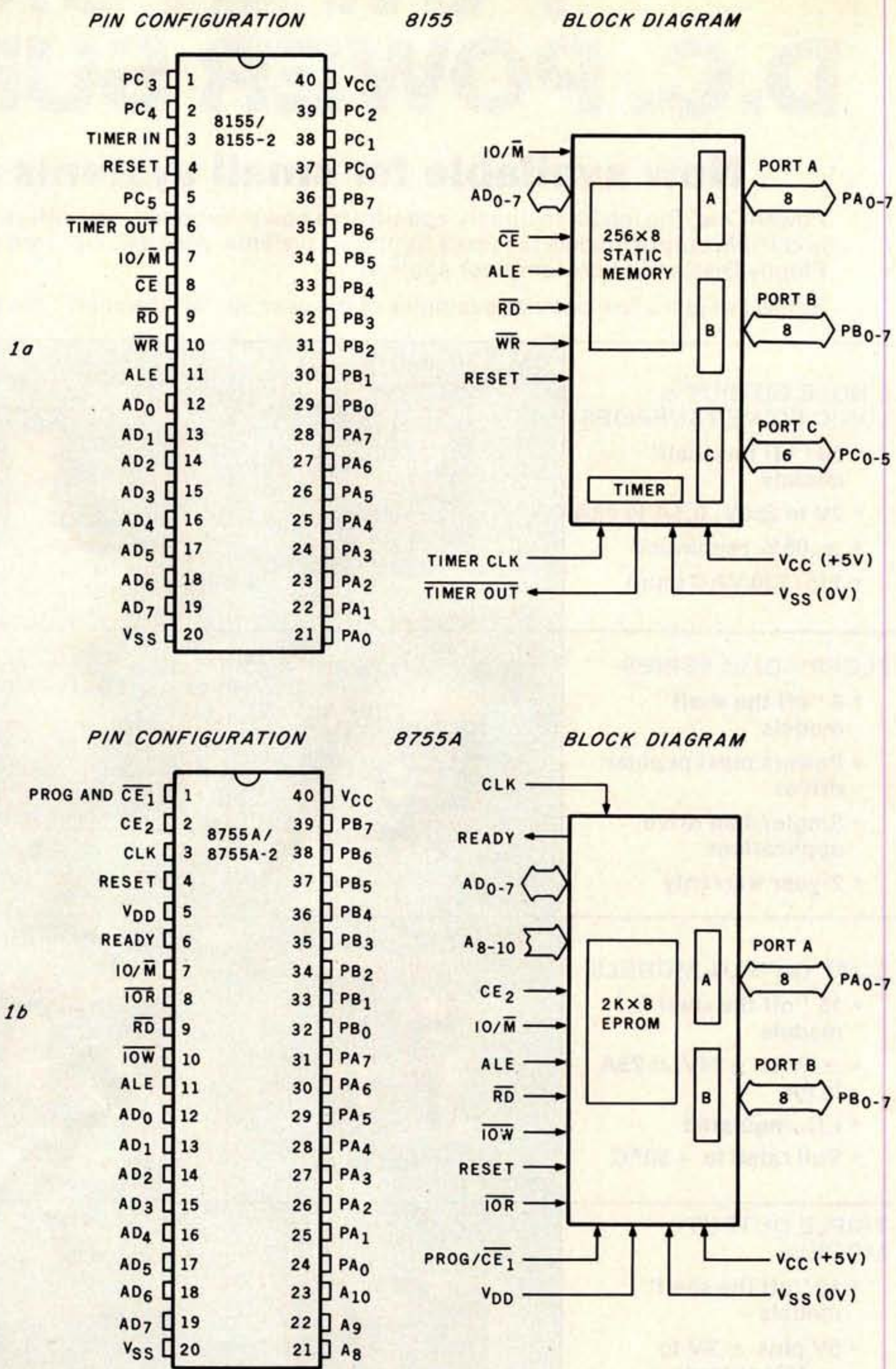


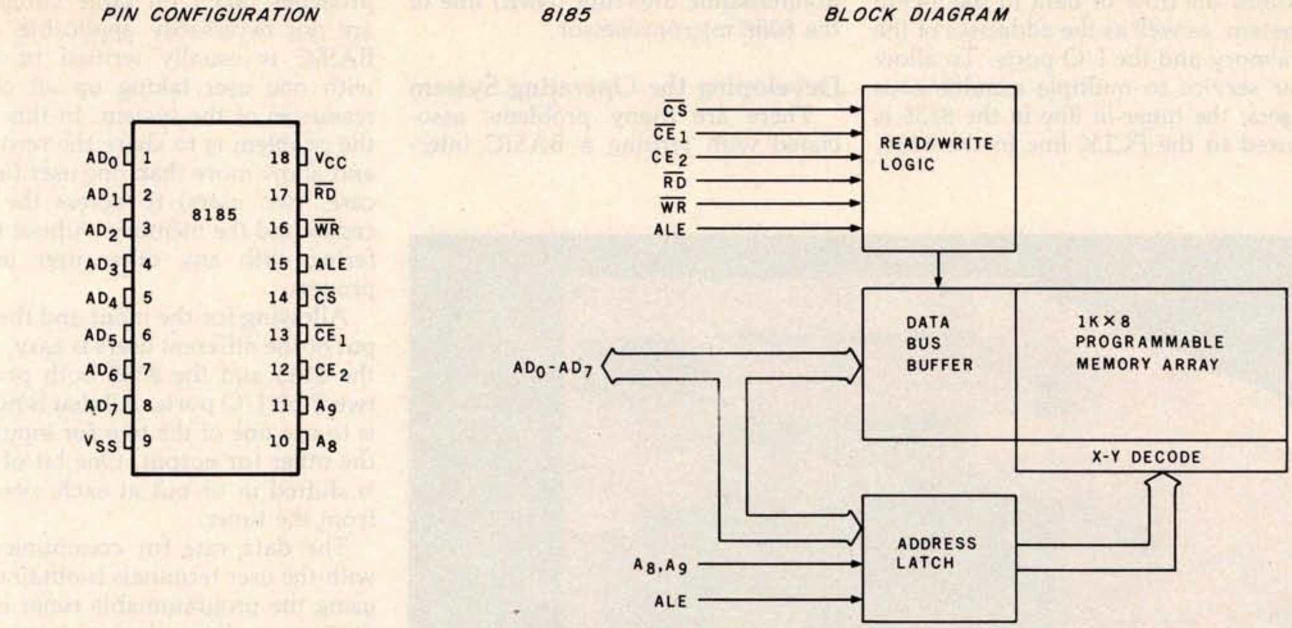
Figure 1: *Integrated circuits that perform support functions for the 8088 in the minimum-configuration system discussed in this article.*
(1a) The 8155 static memory, I/O, and timer device.
(1b) The 8755A EPROM and I/O device.
(1c) The 8185 1 K-byte static memory part.
(1d) The 8284 clock generator/driver device.

(EPROM) and I/O device, all from Intel Corporation.

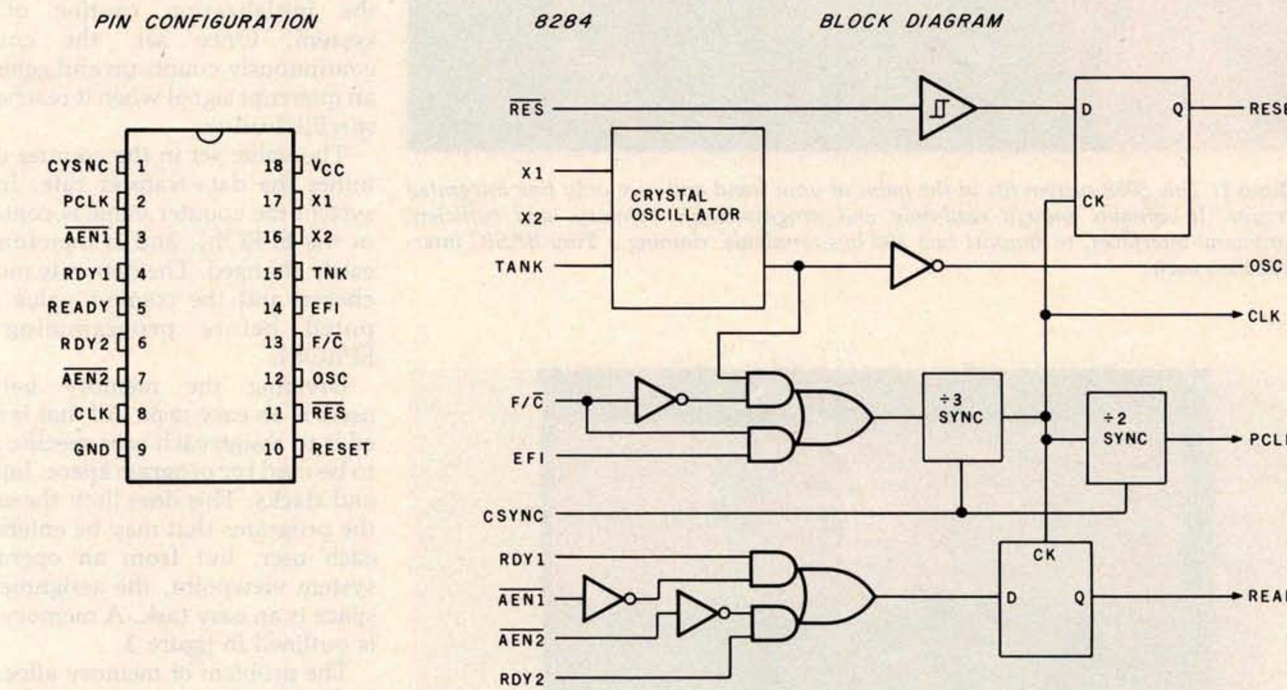
The 8088, residing in a 40-pin package, executes the complete 16-bit instruction set of the 8086 microprocessor, while communicating over an 8-bit data bus. The 8088 was discussed last month in Part 1.

The 8155, shown in figure 1a, is also in a standard 40-pin dual in-line package (DIP). It provides 256 8-bit words of static memory and is powered by a single +5 V power supply. Since it is static memory, no

1c



1d



refresh circuitry is required.

In addition to the memory and a programmable timer, the 8155 also provides two programmable 8-bit I/O ports and one 6-bit programmable I/O port. The high-order bit of port B is chosen as the serial input line for one of the two user terminals, and the low-order bit of port A is used as the serial output line for the same terminal.

Figure 1b presents the internal block diagram of the 8755A. The 8755A combines EPROM and I/O functions. The EPROM contains the system software; the I/O ports serve the second user's terminal.

The last major part in the system is the 8185, which contains 1 K bytes of static memory. (See figure 1c.) It is used by the system as the major block of memory allocated for program storage.

All of these integrated circuits are specifically designed to work with the multiplexed address and data buses. Hence, there is no need to have any outside latches to provide address signals for their operation. Address latching for each device is provided internally.

All of the integrated circuits used in this design are directly compatible with the 5 MHz signal which is generated by the 8284 clock generator (figure 1d); however, the 8155 timer/counter appears to work better if driven by the 2.5 MHz signal that is output on the PCLK line of the 8284.

Figure 2 is a diagram that demonstrates the flow of data in the 5-chip system, as well as the addresses of the memory and the I/O ports. To allow for service to multiple simultaneous users, the *timer-in* line in the 8155 is wired to the PCLK line in the 8284. Also, the *timer-out* line is tied to the nonmaskable interrupt (NMI) line of the 8088 microprocessor.

Developing the Operating System

There are many problems associated with writing a BASIC interpreter for such a limited system. Approaches taken on large computers are not necessarily applicable. Tiny BASIC is usually written to work with one user taking up all of the resources of the system. In this case, the problem is to share the resources and allow more than one user (in this case, two users) to access the processor and the memory without interfering with any other user in the process.

Allowing for the input and the output of the different users is easy, since the 8155 and the 8755 both provide two 8-bit I/O ports. All that is needed is to use one of the two for input and the other for output. One bit of data is shifted in or out at each interrupt from the timer.

The data rate for communication with the user terminals is obtained by using the programmable timer in the 8155 as a data-rate generator. The 14-bit binary counter is preset during the initialization routine of the system. Once set, the counter continuously counts up and generates an interrupt signal when it reaches the specified value.

The value set in the counter determines the data-transfer rate. In this system the counter value is contained in the EPROM, and is therefore not easily changed. The data rate must be chosen and the counter value computed before programming the EPROM.

Dividing the memory between users is an easy task. All that is needed is to assign each user specific areas to be used for program space, buffers, and stacks. This does limit the size of the programs that may be entered by each user, but from an operating-system viewpoint, the assignment of space is an easy task. A memory map is outlined in figure 3.

The problem of memory allocation in this situation is getting the processor to differentiate between users, buffers, and programs. Since there are 2 K bytes of EPROM to contain all of the system programs, it would be easy for the operating system to use all of the memory space in just initializing the two user terminals. An easy, efficient method of differentiating the two users is required.

Another consideration in the interest of total system efficiency is the allocation of more execution time to one of the users if the other user has his job executing some kind of I/O

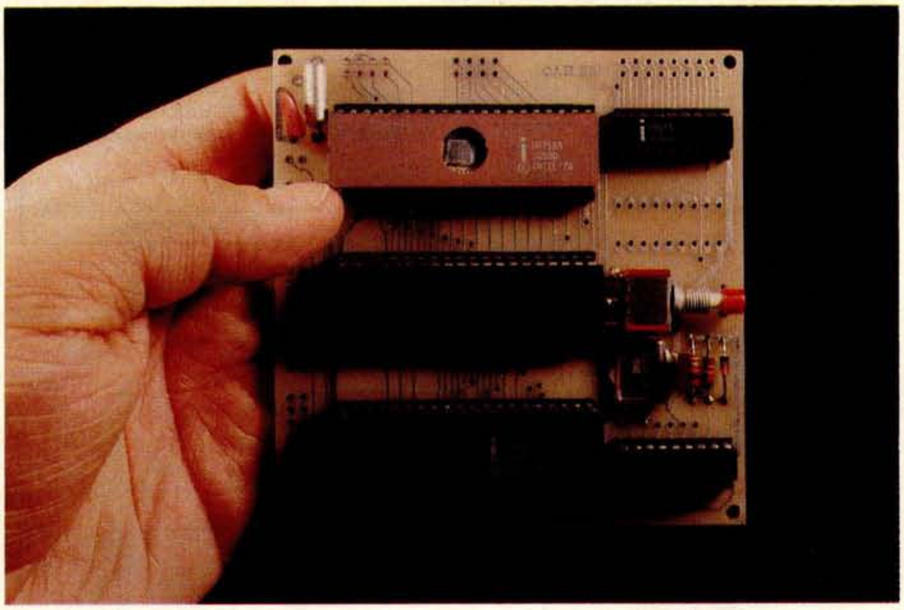


Photo 1: *This 8088 system fits in the palm of your hand and uses only five integrated circuits. It contains enough read-only and programmable memory, and sufficient peripheral interfaces, to support two 300 bps terminals, running a Tiny BASIC interpreter on each.*

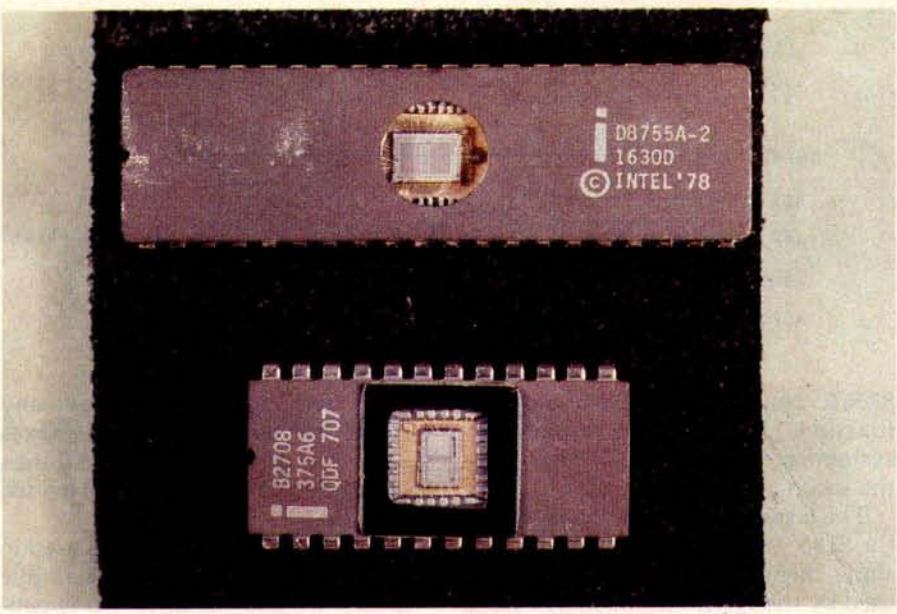


Photo 2: *Side-by-side comparison of the 8755 EPROM, top, and the older 2708 EPROM. The difference in package size is due to the presence of I/O ports on the 8755. The 8755 requires a single 5-V power supply and contains 2 K bytes of memory; the 2708 requires three different power supply voltages (+5 V, +12 V, and −12 V) and contains 1 K bytes of EPROM.*

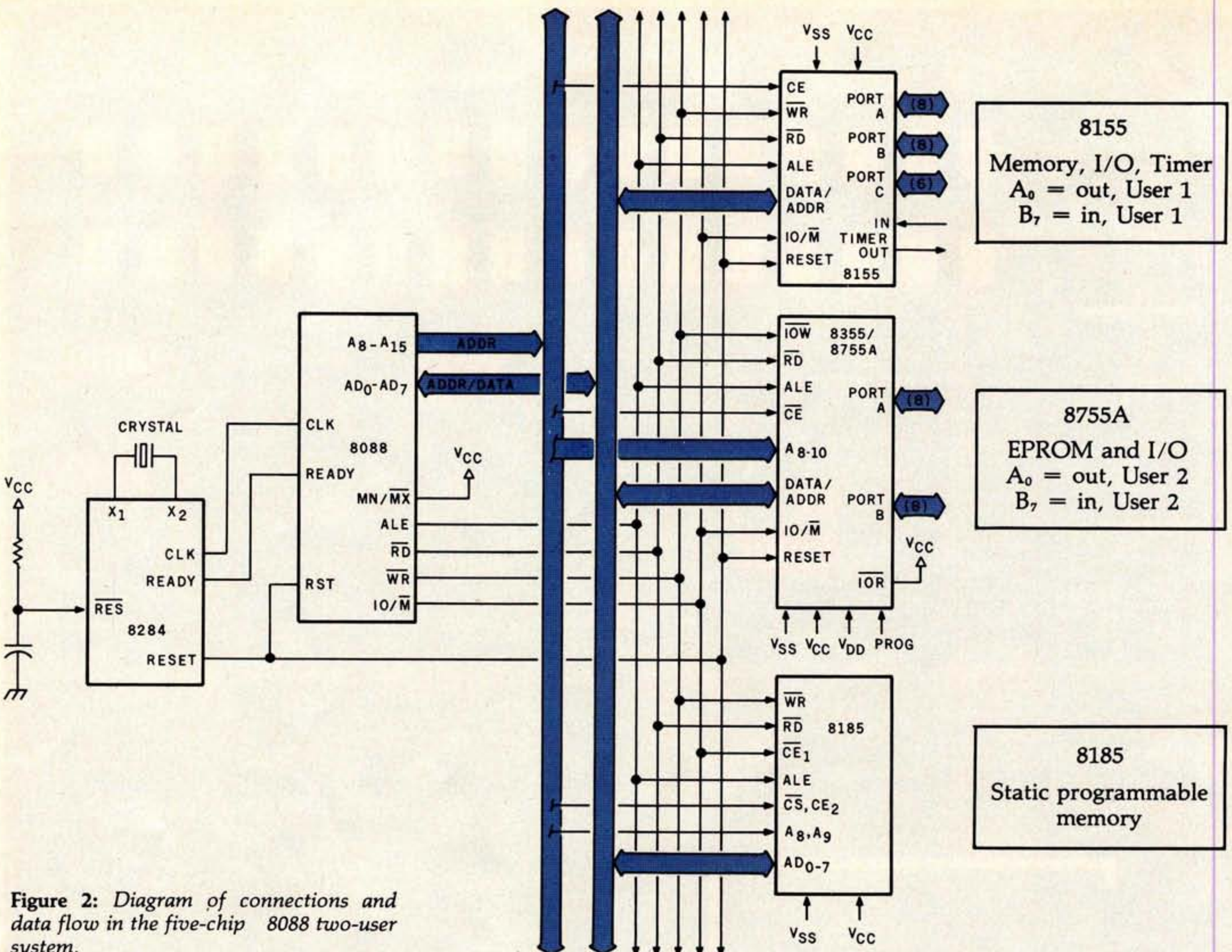


Figure 2: *Diagram of connections and data flow in the five-chip 8088 two-user system.*

Device	Type	Hexadecimal Address
8155	programmable	00 thru FF
8185	programmable	1000 thru 13FF
8755A	EPROM	0F800 thru 0FFFF

Table 1: *Memory addressing in the 8088 system.*

Device	Function	Hexadecimal Address
8155	Command-Status Register	00
	Port A	01
	Port B	02
	Port C	03
	Timer (low)	04
	Timer (high)	05
8755A	Port A	F000
	Port B	F001
	Data-Direction Register A	F002
	Data-Direction Register B	F003

Table 2: *I/O addressing in the 8088 system.*

wait loop. Normally, the processor will switch the current user-task being executed each time it receives an interrupt from the timer. This way, each user-task will receive an equal amount of execution time on the system.

However, while the system is waiting for a user to enter commands or while it is sending information to the terminal, it has no productive task to perform for that user. If both users are in an I/O mode, as at system-startup time, then the processor enters a wait loop, waiting for the interrupts from the timer. This way, as much as possible, the processor will split time with both users effectively.

Solving the Problems

The biggest concern, differentiation between the two users and their respective buffers and programs, was the easiest to solve with the 8088 microprocessor. This processor, like

```
620 REM        ***   INSTRUCTION IN I CHINGING
630 CLS
640 PRINT"THE I CHING IS ONE OF THE OLDEST BOOKS OF CHINESE PHILOSOPHY.
650 PRINT"ALTHOUGH ITS AUTHORSHIP IS UNCERTAIN, IT IS CONFUCIAN IN MOOD.
660 PRINT"TO CONSULT THE I CHING ONE MUST FIRST CONSTRUCT A HEXAGRAM,
670 PRINT"CONSISTING OF SIX LINES, EACH LINE OF EITHER OF TWO POSSIBLE
680 PRINT"TYPES, BROKEN OR CONTINUOUS, ARRANGED ONE ABOVE THE OTHER TO
690 PRINT"FORM AN OPEN-SIDED RECTANGLE.
700 PRINT"A LINE MAY LOOK LIKE THIS:
710 FORI=6TO56:SET(I,23):NEXTI:FORJ=66TO115:SET(J,23):NEXT
720 PRINT@576,"OR IT MAY LOOK LIKE THIS:
730 FORI=6TO115:SET(I,33):NEXT
740 PRINT@768,"AND THE POSITION OF THE LINE IN THE HEXAGRAM, AS WELL AS THE
750 PRINT"TYPE OF LINE, IS IMPORTANT IN ITS INTERPRETATION.
760 PRINT:INPUT"PRESS <ENTER> TO CONTINUE";EN
770 CLS:PRINT"THE HEXAGRAM IS COMPOSED OF TWO TRIGRAMS, AN UPPER AND A LOWER.
780 PRINT"EACH TRIGRAM, AS WELL AS EACH LINE IN IT, HAS INTERPRETIVE
790 PRINT"POSSIBILITIES.
800 PRINT"SO YOUR CHANCES OF WORKING OUT SOLUTIONS TO THE PROBLEMS ON
810 PRINT"WHICH YOU CONSULT THE I CHING DEPEND UPON:
820 PRINT:PRINT"     A. THE HEXAGRAM YOU CAST, WHICH CAN BE ANY OF
830 PRINT"     64 POSSIBLE FORMS, AND ITS UNIQUE DESCRIPTION;
840 PRINT:PRINT"     B. THE TYPES AND POSITIONS OF THE TWO TRIGRAMS
850 PRINT"     WHICH COMPOSE IT (8 POSSIBLE TYPES); AND THE
860 PRINT:PRINT"     C. TYPES AND POSITIONS OF EACH OF THE SIX LINES,
865 PRINT"     READING FROM THE BOTTOM LINE UPWARDS.
870 PRINT:PRINT:INPUT "PRESS <ENTER> TO CONTINUE";
880 CLS:PRINT:PRINT"IT IS EASY TO SEE THAT A LOT OF INFORMATION CAN BE DERIVED
890 PRINT"FROM A SINGLE HEXAGRAM.  IN FACT, YOUR OWN INTERPRETATION OF
900 PRINT"THE HEXAGRAM IS THE MOST IMPORTANT PART OF THE ACTION.
910 PRINT"IT IS ESSENTIAL FOR YOU TO THINK SERIOUSLY ABOUT THE TEXT THAT
920 PRINT"DESCRIBES THE LINES, TRIGRAMS AND HEXAGRAMS, TO SEE HOW ITS
930 PRINT"GENERAL MEANINGS CAN BE APPLIED TO YOUR PARTICULAR CASE."
940 PRINT"THIS PROGRAM WILL CAST A HEXAGRAM AT YOUR DISCRETION, AND IT
950 PRINT"WILL PRINT OUT THE REFERENCE CODE OF THE HEXAGRAM IN THE LOWER
960 PRINT"LEFT HAND CORNER OF THE VIDEO SCREEN.  THE FIRST DIGIT REFERS
970 PRINT"TO THE BOTTOM LINE OF THE HEXAGRAM AND THE LAST DIGIT REPRE-
980 PRINT"SENTS THE TOP LINE.  AN ODD NUMBER (9) MEANS A SOLID LINE AND
990 PRINT"AN EVEN NUMBER (6) IS A BROKEN LINE.  SEE ANY I CHING TEXT FOR
1000 PRINT"AN EXPLANATION OF ITS USE AND INTERPRETATION.":PRINT
1010 INPUT"PRESS <ENTER> TO RETURN TO THE MAIN PROGRAM";EN
1020 RETURN
```

Listing 1: *Program to cast the* I Ching, *written in BASIC for the Radio Shack TRS-80, Level II microcomputer. The PRINT@ statements cause output to appear at designated locations on the video display screen. The CLS statements cause the display screen to be cleared.*

```
10 REM   *** CASTING THE I CHING
20 REM   *** PART I OF 2 PROGRAMS FOR USING THE ANCIENT CHINESE
30 REM   *** BOOK OF WISDOM CALLED THE I CHING
40 REM   *** THIS PROGRAM PROVIDES SOME BACKGROUND INSTRUCTION
50 REM   *** ALONG WITH FACILITIES FOR CASTING THE HEXAGRAMS.
60 REM   *** PART II WILL PROVIDE INTERPRETIVE DOCUMENTATION.
70 REM   *** PROGRAMS ARE BY E. STEWART DETHLEFSEN
80 REM   *** DEPARTMENT OF ANTHROPOLOGY
90 REM   *** COLLEGE OF WILLIAM & MARY
100 REM *** WILLIAMSBURG, VA 23185  ((804)253 4369)
110 REM *** COPYRIGHT 1980, EDWIN DETHLEFSEN
120 CLS:PRINT@388,"***  THE OLD CHINESE SEER PRESENTS THE YI CHING  ***
130 FORI=1TO1500:NEXT
140 CLS:PRINT:PRINT:PRINT"THIS IS YOUR CHANCE TO GET STRAIGHT ANSWERS TO THE REALLY
150 PRINT"IMPORTANT QUESTIONS.  BEST OF ALL, YOU GET TO MAKE THOSE
160 PRINT"ANSWERS STRAIGHT YOURSELF, WHICH MAY CAUSE YOU TO RE-EXAMINE
170 PRINT"THE QUESTIONS!":PRINT
180 PRINT"IN SHORT, THE I CHING IS NOT A GAME BUT A PHILOSOPHY.
190 PRINT"A PHILOSOPHY IS A WAY OF SEEING, NOT A WAY OF 'DOING'.
200 PRINT"THE I CHING IS BASED ON THE IDEA THAT SEEING CLEARLY MUST
210 PRINT"HAPPEN BEFORE ACTION CAN BE MEANINGFUL.
220 PRINT:PRINT"FOR INSTRUCTIONS ENTER <1>; TO CAST A HEXAGRAM ENTER <2>";
230 REM *** BRIEF OR PROCEED
240 INPUTD:IFD=1GOSUB620
250 CLS:INPUT"WHEN YOU ARE READY TO CAST A HEXAGRAM PRESS ENTER:";EN
260 CLS:FORI=1TO1000:NEXT:RESTORE
270 REM ***  MIND READINESS
280 FORI=1TO1000STEP66:PRINT@I,"%%%% C O N C E N T R A T E %%%%":FORJ=1TO50:NEXT
J:NEXTI
290 PRINT@457,"C * O * N * C * E * N * T * R * A * T * E
300 Q=24:R=19
310 FORL=1TO127:SET(L,Q):NEXTL
320 FORM=127TO1STEP-1:RESET(M,Q):NEXTM
330 FORN=127TO1STEP-1:SET(N,R):NEXTN
340 FORP=1TO127:RESET(P,R):NEXTP
350 Q=Q+3:R=R-3:IFQ>44ANDR<5THEN360ELSE310
360 CLS:FORI=1TO1500:NEXTI
370 REM ***  RANDOMIZE THE HEXAGRAM AND SET LINES
380 FORK=36TO1STEP-7
390 A=RND(2)
400 IFA=1GOSUB540
410 IFA=2GOSUB580
420 GOSUB600:NEXTK
430 PRINT@832,Z(1);Z(2);Z(3);Z(4);Z(5);Z(6)
440 REM ***  TIME TO LOOK AND DECIDE
450 FORI=1TO3000:NEXTI
460 PRINT@896,"ANOTHER CAST? (YES=1/NO=2)";
470 INPUTB:IFB=2THEN520
480 REM ***  ERASE OLD HEXAGRAM
490 FORK=1TO36STEP7
500 FORI=1TO115
510 RESET(I,K):NEXTI:NEXTK:GOTO260
520 INPUT"THANKS FOR THE EXPERIENCE.  IF YOU CHANGE YOUR MIND ENTER <1>";EN:IF E
N=1GOTO260
530 CLS:END
540 REM ***  CONSTRUCT HEXAGRAM LINES
550 A=6:FORJ=115TO66STEP-1:SET(J,K):NEXTJ
560 FORI=55TO6STEP-1:SET(I,K):NEXTI:RETURN
580 A=9:FORI=115TO6STEP-1:SET(I,K):NEXTI
590 RETURN
600 READK,Y:Z(Y)=A:RETURN
610 DATA36,1,29,2,22,3,15,4,8,5,1,6
```

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Computing the *I Ching* with a TRS-80

Dr Edwin Dethlefsen
Anthropology Dept
College of William and Mary
Williamsburg VA 23185

Today most people think of the *I Ching* (or *Yi Ching* or *Yi King*) as a kind of oriental fortune-telling game. Actually, it goes back long before the time of Christ. It was begun in the Chou dynasty in the 12th century BC and was mostly completed in its present form about 900 years later. Even Confucius is supposed to have tried it. It originated as a philosophical manual and set of exercises for looking at one's world and its problems in the broadest and most perceptive possible way, a little like the idea of "making your own luck" while pretending that what happens is just "the breaks."

You can read and enjoy the *I Ching* just like any book of rather esoteric oriental poetry, but that's really for the literary folks. Most of the college students who become involved with it attempt to use the book as a kind of reference for predicting the future or for figuring out solutions to such deep, personal problems as, "Does he *really* love me?", or, better yet, "What's the best way to make some money *fast*?"

I first became interested in the *I Ching* when I was a college student more than 30 years ago, because it was a terrific way to attract the attention of the opposite sex. Helping young ladies "cast" their fortunes was a foolproof way to get their undivided, personal attention.

About the Author

Edwin S Dethlefsen is a professor of anthropology at the College of William and Mary. He bought a Radio Shack TRS-80 computer in January 1979 with no definite purpose in mind, but he soon found a use for it in cataloging archaeological statistical data. He also uses his computer to write and record correspondence, to organize class notes and material, and to play games like the one presented here.

Doing the *I Ching* thing is a very absorbing and satisfying pastime, once you understand how to play the game. Since there are several popular books written on the subject, I won't attempt to tell you all about it here, but I will talk about how easy it is to get a microcomputer to do the mechanical parts in a properly mystical fashion. I'll also say a little bit about how to consult this magical oracle. (It really is more magical than you might think, since the limits to its magical powers of knowledge are only determined by your imagination. Everyone I have ever seen use the *I Ching* has marvelled at its wondrous powers.)

Using the *I Ching*

Getting started with the *I Ching* is no big problem, once you understand that the whole thing is based on a six-position binary system. The two possible digits represent the *Yin* and the *Yang*, a Chinese representation of the concept of opposites (weak-strong, bad-good, dark-light, etc). In this case, the digits are simply line segments that are either continuous or broken in the middle, as shown in figure 1. These lines are the binary choices, just as we non-I-Chingers would use heads or tails.

In fact, determining the input for a *hexagram* is often done by casting Chinese coins and counting the heads and tails, but, if you will pardon my change of culture, this procedure is not exactly Kosher. I can remember once fruitlessly dashing all over the city of Berkeley, California, one lovely summer night, searching for the hard-to-get Chinese coins while accompanied by a particularly attractive young lady who was just dying for a chance to cast her fortune!

Ordinary Chinese fortune tellers use a fistful of marked, tortoiseshell wands, which, until the invention of the microcomputer, provided the only true path to the secret inner recesses of I Chingery. I have only seen one set of these wands outside a museum—in a Manhattan antique store where they were priced just a little higher than my TRS-80.

Now that I have leaked the word "hexagram," I'll have to explain that the *I Ching* is based upon all the possible combinations of six binary choices. That is to say, one must make six binary "casts" to produce a hexagram, which is then composed of the six lines determined by the casts. The hexagram, therefore, is one of sixty-four possible configurations. Each line has a binary value, as well as a value corresponding to its position, that is, the particular point in the hexagram at which that line was cast. Let's look at a sample hexagram, shown in figure 2.

First, observe that there are six positions, each occupied either by a solid or by a broken line. But the hexagram, as well as being composed

Text continued on page 102

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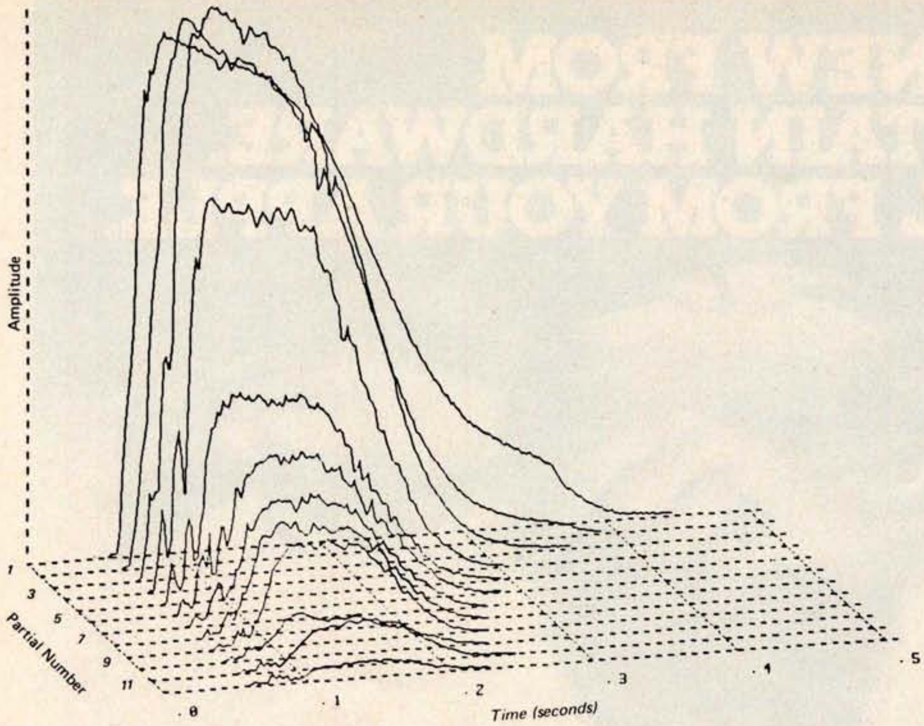

Figure 7a: *Computer analysis of a tone produced by a trumpet. This is a two-dimensional projection of a three-dimensional plot. Amplitudes of different harmonics present in the note have different attack and decay characteristics. (Figure reproduced from the* Computer Music Journal, *volume 2, number 2, 1978, page 1; used by permission).*

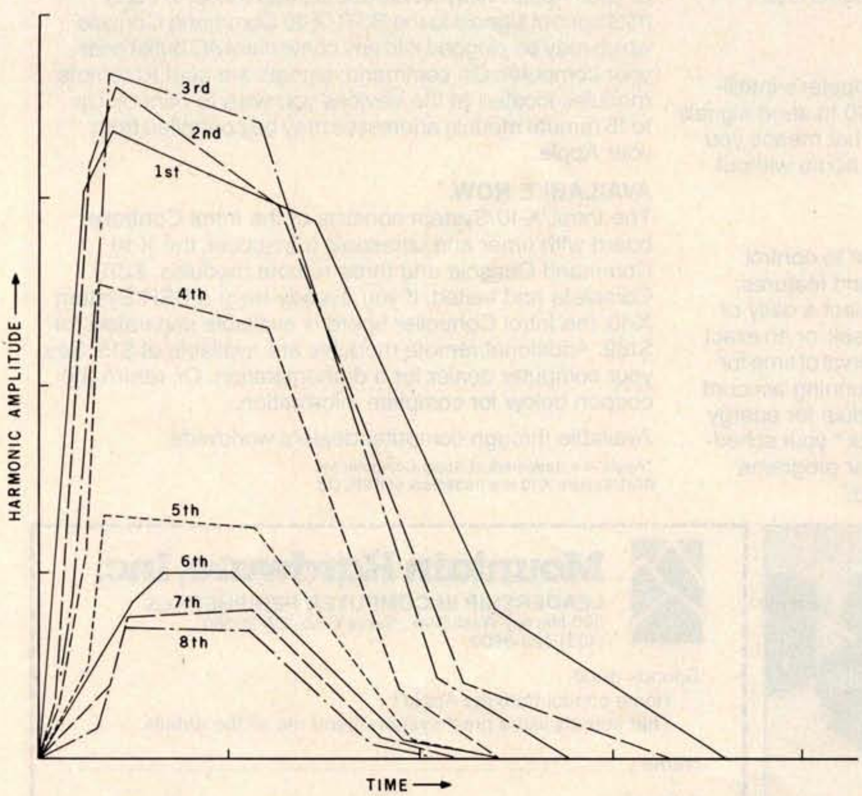

Figure 7b: *Simplified analysis of a trumpet note. The complex curves seen in figure 7a have been divided into relatively long line segments to reduce the amount of information necessary to specify the sound to the computer. The graph here is based on Moorer's straight-line-segment simplification of his trumpet analysis; see reference 3.*

groups of harmonics at different times.

Although all physical instruments have some degree of timbre variation during notes, much synthesized music tends to emphasize the timbre envelope because of the dramatic effect and because of the ease with which the effect may be created on an analog synthesizer.

Figure 7a shows a two-dimensional projection of a three-dimensional plot of a typical trumpet tone. The horizontal axis is time, the vertical axis is amplitude, and the perpendicular axis is frequency. Since trumpet tones contain only harmonic components, the plot becomes a family of curves, one for each significant harmonic. Each curve in figure 7a represents the amplitude envelope of the corresponding harmonic.

In general, exact duplication of each undulation and wiggle of the curve is not needed for fidelity. Figure 7b shows the graph of a considerably simplified version of the trumpet tone, which uses straight line segments to approximate the detailed computer analysis in figure 7a. Such an approximation greatly reduces the amount of information needed to specify the curves to a computer.

It should be noted that the analysis of a tone emitted by a particular musical instrument is completely valid only at the analyzed fundamental frequency and volume level (amplitude). Notes at other fundamental frequencies and amplitudes will give different analysis results. If the goal is accurate simulation of real musical instruments, several timbre envelopes will have to be available to cover the range of the instrument.

On an analog synthesizer, variable filters are used to smoothly vary the harmonic content of tones. A variable bandpass filter, for example, will emphasize harmonics falling between its upper and lower cutoff frequencies. By varying the filter parameters that determine these cutoff frequencies, the harmonic content of the filtered tone may be made to vary. By using a number of filters with different variations in parameters, it is possible, but difficult, to vary the harmonic content in any arbitrary manner. For sampled waveforms, we can use *digital filters* in the same manner, but the need for multiplication prevents the use of digital filters

Text continued on page 180

forms a very important contribution to the overall "timbre impression" of a note. A convincing demonstration is to play a recording of a piano backwards. The result is an organ-like sound that bears little resemblance to a piano. Any serious music-synthesis system should have some provision for nonrectangular envelopes.

The obvious way of obtaining a varying amplitude envelope from our system is to multiply the samples obtained from waveform tables by a variable-amplitude factor which itself may be obtained from an *envelope shape table*. Although simple in concept, this multiplication is not practical for real-time operation on a microprocessor. A crude application of this method involves restricting the multiplier to powers of 2, but the resulting 6 dB amplitude steps are widely spaced.

Another method involves using a device called a *multiplying digital-to-analog converter*, connected to the microcomputer. A multiplying D/A converter contains *two* data registers and produces an output voltage proportional to the *product* of the numbers stored in the registers. The multiplying D/A converter can be viewed as a regular D/A converter followed by a digital volume control. The analog circuitry of a multiplying D/A converter is far simpler than that of a digital multiplier and costs roughly twice as much as a standard D/A converter. The primary problem with the multiplying D/A converter is that it can provide an amplitude envelope for only one tone; simultaneous multiple tones receive the same envelope. Use of the multiplying unit also compromises our concept of the D/A converter as a completely general sound-output device.

A third method of generating varying amplitudes is to use a *sequence* of waveform tables, each table having a slightly different amplitude, to approximate an envelope. Since the tables are computed in advance, multiplication time is of no consequence. This technique was first proposed by my associates, Frank Covitz and Cliff Ashcraft, but it was deemed impractical on the grounds that any reasonable approximation would require too much memory.

Frank and Cliff went ahead and tried it anyway. The results, even using moderate amounts of memory, were much better than expected.

During the interval that a note is to be sounded, the amplitude envelope is determined by selecting waveform samples from various tables in succession. Each table contains samples of the same waveform, but stored with the amplitude differing from the samples in the other tables.

An undesirable effect might occur, however, if the amplitude steps between the samples from different tables are distinctly audible. This has not been a problem, for the following reason.

The relative difference between two amplitudes must exceed a certain threshold to be audible to human ears. When we consider that we can store thirty-two waveform tables in 8 K bytes of memory, we see that for notes of moderate duration (about 1/4 second) and of moderate frequency (around 250 Hz), waveform samples are taken from a new table every second cycle of the wave. This rate is fast enough to obviate any audible amplitude stepping. Although the memory usage is high, the decreasing cost of memory makes the method reasonable in many circumstances.

[**Editor's Note:** *For more information about the threshold of audibility for changes in musical dynamics, see the article "Musical Dynamics" by Blake R Patterson in the November 1974 issue of* Scientific American, *pages 78 thru 95 . . .* **RSS**]

Timbre Envelopes

There is still something missing in tones synthesized with a constant waveform, even when we employ a varying amplitude envelope. The harmonic content of most musical tones is not static during the time a note sounds, but rather changes considerably.

Some examples follow. The higher harmonics of a piano tone decay faster than the lower harmonics. This is due to viscous losses in the string and better radiation coupling to the air (for the higher harmonics). In a trumpet note, the high harmonics take a while to build up during the attack phase of the note. The use of a hat mute to impart the distinctive "wah-wah" effect to a trombone creates a resonant cavity around the instrument's bell. Moving the mute changes the resonant frequency of the cavity and thus emphasizes different


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(J index) stepping through the harmonics.

As the program is written, the harmonic amplitudes must be such that the maximum positive or negative waveform peak does not exceed the −128 to +127 range of the table entries. An improved program would automatically *normalize* the computed waveform for maximum utilization of 8-bit table entries. Since the tables have to be filled only once (either when the music is coded or immediately before performance), the slow speed of an interpreted BASIC program is adequate to get the job done.

One other possibility is using an A/D converter to digitize the waveform of a real musical instrument. The trick to doing this successfully is to get exactly one cycle of the waveform into the table. This in turn requires an accurate knowledge of the pitch of the digitized note and a very good interpolation routine. Although the process can be practical, simply storing and reproducing a single cycle of the waveform does not necessarily duplicate the complete timbre of the instrument, as will be shown later.

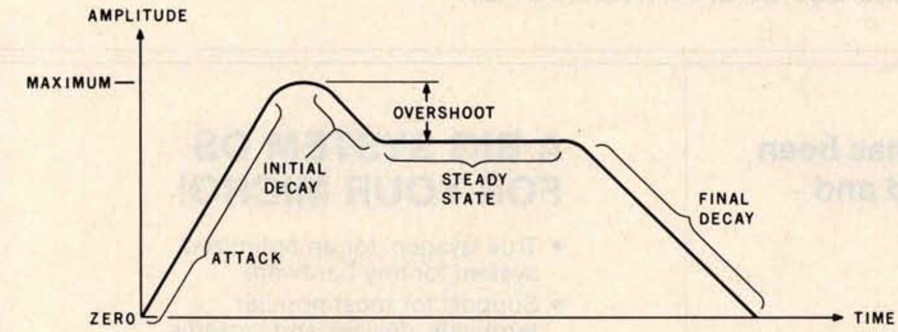

Figure 6: *Amplitude envelope for a typical musical sound. This exhibits in graphic form how fast a given tone builds up, continues to sound, and then dies away. Terms for various parts of the envelope are shown.*

It should be mentioned here that table scanning is not a perfectly general method of generating tones because only *periodic* (harmonic) waveforms may be produced. Some tones, notably those from bells, are made up of sine-wave components (overtones) that are not harmonics of any well-defined fundamental. The waveforms of such tones are constantly changing, to the point that there *is* no identifiable period. As a result, such sounds cannot be generated by scanning a single waveform table. As a practical matter though, such tones may be approximated by building a waveform table having only high-order, prime-number harmonics (such as 7, 11, 13) of a low-frequency, zero-amplitude fundamental.

Amplitude Envelopes

Although the ability to synthesize any periodic waveform offers a great deal of variety in timbre, it is not the last word. In experimenting with a music system based only upon the principles that have been discussed so far, we discover that all of the different waveforms sound more or less like an organ; just different stops. We will never find a mere waveform that sounds like a piano, or a plucked string, or a horn. One of the missing ingredients is called an *amplitude envelope*, which is involved with the attack (build-up) and decay of notes.

Figure 6 presents a typical amplitude envelope along with terms for the various parts. Using a plucked string as an example, we have a rapid (but not instantaneous) attack as the string is released, no overshoot or steady state, and a slow decay as the vibrations damp out. In contrast, a pipe organ has both a rapid attack and decay, but a level, steady state in between. An electronic organ or a music program based on simple waveform-table scanning has an instantaneous attack and decay and a level, steady state. We call this a "rectangular envelope."

It turns out that the shape and duration of the amplitude envelope

Listing 3: *A BASIC program that calculates and prints out values to fill a waveform-sample table. The user must specify the number of harmonics desired in the tone (ten is a typical number). Then the user must type in amplitude and phase information for each harmonic. This program produces only printed output, but it could just as well place the waveform samples directly in the memory locations reserved for the tables, using POKE statements.*

```
5    REM: FOURIER SERIES WAVEFORM TABLE FILLER
10   REM: N IS HIGHEST HARMONIC
20   REM: A IS AMPLITUDE ARRAY
30   REM: P IS PHASE ARRAY
35   PRINT "WHAT IS HIGHEST DESIRED HARMONIC";
40   INPUT N
45   DIM A(N), P(N)
50   PRINT "INPUT AMPLITUDE ARRAY"
55   FOR I = 1 TO N
60   INPUT A(I)
65   NEXT I
70   PRINT "INPUT PHASE ARRAY"
75   FOR I = 1 TO N
80   INPUT P(I)
85   NEXT I
90   REM: CALCULATE AND PRINT WAVEFORM TABLE
100  FOR I = 0 TO 255
110  W = 0
120  FOR J = 1 TO N
130  W = W + A(J) * COS (0.02454369 * I * J + P(J) )
140  NEXT J
150  PRINT I, INT(127*W)
160  NEXT I
170  STOP
999  END
```


Hz, somewhere between the notes B0 and C1. If middle C (C4) is desired instead, the increment value would be set to about 8.37 in order to produce 261 Hz. Now, since the waveform was drawn by hand, it could have some very high harmonics in its shape, possibly as high as the 128th harmonic (one half the table length).

For argument, let's say that the 40th harmonic has a significant amplitude in the drawn shape. The 40th harmonic of 261 Hz is 10.44 kHz, which is much more than one half of the 8 kHz sample rate. The result is that the 40th harmonic will *alias*, and for this example will actually sound at 2.44 kHz. Thus, not only will a digital-sampling system fail to reproduce frequencies above one half of the sample rate, but it will severely distort any attempts to do so. As a result, waveforms used in the tables must have a controlled harmonic content in order to avoid such alias distortion.

Actually, it is quite desirable to fill the tables by directly specifying the harmonic content. One advantage is that there is a direct, although sometimes subtle, correlation between harmonic content and timbre. Another advantage is that alias distortion may be precisely predicted and therefore avoided. The rule is that the *highest* nonzero harmonic of the *highest* note played using the table must not exceed one half of the sample frequency.

Writing a program to fill waveform tables from harmonic specifications is actually quite simple, particularly if a high-level language is used. In listing 3 is shown a BASIC program that will print out a 256-byte waveform table, once it has been given harmonic amplitude and phase arrays. The program could just as easily POKE the values into memory for use by the machine-language table-scanner program.

In the program of listing 3, the variable N is the highest harmonic number to be included; A is the amplitude array, which contains amplitude factors between 0 and 1.0; and P is the phase array, which contains phase angles between 0 and 6.28 radians, relative to a cosine wave. The program structure is simply two nested loops with the outer loop (I index) stepping through the waveform table entries and the inner loop

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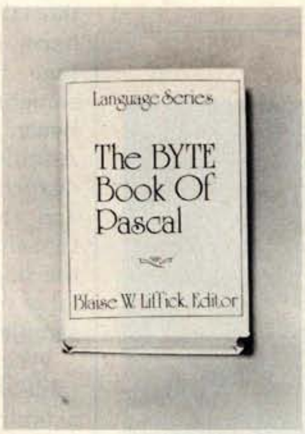

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70 Main Street, Peterborough, NH 03458 B4 all that is required is a normal double-precision addition operation on the integer and fractional parts of the pointer. Overflow from the integer part of the result is simply ignored. Ignoring the overflow causes the lookup routine to wrap around the table, conceptually bending the table into a circle, as mentioned earlier. Using a 1-byte fractional component gives a tone-frequency accuracy of 0.12 Hz when the sample rate is 8 kHz, which is accurate enough for musical applications.

A segment of 6502 assembler code for adding the increment to the pointer and looking up in the waveform table is shown in listing 2. Since all operands are in memory (they should be in page 0 for maximum speed), any number of tables and pointers may be manipulated concurrently for simultaneous tones. Total execution time for the instructions is only 23μs for a 1 mHz processor clock rate, so the technique seems promising for real-time synthesis of several simultaneous tones. The clear-carry instruction normally required before an addition has been omitted, since its effect on the tone is very small (it will be sharp by a maximum of 0.12 Hz), and 2 μs are saved by the omission.

Other microprocessors can certainly perform these operations too, although all other 8-bit processors I have studied are significantly slower than the 6502, when straightforward programming techniques are used. The problem is that other comparable processors have neither indirect addressing through memory nor enough index registers to hold several pointers at once. Thus, the pointer must be loaded into a register before the table-lookup operation is done, which is a time-consuming operation. (Z80 programmers could use both register sets and probably have enough registers.)

One possibility for speeding up execution which involves cheating a little is to simulate indirect addressing by using the address bytes of a load instruction as the page and integer part of the table pointer and keeping the fractional part elsewhere. Although this is program self-modification, it is completely crash-proof and self-initializing. In the case of a system stored in read-only memory, the table-lookup code would have to be copied to programmable memory and executed there.

So far we have a method of producing single tones of specified frequency and waveform (amplitude control will be discussed later), but the goal is generation of at least three simultaneous tones. Fortunately, this is very simple; we simply maintain a separate pointer and increment for each tone, access the waveform tables individually, *add* the samples fetched from each, and send the *sum* to the D/A converter. There is no theoretical limit to the number of simultaneous tones, but there is a practical time limit to the manipulation that can be performed in the short period between samples.

Filling the Waveform Tables

Now that we have a mechanism for synthesizing any desired waveform at any desired fundamental frequency, the next problem is to fill the tables with desirable waveforms. Since anything can be put in the table, our first inclination is to draw waveforms by hand and enter empirically derived values into the table. This might even be a practical application of the graphics "doodle" programs that are so common, or a good application for a graphic digitizer.

When we actually try it, however, drawing waveforms turns out to be an unsatisfactory method of filling tables. One problem is that there is very little obvious relationship between the drawn shape and the resulting sound timbre. For example, if a shape has been drawn and it generates a sound that is close to what we want, there is no way to know what should be changed to make the sound timbre more like what is desired. In practice, experimenting with drawn shapes is little better than listening to the results produced by a random-number generator and saving the "best ones" for later use.

A more severe problem in using drawn waveforms is *alias distortion*, which occurs when the waveform table is scanned with an increment greater than 1, which is the usual case. For example, with a 256-byte table and an 8 kHz sample rate, a table increment of 1 will produce a fundamental frequency of about 31

Circle 50 on inquiry card.

Listing 2: *A segment of 6502 code that increments the waveform-table pointer and looks up entries in the waveform table to be sent to the D/A converter. All operands are assumed to be stored in page 0 of memory for maximum speed; any number of tables and pointers may be manipulated concurrently for producing multiple, simultaneous tones. Execution times are given in microseconds for a 1 MHz clock.*

```
Symbol    Operation                 Comments                       Execution Time

LOOKUP:   LDA PF        ; ADD FRACTIONAL PART OF                        3
          ADC IF        ; INCREMENT TO FRACTIONAL                       3
          STA PF        ; PART OF POINTER.                              3
          LDA PI        ; ADD INTEGER PART OF                           3
          ADC II        ; INCREMENT TO INTEGER PART                     3
          STA PI        ; OF POINTER WITH CARRY.                        3
          LDA (PP), Y   ; PERFORM THE TABLE LOOKUP,                     5
                        ; ASSUME Y=0, REGISTER A
                        ; CONTAINS TABLE ENTRY WHEN DONE.
                                                                      ----
                               Total Execution Time                    23
```

difference if n is large. In general, complex waveforms will incur more interpolation noise than simple waveforms. If waveform complexity is measured by giving the highest dominant harmonic number in the waveform, doubling this number will increase the noise level by 6 dB.

A 256-entry table containing a simple sine wave will have a signal-to-interpolation-noise ratio of approximately 42 dB with no interpolation and 83 dB when using linear interpolation. The corresponding figures for a typical complex waveform having sixteen harmonics would be 27 dB and 52 dB. Clearly, interpolation noise is a limiting factor when short tables and zero-order interpolation is used.

While scanning tables using indices containing a fractional component may seem complex, it is actually very simple on a microcomputer if things are set up correctly. In particular, the waveform tables are made 256 bytes long, which simplifies things considerably. Figure 5 shows how table scanning can be handled on a 6502 microprocessor.

The table pointer is actually a string of 3 bytes in memory. (The bytes are shown in natural order here, but in the microprocessor they are stored in reverse order.) The most significant byte contains the memory-page number of the waveform being scanned. Normally this value is constant during the scanning, but it can be easily changed for reference to a different table. The middle byte contains the integer part of the pointer value, and the rightmost byte contains the fractional part. A simple indirect register-load operation using the left 2 bytes of the table pointer is all that is required to perform the table lookup with no interpolation.

The table increment is a 2-byte value with the integer part on the left and the fractional part on the right. To add the increment to the pointer,

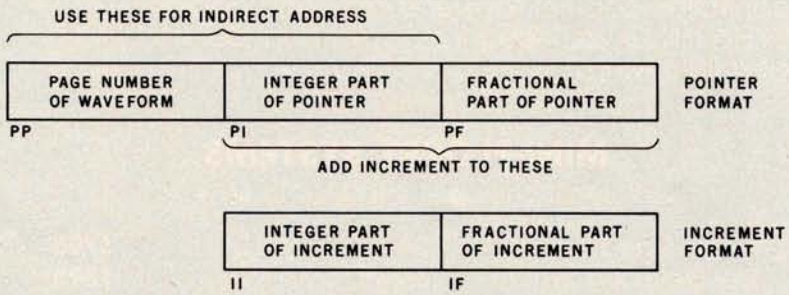

Figure 5: *Method employed to scan the waveform-sample tables on the 6502 microprocessor. Each waveform table is made to be 256 bytes long, one page of memory. The pointer to the table entries is 3 bytes long; it is shown here in natural order, but is stored in memory in reverse order. Indirect addressing is used. Interpolation between table entries is not performed (see text). The fractional component of the pointer is not used in addressing the table. The 6502 assembler-language code for accessing table entries is shown in listing 2.*

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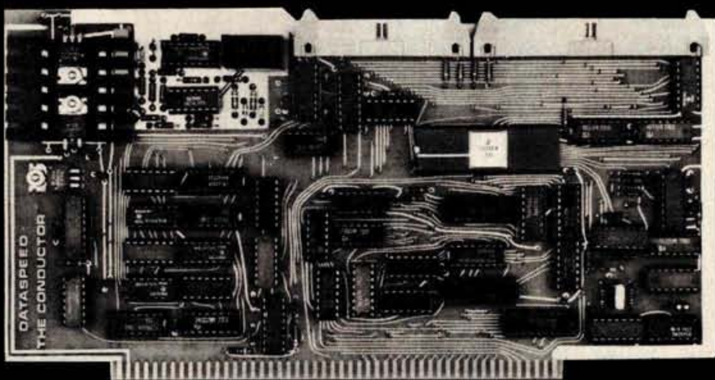

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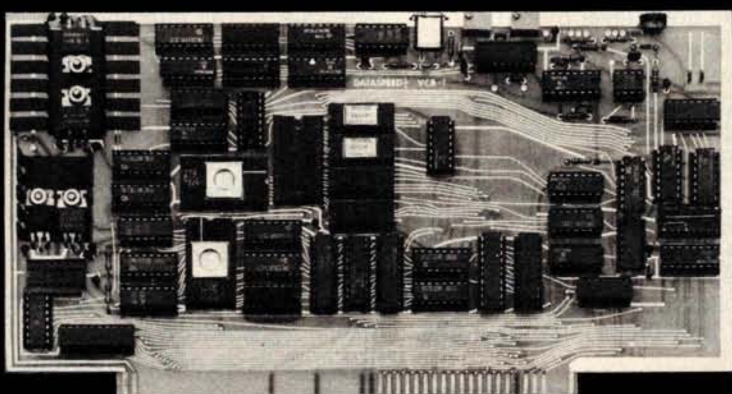

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DATASPEED, INC., 1300 NOE STREET, SAN FRANCISCO, CALIFORNIA 94131 (415) 641-8947 tion for the sine function used in high-level languages is unsuitable. The solution is to use a *sine table* stored somewhere in memory.

Fortunately, table lookup is a very fast operation on most microprocessors, and doubly so on the 6502 with its indirect addressing modes. Because of its smoothly rising ramp, sample values from the sawtooth calculation can be used as an *index* into the sine table; the values retrieved from the table are the output samples that are sent to the D/A converter. In essence, the table is being repeatedly *scanned* to produce a periodic waveform (which actually can be any waveform) for the D/A converter. This *table-scanning* concept is the key to D/A converter-based microcomputer music.

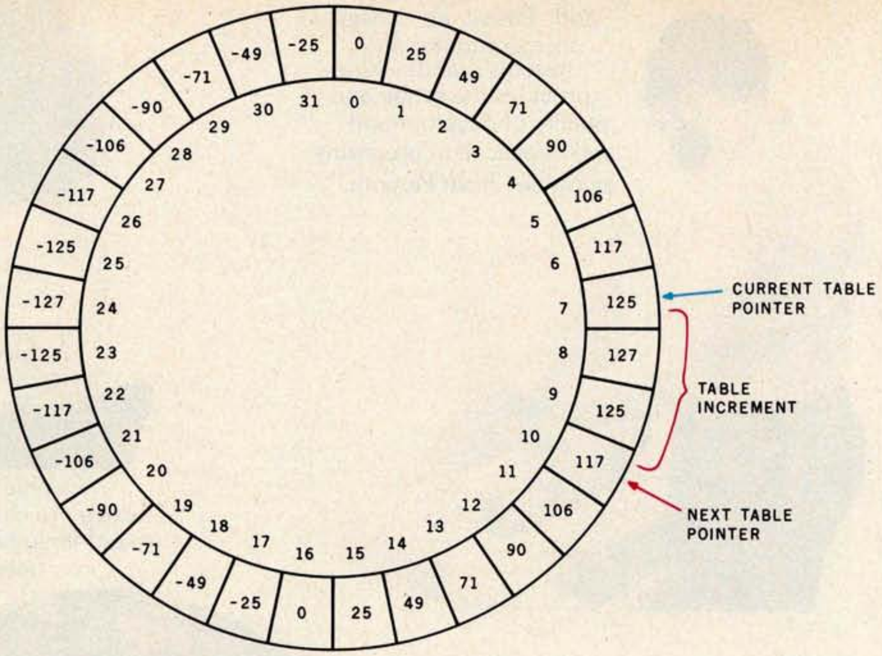

Figure 4: *Conceptual diagram of a waveform-scanning table. The table, in this case containing thirty-two waveform samples, is scanned in such a manner that the end of the table seems to be contiguous with the beginning. The table pointer indicates the value that is currently being sent to the D/A converter. During each sample period, a table-increment value is added to the table-pointer value, yielding a new pointer position further around the table.*

Scanning Waveform Tables

Figure 4 illustrates the waveform-table-scanning concept in more detail. Since a periodic, repeating waveform is to be generated, one cycle of the waveform is stored in the table. The scanning is done such that the end of the table seems to be contiguous with the beginning; thus the linear table in memory is conceptually bent into a circle. A *table pointer,* represented by an arrow in the diagram of figure 4, points to the current table entry that is being sent to the D/A converter. During each sample period a *table increment* is added to the pointer value. This yields a new pointer position further around the circle, which is used to fetch a new waveform sample for the D/A converter.

If the sample period remains constant, which it always must when multiple sounds are synthesized simultaneously, control over fundamental frequency is exercised solely by changing the table increment value. When the increment is greater than 1, the scanning process will skip samples in the table. While this may seem to reduce the accuracy of waveform reproduction, there is no audible effect if the tabulated waveform conforms to certain restrictions that will be discussed later. Keep in mind the sampling distortion results discussed previously.

When the pointer and increment values are restricted to integers, the result is a severely limited variety of frequencies, unless the waveform table is very large. To make use of tables of practical size, such as 256 entries, and to allow a wide range of possible frequencies, it is necessary to allow for the case of the pointer and the increment taking on values with *fractional* parts. The scanning procedure is the same when fractional parts are present, but a problem arises when the "78.1854th table entry" is to be fetched.

The logical thing to do is to interpolate between the values of the 78th and 79th table entries to determine the correct value to be sent to the D/A converter. The easiest method of interpolation, linear interpolation, is certainly an improvement over no interpolation at all, but it is not perfect. Higher order interpolation (quadratic, cubic, etc) is needed for really good results. Sinc-function interpolation using the *sin(x)/x* curve is required for theoretically perfect sampled-waveform interpolation. The result of imperfect interpolation is a background-noise level that is present regardless of the precision of the D/A converter used to reproduce the waveform. Noise from this source is termed *interpolation noise*.

The problem with interpolation is that multiplication and division operations are required. Even the simplest linear-interpolation scheme requires two table-lookup operations, one multiplication, and one addition; and therefore such a scheme is not practical in a real-time synthesis program for a microcomputer. In the software described later in this article, the fractional part of the pointer is simply ignored when table lookup is performed, which is equivalent to truncating the pointer to the next lower integer value. It is important to note that rounding the pointer (to the closest integer value, up or down), rather than truncating it, has no audible effect on the interpolation-noise level, contrary to some published data. Rounding merely shifts the phase of the reproduced waveform slightly.

The amount of interpolation noise depends on the length of the waveform-sample table, the interpolation algorithm, and the properties of the actual waveform being scanned. In general, doubling the length of the table will reduce interpolation noise by 6 dB, a substantial but not dramatic change. If the noise level from truncation (zero-order interpolation) is $-n$ decibels, then the noise level from i-th order polynomial interpolation is $-(i+1)n$ decibels, a dramatic

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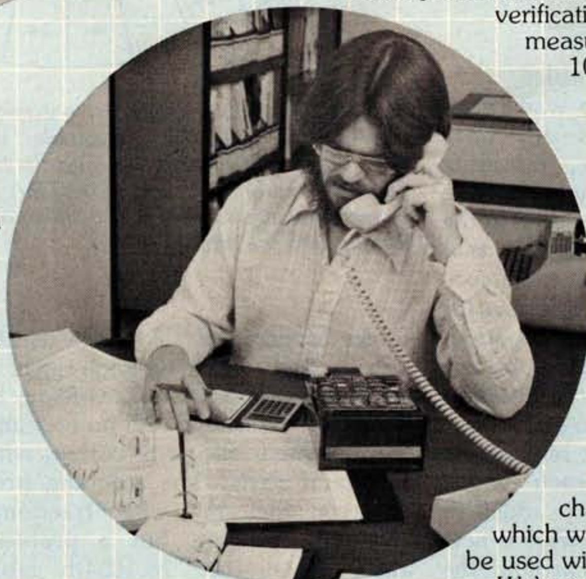

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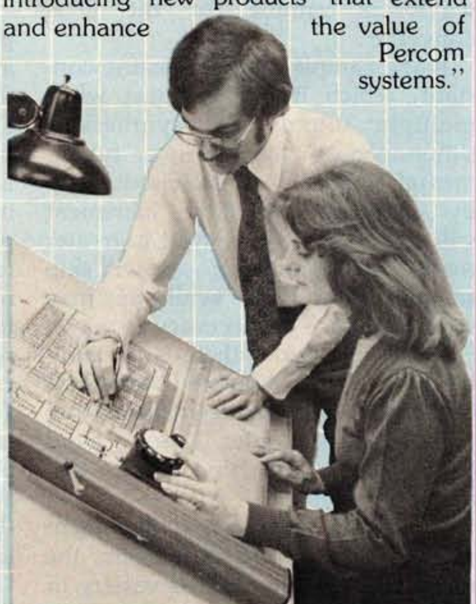

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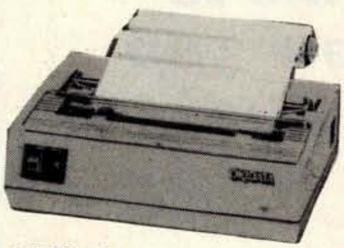

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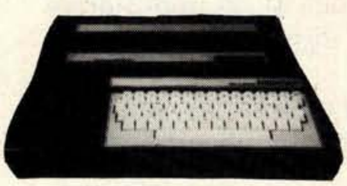

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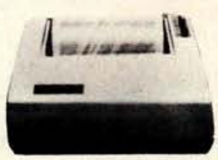

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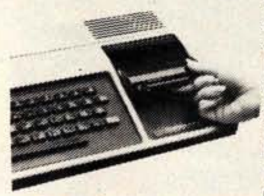

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Listing 1: *A routine written in assembler language for the 6502 microprocessor. This routine generates a sawtooth waveform, such as the one shown in figure 1.*

```
LOOP: CLC        ;CLEAR CARRY FLAG
      ADC FREQ   ;ADD FREQ TO ACC
      STA DAC    ;SEND RESULT TO D/A
      JMP LOOP   ;LOOP FOREVER
```

code in listing 1 will generate it. In essence, the accumulator (register A) is the sawtooth generation register, and the content of the memory location FREQ determines the frequency of repetition of the sawtooth waveform. For example, assume that the accumulator initially contains the value 0 and that FREQ contains a 1. Each time around the loop, the accumulator will be incremented so it will contain successive values (in two's complement arithmetic) of 0, +1, +2, . . ., +125, +126, +127, −128, −127, −126, . . ., −2, −1, 0, +1, +2, etc. The incrementing represents the smooth upward ramp of the waveform while the overflow from +127 to −128 represents the retrace or "flyback" of the waveform, the point where the signal drops to its extreme negative value. If FREQ contained a 2, then the ramp-flyback sequence would be repeated twice as fast and result in a sawtooth of twice the frequency, provided that the loop time, which is the interval between samples from the D/A converter, remains constant.

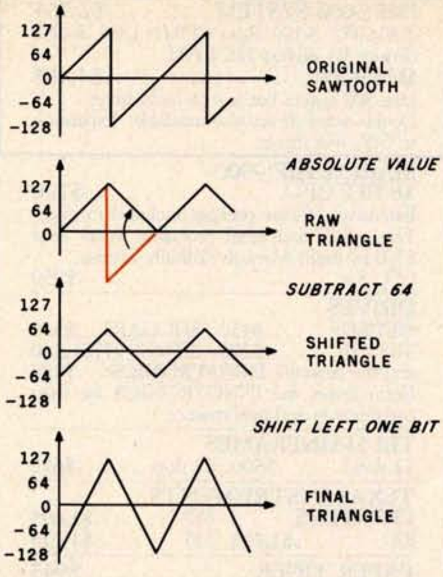

Figure 2: *Method for transforming samples of a sawtooth waveform into samples of a triangular waveform. First the absolute value of the contents of the accumulator is determined. A constant value, 64, is subtracted from the accumulator. The remaining value is multiplied by 2; the multiplication is performed by the simple method of shifting the binary value one bit to the left.*

Figure 2 illustrates how the samples representing a sawtooth wave can be transformed into samples representing a *triangle* waveform. Although the appearance is similar, the sound is quite different. The sawtooth wave has a robust, somewhat buzzy sound while the triangle has a mellow, fluty timbre. The actual operations involved are simply finding the absolute value of the sawtooth samples, subtracting a constant, and multiplying by 2 (which is done by a simple register-shift operation).

A rectangular waveform is even easier to derive and is illustrated in figure 3. The sawtooth samples are simply compared to a *width* value; +127 is output if the samples are equal to or greater than the width, or −128 is output if the samples are less. The timbre of the rectangle varies from the kazoo sound of a square wave (width = 0) to something very similar to a sawtooth (width = 64) to a thin buzz (width = 120).

The most interesting standard waveform, however, is the *sine* wave. Since complicated math cannot be used, the normal series approxima-

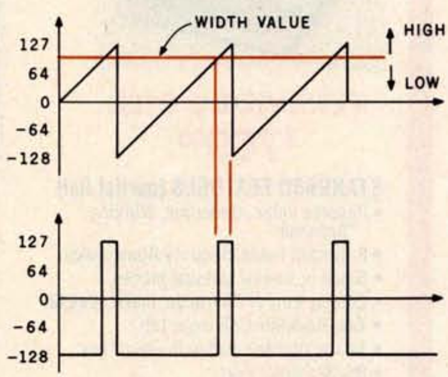

Figure 3: *Derivation of a rectangular waveform. The value of samples from a sawtooth waveform are compared with some constant width value. If the sawtooth value is greater than or equal to the width value, the constant +127 is sent to the D/A converter. If the sawtooth value is less than the width value, the constant −128 is sent to the D/A converter.*

will allow signal frequencies up to about 40% of the sample rate to be utilized. Thus a sample frequency of 50 kHz is suitable for covering the full audio range from 20 Hz to 20 kHz. Because the bandwidth of commercial frequency-modulated (FM) radio broadcasts is limited by the Federal Communications Commission (FCC) to 15 kHz, a 37 kHz sample rate is sufficient for FM broadcast applications. The 5 kHz bandwidth of amplitude-modulated (AM) radio requires a sample rate of at least 12.5 kHz. Speech can be understood and the speaker can be identified at sample rates down to 6 kHz.

Six bits of resolution in a D/A converter gives a 36 to 40 dB signal-to-noise ratio, which is comparable to that obtained with inexpensive, audio-cassette tape recorders that utilize DC record bias. Eight bits yields about 50 dB, which is in the range obtained with cassette machines costing $50 to $100. Ten bits of resolution gives a ratio of a little over 60 dB, which challenges the best home audio tape recorders and most phonograph disks. Professional mastering audio tape recorders have a difficult time keeping up with 12-bit D/A conversion, while 14- and 16-bit conversion must be listened to "live" for full effect since any analog recording device will add a considerable amount of noise (comparatively) to the signal.

Professionals working in the digital audio field generally consider 16-bit conversion at a 50 kHz sample rate to be a level of performance which need never be exceeded. A practical goal for microcomputer music synthesis is 12 bits at a 35 kHz sample rate, while half that rate would be ample to replace the function of home organs and pianos.

The programs, experiments, and results that will be discussed in the remainder of this article utilize 8-bit conversion at a rate of approximately 8 kHz. The effect is similar to that of listening to an AM car radio while speeding down the highway; and many people do the majority of their music listening in exactly this way. Actually, the quantization noise caused by 8-bit conversion is far less than the wind and road noise would be, but it is definitely audible.

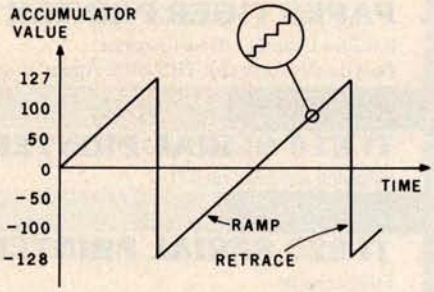

Figure 1: *Generation of a sawtooth waveform by software. Coordinate points along the waveform are generated by continuously adding a constant value, FREQ, to the accumulator (register A). The point values (samples) are sent to the D/A converter. A close-up circle demonstrates the inevitable stair-step quality of the curve reproduced from discrete samples. The 6502 assembler code to produce the sawtooth is shown in listing 1.*

Computing Waveform Samples

The real challenge in programming a D/A converter-based music system is of course computing the sound waveforms at a constant high speed. In particular, the calculations cannot use any multiplication or division operations (except by powers of 2) since only one such operation would require more time (100 to 150 μs for an 8-bit by 8-bit software multiply) than is available between samples. Actually, these restrictions apply only to a real-time music-playing program; sound waveform samples can also be computed using whatever mathematical operations are desired, and the samples can be saved on a disk as they are computed for later playback at a higher speed. Implementation of such non-real-time programs on personal-computer hardware will be the next step in improving microcomputer music synthesis quality and flexibility. More will be said about this possibility later.

There are a few waveforms that can be quickly computed without the need for multiplication and division. In fact, these turn out to be the same waveforms that are easy to generate by analog electrical circuits and are therefore used by most analog music synthesizers.

Perhaps the easiest is a *sawtooth* waveform, which is illustrated in figure 1; the 6502 assembler-language

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at much higher frequencies than the desired signal. Thus, use of a low-pass filter (one that allows low frequencies through, but blocks high frequencies) will block the distortion and pass the signal distortion-free.

In fact, it turns out that if a signal of frequency f is to be reproduced using a sample rate of r, then the lowest frequency distortion component produced will have a frequency equal to the difference f-r. If the sound is complex and therefore contains many frequency components, the above applies to each component individually.

As long as the distortion components are higher in frequency than the desired signal components, the distortion components may be filtered out, although the closer the two sets of components approach each other in frequency the better the filter must be. The limit occurs when signal frequencies approach one half of the sample rate from below, since the distortion will then be approaching one half of the sample rate from above, and the filter has to be very good to separate the two. Any attempt to reproduce signal frequencies higher than this limit will result in the distortion getting through the filter and the signal being blocked!

In many ways this is a surprising result, since just two and a fraction sample points per cycle of a sine wave is a very coarse approximation indeed. Although this *frequency-domain* argument just given is the easiest to prove mathematically, most people have a hard time believing that a simple low-pass filter can convert such a mess, which may not even be the same shape for each cycle of the reproduced waveform, into a smooth, distortion-free sine wave. The best explanation is that when a system is expected to operate close to the one-half-sample-rate limit, the filter is *not* simple at all; it must be a multisection, sharp-cutoff design. All sharp-cutoff filters ring (oscillate in a usually undesired manner) when given a short signal pulse or the edge of a square wave, and the sharper they are, the longer they ring after being excited. It is this ringing, which is a damped sine wave, that fills in the gaps between samples with just the right curve to give a distortion-free output.

Quantization in *amplitude*, which is the result of roundoff error, is not so well behaved. Unfortunately, distortion from this source is spread evenly throughout the audio-frequency range, and as such is better characterized as noise. This *quantization noise* cannot be filtered out; it can only be reduced through the use of higher-resolution D/A converters.

Every D/A converter has a limit to the loudness or amplitude of the signals it can process; this limit is determined by the range of numeric values the D/A converter can handle. When we compare the amount of quantization noise with the loudest possible signal that the D/A converter can handle, we can determine a factor called the *dynamic range* or maximum *signal-to-noise ratio* (S/N ratio) of the system. The dynamic range is given in decibels (dB). Simply put, this ratio will be $6n+4$ dB for n greater than about 5, where n is the number of bits of resolution, including the sign bit, of the D/A or A/D converter in use. Real converters have errors of their own that introduce excess noise, so a handy rule of thumb is simply $6n$ dB.

Table scanning is the key to D/A-converter-based microcomputer music.

Note that this signal-to-noise ratio is greatest when the signal is on the verge of overload. Lesser signal amplitudes will degrade the ratio since the noise amplitude is essentially constant (at very low signal levels the noise amplitude will vary some, and at zero-signal amplitude the noise will be zero as well).

Recently, *exponential* D/A converters have become available which are claimed to be better suited for audio use. What actually happens is that an absolute *maximum* signal-to-noise ratio is traded for a ratio that is lower but more constant with varying signal amplitudes. When the D/A converter has 8 bits of precision, the resulting signal-to-noise ratio is rather low (35 dB), but when the precision is 12 bits or more, the exponential conversion method has important advantages.

Now let us consider practical matters, taking into account these frequency-response and noise-level properties of digital audio production. First, a practical low-pass filter

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Audio D/A converters are by no means absent, however. Newtech has a 6-bit unit with a built-in power amplifier for S-100 and SS-50 bus systems. HUH Electronics has a simple 8-bit unit, the Petunia, for Commodore PET computers. My company, Micro Technology Unlimited, has two versions of a high-quality 8-bit D/A converter with filter and amplifer, one for the Commodore PET and the other for general application with any computer having an 8-bit parallel output port. Micro Music Inc has a similar unit supported by software for Apple II computers. The Ohio Scientific Challenger C4P and C8P models have an 8-bit exponential D/A converter built-in.

The fundamental problem with D/A synthesis of musical sounds is that the waveforms must be computed at a very high rate of speed for an acceptable frequency range in the reproduced sound. To do this in real time with currently available 8-bit microprocessors requires highly efficient programs and a few compromises as well. The results that have been obtained to date are well worth the effort, however, and are the subject of the remainder of this article. Higher speed, longer word-length microprocessors and cheaper memory can only extend the quality and flexibility of D/A synthesis to the point that synthesizer boards will go the way of discrete-transistor logic circuits.

Digital Audio Properties

For the benefit of those who may have not have seen it before, I shall now briefly describe the theory of D/A and analog-to-digital (A/D) conversion. More details, including mathematical proofs, may be found in many of the references. Everything discussed applies equally well to conversion in both directions, although the emphasis is on synthesis using D/A conversion.

A *digital-to-analog converter* is best described as a programmable power supply that generates an instantaneous output voltage (or current) directly proportional to a numerical value received from the computer, typically through a parallel output port. When the program changes the value sent to the converter, the output voltage immediately changes to the new value.

To approximate an audio waveform, the D/A-converter input is rapidly updated with numbers representing discrete points along the desired continuous waveform. The update rate or *sample rate* is nearly always constant and is chosen when the system is designed. Obviously any finite sample rate will lead to some degree of distortion, since the D/A converter will be generating a stair-step approximation to normally well-rounded audio waveforms.

Another source of distortion is the error that results when waveform computations are truncated to fit the word length of the D/A converter. The central question then, is what kind of and how much distortion is introduced through this two-dimensional quantization (approximation) of smooth audio waveforms.

Let us look first at sample-rate effects, which represent waveform quantization in *time*. It is easily shown that when the sampling is dense with respect to the frequency content of the waveform being reproduced, the distortion components are

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Advanced Real-Time Music Synthesis Techniques

Hal Chamberlin
29 Mead St
Manchester NH 03104

At this time, sound and music synthesis is a well established application of small computer systems. Currently there is some kind of music program for every microcomputer system known to the author; even a musical calculator advertisement has been seen (the unit also calculates). All of the recently introduced packaged personal computers have some kind of built-in provision for sound generation, and while aimed primarily at sound effects for games, all have music programs of varying degrees of sophistication. Several independent manufacturers offer more serious music software systems, most of which make use of specialized music hardware as well. All in all, music synthesis on personal computer systems is taking on greater importance every year and soon may approach the popularity of accounting, word processing, and games as a major application area.

Programmed performance of music by a low-cost microcomputer has many "practical" applications beyond the sheer gratification of coding the score, orchestrating the piece, and hearing the results. I have heard from a man who has taken the four-voice synthesis program from my previous article "A Sampling of Techniques for Computer Performance of Music" (September 1977 BYTE, page 62) and used it extensively in producing commercial music for radio and television advertising (about 75% of all such music is synthesized nowadays). Another person has used it with a KIM-1 system to supply simulated organ music for a small rural church. Yet another fills long hours of hospital confinement with music from an inexpensive single-board microcomputer. Some university music departments have even disguised ear-training exercises for students as a stimulating computer game. Surely music synthesis as an everyday application of personal computers need not be justified further.

Perceived difficulties in computing waveforms fast enough for real-time performance have limited the application of D/A conversion in low-cost systems.

At this point, the discussion is going to be confined to the more advanced microcomputer-music-synthesis systems. Such a system must be able to synthesize at least three tones simultaneously (for chords) and have some degree of control over the timbre (tone color) of the notes so that "orchestration" of the piece becomes a variable.

Fundamental Synthesis Techniques

A computer may produce musical sounds either by *controlling* the operation of an external sound synthesizer or by *computing* the sound waveform itself and using a digital-to-analog (D/A) converter to make it audible. Of these two methods it would seem that computing the waveform is more desirable; then the system would not be limited by the quantity and variety of external sound-generating elements. This is indeed the case, but perceived difficulties in computing waveforms fast enough for *real-time* performance have limited the application of the D/A conversion method in low-cost systems.

Because of this, we find an abundance of synthesizer boards on the market and a relative dearth of D/A converters with the necessary audio-postprocessing circuitry and supporting software. One example of a currently available synthesizer board is the SSM SB-1 (for S-100 bus systems), which allows control over the frequency, waveform, and amplitude for a single tone per board. ALF Products offers a small Apple II-compatible synthesizer (as well as a larger S-100 bus unit) which allows control over the frequency and amplitude of three rectangular waveforms per board. RCA has an inexpensive, two-voice, square-wave synthesizer for its COSMAC VIP system which can be used in multiples for more complex music. While the previous devices are add-on accessories, the Texas Instruments 99/4 personal computer has a built-in,

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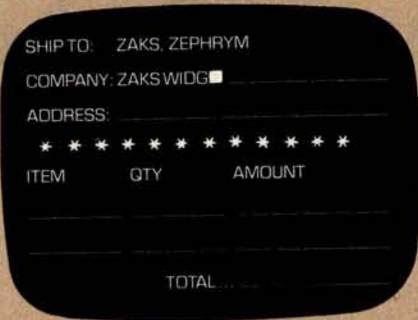

COBOL-80 formatted screen display

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Secure Besides being an indispensable system software tool for developing your own utilities and application programs, the BASIC compiler is ideal for producing programs for resale. The machine code for any application program may be placed on a diskette, ROM, or other media, but the BASIC source program need not be distributed. Thus the original application program is protected from unauthorized alteration.

```
110  I = 4*J: K = (4*J-1) AND &HOFFO
**0025' L00110:    LD     HL,(J%)
**0028'            ADD    HL,HL
**0029'            ADD    HL,HL
**002A'            LD     (I%),HL
**002D'            DEC    HL
**002E'            LD     A,L
**002F'            AND    FO
**0031'            LD     L,A
**0032'            LD     A,H
**0033'            AND    OF
**0035'            LD     H,A
**0036'            LD     (K%),HL
```

BASIC compiler object code listing

Optimized Machine Code Compiled BASIC programs are fast and compact due to extensive optimizations performed during compilation: **1.** Expressions are reordered to minimize temporary storage and eliminate common subexpressions **2.** Constants are folded wherever possible **3.** Peephole optimizations are performed **4.** The code generator is template-driven, allowing optimal sequences to be generated for the most commonly used operations **5.** String operations and garbage collection are extremely fast

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A White-Noise Generator for the Apple II

John O'Flaherty, 3432 A Evergreen Ln, St Louis MO 63125

Listing 1 is a simple machine-language routine to turn an Apple II into a white-noise generator. The program is a software machine that simulates the National Semiconductor MM5837 Digital Noise Generator (see figure 1).

It uses 2 bytes of memory, hexadecimal locations 300 and 301 (see listing 1) as sixteen of the shift-register stages, and the processor-status-register carry flag as the seventeenth.

The rotate-left (ROL) instruction at hexadecimal location 303 shifts the bits of the low-order memory location (hexadecimal 300) left, moving bit 8 into the carry flag. The next ROL instruction, at location 306, shifts each bit of location 301 left, shifts the carry flag into bit 0 of location 301, and shifts bit 8 into the carry flag. One seventeen-bit shift cycle is now complete.

At this point, if the carry flag, which is now the output bit of the seventeen-stage register, is equal to 0, the program jumps to location 30E; but if it is set to 1, the program toggles the speaker by the instruction at hexadecimal location 30B.

Now the accumulator is rotated right three times, bringing the carry flag (bit 17) into bit 6 of the accumulator, which is exclusive-ORed (at location 311) with bit 6 of location 301 (bit 14). Then the accumulator is shifted left three times to put the bit of interest back into the carry flag. Then control branches back to address 303 with the correct bit ready to be shifted into the front of the low-order memory byte by the ROL instruction.

The routine is entered at hexadecimal address 302. Reset must be pressed to stop the program.

It is also possible to insert counting loops and a conditional subroutine return to create a time-limited burst of white noise: the program in listing 2 will produce a short "chiff" sound.

With seventeen stages of shift register in a pseudo-random circuit, there are nearly 2^{17} or 131,071 unique states. The cycle time of the loop averages 27 microseconds, so the total cycle time before repetition will be 3.54 seconds (for the program of listing 1). ■

Listing 1: *6502 assembly language program for a continuous white-noise generator.*

```
300  XX             (low-order)
301  XX             (high-order)
302  38             SEC
303  2E  00  03     ROL  $300
306  2E  01  03     ROL  $301
309  90  03         BCC  $30E
30B  AD  30  C0     LDA  $C030
30E  6A             ROR  ACC
30F  6A             ROR  ACC
310  6A             ROR  ACC
311  4D  01  03     EOR  $301
314  0A             ASL  ACC
315  0A             ASL  ACC
316  0A             ASL  ACC
317  4C  03  03     JMP  $303
```

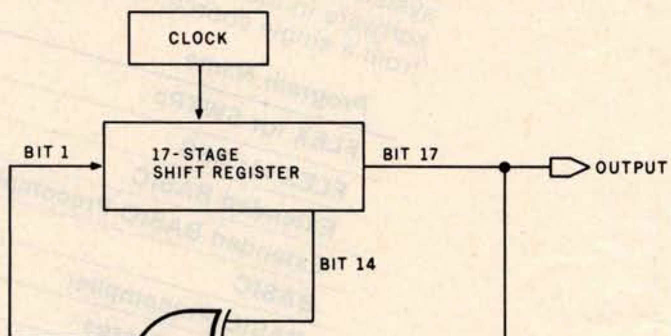

Figure 1: *Logic diagram of the National Semiconductor MM5837 digital noise generator circuit.*

Listing 2: *Subroutine to generate bursts of white noise.*

```
300  XX             (low-order)
301  XX             (high-order)
302  A9  00         LDA  #$00
304  A8             TAY
305  38             SEC
306  2E  00  03     ROL  $300
309  2E  01  03     ROL  $301
30C  90  03         BCC  $311
30E  AD  30  C0     LDA  $C030
311  6A             ROR  ACC
312  6A             ROR  ACC
313  6A             ROR  ACC
314  4D  01  03     EOR  $301
317  0A             ASL  ACC
318  0A             ASL  ACC
319  0A             ASL  ACC
31A  88             DEY
31B  98             TYA
31C  D0  01         BNE  $31F
31E  60             RTS
31F  4C  06  03     JMP  $306
```

BYTE's Bugs

Current Sinking

I found the article by Mark Bernstein, entitled "Morse Code Trainer" (December 1979 BYTE, page 247) very interesting. I did, however, find one disturbing item in the circuitry. Figure 3, on page 248, shows a 7404 inverter driving a transistor-radio speaker through a 100-ohm resistor to ground. This arrangement requires that the inverter source current on the order of 40 mA. According to the National Semiconductor Corp *TTL Databook*, a 7404 inverter can source roughly 0.5 mA. Thus, the ground symbol in the circuit diagram *should* clearly read "+5 V" (I assume that this was a layout error). However, the *TTL Databook* also specifies maximum sink current on the order of 20 mA per inverter. Therefore, the 40 mA sink requirement for the circuit is marginal. The circuit probably works with no apparent adverse effects, but the inverter is being overstressed nonetheless. The oscillator duty cycle may be the saving grace. For a more reliable design, I suggest that the resistor value be increased to 300 ohms.

J C Hassall
H and H Enterprises
Microcomputer Specialists
1201 Highland Cr
Blacksburg VA 24060

We brought this question to the attention of our hardware expert, Steve Ciarcia. He gave us the following reply: "The circuit shown in the article does work in its present configuration. The 0.5 mA specification is the maximum current that can be sourced by the 7404 while maintaining a logical 1 output (the minimum voltage for a logical 1 is 3.5 V). Actually, the 7404 can put out a lot more current than that, but the voltage will drop below 3.5 V. This is no problem when you are using the device as a linear amplifier to drive a loudspeaker (a somewhat unconventional application for the 7404). To prevent undue stress on the 7404, it is probably best to tie the speaker to +5 V rather than to ground, and to use a 470 ohm resistor instead of 100 ohm."

Ultrasonic Substitution

The schematic diagram of figure 4 in the January Ciarcia's Circuit Cellar ("Computerize a Home," by Steve Ciarcia, January 1980 BYTE, page 28) specifies that a Model TR-89 40 kHz ultrasonic transducer from Massa Products Corporation be used. Several readers have made inquiries concerning how to get this component.

Steve Ciarcia suggests that an equivalent transducer from Panasonic be substituted for the Massa Products unit. The Panasonic transducer may be ordered from: The MicroMint Inc, 917 Midway, Woodmere NY 11598, telephone (516) 374-6793.

The MicroMint stock number for the device is MM1002; the cost is $6 postpaid.

A Dotty Ratio

An alert reader in Morro Bay, California, discovered an error in the article "Morse Code Trainer" by Mark Bernstein, which appeared in the December 1979 BYTE (page 247). In listing 1, on page 248, the values given for constants that determine the relative lengths of dots and dashes cause the ratio of lengths to be incorrect. The values given in the article (dot = 1000, dash = 2000) give a 1 to 2 ratio. The correct ratio is 1 to 3. One set of values that could be used for the correct ratio is dot = 1000 and dash = 3000. ■

```
5010   PLOT3:PLOT35:PLOT10
5020   PRINT" $$$$$$$ "
5030   FOR I=12 TO 36 STEP 2
5040   PLOT03:PLOT27:PLOT I
5050   PLOT6:PLOT34
5060   FOR K=1 TO 25:PLOT32:NEXT K
5070   NEXT I
5073   REM HANDLE
5075   PLOT6:PLOT120
5080   FOR I=16 TO 26 STEP 2
5090   PLOT3:PLOT54:PLOT I
6000   PLOT32
6010   NEXT I
6015   REM CONNECT HANDLE TO BODY
6020   PLOT15:PLOT3:PLOT52:PLOT27
6030   PLOT32:PLOT32
6035   REM ORNAMENTS
6038   PLOT6:PLOT16
6040   PLOT3:PLOT33:PLOT11
6050   PLOT32:PLOT32
6060   PLOT3:PLOT44:PLOT11
6070   PLOT32:PLOT32
6075   REM PAYOFF SLOT
6080   PLOT6:PLOT7
6090   FOR I=30 TO 32
7000   PLOT3:PLOT34:PLOT I
7010   FOR J=1 TO 11
7020   PLOT32:NEXT J
7030   NEXT I
7032   REM IN SLOT
7034   PLOT3:PLOT49:PLOT14:PLOT32
7035   PLOT10:PLOT26:PLOT32
7036   PLOT10:PLOT26:PLOT32
7038   REM PRINT
7040   PLOT3:PLOT34:PLOT26:PLOT6
7050   PLOT3:PRINT"INTECOLOR"
7060   PLOT3:PLOT36:PLOT28:PLOT6
7070   PLOT3:PRINT"CASINO"
7072   PLOT3:PLOT34:PLOT14
7073   PLOT6:PLOT37
7074   PLOT14:PRINT "BIG BERTHA"
7080   REM WINDOWS
7090   PLOT15:PLOT3:PLOT28:PLOT18
8000   PLOT6:PLOT56
8005   PRINT"                    "
8007   PLOT3:PLOT28:PLOT19
8010   PRINT "LIBERTY LIBERTY LIBERTY"
8015   PLOT14
8020   PLOT6:PLOT16
8030   PLOT3:PLOT35:PLOT18:PLOT32
8040   PLOT3:PLOT43:PLOT18:PLOT32
8050   PLOT3:PLOT29:PLOT42
8060   PLOT14:PLOT6:PLOT7
8070   PRINT"YOUR BALANCE IS $";S
8075   PLOT3:PLOT80:PLOT0
8080   RETURN
9000   REM PULL THE HANDLE
9005   PLOT14:PLOT6:PLOT7
9010   FOR I=16 TO 24 STEP 2
9020   PLOT3:PLOT54:PLOT I
9030   FOR J=1 TO 20:NEXT J
9040   PLOT32:NEXT I
9042   REM CLEAR THE COIN SLOT
9043   PLOT15
9044   PLOT3:PLOT49:PLOT14:PLOT32
9046   PLOT10:PLOT26:PLOT32
9048   PLOT10:PLOT26:PLOT32
9050   PLOT14
9055   PLOT6:PLOT120
9060   FOR I=24 TO 16 STEP-2
9070   PLOT3:PLOT54:PLOT I
9080   FOR J=1 TO 20:NEXT J
9090   PLOT32
9095   NEXT I
9098   PLOT6:PLOT57
9099   PLOT15
10000  FOR I=1 TO 5
10010  FOR J=1 TO 6
10020  PLOT3:PLOT28:PLOT19
10022  IF I>3 THEN 10045
10024  PLOT14:PRINT"                    "
10026  PLOT3:PLOT28:PLOT19:PLOT15
10028  IF I>3 THEN 10045
10030  IF I<3 THEN PRINT T$(J)
10035  IF I=3 THEN PRINT T$(T(1))
10045  PLOT3:PLOT36:PLOT19
10046  IF I>4 THEN 10066
10047  PLOT14:PRINT"                    "
10048  PLOT3:PLOT36:PLOT19:PLOT15
10049  IF I>4 THEN 10066
10050  IF I<4 THEN PRINT T$(J)
10055  IF I=4 THEN PRINT T$(T(2))
10066  PLOT3:PLOT44:PLOT19
10067  PLOT14:PRINT"                    "
10068  PLOT3:PLOT44:PLOT19:PLOT15
10070  IF I<5 THEN PRINT T$(J)
10075  IF I=5 THEN PRINT T$(T(3))
10080  NEXT J
10090  NEXT I
10100  PLOT15:PLOT6:PLOT7
10110  RETURN
10120  REM OUT OF MONEY
10125  PLOT12:PLOT14:PLOT6:PLOT1
10130  PRINT:PRINT:PRINT:PRINT "YOU HAVE RUN OUT OF MONEY MY FRIEND"
10140  PRINT:PRINT "THE GAME IS OVER. . .BETTER LUCK NEXT TIME"
10150  PRINT:PRINT "DID YOU HAVE A GOOD TIME";:INPUT A$
10160  RETURN ■
```

Listing 1 continued:

```
4480    PLOT3:PLOT37:PLOT32
4490    PRINT"          "
4495    RETURN
4500    REM BAD BET PLACED
4510    PLOT3:PLOT56:PLOT15
4520    PLOT6:PLOT65:PLOT14
4530    PRINT "BAD BET      "
4535    PLOT3:PLOT80:PLOT0
4540    FOR I=1 TO 500:NEXT I
4550    PLOT15:PLOT6:PLOT7
4560    REM CLEAR SLOT
4570    PLOT3:PLOT49;PLOT14:PLOT32
4580    PLOT10:PLOT26:PLOT32
4590    PLOT10:PLOT26:PLOT32
4600    RETURN
4700    REM JACKPOT
4720    PLOT14:PLOT3:PLOT36:PLOT10
4730    PLOT6:PLOT79
4740    PRINT "JACKPOT"
4742    PLOT3:PLOT34:PLOT14
4744    PRINT "BIG BERTHA"
4750    PLOT3:PLOT80:PLOT0
4765    FOR I=1 TO 25:OUT7,64
4766    FOR J=1 TO 20:OUT7,0:NEXTJ:NEXTI
4768    PLOT3:PLOT36:PLOT10
4770    PLOT6:PLOT34:PRINT"$$$$$$$"
4772    PLOT3:PLOT34:PLOT14:PLOT6:PLOT37
4774    PRINT "BIG BERTHA"
4780    PLOT15:PLOT6:PLOT7
4790    RETURN
4800    REM WANTS TO QUIT
4810    PLOT12:PLOT6:PLOT7:PLOT14
4820    PRINT:PRINT:PRINT:PRINT "SO. . .YOU WANT TO QUIT. . . . ."
4830    PRINT:PRINT:PRINT "STOP OVER AT THE ROULETTE TABLE AND TRY YOUR LUCK"
4840    PRINT:PRINT "SEE YOU AROUND THE SLOTS AGAIN SOMETIME"
4850    FOR I=1 TO 2500:NEXT I
4860    PLOT15:PLOT6:PLOT7
4870    END
4900    REM BREAKS THE BANK
4910    PLOT12:PLOT6:PLOT8:PLOT12
4920    FOR I=1 TO 100:NEXT I
4930    PLOT6:PLOT7:PLOT12:PLOT14:PLOT6:PLOT15
4940    PRINT:PRINT:PRINT:PRINT:PRINT "YOU 'B R O K E  T H E  B A N K'
4950    PRINT:PRINT "YOUR WINNINGS AMOUNT TO $";S
4960    PRINT:PRINT "THE GAME IS OVER — YOU HAVE WON TOO MUCH AND"
4970    PRINT:PRINT "YOU ARE UNDER INVESTIGATION BY THE 'IGB'"
4980    PRINT:PRINT "(INTECOLOR GAMBLING BUREAU)"
4985    FOR I=1 TO 4000:NEXT I
4990    PLOT15:PLOT6:PLOT7
4995    RETURN
4999    REM DRAW MACHINE
5000    PLOT12:PLOT14
5005    PLOT6:PLOT34
```

```
580   GOTO 510
590   REM
600   FOR I=1 TO 3                      :REM FIND THE 3 RESULTS
610   R=RND(R1)
620   FOR J=1 TO 6                      :REM AND LOOK ACROSS THE PROB. MATRIX
630   T(I)=J                            :REM REMEMBERING THE CURRENT COLUMN
640   IF R<P(I,J) THEN 660              :REM IS IT THIS ONE?
650   NEXT J                            :REM NO..KEEP LOOKING
660   NEXT I                            :REM T(I) IS THE ITH RESULT
670   GOSUB 9000                        :REM DISPLAY THE RESULTS
680   D=100*T(1)+10*T(2)+T(3)           :REM CODE RESULT AS INTEGER
690   FOR I=1 TO 15
700   IF D=D(1,I) THEN 750              :REM IF INTEGER THEN WIN
710   NEXT I                            :REM ELSE KEEP LOOKING
720   REM
730   D=0                               :REM SET WINNINGS TO ZERO
740   GOTO 820
750   IF D(2,I)<0 THEN 780              :REM IS IT A JACKPOT
760   D=Z*D(2,I)                        :REM NO--CALCULATE PAYOFF
770   GOTO 810          :REM AND DISPLAY
780   D=INT(200+400*RND(R1))            :REM 'JACKPOT'
790   GOSUB 4700                        :REM DISPLAY JACKPOT
800   REM
810   GOSUB 4200                        :REM DROP WINNINGS
820   S=S+D-Z                           :REM CALCULATE NEW BALANCE
830   IF S<=0 THEN 870                  :REM IS USER BROKE?
840   IF S>=1000 THEN 910
850   GOSUB 4400                        :REM UPDATE BALANCE
860   GOTO 510                          :REM GET NEW BET
870   REM HERE IF USER BROKE
880   GOSUB 10120                         :REM DISPLAY BROKE
890   GOTO 950                          :REM ASK ABOUT ANOTHER GAME
910   GOSUB 4900                          :REM BROKE THE BANK
950   REM ANOTHER GAME?
960   PLOT12
970   PRINT:PRINT "HOW ABOUT ANOTHER GO? (Y OR N) ";:INPUT A$
980   IF A$="Y" THEN 480
985   PLOT14:PLOT6:PLOT2
990   PRINT:PRINT "WELL I HOPE YOU HAD A BIT OF THRILL AND WE HOPE"
1000  PRINT "TO SEE YOU BACK AT THE 'COMPUCOLOR CASINO' REAL SOON"
1010  PRINT:PRINT "SEE WHEN YOU HAVE MORE MONEY TO DONATE"
1020  FOR I=1 TO 2500:NEXT I
1030  PLOT15:PLOT6:PLOT7:PLOT12
1040  END
4000  REM PLACE THE BET
4010  PLOT3:PLOT56:PLOT15
4020  PLOT6:PLOT79:PLOT14
4030  PRINT "PLACE BET"
4035  PLOT3:PLOT80:PLOT0
4040  FOR I=1 TO 500
4050  NEXT I
4060  PLOT3:PLOT56:PLOT15
4070  PLOT6:PLOT2
4080  PRINT "          "
4090  REM PUT INPUT IN SLOT
4100  PLOT15:PLOT6:PLOT2
4105  PLOT3:PLOT49:PLOT14
4110  PLOT155:PLOT10
4120  INPUT "";Z
4130  PLOT155:PLOT11
4140  PLOT155:PLOT24
4150  PLOT6:PLOT7
4160  RETURN
4200  REM DROP WINNINGS
4210  PLOT15:PLOT3:PLOT37:PLOT30
4220  PLOT6:PLOT7
4225  REM
4230  PRINT "WINNER"
4232  FOR I=1 TO 25:OUT7,64
4234  FOR J=1 TO 15:OUT7,0:NEXT J:NEXT I
4240  PLOT3:PT37:PLOT32
4250  PLOT6:PLOT2
4260  PRINT "$ ";D
4270  PLOT3:PLOT80:PLOT0
4280  PLOT6:PLOT7
4290  FOR I=1 TO 1000:NEXT I
4300  RETURN
4400  REM SHOW ACCUM AND CLEAR DROP
4410  PLOT14:PLOT3:PLOT46:PLOT42
4420  PLOT6:PLOT2
4430  PRINT S
4440  PLOT15:PLOT6:PLOT7
4450  REM CLEAN OUT DROP
4460  PLOT3:PLOT37:PLOT30
4470  PRINT"          "
```

Listing 1 continued on page 64

Listing 1: *BASIC listing of the slot machine program.*

```
100    REM THE GAME OF SLOT MACHINE RUNS IN 8K AND WAS
110    REM CONVERTED FROM DARTMOUTH BASIC FOR THE ISC8001 BY:
120    REM W.C. HOFFER-2721 N. WANDA-SIMI VALLEY, CA-93065
122    PLOT6:PLOT33:PLOT12:PLOT27:PLOT11:PLOT14:PLOT3:PLOT17:PLOT6
124    PLOT6:PLOT25
126    PRINT "INTECOLOR PRESENTS THE ONE ARMED BANDIT"
135    PLOT3:PLOT80:PLOT0
140    FOR I=1 TO 1000:NEXT I
150    PLOT6:PLOT2:PLOT12
200    DIM P(3,6),T$(6),D(2,15)
205    DIM T(3)
210    R1=4
220    PRINT
240    FOR I=1 TO 3
242    FOR J=1 TO 6
244    READ P(I,J)
246    NEXT J
248    NEXT I
249    REM PROBABILITY MATRIX (MODIFIED FOR BETTER PAYOFFS & JACKPOTS)
250    DATA 0,.4,.65,.83,.9,1
260    DATA .1,.45,.65,.80,.87,1
270    DATA .3,.45,.5,.7,.9,1
280    FOR I=1 TO 6
282    READ T$(I)
284    NEXT I
285    DATA "↑]↑S↑[B↑Y↑Y↑P↑T↑U↑ \ ↑S↑W↑V↑Y↑S↑R↑Q↑W↑V↑U↑T
       ↑Q↑R↑T↑U↑V↑W↑Y↑S↑R↑Q↑P↑V↑U↑T↑ \ ↑S↑R↑Q↑P↑W↑V↑U↑Y↑S↑R↑W
       ↑Q↑T↑Y↑Y↑CC↑]↑W"
286    REM
287    DATA "↑]↑Q↑[B↑Y↑Y↑T↑U↑ \ ↑W↑V↑Y↑S↑R↑Q↑W↑V↑U↑T
       ↑Q↑R↑T↑U↑V↑W↑Y↑S↑R↑Q↑P↑V↑U↑T↑ \ ↑S↑R↑Q↑P↑W↑V↑U↑Y↑S↑R
       ↑Q↑Y↑Y↑CC↑]↑W"
288    REM
290    DATA "↑]↑R↑[B↑Y↑Y↑T↑U↑ \ ↑W↑V↑Y↑S↑R↑Q↑W↑V↑U↑T
       ↑Q↑R↑T↑U↑V↑W↑Y↑R↑Q↑P↑U↑T↑ \ ↑S↑R↑Q↑W↑V
       ↑Y↑Y↑CC↑]↑W"
293    REM
294    DATA "↑]↑U↑[B ↑U↑T↑ \ ↑W↑V↑Y↑S↑R↑Q↑W↑V↑U↑T
       ↑Q↑R↑T↑U↑V↑W↑Y↑S↑R↑Q↑P↑V↑U↑T↑ \ ↑S↑R↑Q↑P↑W↑V↑U↑Y↑S↑R
       ↑Q↑Y↑Y↑CC↑]↑W"
295    REM
296    DATA "↑]↑V↑[B↑Y↑S↑W↑V↑ \ ↑Q↑U↑P↑T↑Y↑P↑T↑Q↑U↑V↑W
       ↑Q↑R↑S↑W↑V↑U↑T↑Y↑S↑R↑Q↑P↑T↑U↑V↑W↑ \ ↑S↑R↑Q↑P↑W↑V↑U↑T↑V↑W↑Y↑P↑Q↑T↑U
       ↑W↑R↑Y↑Y↑CC↑]↑W"
297    REM LIBERTY IN BLACK
298    DATA "↑]↑PLIBERTY↑]↑W"
300    FOR I=1 TO 2
302    FOR J=1 TO 15
306    READ D(I,J)
308    NEXT J:NEXT I
310    DATA 221,222,223,224,225,226,333,335,336,444,445,446,555,556,666
320    DATA 2,-1,2,2,4,6,-1,16,18,-1,20,22,-1,24,-1
330    INPUT "WOULD YOU LIKE INSTRUCTIONS? (Y OR N) ";A$
340    PRINT
350    IF A$="N" THEN 470
360    PLOT14:PLOT6:PLOT2
370    PRINT "RULES OF PLAY:"
380    PRINT "ON EACH PLAY YOU CAN BET ANY NUMBER OF 'SILVER DOLLARS'"
390    PRINT "BETWEEN $1 AND YOUR BALANCE OR $999 WHICHEVER IS SMALLER."
400    PRINT "JUST TYPE IN THE NUMBER WHEN THE 'PLACE BET' SIGN STOPS BLINKING."
405    PRINT "(FULL DOLLAR BETS ONLY PLEASE)"
410    PRINT
420    PRINT "YOU 'PULL DOWN THE HANDLE' BY DEPRESSING THE RETURN KEY."
430    PRINT
440    PRINT "THE GAME IS OVER WHEN YOUR BALANCE REACHES ZERO OR"
450    PRINT "YOU BREAK THE BANK. IF YOU DECIDE TO QUIT EARLY THEN, BET 0."
452    PRINT "HERE IS WHAT THE SYMBOLS LOOK LIKE:"
453    PRINT: PLOT15
454    PRINT "↑]↑SLEMON↑]↑W ";T$(1);" ↑]↑QCHERRY ↑]↑W";T$(2)
455    PRINT
456    PRINT " ↑]↑RORANGE(UNRIPE) ↑]↑W";T$(3);"↑]↑UPLUM ↑]↑W";T$(4)
457    PRINT
458    PRINT " ↑]↑VBELL ↑]↑W";T$(5);" LIBERTY ";"↑]↑P↑↑↑WLIBERTY↑]↑W↑↑↑P"
459    PRINT:PRINT:PRINT:PLOT14
470    PRINT "HIT THE SPACE BAR WHEN YOU ARE READY TO BEGIN"
475    R1=RND(1):IF INP(1)<>96 THEN 475
480    S=200            :REM GIVE A STARTING BALANCE
490    GOSUB 5000
510    GOSUB 4000                          :REM ASK FOR THE BET
520    Z=INT(Z)         :REM FULL DOLLARS ONLY
530    IF Z=0 THEN GOSUB 4800              :REM WANTS TO QUIT NOW
540    IF Z<0 THEN 560
550    IF Z<S+1 THEN 590                   :REM TRYING TO BET MORE THAN BALANCE
560    GOSUB 4500                          :REM ERROR ROUTINE
```

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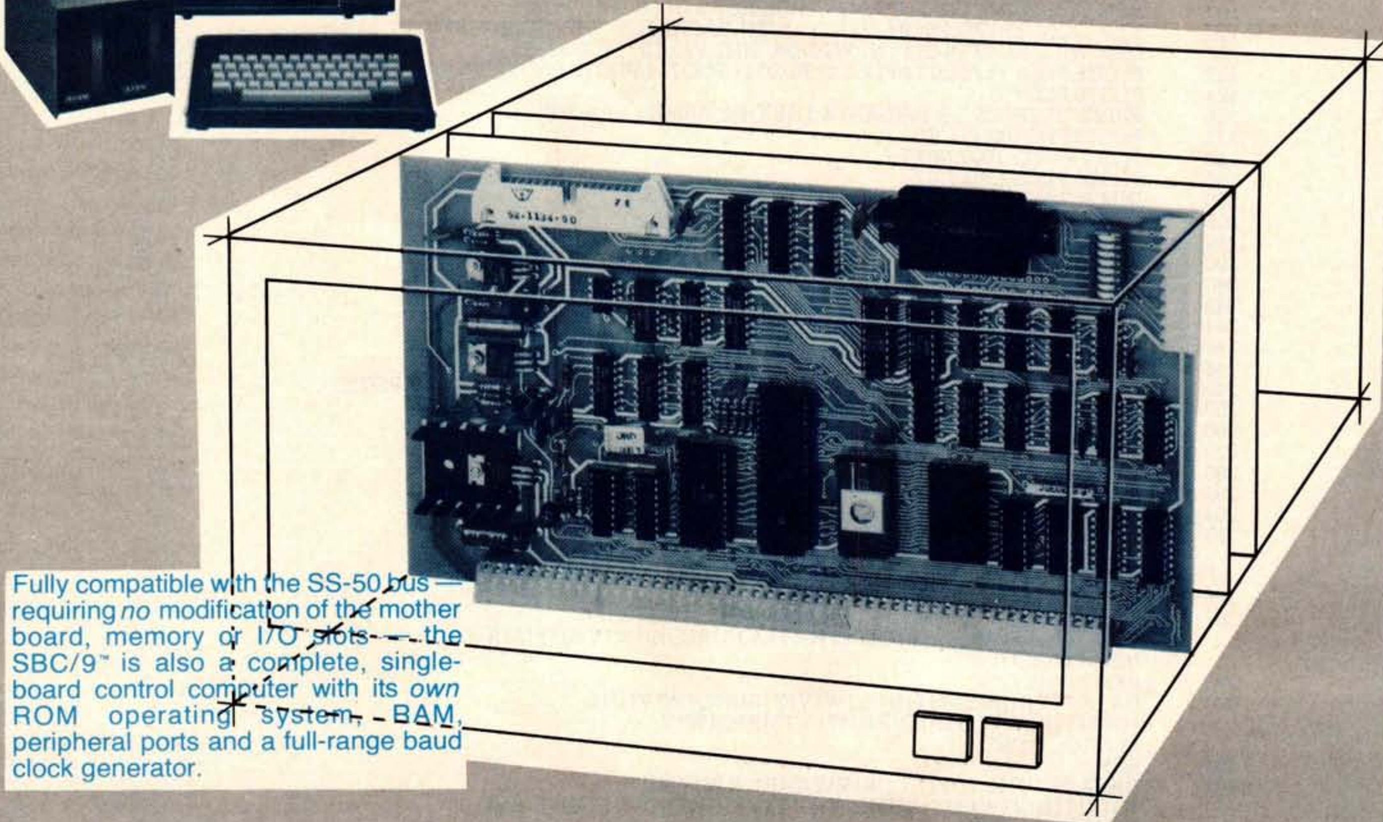

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Nearly everyone has some gambling desire in his chemistry. Many dollars have been spent in the pursuit of gambling happiness. If you are the owner of, or have access to an Intecolor or Compucolor microcomputer system, this program (see listing 1, pages 62 thru 65) may satisfy some of your gambling anxieties.

The program was originally written in Dartmouth BASIC. I converted it and then added the color and animation. Since the hard copy listing cannot display the graphics or colors, which consist of a series of control codes, you will see the symbol ↑ (up arrow) throughout the listing. This symbol stands for the control key on the keyboard. In each case, the ↑ is followed by an American Standard Code for Information Interchange (ASCII) character. An example is ↑]↑S, which means "control-], control-S," and converts to "set foreground color to yellow," in Compucolor nomenclature. Occasionally you will see ↑↑ which again means "control ↑" or "set background color." Keep in mind that the ↑ is also an ASCII character. The program has been generously laced with comment statements in an effort to inform you of the function performed by each section of code.

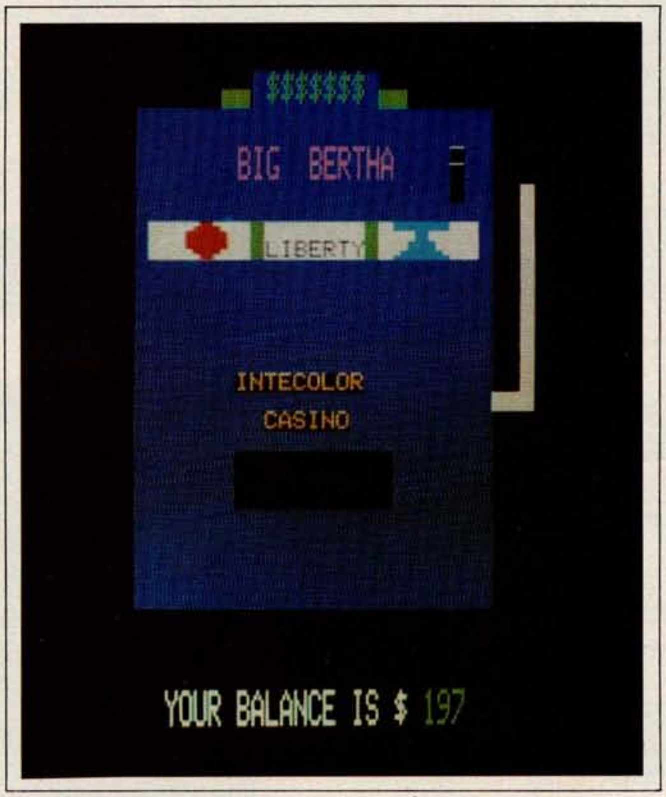

Photo 1: *A graphic representation of an animated slot machine on the Intecolor microcomputer system.*

Since the machine cannot display an orange color, the orange fruit in the slot machine is displayed as unripe green. My original version of this program, which has made its way into the user world, displayed only the words (PLUM, BELL, etc) in the windows. This version displays the graphic representation of each symbol. The gambler should request instructions when first using the program, and have the rules of play and the symbols displayed and explained.

I am sure you will do quite well with this gambling endeavor since I have modified the original Las Vegas odds in favor of the player.

About the Author

Mr Hoffer began his data processing career in 1966, and has lectured on FORTRAN at the University of Arizona. Since 1976 he has been involved in an on-going evaluation of small systems. Mr Hoffer is presently employed at Hughes Aircraft Company as Manager of Computing and Data Processing for the Missile Systems Group, in Canoga Park, California.

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Listing 1 continued:

```
FF6C    52                    PUSH    DX
FF6D    56                    PUSH    SI
FF6E    57                    PUSH    DI
FF6F    55                    PUSH    BP
FF70    06                    PUSH    ES
FF71    8926A700     R        MOV     STACKP,SP          ;AND SET STACK & DATA
FF75    8CD1                  MOV     CX,SS
FF77    33C0                  XOR     AX,AX              ;SEGMENTS FOR USER 1.
FF79    8ED0                  MOV     SS,AX
FF7B    8ED8                  MOV     DS,AX
FF7D    8B26A700     R        MOV     SP,STACKP
FF81    36890E0C00            MOV     SS:STACKS,CX
FF86    53                    PUSH    BX
FF87    C3                    RET
----                  CODE ENDS
----                  CONST2 SEGMENT
FFF0                  ORG 0FFF0H
FFF0    B8----       R        MOV     AX,DGROUP
FFF3    8ED8                  MOV     DS,AX
FFF5    BC7F0090     R        MOV     SP,OFFSET(STK)
FFF9    EA            DB      0EAH                       BOOTSTRAP
FFFA    94FD         R DW OFFSET INIT
FFFC    0000          DW 0
----                  CONST2 ENDS



----                  CONST   SEGMENT

0055    483F          HOW     DB      'H?',CR
0057    0D
0058    4F4B          OK      DB      'OK',CR
005A    0D
005B    573F          WHAT    DB      'W?',CR
005D    0D
005E    53            SORRY   DB      'S',CR
005F    0D
```

Text continued from page 52:

interrupt switches the user-tasks on each interrupt cycle and determines when it is time to input and output information to the terminals.

The timer-out routine is shown in flowchart form in figure 4. This interrupt-handling routine is the key to getting the other software to process multiple users.

When called in response to an interrupt, it proceeds thusly. After saving the registers of the current user so that the information stored in them will be available when execution resumes on this user's task, the routine reads a byte from each of the input ports. This is done first so that the inputs will always occur at the same time.

Next, the data is output to the terminals. To accomplish this task, a task-status byte is reserved in memory for each user. This byte is a 1 if the terminal is in an output mode, a 2 if the user terminal is in an input mode, and a 0 if the user's task is currently executing without performing I/O operations.

When the I/O has been taken care of, the processor determines which user-task is to be serviced next. The timer-out routine switches current user-tasks, proceeding to work on the task not most recently processed unless that user is still in an input or output mode. If that user is in an I/O mode, control will go back to the task that was being executed when the timer-out interrupt occurred.

This switching process allows both users to "simultaneously" be served by the same processor. At least to human perception, the service appears to be simultaneous. The flowchart in figure 4 supplies a more detailed accounting of how the multitasking takes place. The assembly code that actually performs the multitasking may be seen in listing 1.

In Conclusion

The hardware discussed in this article is really a bare-bones system. Through the use of more memory (both programmable and read-only memory), as well as through the use of peripheral controllers and programmable interrupt controllers, the whole system could be made to run very efficiently in a multi-user or multiprocessor environment. The possibilities of the new technological developments are impressive.

In the future I will try to let you know about some of the other 16-bit microprocessors. I'd like to wait until I get some evaluation hardware, so that I can relay firsthand experience.

Next Month: *Parallel and serial I/O for the TRS-80.* ■

Listing 2: *A benchmark program in Tiny BASIC that can be used to compare execution speeds of various computer systems. It is used here to test the efficiency of the multitasking system.*

```
100 REM 8088 TINY BASIC BENCHMARK
110 REM SINGLE USER-300 BPS
120 LET A=0
130 PRINT"START"
140 FOR B=0 TO 25
150 FOR X=0 TO 1000
160 LET A=A + 1
170 NEXT X
180 LET A=0
190 NEXT B
200 PRINT"DONE"
210 END
```

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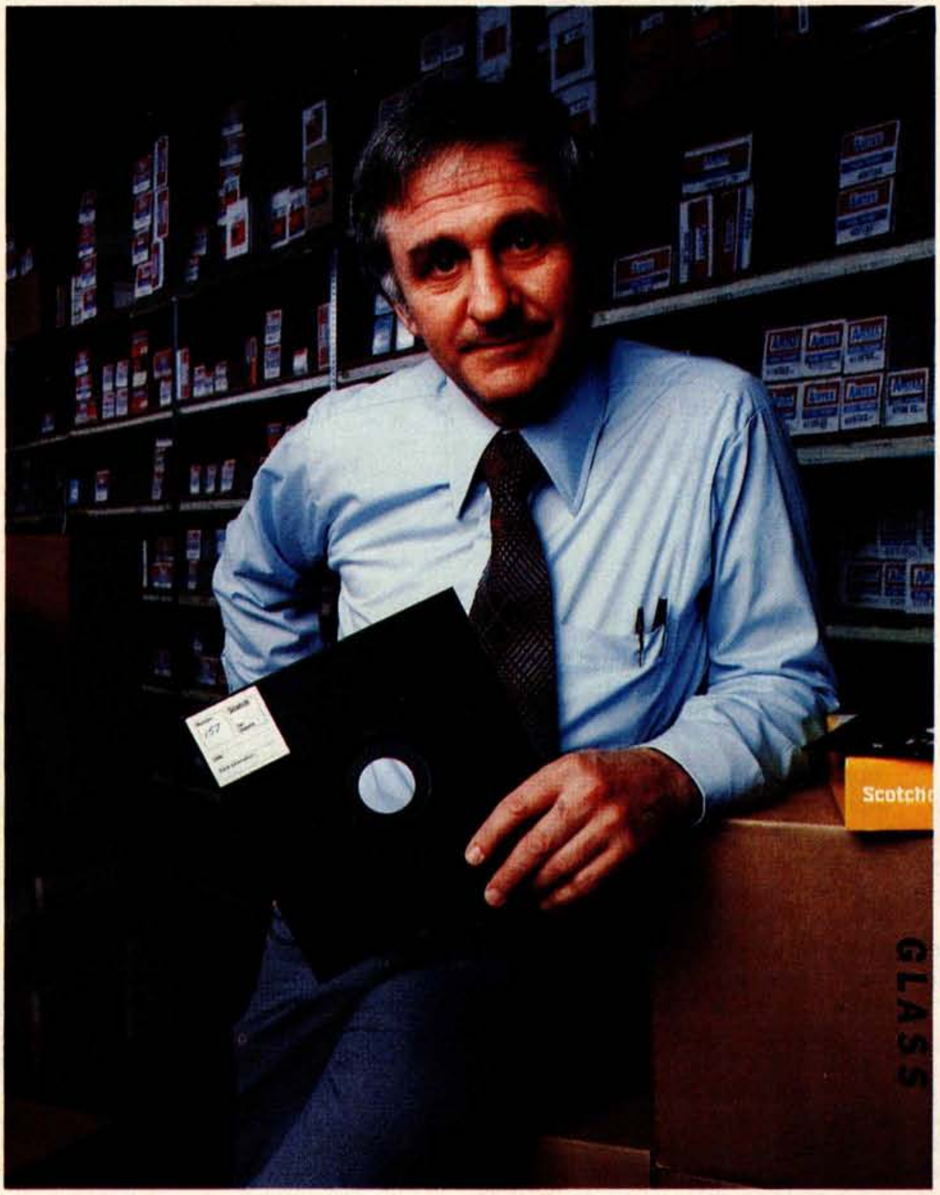

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Listing 1 continued:

```
FEB2  CF                    IRET                              ;RETURN TO PLACE WHERE INTERRUPTED
FEB3  A1AB00        R       OUTWORD: MOV  AX,WORDDOT          ;LOAD WORD OUT
FEB6  8A1EAE00      R       MOV   BL,STATUS                   ;LOAD STATUS BYTE
FEBA  80CBFE                OR    BL,0FEH
FEBD  F6D3                  NOT   BL                          ;MAKE BL = 00 IF IN, CO OR 01 IF NOT
FEBF  0AC3                  OR    AL,BL
FEC1  EE                    OUT   DX,AL                       ;OUTPUT BYTE ; OUTPUT BYTE
FEC2  D1F8                  SAR   AX,1                        ;SHIFT FOR NEXT BIT
FEC4  A3AB00        R       MOV   WORDDOT,AX                  ;AND SAVE WORD FOR NEXT CYCLE
FEC7  C3                    RET
FEC8  8A1EAE00      R       INBYTE:  MOV  BL,STATUS
FECC  8AFB                  MOV   BH,BL                       ;SEE IF USER IN OUTPUT MODE
FECE  80E301                AND   BL,01H
FED1  7431                  JZ    CKIN                        ;NO, GO TO CKIN
FED3  FE06AA00      R       INC   OUTCYC                      ;IN OUTPUT MODE, INCREMENT BITS OUT
FED7  803EAA000A    R       CMP   OUTCYC,10                   ;OUTPUT 10 BITS?
FEDC  7515                  JNE   BRET                        ;NO RETURN
FEDE  C606AE000090  R       MOV   STATUS,00H                  ;YES, RESET STATUS AND
FEE4  BB44FE        R       MOV   BX,OFFSET (CGROUP:CORT)     ;SET UP RETURN
FEE7  8926A700      R       RSST:    MOV  STACKP,SP           ;FOR CHARGE-OUT OR CHARGE-IN
FEEB  83C414                ADD   SP,20
FEEE  53                    PUSH  BX
FEEF  8B26A700      R       MOV   SP,STACKP
FEF3  59                    BRET:    POP  CX
FEF4  8926A700      R       MOV   STACKP,SP                   ;SET UP REGISTERS FOR USER 1
FEF8  33C0                  XOR   AX,AX
FEFA  8ED0                  MOV   SS,AX
FEFC  8ED8                  MOV   DS,AX
FEFE  8B26A700      R       MOV   SP,STACKP
FF02  51                    PUSH  CX
FF03  C3                    RET
FF04  8ADF                  CKIN:    MOV  BL,BH               ;SEE IF IN INPUT MODE
FF06  80E302                AND   BL,02H                      ;IF NOT, RETURN (THRU BRET)
FF09  74E8                  JZ    BRET
FF0B  EC                    IN    AL,DX                       ;INPUT AGAIN & VERIFY VALID DATE
FF0C  3AC1                  CMP   AL,CL                       ;VALID,
FF0E  7408                  JZ    BITGD                       ;YES, BIT IS GOOD
FF10  800EAE008090  R       OR    STATUS,80H                  ;NO, BIT "ERROR" IN STATUS
FF16  EBDB                  JMP   BRET
FF18  80E180                BITGD:   AND  CL,80H              ;WAITING FOR START BIT?
FF1B  80E704                AND   BH,04H
FF1E  7435                  JZ    WAITST                      ;YES, GO TO WAITST
FF20  A0AD00        R       MOV   AL,BYTEIN                   ;GET BYTE SO FAR
FF23  D0E8                  SHR   AL,1                        ;SHIFT ONCE FOR NEW BIT
FF25  0AC1                  OR    AL,CL
FF27  A2AD00        R       MOV   BYTEIN,AL                   ;SAVE BYTE IN
FF2A  FE06A900      R       INC   INCYCL
FF2E  803EA90008    R       CMP   INCYCL,8                    ;SEE IF 8 BITS IN
FF33  75BE                  JNE   BRET                        ;--NO
FF35  C606A9000090  R       MOV   INCYCL,0                    ;YES RESET COUNT OF BITS IN
FF3B  A0AE00        R       MOV   AL,STATUS
FF3E  2480                  AND   AL,80H                      ;SEE IF BAD BIT IN MIDDLE
FF40  7408                  JZ    DELFI                       ;--NO, CHARACTER GOOD,
FF42  C606AE000290  R       MOV   STATUS,2                    ;BAD UNIT, RESET STATUS AND
FF48  EBA9                  JMP   BRET
FF4A  C606AE000090  R       DELFI:   MOV  STATUS,0            ;RESET STATUS
FF50  BB2DFE        R       MOV   BX,OFFSET (CGROUP:CIRT)
FF53  EB92                  JMP   RSST                        ;PREPARE FOR RETURN
FF55  0AC9                  WAITST:  OR   CL,CL               ;SEE IF START BIT IN
FF57  759A                  JNZ   BRET                        ;--NOT YET
FF59  C606AE000690  R       MOV   STATUS,06H                  ;--YES, RESET STATUS
FF5F  EB92                  JMP   BRET
FF61  891E0000      R       SVREG:   MOV  BL1,BX
FF65  5B                    POP   BX                          ;SAVE REGISTERS
FF66  50                    PUSH  AX
FF67  FF360000      R       PUSH  BL1
FF6B  51                    PUSH  CX
```

Listing 1 continued on page 58

Listing 1: *Multitasking code that allows two users to be served by the same processor, seemingly simultaneously. Here it is written in assembly language for the 16-bit Intel 8088 microprocessor. When no user requires service, the processor executes a tight loop. When some operation must be carried out, this routine supervises the process. Various I/O operations and counter events cause this code to be entered. The algorithm is shown in flowchart form in figure 4.*

Hexadecimal Address	Hexadecimal Code		Label	Instruction Mnemonic	Operand	Commentary
FE28	EB5990			JMP	USER?	
FE2B	EBFE		IORTI:	JMP	IORTI	;LOOPS TO ITSELF
FE2D	A0AD00	R	CIRT:	MOV	AL,BYTEIN	;RETURNS HERE
FE30	C3			RET		
FE31	50		CO:	PUSH	AX	;SAVE REGISTERS
FE32	D1E0			SAL	AX,1	;SHIFT LEFT TO SET
FE34	0D000F			OR	AX,0F00H	;OR TO SET UP STOP
FE37	A3AB00	R		MOV	WORDOT,AX	
FE3A	C606AA000090	R		MOV	OUTCYC,0	;RESET OUTCYCLES
FE40	B001			MOV	AL,1	;SET STATUS TO OUT
FE42	EBD8			JMP	COMP	;SEE IF NEED TO GO
FE44	58		CORT:	POP	AX	
FE45	C3			RET		
FE46	E81801		TIMEOUT:	CALL	SVREG	;SAVE REGISTERS
FE49	BA0200			MOV	DX,INPORT	
FE4C	EC			IN	AL,DX	;INPUT USER 1
FE4D	8AE0			MOV	AH,AL	
FE4F	BA01F0			MOV	DX,INPRT2	
FE52	EC			IN	AL,DX	;INPUT USER 2
FE53	50			PUSH	AX	;SAVE FOR FUTURE USE
FE54	8BC8			MOV	CX,AX	;INPUT DATA,SAVE
FE56	BA0100			MOV	DX,OUTPORT	;SET UP OUTPUT, USER 1
FE59	E85700			CALL	OUTWORD	;OUTPUT
FE5C	8926A700	R		MOV	STACKP,SP	;NEXT BIT OR STOP BIT
FE60	BA00F0			MOV	DX,OUTPT2	
FE63	B80800			MOV	AX,00008H	
FE66	8ED0			MOV	SS,AX	;SET UP SEGMENTS FOR USER 2
FE68	B82000			MOV	AX,20H	
FE6B	8ED8			MOV	DS,AX	
FE6D	8B26A700	R		MOV	SP,STACKP	
FE71	E83F00			CALL	OUTWORD	;OUTPUT NEXT BIT OR CHIP BIT
FE74	BA01F0			MOV	DX,INPRT2	
FE77	E84E00			CALL	INBYTE	;PROCESS INPUT/OUTPUT CYCLES, USER 2
FE7A	59			POP	CX	;RESTORE INPUTS
FE7B	8ACD			MOV	CL,CH	
FE7D	BA0200			MOV	DX,INPORT	;PROCESS INPUT/OUTPUT ,USER2
FE80	E84500			CALL	INBYTE	
FE83	A0AE00	R	USER?:	MOV	AL,STATUS	;DETERMINE WHICH USER TO RESTORE
FE86	2403			AND	AL,03H	
FE88	7406			JZ	CKU2	;IF UI IN CO OR CI
FE8A	B80800			MOV	AX,00008H	;UI IN CO OR CI
FE8D	EB0F90			JMP	PRETI	;GO TO U2
FE90	A0AE02	R	CKU2:	MOV	AL,STATS2	
FE93	2403			AND	AL,03H	
FE95	7509			JNZ	PRET	;USER 2 IN CO OR CI,RETURN TO UI
FE97	36A10C00		SWUS:	MOV	AX,SS:STACKS	
FE9B	350800			XOR	AX,0008H	;SWITCH USER FROM PREVIOUS
FE9E	8ED0		PRETI:	MOV	SS,AX	
FEA0	D1E0			SAL	AX,1	
FEA2	D1E0			MOV	SP,STACKP	
FEA	8ED8			SAL	A,1	
FEA6	8B26A700	R		MOV	DS,AX	;SET UP STOCK & DATA SEG
FEAA	07			POP	ES	
FEAB	5D			POP	BP	;RESTORE REGISTERS
FEAC	5F			POP	DI	
FEAD	5E			POP	SI	
FEAE	5A			POP	DX	
FEAF	59			POP	CX	
FEB0	5B			POP	BX	
FEB1	58			POP	AX	

Listing 1 continued on page 56

result to the position within the segment.

For example, if the processor was instructed to load the byte at hexadecimal location 154 within the segment, and the data-segment register contained the hexadecimal value 14, the resulting *effective* address is computed as:

$$14_{16} \times 10_{16} = 140_{16}$$
(data segment value times 16)
$$\frac{+\ 154_{16}}{294_{16}}$$
(location within the segment)

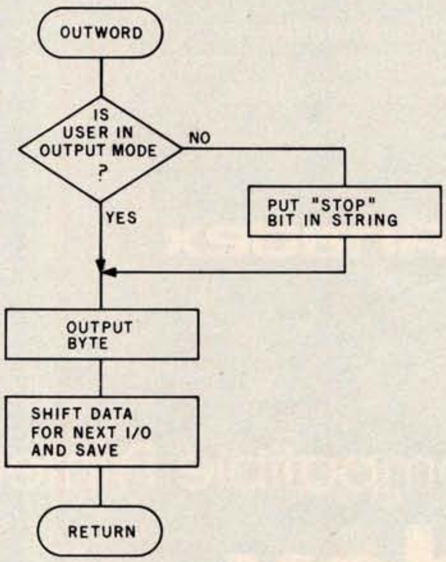

Figure 4c: *Routine to send output from one of the users.*

Therefore, if I want the processor to access user 1's pushdown-stack buffers, I set the stack-segment register equal to 0. When I access the stack buffer, which is located from hexadecimal addresses 10 to 7F, the effective address computed will still be hexadecimal 10 to 7F.

If I want to access user 2's stack, I set the stack-segment register to a value of 8. When the processor computes the effective address, it will multiply the stack-segment value by 16 and add the product to the location within the segment. This means that user 2's stack buffer will be correctly addressed in hexadecimal locations 90 thru FF while allowing the program to use the same address values used to access user 1's stack.

The program buffers are handled in essentially the same way. For user 1, the data-segment register and extra-segment register are set to 0, and the program is written to address the buffers as hexadecimal addresses 1000 to 11FF. When I want to access user 2's program, I load the segment registers with the hexadecimal value 20. When the processor computes the effective address, it will come up with hexadecimal addresses 1200 thru 13FF, which is what I want.

Since the interpreter itself does not modify values in the segment registers, the interpreter never knows which user-task it is currently working on, but it does not care. With the proper loading of the segment registers by the *operating system,* the correct buffer of the current user will be used.

Using this feature, the 8088 processor can work for several users, switching between them by manipulating only the segment registers. Because of memory limitations, the maximum practical number of users on the system described here is only two. However, the programs could just as easily serve three or four users as two users.

Software Modifications

There are two other software routines that must be specifically modified to handle multiprocessing. The initiating sequence of code that is executed when a restart signal is received must be changed. Also, an interrupt handler for the nonmaskable interrupt generated by the timer of the 8155 must be added.

When the microprocessor is reset, the initiating routine initializes all the I/O ports and sends out the initial stop-bit signal to the terminals. It also sets up user 2's stack area so that the processor will begin execution at the START routine when it is through processing user 1. After setting the correct data-transfer rate for the user terminals, the initiating routine jumps to START for user 1. The initiating routine is required so that the registers, buffer areas, and the stacks will be set up properly for each user before any other processing begins.

Once normal processing has begun, the routine that handles the timer-out

Text continued on page 58

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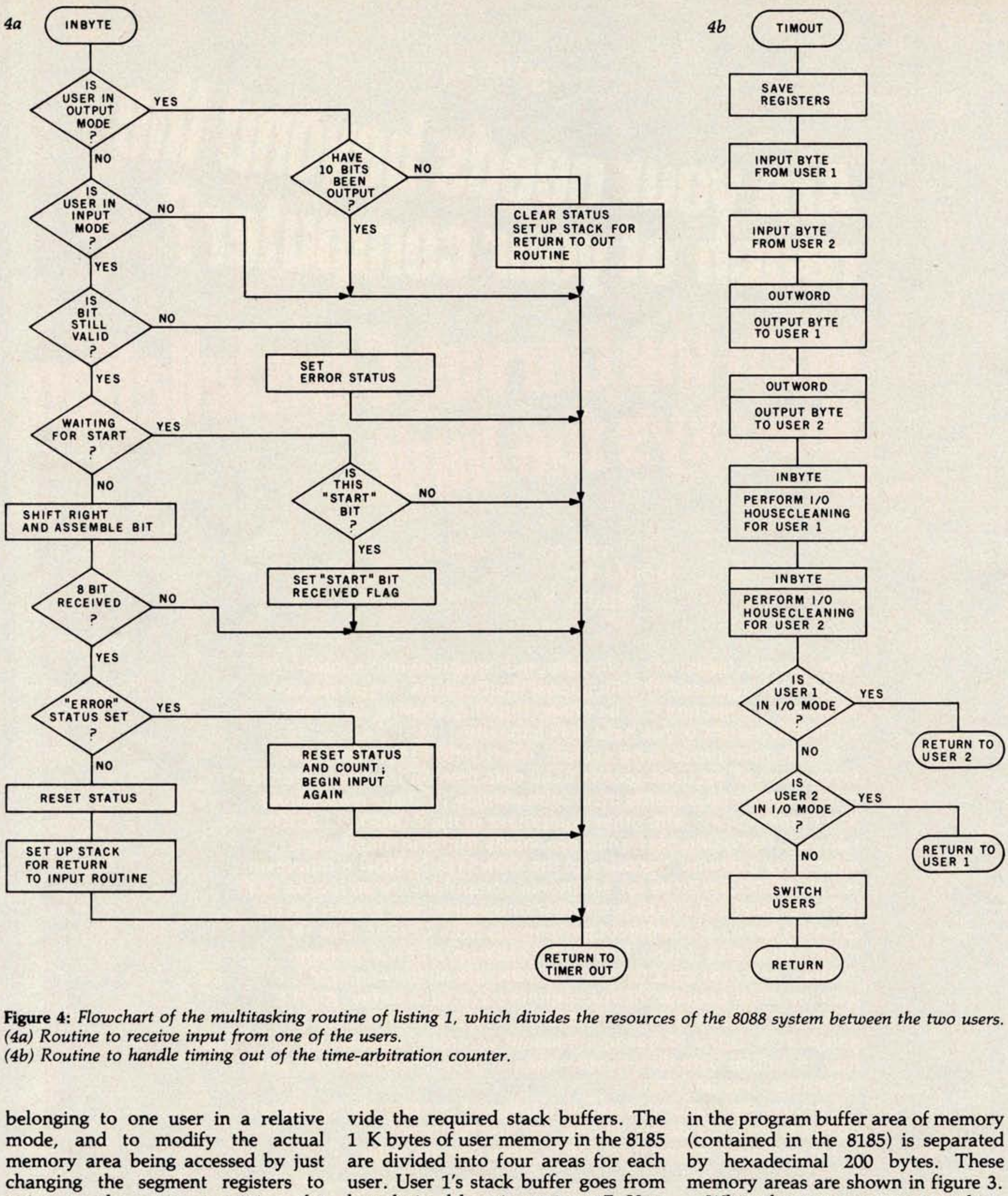

Figure 4: *Flowchart of the multitasking routine of listing 1, which divides the resources of the 8088 system between the two users. (4a) Routine to receive input from one of the users. (4b) Routine to handle timing out of the time-arbitration counter.*

belonging to one user in a relative mode, and to modify the actual memory area being accessed by just changing the segment registers to point to the area containing the specific user-task we currently want to work with.

Specifically, the 256 bytes of user memory in the 8155 are divided into two areas, one for each user, to provide the required stack buffers. The 1 K bytes of user memory in the 8185 are divided into four areas for each user. User 1's stack buffer goes from hexadecimal locations 10 to 7F. User 2's stack buffer goes from hexadecimal locations 90 to FF.

Corresponding areas in the two stack buffers are separated by hexadecimal 80 bytes. Each of the buffers in the program buffer area of memory (contained in the 8185) is separated by hexadecimal 200 bytes. These memory areas are shown in figure 3.

When the microprocessor needs to access a given area in memory, the effective address of the memory that is to be accessed is computed by multiplying the appropriate segment register by 16, and then adding the

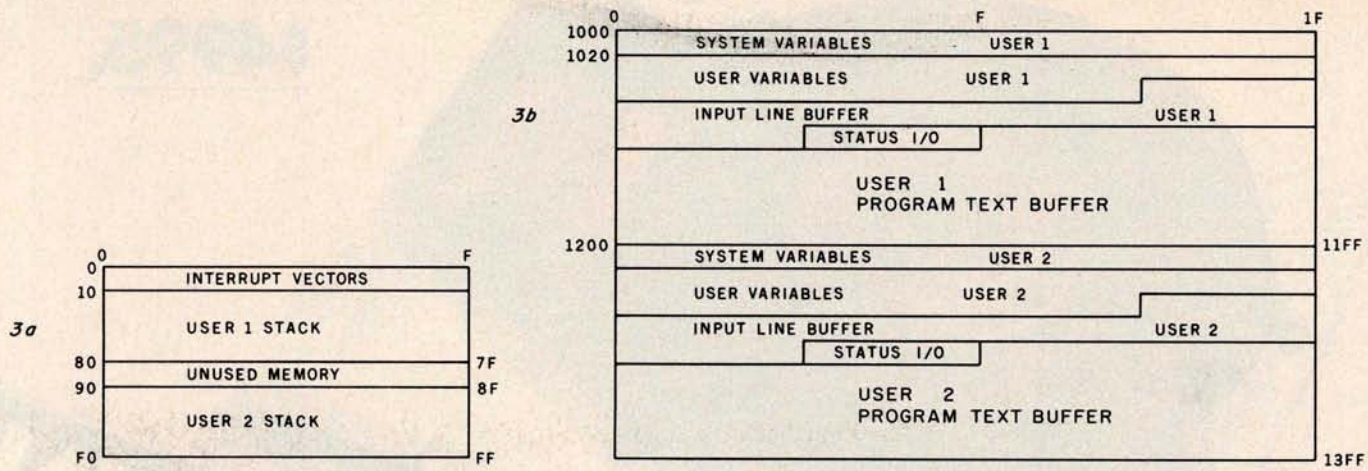

Figure 3: *Map of memory use of the 8088 multi-user operating system. Programmable memory from hexadecimal addresses 00 thru FF is contained in the 8155 integrated circuit and is used chiefly to hold the pushdown stack for each user. Memory from hexadecimal locations 1000 thru 13FF is in the 8185 device, and stores various data belonging to the two user-tasks. Memory from hexadecimal addresses 0F800 to 0FFFF takes the form of EPROM in the 8755A, which stores the operating system.*

the 8086, addresses all memory locations using one of four *segment registers*.

All of the jumps and subroutine calls within a program are made relative to the current position of the instruction pointer. Hence, the jumps and calls are not specific to the memory segment where a given section of program code is placed. The code can be moved from place to place within memory, and will still execute properly if the segment registers are set up correctly.

It is also this segmenting feature that allows us to write the BASIC interpreter in such a way as to address the buffers and programs

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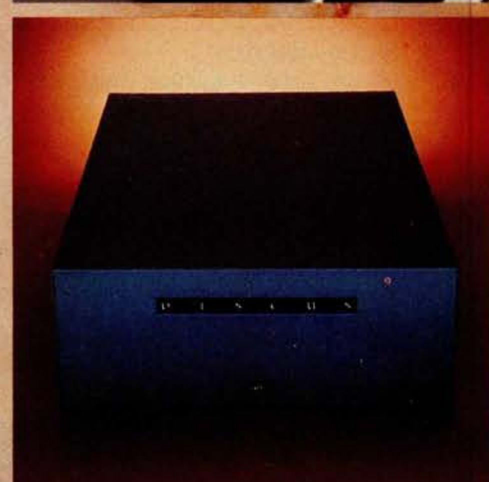

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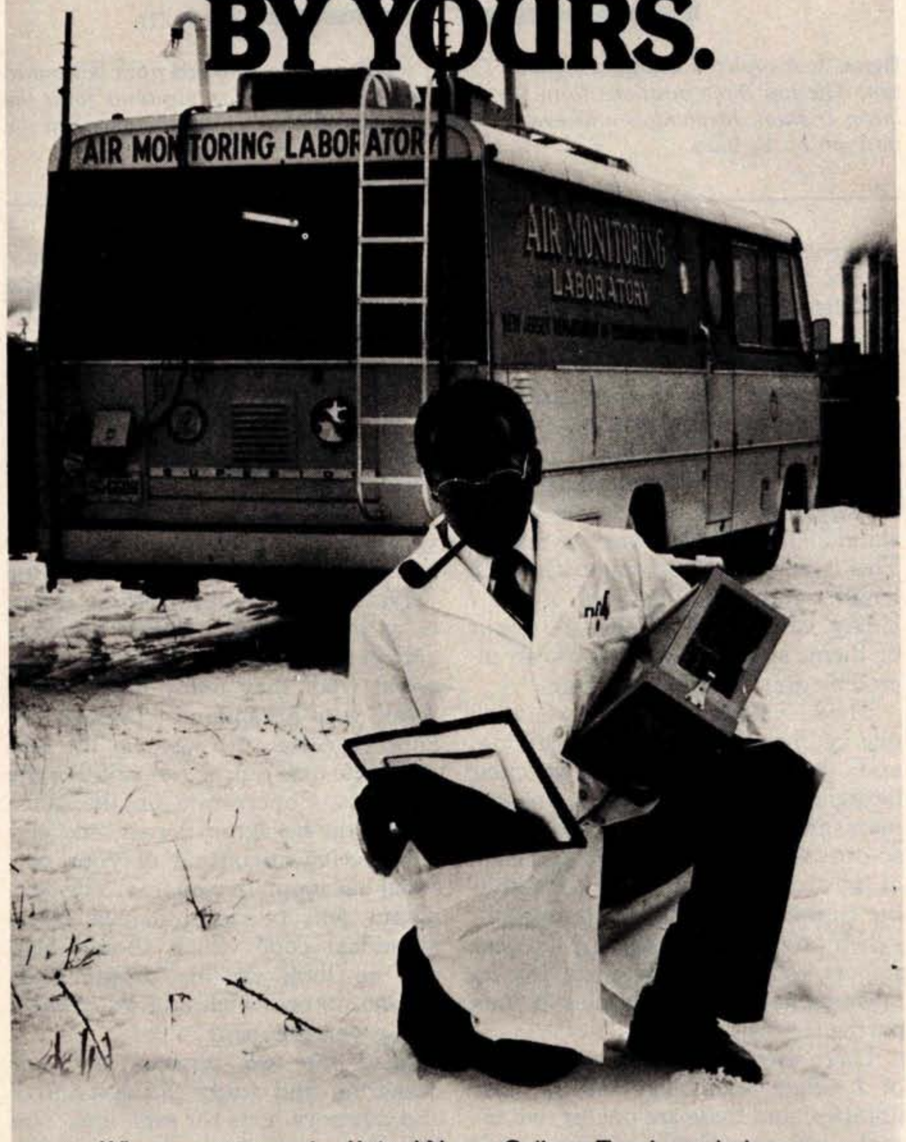

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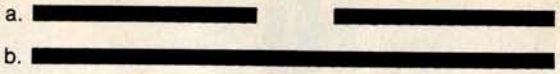

Figure 1: *Broken and continuous line segments, the two states used by the* I Ching *hexagrams.*

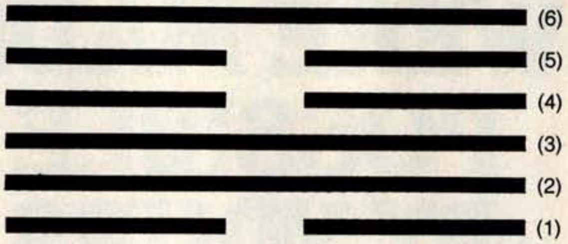

Figure 2: *A typical* I Ching *hexagram. The six positions are numbered from bottom to top. The top three positions form the upper trigram; the bottom positions form the lower trigram. Meaning is attached to both the state, broken or continuous, and the position of the lines.*

Text continued from page 96:
of six lines with chingish meaning attached to binary state and to position, also contains an upper and lower trigram. Each trigram has a meaning, not only independently but in relation to the other trigram.

Since the "magic" resides in your ability to read your own hexagram, it is important that you clearly understand all the different ways to read it. This is why I am carrying on at such length, and why the texts of the *I Ching*, while there are only sixty-four of them, are capable of doing an incredible job of fortune-hinting.

The *I Ching* is a book of texts, each one of them describing, explaining, and commenting on a particular hexagram. Each hexagram has a name and a meaning as a whole, but so does each of the trigrams and each of the six lines, both in the context of its trigram and of the hexagram. When you cast a hexagram, the next step is to consult the texts for its meaning to see how it applies to your particular case.

There are many good translations of *I Ching* texts available at most libraries, and there are one or two inexpensive paperback editions of *I Ching* texts. Ask your local book dealer; some references are listed at the end of this article. There are several translations, and some are more structured than others. I prefer any translation edition by Legge over the one introduced by Jung, because the latter unfortunately fleshes out the textual bones with a lot of typical Jungian verbosity.

Personally, I prefer *using* the *I Ching* to talking about it. Using the program of listing 1, along with the simplest *I Ching* text you can find at the library or paperback bookstore, is going to give you an unending supply of mental entertainment, and perhaps bring on the surprise of an occasional insight.

Rules for using the program are very simple. First, think of some question you want to ask the "oracle." Be reasonably serious about it, as the "answers" will be involved and you will have to *want* to think about what they really mean. Then "cast" your hexagram by pressing the Enter (or Return) key at the appropriate time during execution of the program. Concentrate on the question as the hexagram is cast, and you will receive an output of your personal hexagram in response. The hexagram will be accompanied by a numerical code which should help you to look up the proper text, depending on which edition of the *I Ching* you are using.

Read the text written for your hexagram and study the descriptive and advisory texts for each line. You will be surprised at what you may learn about your problem and about yourself.

If you cast a hexagram while in the wrong frame of mind, don't hesitate to erase it and try again. Concentration is crucial, and, while a cast of tortoiseshell wands can't be erased, a cast by computer can be returned to nonexistence by merely pressing the Enter key in order to try again.■

Notes on the *I Ching*

The program listed here is a first approximation (good enough "to attract the attention of the opposite sex," especially in California) of a more detailed method of reading the I Ching. *In this method, which is listed in most translations of the* I Ching *book, a second hexagram can be generated using "moving lines," which form under certain conditions. If a hexagram contains one or more moving lines, a second hexagram that is read differently can be generated by changing each moving line to its opposite form, that is, from solid to broken and vice versa. (For those interested, each line randomly chosen has a one-quarter chance of being a moving line. See the preface to Legge's translation for more information).*

Quite apart from its purported mystical use, the I Ching *can be seen with a more Western view. Some psychologists, and notably Carl Jung, have interpreted the* I Ching *as a sounding board for the subconscious. Jung's idea is, given that the interpretations of the* I Ching *are vaguely phrased, the person interpreting a hexagram will unconsciously read it in terms of the subconscious' desires. I find that this interpretation has some practical value when using the* I Ching *as a decision-making device, although some people would say that it merely transfers the motive force of the* I Ching *from one supernatural realm to another....*
GW

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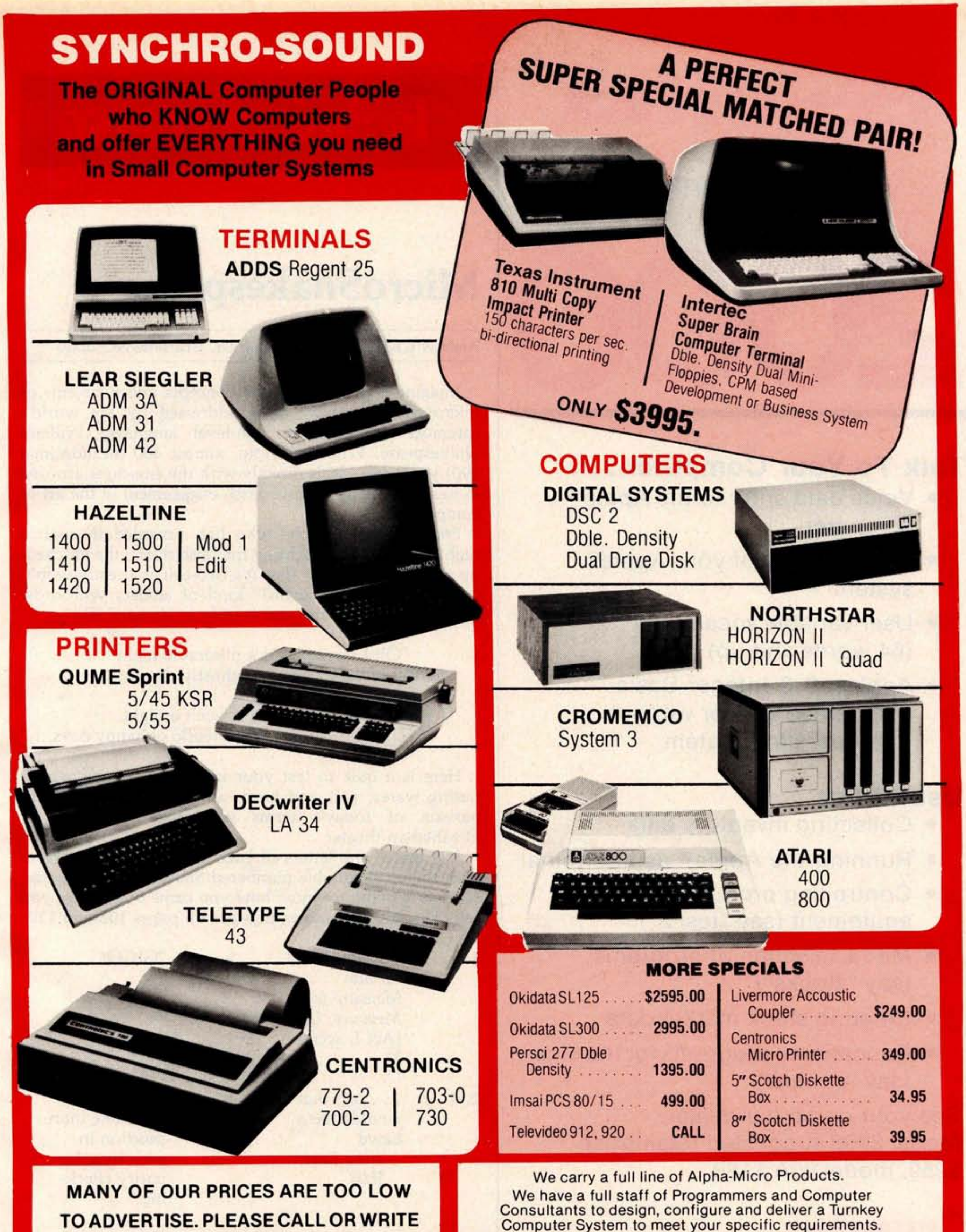

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Technical Forum

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"Oh I have pass'd a miserable night
So full of ugly sights, of ghostly dreams,
That . . .
I would not spend another such a night
Though 'twere to buy a world of happy days...."

Here is a quiz to test your knowledge of microcomputing wares, soft and hard, and to do a quick comparison of today's terms with the high style of Elizabethan theater.

Just match the letters of each of the modern phrases with the most suitable numbered Shakespearean quotes. No one is going to know how you came out, unless you tell. The answers and ratings are on pages 108 and 110.

1. ( )	. . . The needful bits . . . *Measure for Measure,* I/iii (Act I, scene 3)	**a.**	"GIGO!"
2. ( )	. . . one that wouldst be a bawd . . . *King Lear,* II/ii	**b.**	"We should have one more position in each byte for parity checking."
3. ( )	. . . superfluous branches we lop away . . . *Richard II,* III/iv	**c.**	"This program is driving me up the wall."

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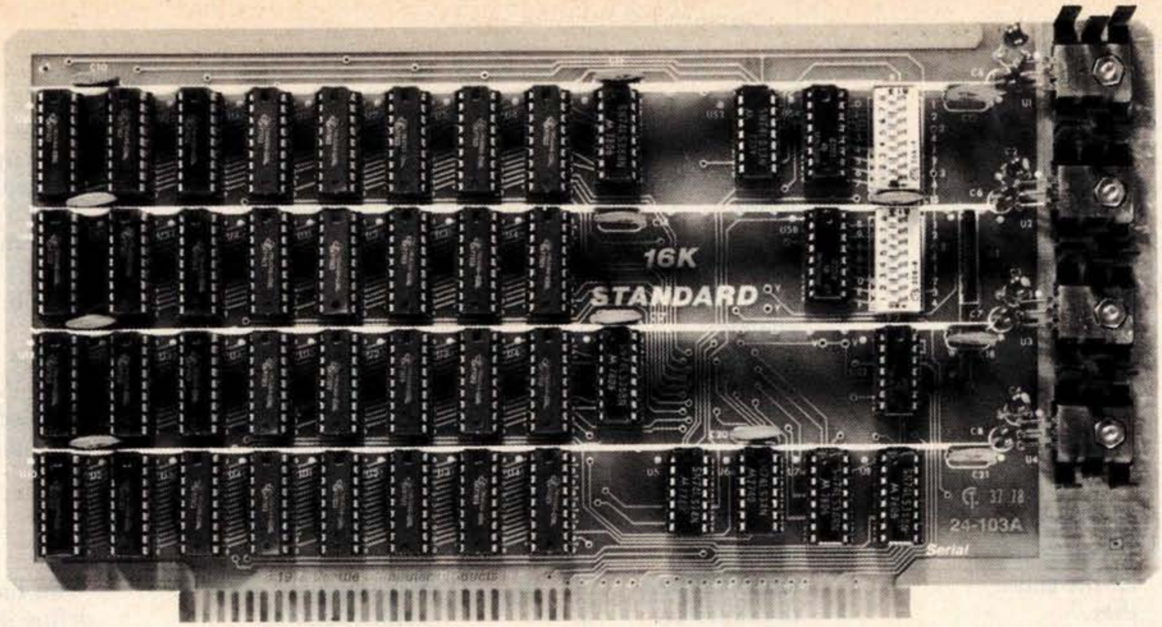
4. ( )	Ho! Such bugs and goblins in my life! *Hamlet,* V/ii	**d.**	"Simple. You just wired 12 V into the 5 V supply bus."
5. ( )	It is bright day that brings forth the adder. *Julius Caesar,* IV/iii	**e.**	"What voltage are we getting at the negative lead of C1?"
6. ( )	Something failing in him that should compare . . . *Cymbeline,* I/i	**f.**	"I don't trust GOTO any more than you do. My students get into trouble every time they use it."
7. ( )	Tellest thou me of 'ifs'? *Richard III,* III/iv	**g.**	"I need a good text processor."
8. ( )	You have done that you should be sorry for. *Julius Caesar,* IV/iii	**h.**	"Only you and I will ever know what's in the read-only memory."
9. ( )	. . . And must we be divided? *Richard II,* V/i	**i.**	"Are you telling me I've loaded the wrong value in the accumulator to start the count?"
10. ( )	I will be correspondent to command. *The Tempest,* I/ii	**j.**	"It's only a thousand bytes; we can always toggle them in by hand."
11. ( )	We but teach Bloody instructions, which, being taught, return To plague the inventor. *Macbeth,* I/vii	**k.**	"We're just not jumping from the test into the subroutine."



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16K PLUS

This board has been sold primarily to dealers/system integrators during the past 20 months. It has become the reliability standard against which other boards are compared. It is fully static, 16K by 8 bits, and a premium quality product featuring Schmitt triggers for all signal inputs. The board has been optimized for the Cromemco systems using output port 40H for its bank select. It also has start-up options which allow the board to come up in either the enabled or disabled condition. It is addressable by DIP switches in any continuous 16K on 4K boundaries. Prices with 300 nsec. chips (for 4 Mhz. Z-80 systems): 1-4, $365; 5-9, $295. Add $30 per board for 250 nsec. chips for faster CPU clock speeds.

16K APEX

This board is very similar to the PLUS card. It differs in that its bank select can use any of 256 output port addresses and it can be addressed on 16K boundaries only. Pricing is the same as for the PLUS.

8/16 RAM

This board was designed for the 1980s. It is configured as 16K by 8 bits when accessed by an 8-bit processor and configured 8K by 16 bits when used with a 16-bit processor. The configuration switching is automatic and is done by the card sampling the "Sixteen Request" signal sent out by all 16-bit CPU boards. The card has all the high noise immunity features of the PLUS and APEX as well as "extended addressing". Extended addressing is a replacement for bank select which makes use of a total of 24 address lines to give a directly addressable range of over 16 megabytes. (For older systems, a switch will cause the card to ignore the highest 8 address lines) This card ensures that your memory board purchase will not soon be obsoleted. It comes with 200 nsec. memory chips only and is guaranteed to run without wait states with our 8086 CPU using an 8 Mhz. clock. Prices: 1-4, $445; 5-9, $345.

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12. ( ) Words, words, words . . .
Hamlet, II/ii

l. "If we can, let's cut down on the nested loops."

13. ( ) Why should I write this down, that's riveted, Screwed to my memory?
Cymbeline, II/ii

m. "Sure, I know where the changes should be. I'll do the documentation later."

14. ( ) O, that way madness lies; let me shun that."
King Lear, III/iv

n. "You have too much resistance tied into the LEDs on the front panel."

15. ( ) 'Tis in my memory locked, and you yourself shall keep the key of it.
Hamlet, I/iii

o. "The number-crunching is what's really eating up processor time."

16. ( ) What error leads must err.
Cymbeline, V/v

p. "Look — you come up with the applications; I'll come up with the circuits to do the job."

17. ( ) . . . Dim register and notary of shame . . . .
Rape of Lucretia, 1. 764

q. "Come on over. We just installed the arithmetic unit."

18. ( ) Where great additions swell us . . .
Alls' Well that Ends Well, II/ii

r. "You have to define it as 1 signal-change per second."

19. ( ) Who hath measured the ground?
Henry V, III/vii

s. "Why don't we calculate the reciprocal just once, store it, and call it out to multiply with it whenever we need to later?"

20. ( ) Power, unto itself most commendable.
Coriolanus, IV/i

t. "It ought to be enough; it puts out 30 A at +5 V."

Number of Correct Matches	MicroShakespeare Rating
20	System thoroughly debugged.
17-19	One or two minor glitches still to be worked out.
13-16	Put it through an edit run.
9-12	Check the flowcharts.
5-8	Reset and restart.
4 and fewer	System crash for reasons unknown. ■

Technical Forum is a feature intended as an interactive dialog on the technology of personal computing. The subject matter is open-ended, and the intent is to foster discussion and communication among readers of BYTE. We ask that all correspondents supply their full names and addresses to be printed with their commentaries. We also ask that correspondents supply their telephone numbers, which will not be printed.

More GOTOXY

George Bolthoff, 3417 S Plaza Dr, Apt 1, Santa Ana CA 92704

I may be able to assist Carl Helmers with the problem expressed in his editorial "The Era of Off-the-Shelf Personal Computers Has Arrived" (January 1980 BYTE, pages 6 thru 10 and 93 thru 98). The problem concerned adapting the GOTOXY procedure used by the UCSD Pascal system to do cursor addressing in Mr Helmers' Computer Peripheral Corporation COPS-10 video terminal.

I offer for Mr Helmer's use the routine shown here as listing 1. It is faster than the one published in his editorial as listing 1 (page 96, January) because the UNITWRITE procedure is taken out of the loops. The error checking can also be removed, if you are careful in your programming. The routine shown here as listing 2 works on my SOROC 120 terminal.■

Listing 1: *Pascal routine to place cursor at specified address on COPS-10 terminal.*

```
PROGRAM FGOTOXY(X,Y:INTEGER);
CONST             HOME=30;
                  DOWN=10;
                ACROSS=12;
                  NULL=0;
              MAX_SIZE=80;
 VAR
    SEND:PACKED ARRAY[0..MAX_SIZE] OF 0..255;
    INDEX:INTEGER;

  BEGIN
      SEND[0]:=HOME; (home the cursor, SOROC requires nulls )
      SEND[1]:=NULL;SEND[2]:=NULL;
      UNITWRITE(2,SEND,3);
           FOR INDEX:=0 TO Y DO
                     SEND[INDEX]:=ACROSS;
           UNITWRITE(2,SEND,Y);
           FOR INDEX:=0 TO X DO
                     SEND[INDEX]:=DOWN;
           UNITWRITE(2,SEND,X);
 END.
```

Listing 2: *Pascal routine to place cursor at specified address on SOROC 120.*

```
This gotoxy procedure works with the SOROC 120 terminal.
PROCEDURE FGOTOXY(X,Y:INTEGER);
 CONST         ESCAPE=27;
  BEGIN
    WRITE(CHR(ESCAPE),'=',Y+32,X+32,CHR(0),CHR(0))
  END;
```

Answers to MicroShakespeare Quiz:

1 - b	6 - k	11 - f	16 - a
2 - r	7 - i	12 - g	17 - n
3 - l	8 - d	13 - m	18 - o
4 - c	9 - s	14 - j	19 - e
5 - q	10 - p	15 - h	20 - t

Who Should Attend

Designers, systems analysts, implementers, and managers with an interest in holding down costs on their software projects. Fields with special applicability include electronics and electronics design, automated manufacturing, scientific instrumentation design, and aerospace control systems.

Tentative Schedule

June 16, 1980

8:00- 9:00 A.M.	**REGISTRATION**
9:00-10:00 A.M.	**INTRODUCTION:** Carl Helmers
10:00-10:30 A.M.	**COFFEE INTERMISSION**
10:30-12:00 P.M.	**THE IMPORTANCE OF TOOLS:** Fred Martin
12:00- 1:30 P.M.	**LUNCHEON**
1:30- 3:00 P.M.	**THE PASCAL PERSPECTIVE:** Peter Grogono
3:00- 3:15 P.M.	**COFFEE INTERMISSION**
3:15- 4:45 P.M.	**AFTER PASCAL, WHAT?:** Ken Bowles
4:45- 5:15 P.M.	**OPEN DISCUSSION**

June 17, 1980

8:30-10:00 A.M.	**TREES AND LISTS AS TOOLS:** Henry Baker
10:00-10:30 A.M.	**COFFEE INTERMISSION**
10:30-12:00 P.M.	**THE FORTH ALTERNATIVE:** Charles Moore
12:00- 1:30 P.M.	**LUNCHEON**
1:30- 3:00 P.M.	**WHAT IS C?:** John Morse
3:00- 4:00 P.M.	**PANEL DISCUSSION:** All speakers

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BYTE News . . . .

NEW DEVELOPMENTS FROM COMMODORE: At a recent private showing during the Winter Consumer Electronics Show in Las Vegas, Nevada, Commodore Business Machines revealed some impressive work in progress. Heading the list was the prototype of the TOI ("The Other Intellect") color computer. Aimed at the low-end market, the TOI is designed to interface with your home color television set. The displayed image will feature 16 colors, 160 by 192 resolution (with three colors in the high-resolution mode), Microsoft BASIC, and a standard keyboard. The price could be under $700. Other devices included the Commodore CBM computer outfitted with a Shugart SA-200 5¼-inch floppy-disk drive (still under development). The SA-200 is a very low-cost drive that is less than 1 inch high, and employs an electromechanical track-to-track seeking mechanism for the head that is somewhat slower than conventional drive mechanisms. Commodore is also working on a Plato-like touch panel and a speech synthesizer (from Votrax). Also on hand was a prototype Memorex model 101 8-inch hard-disk drive and interface. Commodore stressed that all of these products were still under development, and that not all of them would necessarily get to the marketplace.

ATARI AND NAB TAKE FCC TO COURT: Atari Inc and the National Association of Broadcasters (NAB) have gone to the United States Court of Appeals asking that the Federal Communications Commission (FCC) review its recent decision allowing Texas Instruments Incorporated (TI) to sell its TI-900 stand-alone radio frequency (RF) modulator, which will allow a TI home computer to work with a standard color television set.

Late last year the FCC altered its rules (see BYTE News, January 1980) and granted TI a waiver. Atari asked the FCC to delay the effective date of the waiver until appropriate technical standards were developed. The FCC rejected Atari's request. Tandy Corporation and Apple Computer Company made similar requests. The requests claimed that the FCC decision allowed TI to circumvent the FCC's rulemaking.

The NAB is concerned with the interference that modulators cause on television and radio reception. The NAB is also challenging the FCC's radiation limits as being too high. This could cause interference, particularly in weak television signal areas. In addition to interference caused by personal computers, the NAB is concerned with interference from computer games and video recorders.

NEW HIGH-SPEED COMMUNICATIONS BUS: Xerox Corporation recently made a public announcement of a new concept of processor-to-processor communications intended for an office environment. This novel concept is called "Ethernet," and is a result of some of the work being done in their research labs. In this concept, a single coaxial cable is used as a high-speed communications bus between all processors; communication protocol is handled through software or software supplemented by special-purpose hardware. Rumor has it that an Ethernet processor is now being developed by some form of joint arrangement between Xerox and Intel.

NEW 16-BIT PROCESSOR CARDS TO BE INTRODUCED: Several manufacturers will soon introduce Z8000 and 68000 printed circuit cards for S-100 and SS-50 bus systems. Ithaca Intersystems Incorporated will shortly commence shipping its Z8000 processor card for S-100-based systems. They also have a 68000 prototype processor card running on the S-100 bus, but they do not plan to manufacture the card at this time. Gimix Incorporated does plan to manufacture a 68000 processor card for SS-50 bus systems. Gimix plans to use a multiplexed approach so that no reworking of the SS-50 mainframe will be required.

CAN DEPARTMENT STORES SELL PERSONAL COMPUTERS? The answer to this question from the stores, at this point, is a noncommittal "yes." Sears Roebuck and Montgomery Ward (MW) started test marketing personal computer systems last November. MW attempted selling several Ohio Scientific and Interact Electronics systems in a few selected stores. Although at the time of this writing not all results were in, the opinion was that the test, although not meeting with an enthusiastic response, developed sufficient sales to merit continued test marketing. Most system sales were to small businesses rather than consumers. The systems were being used for applications such as inventory control, word processing, and record keeping.

Sears Roebuck also was guarded in its appraisal of the test marketing of the Atari system through its Christmas catalog and selected stores. Although sales have not increased dramatically, they are sufficient for Sears to continue marketing tests.

IBM INDICATES NEW TECHNOLOGY COMING: New computer technologies from IBM will be used in computer systems available at the end of this decade. These systems will employ superconducting quantum interference devices (SQUIDs) using high-speed (0.06 nanosecond) Josephson-junction logic with 0.5 nanosecond programmable memory with up to 1000 connections between chip and carrier.

IBM also plans super-density logic cards (0.6 by 1.2 inch) with more than 300 "micro-pins" per card and up to 2500 printed wiring channels per inch. This will mean up to 10 times the density and 100 times the performance of the new IBM 4300-series systems. IBM will be able to build a processor with an internal performance of 70 million instructions per second (MIPS), 32 K byte cache memory, and 16 megabyte main memory in a 6-inch cube. Josephson-junction logic requires immersion in a liquid helium bath for proper operation.

RADIO SHACK SALES OVER $100 M FOR 79: Radio Shack's computer equipment sales were over $100 million for last year, according to Tandy. Furthermore, almost 150,000 TRS-80s have been sold. Industry experts estimate that Radio Shack has about 35% of the personal computer market. Sales of the TRS-80 appear to be leveling off; Radio Shack attributes this to market saturation. Radio Shack started shipping TRS-80 Model II systems to users in October, and by year's end had shipped about 1000 systems. Radio Shack chief Lewis Kornfeld anticipates selling 15,000 of these systems in 1980. Radio Shack plans to introduce a color-display replacement for the TRS-80 in the coming year, hoping to rejuvenate the sales curve—but normal production delays may affect the timetable.

S-100 MAGAZINE APPEARS: A magazine specifically oriented to S-100 systems users has begun publication. It features articles on S-100 hardware, CP/M (trademark of Digital Research), and Pascal software. A sample copy is $2 and can be obtained by writing *S-100 Microsystems*, POB 1192, Mountainside NJ 07082.

MICROPROCESSOR INVENTOR HONORED: Dr Marcian E Hoff has received recognition for the development of the microprocessor. Dr Hoff, of Intel Corporation, received the Stuart Ballantine Medal as an electronics pioneer. Shortly after joining Intel in 1969, he first proposed the microprocessor architecture which led to the development of the 4004, first produced in 1971. Dr Hoff also worked on the 1103, the first high-density programmable memory integrated circuit (1024 bits), and then Dr Hoff worked on analog-to-digital and digital-to-analog integrated circuits at Intel.

"ROBOTS" DO SALES PROMOTION: A new industry has developed in this country: using "robots" for sales promotion. These robots, which look very much like R2-D2 of *Star Wars*, are being used at public events promoting products like Coca-Cola, bank openings, and even the US Olympics organization.

One such maker is Promotional Concepts Incorporated of Atlanta, Georgia. This year they expect to make about 300 "robots," which they prefer to call "androids." Most will be 4 feet tall, weigh 90 pounds, and will be decorated to appear as Coke cans with arms, legs, and a dome. They move on three legs, talk, sing, whistle, rotate their domes, and move around. Power comes from an automobile battery, while voice and motion are controlled by a human operator via remote radio control and wireless microphone. The robots also have an internal tape player to supply music, beeps, and sounds. You can buy an "android" for $6500, or it can be rented for specific events.

COMPUTER FLEA MARKET COVERS 5 ACRES: The largest and oldest computer equipment flea market will be held this year on April 19 and 20 as a part of the Trenton Computer Festival (TCF) at Trenton State College, Trenton, New Jersey. The fifth annual flea market is jointly sponsored by three computer clubs—Amateur Computer Group of New Jersey, the Philadelphia Area Computer Society, and the Trenton State Computer Club. Hobbyists come from all across the northeastern USA to attend the event, where bargains on surplus gear are in abundance. Both flea market spots and admission are $5. There are also indoor commercial exhibitors, forums, talks, seminars, and user-group meetings. For information call (609) 771-2478 or write TCF, Trenton State College, Trenton NJ 08625.

NASA SHOPPING FOR A SUPERCOMPUTER: The National Aeronautics and Space Administration (NASA) is looking for a supercomputer—a numerical aerodynamic simulator—to perform wind-tunnel simulation. They have set a minimum sustained-performance level of one billion floating-point operations per second, or one "gigaflop." This is 30 to 40 times greater than the performance of machines such as the Cray-1 and Control Data Corporation's Cyber 203, which are presently considered the most powerful computers in production.

64 K EPROMS AVAILABLE BY MID-YEAR: 64 K EPROMs (erasable programmable read-only memory), organized as 8 K by 8 bytes, are currently being sampled by Motorola customers. Production quantities are expected to be shipped by the end of June. Motorola has put the 64 K EPROM in a 24-pin package by multiplexing the program supply and chip-enable signals on the same pin. Intel and Texas Instruments are believed to be using 28-pin packages for their 64 K EPROMs.

Meanwhile the supply of 2708 EPROMs (1 K by 8 bits) has caught up to demand and prices are now in the $6 range. The demand for 2716 EPROMs (2 K by 8 bits) is still very strong, and hence the devices are selling in the $20 to $24 range.

TI is currently the largest manufacturer of EPROMs with about 38% of sales. Intel is second with 29%, Fujitsu and Hitachi share third place with 8% each.

RANDOM RUMORS: At least one printer manufacturer will soon introduce a high-density, dot-matrix printer similar to the Sanders Technology Media 12/7 printer (see BYTE News, February 1979). It will sell for less than $2000 in original equipment manufacturer's (OEM) quantities and it will include a sheet feeder. Furthermore, they are promising a printing speed of 400 characters per second (cps) in a single-dot-density mode and 150 cps in a word processing mode. Like the Sanders Technology printer, the word processing mode will use overlapping dots to produce fully formed characters. . . .It is rumored that Intel will start sampling a 16 K static programmable memory in the third or fourth quarter of this year. . . .Sinclair Radionics, of Great Britain, may soon start sampling its flat cathode-ray tubes (CRTs). The Sinclair CRT has an electron gun that is parallel to the screen. . . .Disk drive designers are starting to talk about the 20 megabyte floppy disk and 200 megabyte 8-inch Winchester disk. These units are in the product planning stages now at a number of manufacturers. . . .Rumor has it that Burroughs is about to introduce a 5 megabyte 8-inch floppy-disk drive.

RANDOM NEWS BITS: Shugart Associates' SA450 5¼-inch Minifloppy™ with 500 K byte capacity may finally get into full production by late summer. Shugart experienced problems with its previous head designs which had a high incidence of media scoring. Shugart will use a new head design developed by and licensed from Tandon Magnetics Corporation. The design employs a fixed "button" head on one side of the disk and a gimballed head on a swing arm on the other side. The original Shugart design used two gimballed heads. Shugart hopes to be producing at least 2000 drives per month by late summer. . . .Dataland of Denmark has introduced a computer system to convert a composer's music into a printed score. A special piano keyboard is used to "play in" the voices in the score. The computer processes the input, and sends output to a digital plotter that creates the finished score ready for printing. . . .Intel is now producing 8 MHz 8086 16-bit microprocessors. The previous top speed was 5 MHz. . . .The Department of Defense (DOD) predicts that software-preparation costs will increase from the present $40 per line to $65 per line by 1984. Thus software preparation will be 8% of the total US defense budget—rising from $6.6 billion in 1979 to $10.5 billion in 1984. . . .Texas Instruments has introduced an alphanumeric display-driver integrated circuit (AC5947) that accepts ASCII character input and drives an 18-segment display . . . . Motorola has introduced opto-isolators with 7.5 kV isolation ratings . . . . Castle Toy Company is selling a "Superstar Guitar" with a built-in microprocessor. . . .William A Davis, Castro Valley, California, has announced a navigational computer that calculates longitude and latitude positions even if the navigator has no idea where he is. It also can calculate distances between any two points on earth and gives true bearing between them. It is accurate to 1/10th of a nautical mile.

MAIL: I receive a large number of letters each month, as result of this column. If you write to me and wish a response, please enclose a self-addressed, stamped envelope.

Sol Libes
Amateur Computer Group of New Jersey
(ACG-NJ)
1776 Raritan Rd
Scotch Plains NJ 07076

Calculating Filter Capacitor Values for Computer Power Supplies

John Thomas
c/o Hewlett-Packard
3070 Directors Row
Memphis TN 38131

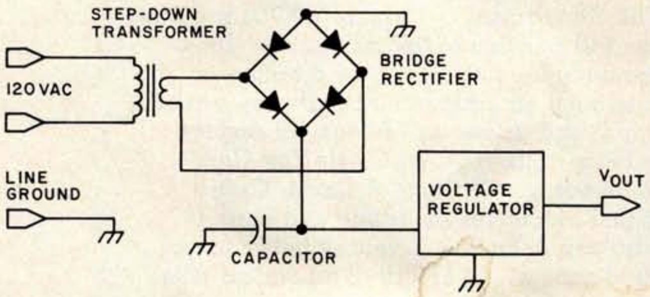

Figure 1: *Schematic diagram of a typical power supply circuit containing a step-down transformer, a full-wave bridge rectifier, a filter capacitor, and an integrated circuit voltage regulator.*

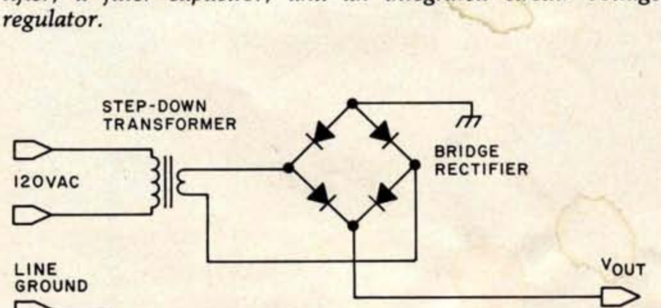

Figure 2: *Schematic diagram of the power supply without capacitor or regulator. This circuit produces the output voltage waveform shown in figure 3.*

Typically there are four functional elements in a homebrew computer power supply. These elements are: the transformer, full-wave bridge rectifier, filter capacitor, and one or more integrated circuit voltage regulators as shown in figure 1. Experience has shown that most homebrewers have little difficulty in choosing any of the components, except when it comes to finding the value of the filter capacitor. Then they must resort to methods of multiple approximation, charts and graphs, or the better known and widely used method of trial and error. The following information will simplify the process of finding the smallest value of capacitance that will work in the circuit.

Equation 1 gives the formula used to calculate the capacitor value:

$$C_{min} = \frac{i_{max}\left[\frac{1}{4f} + \frac{1}{2\pi f}\arcsin\left(\frac{V_{min}}{V_{max}}\right)\right]}{V_{max} - V_{min}} \quad (1)$$

where:
- f = the power-line frequency in hertz
- V_{max} = the value of the peak positive voltage applied to the capacitor under the worst conditions (eg: highest operating temperature, greatest current, lowest power-line voltage)
- V_{min} = the absolute minimum voltage allowable at the input of the voltage regulator


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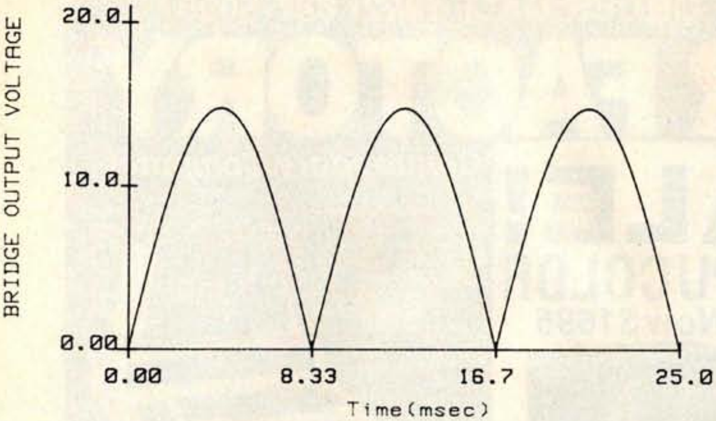

Figure 3: *The voltage waveform produced by the circuit of figure 2. The output of the rectifier stage of the supply is a pulsating current with only positive polarity.*

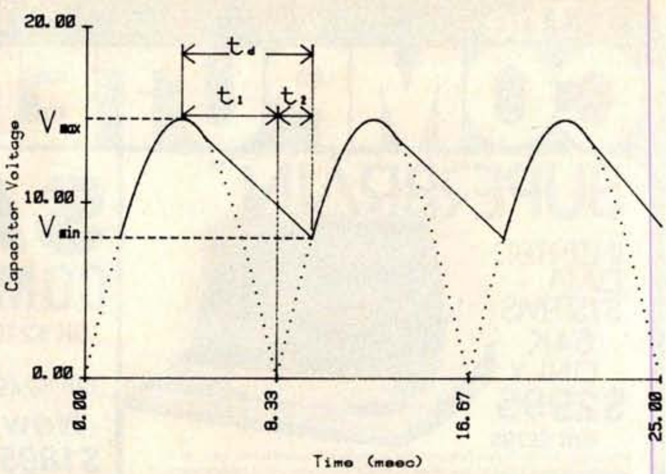

Figure 4: *Addition of a capacitor to the circuit has this effect on the output waveform. The capacitor smooths the humps in the waveform; an almost constant DC voltage with a small fluctuation (ripple) is presented to the voltage regulator stage of the power supply.*

Figures 3 and 4 were produced on a Hewlett-Packard 9872A plotter controlled by a Hewlett-Packard 9845A desk-top computer.

i_{max} = the maximum average current drawn during any one-quarter segment of a power-line cycle

C_{min} = the capacitance in farads; this is the minimum value that will meet the V_{min} specification

Those who are familiar with the above symbols and the effects of the circuit elements on the corresponding component values need read no further. However, anyone wishing to have a better description of V_{max}, V_{min}, i_{max}, and how to choose appropriate values, should read on.

Where the Formula Comes From

If the capacitor and voltage regulator are removed from the power supply in figure 1, the circuit of figure 2 remains. The circuit has an output-voltage waveform resembling that shown in figure 3. The waveform produced emulates the absolute value function of a sine curve. With the capacitor and regulator replaced so that the circuit is once again as shown in figure 1, the voltage across the capacitor will appear as shown in figure 4. Thus the capacitor has a smoothing-out effect on the waveform in figure 3. As shown in figure 4, the voltage across the capacitor follows the waveform of figure 3 while charging. When discharging, the voltage falls down to a value V_{min}. This value is the lowest voltage permissible as input into the voltage regulator, such that the regulator can still function properly. V_{min} should typically be about 2 V greater than the regulator-ouput voltage.

The capacitor formula is derived using the definition of capacitance found in almost any book on network theory:

$$i = C\frac{dv(t)}{dt} \qquad (2)$$

where: i = current in amperes
v = voltage in volts
t = time in seconds

and: C = capacitance in farads

This equation may be simplified by assuming that the current, i, is constant. This assumed value of current is the sum of currents drawn by the computer and the voltage regulator. If the current is not constant, it must be equal to the maximum *average* current drawn during any one-quarter segment of a power-line cycle. Once the current i is chosen and assumed constant, equation 2 can be simplified to give equation 3:

$$C = \frac{i_{max}\, t_d}{V_r} \qquad (3)$$

where: i_{max} = the maximum average current discharging the capacitor during any one-quarter segment of a power-line cycle,

t_d = the capacitor discharge time (see figure 4), and

V_r = the ripple voltage, $V_{max} - V_{min}$

The time t_d over which the capacitor discharges can be broken into two parts, t_1 and t_2, as shown in figure 4. The time t_1 is the interval in which the sine waveform is decreasing, and is equal to one-fourth of the power-line frequency period. The time t_2 is the time required for the sine wave to go from 0 to V_{min}. For a power-line frequency of f, the total capacitor discharge time, t_d, is given by equation 4:

$$t_d = t_1 + t_2$$

$$t_1 = \frac{1}{4f}$$

$$t_2 = \frac{1}{2\pi f}\arcsin\left(\frac{V_{min}}{V_{max}}\right)$$

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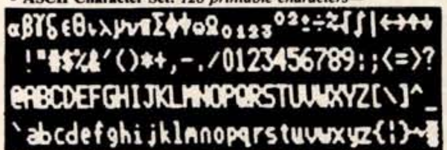

BAUDOT Character Set: *A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ? : • 3 $ # ( ) . , 9 0 1 4 ! 5 7 ; 2 / 6 8 •* **Cursor Modes:** *Home, Backspace, Horizontal Tab, Line Feed, Vertical Tab, Carriage Return. Two special cursor sequences are provided for absolute and relative X-Y cursor addressing* • **Cursor Control:** *Erase, End of Line, Erase of Screen, Form Feed, Delete* • **Monitor Operation:** *50 or 60Hz (jumper selectable.*

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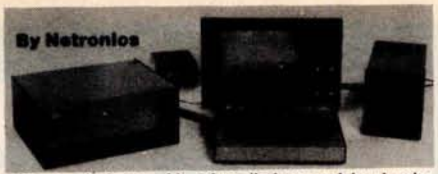

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Hex Keypad/Display Specifications

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or:

$$t_d = \frac{1}{4f} + \frac{1}{2\pi f} \arcsin\left(\frac{V_{min}}{V_{max}}\right) \quad (4)$$

After substituting for t_d and V_r in equation 3, the final cookbook formula given in equation 1 is obtained.

Design Example

As an example, suppose that a microcomputer board requires a 5 V supply to deliver 3 A. Assume that V_{max} under the worst-case conditions is found to be 14.8 V and that the integrated circuit voltage regulator requirements set V_{min} to be 8.0 V. (The values for V_{max}, V_{min}, and i_{max} were taken from chapter 8, page 9 of the *Voltage Regulator Handbook* by National Semiconductor. The value calculated in the handbook was 2400 μF.)

$$C_{min} = \frac{3\text{ A}\left[\frac{1}{4(60\text{ Hz})} + \frac{1}{2\pi(60\text{ Hz})} \arcsin\left(\frac{8.0\text{ V}}{14.8\text{ V}}\right)\right]}{14.8\text{ V} - 8.0\text{ V}}$$

therefore:

$$C_{min} = 2500\mu\text{F}$$

Some Dangers to Watch Out For

In all of the discussion so far, it has been assumed that the capacitor can tolerate any ripple voltage. This is simply not so. Ripple voltages cause the capacitor to heat up inside. If the ripple voltage is too high, the capacitor can become too hot and explode. The value of V_{max} may have to be decreased to meet capacitor ripple voltage requirements. Consult the manufacturer's specifications for the capacitor's maximum ripple voltages and/or currents. Also, carefully check the tolerances for the value of the capacitor.

Also, care must be taken not to choose too high a value of V_{max}. Transformer-winding resistance, diode-voltage drops, diode capacitance, and low power-line voltage are some of the factors that must be considered when choosing the value of V_{max}. Setting V_{max} too high will result in C_{min} being too small.

Conclusion

Use of the formula is a fast and accurate method of finding filter capacitor values. Careful choice of V_{max}, V_{min}, i_{max}, and quality components will produce a power supply which will provide good performance. ■

The author wishes to thank Mr Scott Eanes of Hewlett-Packard for his assistance in producing the graphs for this article.

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A Graphics Text Editor for Music

Part 1: Structure of the Editor

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Apt 121
Torrance CA 90504

This two-part article describes the design of a musical text editor which could be implemented on a home computer graphics system. It is intended to be an overview of the basic design (part 1), along with the essential algorithms (part 2). A complete description of the system would take too much space. The editor allows a user to input a score of music and make corrections or modifications to it. The program stores the score, alters it according to the commands of the user, and displays the music on a graphics screen. All formatting, staffing and arranging of the score on the screen is done automatically by the program. Using the editor requires no special skills or knowledge. Before discussing the editor, it might be helpful to review musical notation.

Musical Notation

Written music is one of the most complex languages that man has invented. Its notation rivals mathematics in the diversity of its symbols and the richness of its expression. I can only hope to provide those readers not familiar with reading music with an appreciation of the problems that must be solved by the editor in storing and displaying this complex language. During the following discussion the reader should consult the accompanying tables and figures.

A score of music consists of a sequence of pages much like a book. A page contains several staffs, each consisting of five parallel horizontal lines stacked on the page. These are called lines of music; at the beginning of each is a clef sign to signify the pitch values of each line of the staff, a key signature which denotes any of twelve major keys that the music can be written in, and a time signature consisting of two numerals, one placed on top of the other, much like a fraction. The upper numeral denotes the number of beats in each measure (to be presently defined) and the lower numeral denotes which note value is to be used as the value of one beat. The rest of the line consists of a sequence of measures separated by bar lines, which are vertical lines on the staff. The number of measures in each line depends only upon the demands of readability. Some measures occupy more space than others, but all of the bar lines at the end of each line are arranged to line up in the same manner as the right margins on a page of written text (a process called *right justification*). The contents of the measures consist of notes, rests, and other symbols.

Each note consists of an oval area which is either filled in with ink or left empty, and a stem, which is a straight line segment. Associated with each note is a pitch and a duration. The pitch is indicated by the clef and the note's vertical displacement on the staff — the higher up the staff, the higher the pitch. Notes that have a higher pitch than the top line of the staff would indicate are positioned on small lines (called ledger lines). The ledger lines are a temporary continuation of the main staff lines. One can thus think of the staff as being many parallel lines, of which only five are shown.

The time duration in which a given note is to sound is determined by the intrinsic relative value given to its symbol, the time signature of the particular piece of music, and the tempo indicated. To simplify the discussion here, assume that a quarter note has a

About the Author
Randolph Nelson has a background both in music and in computer science. He studied clarinet for 15 years, and wavered between the two fields before deciding to complete a master's degree in computer work. Now he is studying for a PhD in computer communication networks at UCLA.

value of one beat (ie: that the lower numeral in the time signature is 4), and relative beat values will be given according to this standard.

Often a small dot is placed after a note. This increases the time value of the note by half of its original value. Dot placement may be done recursively; two dots increase the value by 3/4, three dots by 7/8, etc.

When notes with flags (eighth, sixteenth, and smaller values) occur adjacently, they are often grouped together by changing the flags into a roughly horizontal bar or bars, which connect the stems of the notes. These bars are properly called *beams*, or *ligatures*. Each beam represents one flag in determining the time value of the note.

Depending upon whether the note stems are pointing up or down, the beams may be located either above or below the notes. Descriptive terms that I use are as follows: a group of notes connected by a beam is a *beaming group*. Placing the beam above the note heads and stems is overbeaming. Placing the beam below the note heads and stems is underbeaming.

Additional symbols occurring in music are sharps, flats, double sharps, double flats, and natural signs. These may be placed together to indicate a *key signature*, or singly (as *accidentals*) to indicate modification of pitch for a single note. In the latter case, they are placed immediately to the left of the note head, the oval part of the note. (See table 2.)

Rests indicate durations during which no notes in a given part are played (ie: silence). They have a duration which is determined only by their shape, the time signature, and for some types, the number of flags they exhibit. Music abounds in special symbols that are used to indicate the amplitude (ie: volume) of the sound, changes in amplitude, the speed (ie: tempo) of the music, and rhythmic variations. The placement of these symbols often depends upon the context of the music, and for every rule regarding their location there are numerous exceptions.

We do not have space here to discuss all of the details of musical notation. An exhaustive description

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Half Note	2 Beats
Quarter Note	1 Beat
Eighth Note	½ Beat
Sixteenth Note	1/4 Beat
Thirty-second Note	1/8 Beat
Sixty-fourth Note	1/16 Beat

For notes whose duration is not a power of 2, one indicates the value of the note with an integer and proper staffing. For example, to express a rhythm of three notes to one beat one would write:

Similarly, five notes to one-half beat would be:

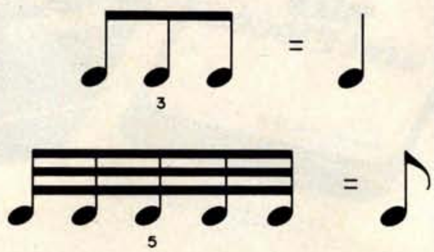

Table 1: *The most common musical notes and their duration in beats, where a quarter note equals one beat.*

Figure 1: *Symbols used in musical notation, shown in their natural habitat, the staff. They are as follows:* **a**, *treble or G clef;* **b**, *key signature of two flats (showing key of B flat major or its relative minor key of G minor);* **c**, *time signature (indicating four beats to a measure with the quarter note receiving one beat);* **d**, *bar line;* **e**, *whole note on leger line below staff;* **f**, *whole note on leger lines above staff;* **g**, *bass or F clef;* **h**, *key signature of one sharp (indicating key of G major or E minor);* **i**, *whole note;* **j**, *half note;* **k**, *quarter note;* **l**, *eighth note (with flag);* **m**, *sixteenth note (with two flags);* **n**, *dotted half note (receives 150% of its normal time value);* **o**, *eighth notes (with beam and marked with dots under note head, indicating staccato);* **p**, *sixteenth notes (with double beam);* **q**, *half note with sharp accidental (raising its pitch one semitone) that has a fermata above it (indicating a longer time value with performer discretion);* **r**, *a dotted eighth note followed by a sixteenth note (indicated by a broken beam);* **s**, *a whole rest;* **t**, *a half rest;* **u**, *a quarter rest;* **v**, *an eighth rest;* **w**, *a sixteenth rest.*

may be found in the book *Music Notation: A Manual of Modern Practice* by Gardner Read. Figure 1 shows many of the more common symbols which are used in the editing system.

Basic Problems of the Editor

Now that we have an appreciation for the notation we are trying to computerize, let us approach the basic problems of the editor. There are four main problems to be solved:

- **Input** — How will the user translate the score into a computer readable form?
- **Data Structures** — After the score is entered, what structures will the program use to store the information?
- **Commands** — What commands should be provided for the user to allow ease in editing the score?
- **Output** — How will the internal encoding of the score be finally displayed on the graphics screen?

I will discuss each of these problems in detail and outline the solutions.

Input

All input to a computer consists of a linear sequence of integers. Our problem then consists of finding a way to convert a musical score into such a sequence. The nature of musical notation is two-dimensional, with a horizontal component and, since symbols can be stacked on top of each other, a vertical component. Converting this essentially planar notation into a linear notation is no easy task, and if the user is not to be burdened with a complicated input format, some way must be found to structure the input also to be two-dimensional, and to let an interface program convert the input into integers.

Fortunately there is a specialized hardware unit that allows us to do

Text continued on page 132

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Placement of Symbols

Sharps ♯ Flats ♭ Naturals ♮ Double sharps 𝄪 and double flats 𝄫 are placed immediately to the left of the note:

Dots · , which increase the value of the note by 1/2, are placed to the right of the note.

Tenuto — and staccato · are placed immediately below (overbeamed) or above (underbeamed) the note.

Tie and slur ⌒ are placed above or below the note and occur after any tenuto or staccato.

Accent < is placed above or below the note and occurs after any slur or tie.

Fermata 𝄐 occurs above the note and is placed after any slur or tie.

We thus have the following possible arrangement of symbols for an overbeamed note (underbeamed is analogous).

(sharp, flat, natural, double sharp and flat) ♯.♭.♮.×.𝄫 (dot)

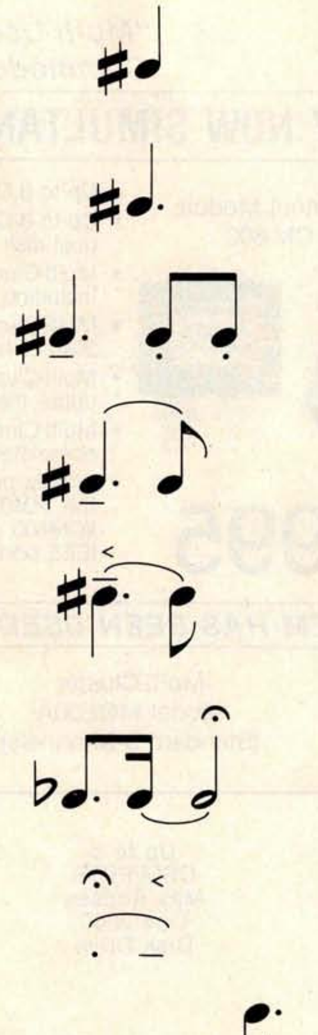


Table 2: *Symbols that modify the meaning of notes are placed in various positions around the notes.*

Text continued from page 128:

this, called a graphics tablet. It consists of a flat board which has sensors placed in a cartesian coordinate system. Using a pen-sized stylus, one of the coordinates from the tablet can be designated by placing the stylus on the board and pressing. A typical way to use the tablet is to prepare a template or menu that is placed over the board. This template is divided into regions, each region representing a different command. If a particular command, say to *edit*, occupies the area bounded by the X coordinate within 100 and 200, and the Y coordinate within 300 and 400, the placement of the pen at the point (150, 310) allows the interface program, with two conditional statements, to ascertain the command to *edit*.

Lest this special hardware unit dissuade the reader from continuing, I might add that there are a number of excellent data tablets on the market whose prices are far below previous commercial models. One of these is the Summagraphics Bit Pad, which offers an 11-inch (29 cm) square coordinate system with a possible resolution of 0.1 mm. This means that the pad can distinguish between placements of the stylus that are only 0.1 mm apart. The capabilities of this unit far surpass our needs here.

Let us now look at a subset of the template for the editor (see figure 2). The template consists of two main areas: the first contains the commands and symbols that will be used, and the second contains a staff on which the notes and symbols of the score are placed. A program which

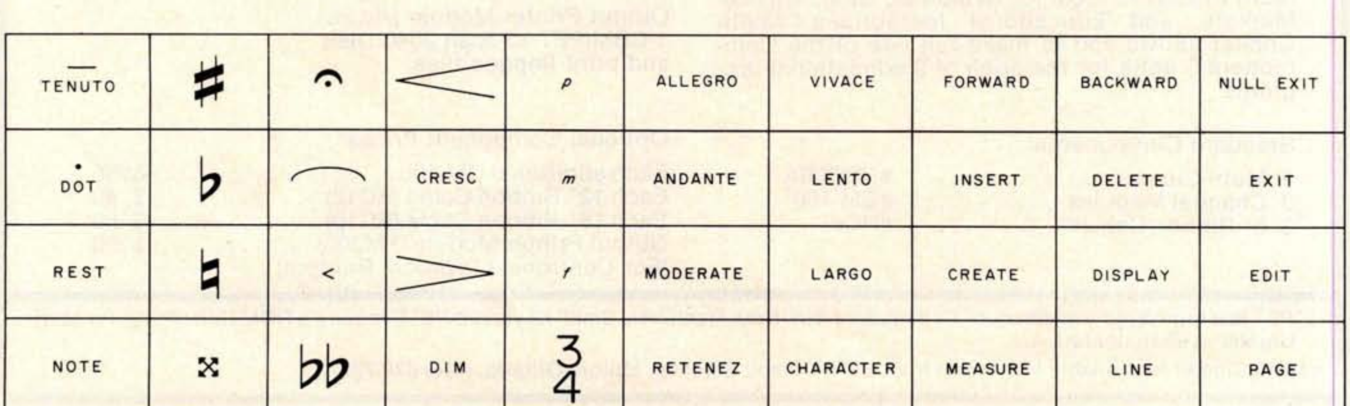


Figure 2: *Musical template for the editor. The software music editor described in the article uses a data entry tablet with a pen for entering musical symbols. The top of the template contains the commands and symbols recognized by the editor, and the bottom is a musical staff on which the notes and symbols are placed. A program acting as the interface between the output of the tablet and the input to the editor reads the placement of the stylus, converts this into a set of commands, and sends them to the editor in the computer.*

acts as the interface between the output of the tablet and the input to the editor reads the placement of the stylus, converts this into an internal code, and encodes a set of commands that it will eventually send to the editor. This interface program also handles the sorting and placement of all symbols, thus alleviating the user from the left-right horizontal input of the score.

The following is the procedure for entering a typical musical score (see figure 3) into the computer:

1. Touch the stylus to the treble clef sign of the template. This tells the program that the measure being created starts with a clef.
2. Touch the appropriate position for key signature placement.
3. Touch the time signature command, as appropriate.
4. Touch the note symbol. This tells the interface that the input of notes now begins. Everywhere the pen is touched on the staff is a place for a note until a future command is activated.
5. Touch the staff in the correct places for the notes indicating both time (the horizontal distance using the notes on the template as a guide) and pitch (the vertical placement on the staff).
6. Touch the sharp sign and touch the note that is to receive it as an accidental.
7. Touch the f, mp, and mf signs, and touch the staff in the correct places.
8. Touch the crescendo sign and the first and last points that bound its range.

Whole rest	4 Beats
Half rest	2 Beats
Quarter rest	1 Beat
Eighth rest	1/2 Beat
Sixteenth rest	1/4 Beat
Thirty-second rest	1/8 Beat
Sixty-fourth rest	1/16 Beat

Table 3: *Rests and their values.*

Crescendo (getting louder)
Diminuendo (getting softer)
Soft *p* Loud *f* Medium *m* and all combinations ie: *mp*, medium soft
Numerous others and written text usually in italics.

Table 4: *Other symbols.*

9. Touch the diminuendo sign and the first and last points that bound its range.
10. Touch the bar line at the end of the staff to indicate the end of a measure.

The Data Structures

There are four main data areas in the editor, each with different formats and methods of access:

1. The score area. In this area is the computer version of the score, which is divided into four main sections: character, measure, line, and page information. Access can be made to any of these four sections.
2. The screen area. Data here consists of codes that allow the computer to easily display the score on the screen. Each of these codes causes the machine to draw or point to a different spot of the graphics screen or invoke a routine to draw a symbol. There is a mapping program that takes a measure in score-area format and converts it into screen-area format.
3. The work area. When a measure is being edited, it is brought into the work area from the score area and the screen area. All changes to the characters occur in the work area. There is a mapping from the screen (ie: where the user does the editing) to the work area, so that any changes made appear in both places. After editing, the new measure is put into a free location determined by the free storage routines, and the score and screen areas are adjusted accordingly.
4. The free area. These areas record the locations and lengths of free storage area in the score and screen areas. Storage routines access this area to determine the locations of the measures in each of the score and screen areas.

Whenever the user writes a program, the commitment to the actual form of the data should be postponed until the last moment. The methods

Figure 3: *Section of a typical musical score. The procedure for entering it into the computer by use of the graphics tablet is explained in the text.*

of access should be specified in detail before deciding on the actual structure of the information. Once the form is decided, the structures should be accessed only through routines that may be called from the procedures of the program. This design method is called *encapsulating the data*. Its use is essential if you anticipate modifications or changes to the way the information is stored.

The editor has a two-level encapsulation scheme. The first level consists of primitive data operations that manipulate the actual data of the score, screen, work, and free areas. References to the actual data can be made only through these primitive routines, and it is only for these routines that the actual form of the data is important. For example, the score area is divided into four types of data manipulation. Routines for character, measure, line, and page manipulation are provided. All of the primitive routines for manipulating characters of a measure are listed below:

GETFCH (Get forward character) This routine increments a pointer so that it points to the next character of the measure.

PUTFCH (Put forward character) This routine inserts information about a new character after the current pointer.

KILLCH (Kill character) This routine deletes the character presently pointed to. The pointer points to the next character.

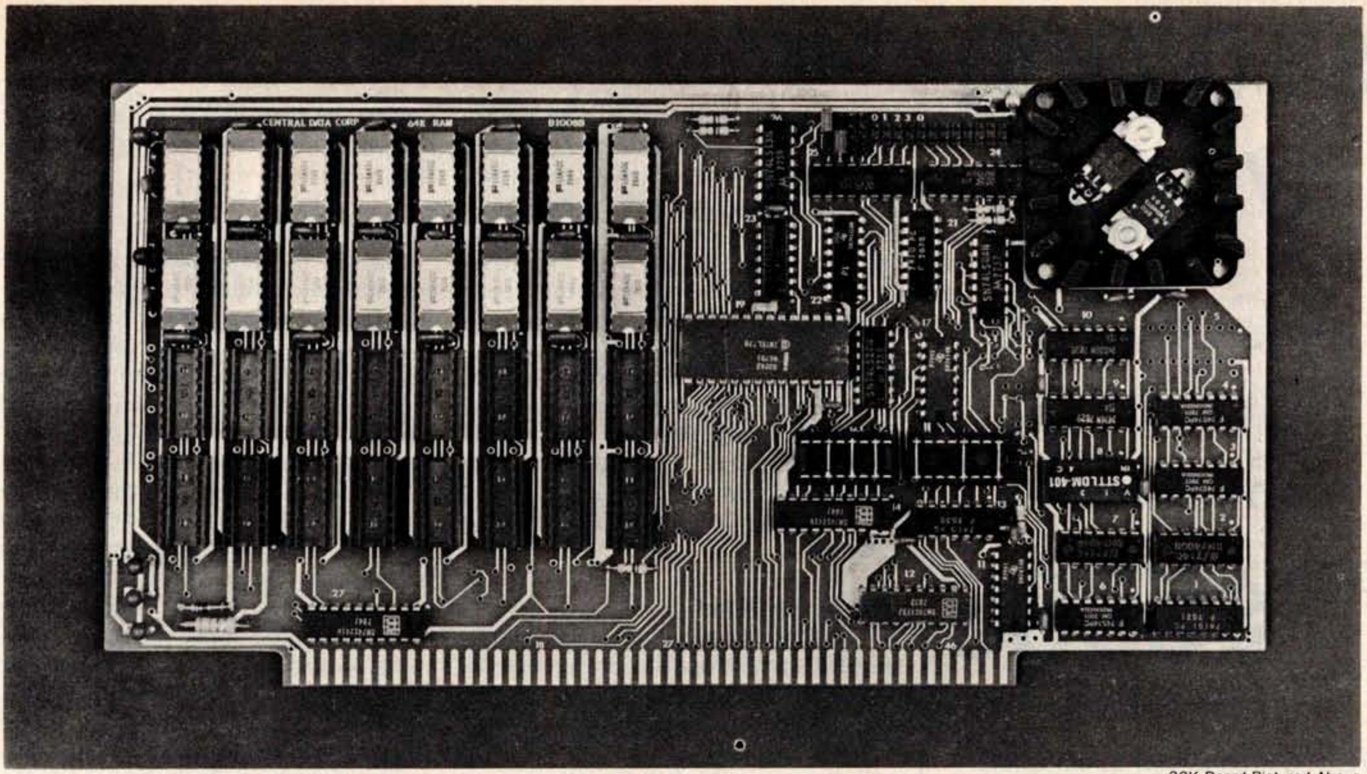
GETPCH (Get previous character) This routine moves the pointer so that it points to the previous character. GETPCH is the opposite of GETFCH.

PUTPCH (Put previous character) This routine inserts a new character before the current pointer. PUTPCH is the opposite of PUTFCH.

These are the only routines which reference characters of the score area; all character manipulations must be done via these primitives. For example, if the user wishes to edit measure 5, the editor must first transfer the contents of measure 5 to the work area. The routine MOVMSR, which is in the second level of encapsulation, performs this task by making calls to the primitive routines GETFCH and PUTWRK. PUTWRK is a primitive routine for the work area that takes a character and inserts it after the current work pointer. MOVMSR, like all routines in the second level, consists of a sequence of calls to the primitive routines of the first level. It would appear something like:

1. IF at end of measure THEN exit
2. GETFCH
3. PUTWRK
4. GO TO 1

There are about 50 first-level primitive routines, most of which are only a few lines of code, and about 150 second-level routines in the editor. Any changes to the structure of the data (eg: changing the way the score is stored from a set of arrays to a tree) influences only a subset of the



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50 primitive routines. Nothing has to be altered in the second-level routines nor in the procedures that call them. Thus, changing the form of the data is a relatively easy task. Each data structure area has its own primitive and second-level routines that perform all manipulations on them.

Let me now discuss the actual data structures which I chose to use. Since I was designing the project using the FORTRAN language, arrays were a natural choice. For clarity, the packed arrays are separated into single arrays containing one integer each.

The Score Area

The score area consists of four sets of arrays which are linked together as a doubly-linked list. This structure allows easy determination of the location of any measure in the score. I will discuss each of these arrays.

1. The Page Array

The page array contains a pointer (index) to the first line of that page. Figure 4 shows that the first page starts with line one (always the case) and the second page starts with the fifth line. Since the number of lines per page is determined when the user specifies the size of the staff, you might think that the array could be eliminated with a simple division. In the actual design, however, the page array also contains information used to determine if the page had been edited, and would thus need to be reformatted. It is included here for clarity.

2. The Line Array

Each line contains a pointer to the page that it belongs to and also to its first measure. Also contained is the scale factor for the line, which will be used when displaying the line on the screen. Later we will show the algorithm for calculating this factor and its use. Figure 4 shows that the fifth line belongs to the second page, that it starts with the fourteenth measure, and that it has a scale factor of 1.01.

3. The Measure Array

The measure array contains three pointers. One points back to the line array, one to the first character of the measure in the character array, and one to the first character that will be drawn on the screen in the screen array.

4. The Character Array

All of the information about the measure is contained in these arrays. The first two elements of these arrays are a pointer back to the measure array and the virtual length of the measure (later to be defined and calculated). The rest of the array contains codes and integers that identify the symbol, its X and Y location coordinates, and its duration (if it is a note or rest). Note that the ordering of the measures in the character array is not necessarily sequential. The example shows that the third measure, locations 35 thru 60, comes between the first, 1 thru 20, and the second, 101 thru 150. The reasons for this will be clear when the free area is discussed.

The doubly linked nature of the data allows you to easily answer questions concerning the location of pages, lines, and measures. For example, the page and line that contain measure 15 can be determined by tracing the pointers in measure 15 to line 5, and tracing the pointer in line 5 to page 2. It is clear that all such questions can be answered in this manner. I will show the use of this feature when I discuss the commands of the editor.

The Screen Area

The screen array contains information used when the score is displayed on the screen. Remember that the measure array contains a pointer to the screen area which identifies the screen locations containing the characters for that measure. Likewise the screen array contains a pointer to the measure array. The rest of the information in the screen array consists of the X and Y location of a symbol to be drawn on the screen, and a code which denotes the character to be drawn. The editor has a procedure that takes all of the information about one measure in the character array and translates it into the form required by the screen array. The screen array also has a nonsequential placement of measures like the character array.

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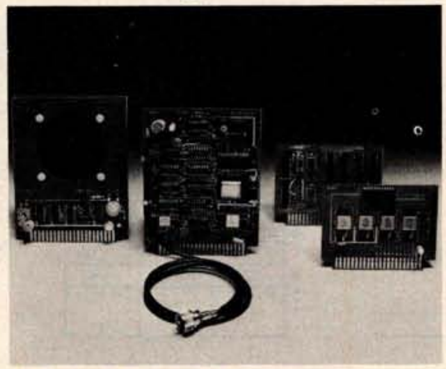

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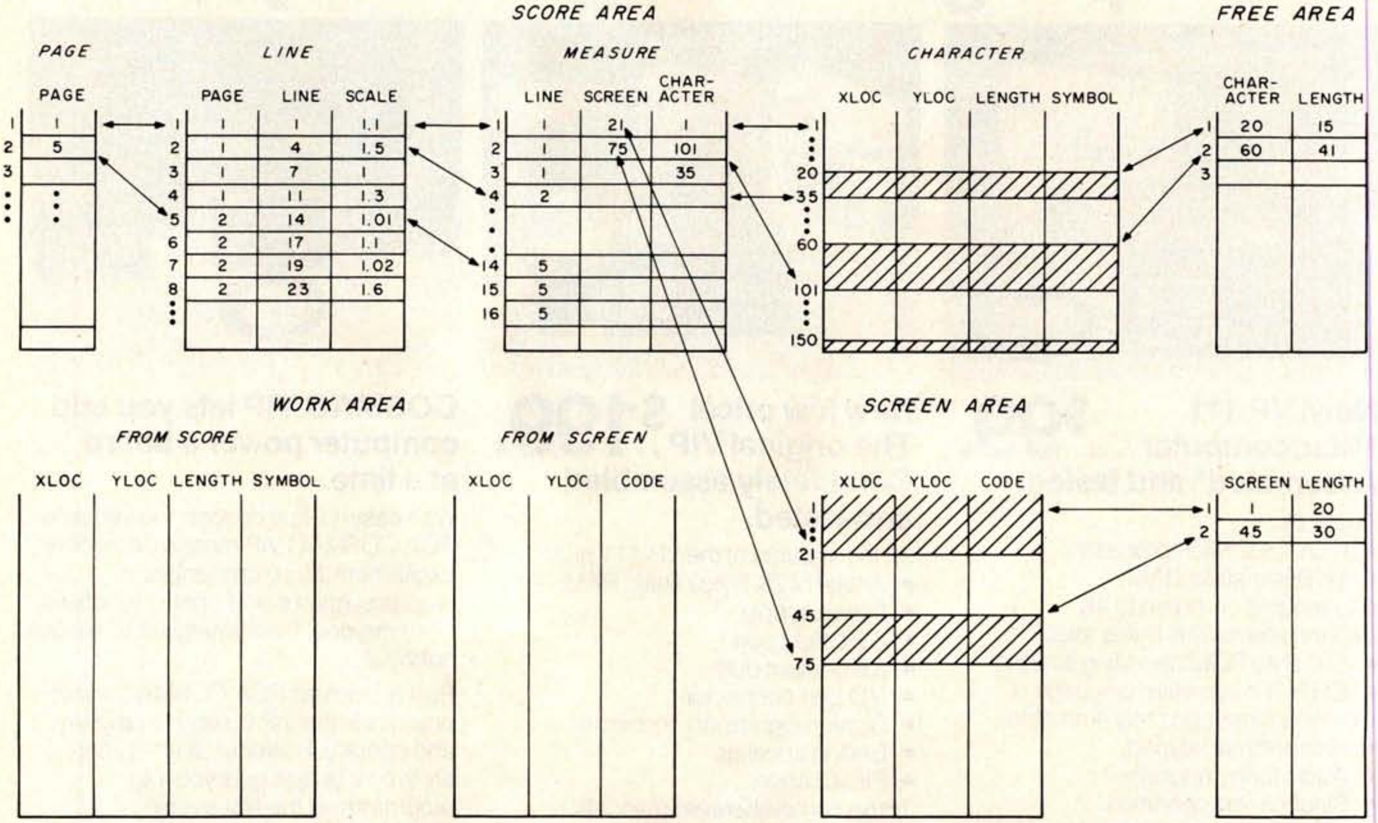

Figure 4: *Data structure within the music editor showing the various areas and pointers used in the system. The score area consists of four arrays linked together as a doubly linked list. This allows the user to determine the location of any measure in the score easily. The work area consists of two sets of arrays. One set contains information from the character arrays. The other set contains information about a measure in screen format. The screen area contains information used when the score is displayed on the screen. The free area contains two sets of arrays used to store measures efficiently in the character array and to consolidate fragmented free areas in storage.*

arrays. One set contains information from the character array about a measure. The format of this information is similar to that of the character arrays. The other set of arrays contains information about a measure in screen format. When editing or creating a measure, the changes are made in the work arrays. Any changes made to the score must be made in the score section of the work area and also in the screen area so that the new measure can be displayed to the user. When the user decides that the measure should be permanent, the contents of the work area must be transferred to the character and screen arrays with all format changes, and the pointers in the measure array must be adjusted. Placement of the new measure in both the character and screen arrays is done with a storage allocation procedure that manages the storage in both of these arrays.

The Free Area

The free area contains two sets of arrays. The first set contains information about the free space in the character array. It contains a pointer to the first free word of storage, and an integer representing the number of words of the free area. Figure 4 shows two free areas in the character arrays (indicated by the darkened areas). One starts at index 20 and contains fifteen words, the other at index 60 with forty-one words. If a measure is created or edited and the user wishes to make it a permanent part of the score, a storage procedure determines the length of the measure in the work area and then scans the free area for a contiguous area of storage that is at least that length. It then transfers the measure from the work area to that location and adjusts the values in the free arrays. The description for the second set of arrays in the free area, those for the free areas of the screen array, is completely analogous. After editing a score for an extended period of time, the character and screen arrays will be fragmented with many areas of space that are too small to be useful. This point is detected by the editor, and the routines that compact the space, leaving only one large area of free storage, are executed automatically.

In part 2 of this article I shall give details of the routines which perform the editing.■

Reference

Read, Gardner. *Music Notation: A Manual of Modern Practice*, second edition, Crescendo Publishing Company, Boston, 1969. ISBN 0-87597-080-X

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System Specifications

CPU	
Microprocessors	Twin Z80A's with 4MHZ Clock Frequency. One Z80A (the host processor) performs all processor and screen related functions. The second Z80A is "down-loaded" by the host to execute disk I/O. When not processing disk data, the second Z80 may be programmed by the host for other processor related functions.
Word Size	8 bits
Execution Time	1.0 microseconds register to register
Machine Instructions	158
Interrupt Mode	All interrupts are vectored.
Floppy Disk	
Storage Capacity **(Shugart drives)**	**285K** total bytes formatted on two double density drives. Optional external 10-300 megabyte hard disk storage is available using optional S-100 bus adaptor.
Data Transfer Rate	250K bits/second
Average Access Time	250 milliseconds. 35 milliseconds track-to-track
Media	5 1/4 inch mini-disk
Disk Rotation	300 RPM
Internal Memory	
Dynamic RAM	32K bytes dynamic RAM (standard) 32K memory upgrade available.
Static RAM	256 bytes of static RAM is provided in addition to the main processor RAM. This memory is used for program and/or data storage for the auxiliary processor.
ROM Storage	1K bytes standard. Allows ROM "bootstrapping" of system at power-on. ROM storage is 2708 compatible and may be reprogrammed by the user for custom applications.
CRT	
Display Size	12-inch, dynamically focused. P4 phosphor.
Display Format	25 lines x 80 characters per line.
Character Font	8 x 8 character matrix on a 8 x 12 character field
Line Drawing Characters	Eleven special graphics symbols used for form generation.
Display Presentation	Light characters on a dark background. Reversible through keyboard/program selection.
Bandwidth	20 MHZ.
Cursor	Reversed image (block cursor)
Communications	
Screen Data Transfer	Memory-mapped at 38 kilobaud. Serial transmission of data at rates up to 9600 bps.
Auxiliary Interface	Universal RS-232 asynchronous. Synchronous interface optional.
Parallel Interface	Radio Shack TRS-80 compatible.
S-100 Bus	Printed circuit edge connector provided for connection of optional S-100 bus adaptor.
Transparent Mode	Enables display of all incoming and outgoing control codes.
Parity	Choice of even, odd, marking, or spacing.
Transmission Mode	Half or Full Duplex. One or two stop bits.
Addressable Cursor	Direct positioning by either discrete or absolute addressing.
System Utilities	
Disk Operating System	CP/M
DOS Software	An 8080 disk assembler, debugger, text editor and file handling utilities.
Optional Software	
FORTRAN	ANSI standard. Relocatable, random and sequential disk access.
COBOL	ANSI standard. Relocatable, sequential, relative and indexed disk access.
BASIC	Sequential and random disk access. Full string manipulation, interpreter.
Application Packages	Extensive software development tools are available including software for the following applications: Payroll, Accounts Receivable, Accounts Payable, Inventory Control, General Ledger and Word Processing.
Keyboard	
Alphanumeric Character	Generates all 128 upper and lower case ASCII characters.
Special Features	N-Key Rollover, Automatic repeat (at 15 CPS), Keyboard lock/unlock.
Numeric Pad	0-9, decimal point, comma, minus and four user-programmable function keys.
Special Functions Keys	Up to 64 user-defined two-key function sequences.
Cursor Control	Up, down, forward, backward, and home.
Internal Construction	
Cabinetry	Structural foam
Component Layout	Two board modular design. All processor related functions and hardware are on a single printed circuit board. All video and power related circuits on a separate single board. These two boards are interconnected via a single 22-pin ribbon cable.
Mounting	CRT and two circuit boards mounted to base. CRT in a rigid steel frame. Disk Drive assembly mounted into upper cover for ease of servicing.
Environment	
Weight	Approximately 45 pounds
Physical Dimensions	14 [illegible]" (H) x 21 [illegible] (W) x 23 [illegible] (D)
Environment	Operating: 0° to 50° C Storage: 0° to 85° C, 10 to 95% rel. humidity - non condensing.
Power Requirements	115 VAC, 60 HZ, 1 AMP (optional 230VAC/50HZ model available)

*Specifications subject to change without notice

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The Great Race and Micro Disk Files

Horse Race Simulations

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Middle Village NY 11379

The purpose of this article is to present a sophisticated horse racing game and to demonstrate the use of sequential and random access disk files. The first part of the article will describe the racing simulation, while the second part will detail the implementation of disk files, including the computer time required for certain operations. In addition, the second part will illustrate how the horse racing model can be utilized without using disk files, while limiting the memory requirements.

The Race game was written in North Star BASIC for a system having an 8080 processor, a video terminal, and 32 K bytes of memory. The program contains numerous subroutines, and memory can be saved by eliminating some of them. However, each deletion of a subroutine will also cause the loss of one of the game's features.

Listing 1 shows the available free memory (19,756 bytes) after loading BASIC and before program RACE is entered. Once RACE is entered and the RUN command is typed, the computer begins to solicit information that is necessary for the program's execution. A random number (the sample shows 7 being input) and the number of horses in the simulation are requested. The number of horses can range anywhere from one to forty. However, a minimum of four horses is necessary to simulate the running of most races. In addition, the program always uses an even number of horses. Therefore, all odd numbered responses are incremented by 1. The next entry is for the file name containing the data. RACE-D is input for the sample run (the setup of this file and the file structure will be discussed later).

All of the preliminary data is now input and the user is ready to choose any one of four possible actions: 0 to end, 1 for a list of horses, 2 for statistics, or 3 to run a race. In listing 1, a "1" is input. This causes the free memory space to be printed (now only 3726 bytes, telling us that the program is already occupying 16,030 bytes of memory), along with a list of the horses. An identification number, name, races run, races won, races placed second, races finished third and dollars earned is printed for each horse. All results in the sample are zero because we started with a blank file: RACE-D.

After printing the requested data, the computer branches back to the action code selection area. This time a race is the desired action and a "3" is input. The computer prints the six types of races that can be run, the possible distances (six to twelve furlongs with a furlong equaling ⅛ of a mile), and the maximum number of horses: twelve. The minimum number of horses for all types of races is four, except for the condition which corresponds to a workout, in which one horse is the minimum. Historical data is maintained for all races except workouts. The sample input is 4,8,12, corresponding to a maiden race (only horses who have never won a race are eligible) of eight furlongs, with a maximum of twelve horses being entered. The computer then branches to the automatic horse selection portion of the program. This mode is always entered for maiden and conditioned races and can be optionally used for other types of races.

In the automatic mode, the computer selects the horses to be entered into the race. The horses with the highest earnings-per-race ratio between two user-supplied identification numbers are selected. There are two exceptions: in maiden races only nonwinners can be chosen, and for handicap races the horses with the least earnings-per-race ratio are picked. Listing 1 shows the computer asking for the start and end identification numbers for the search and the user supplying "0,8". This response offers only nine possible horses for the race (the horses from identification number 0 to number 8). The program selects all nine horses, since none have ever won, or for that matter entered a race.

A list of the entries is then printed, giving the post positions, names, weights, odds, and historical data. The weights will always be 120 pounds, with the exception of allowance and handicap races where the computer calculates weights to handicap the horses. The odds are given as odds to win against each dollar bet. Therefore, odds of $5 pay $12 for a successful $2 win bet.

At this point the user can decide to

Text continued on page 146

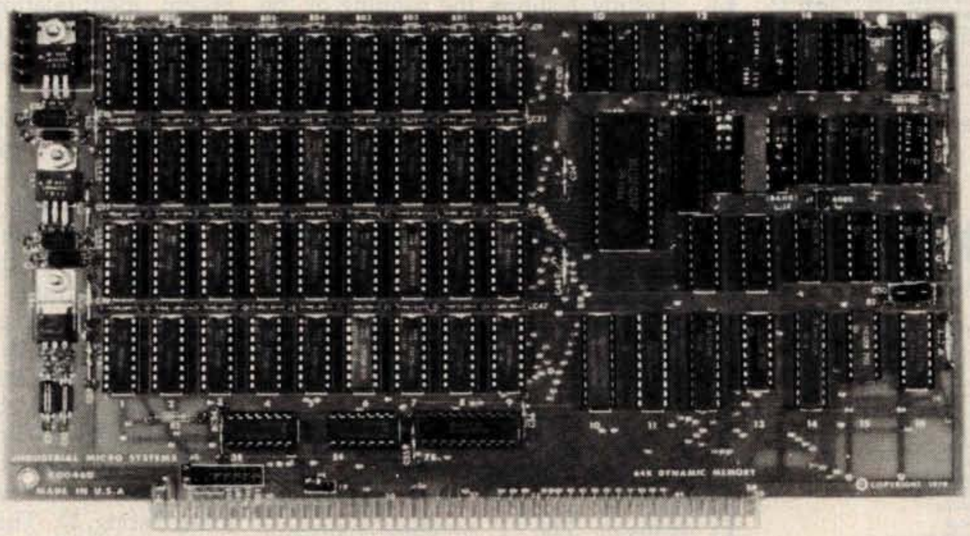
Listing 1: *This listing shows a request first for a list of horses, and then calls to start a race. In response to that request, the user must specify the type of race, the distance, and the number of horses in the race. Finally, the user must provide the start and end point for a search for eligible horses. A list of entries and statistics are then displayed for each horse in the race. Now hit the return key and "They're off!"*

```
!FREE(0)
 19756
READY
LOAD RACE
READY
RUN

RANDOM NUM ? 7
# OF HORSES ? 12
FILE: RACE-D

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 1          3726

ID NAME        R#  1  2  3     $ WON ID NAME        R#  1  2  3      $ WON
==========================================================================
 0 BUCKPASSER  0   0  0  0       $0.  6 SECRETARIT  0   0  0  0        $0.
 1 DAMASCUS--  0   0  0  0       $0.  7 FOOLISH PL  0   0  0  0        $0.
 2 DR FAGER--  0   0  0  0       $0.  8 RUFFIAN---  0   0  0  0        $0.
 3 RIVA RIDGE  0   0  0  0       $0.  9 BOLD RULER  0   0  0  0        $0.
 4 SUE'S GIRL  0   0  0  0       $0. 10 GALLANT MA  0   0  0  0        $0.
 5 FOREGO----  0   0  0  0       $0. 11 ROUND TABL  0   0  0  0        $0.
READY TO RETURN ?

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 3          3669

TYPES ARE 1=STAKES 2=ALLOWANCE 3=CONDITIONED 4=MAIDEN 5=HANDICAP 6=WORKOUT
DISTANCE= 6 TO 12 FURLONGS  MAXIMUM HORSES = 12
TYPE, DISTANCE, HORSES? 4,8,12
ID START & ID END SEARCH ? 0,8
POST  1   RUFFIAN---
POST  2   FOOLISH PL
POST  3   SECRETARIT
POST  4   FOREGO----
POST  5   SUE'S GIRL
POST  6   RIVA RIDGE
POST  7   DR FAGER--
POST  8   DAMASCUS--
POST  9   BUCKPASSER

THIS IS A 8 FURLONG MAIDEN   RACE WITH A PURSE OF $ 31000

POST NAME         WGH    ODDS  R# 1ST 2ND 3RD   EARNINGS
=============================================================
   1 RUFFIAN---  120    $5.00   0   0   0   0          $0.
   2 FOOLISH PL  120   $16.40   0   0   0   0          $0.
   3 SECRETARIT  120    $4.00   0   0   0   0          $0.
   4 FOREGO----  120    $5.80   0   0   0   0          $0.
   5 SUE'S GIRL  120   $68.60   0   0   0   0          $0.
   6 RIVA RIDGE  120    $5.00   0   0   0   0          $0.
   7 DR FAGER--  120    $4.00   0   0   0   0          $0.
   8 DAMASCUS--  120    $8.80   0   0   0   0          $0.
   9 BUCKPASSER  120    $5.80   0   0   0   0          $0.

RETURN FOR RACE OR ANYTHING TO KILL ?
```

Listing 2: *The running of the first race. The : markings on the track indicate the furlong divisions. The I markings form the finish line. The results below the track are printed upon completion of the race, then the newly created data is stored on file RACE-D.*

```
            :...........:...........:...........:...........:6....
          ..:...........:...........:...........:...........:5......
        ....:...........:...........8...........:...........:4........
      ......:...........:...........7...........:...........:39.........
      ......4...........:..........26.9.........:...........:28.........
      ....6392..5.......:..........13.45........:...........:17.........
      ....87                                                      ......
    ....1                                                           ......
  ......                                                              ......
......              DAMASCUS--(# 8)     RUFFIAN---(# 1)                 ::::::
......              SECRETARIT(# 3)     FOOLISH PL(# 2)                 ......
......              FOREGO----(# 4)     SUE'S GIRL(# 5)                 ......
......              BUCKPASSER(# 9)                                     ......
......              DR FAGER--(# 7)                                     ......
::::::              RIVA RIDGE(# 6)                                     ......
  ......                                                              ......
    ......                                                          ......
      ......                                                      ......
      .........2.4961........:...........I17..3......:...........:......
      .........5.:..8........:...........569..8......:...........:......
      ...........:..3........:...........2.4.........:...........:......
        .........:..7........:...........I...........:...........:....
          .......:...........:...........I...........:...........:..
            .....:...........:...........I...........:...........:?


ID NAME        WT  F  S  H  S  F BY  L M:SS.F    ODDS
=====================================================
 1 DAMASCUS-- 120  8  3  3  3  1 BY  0 1:33.2    8.80
 6 SECRETARIT 120  3  6  4  2  2 BY  0 1:33.2    4.00
 5 FOREGO---- 120  4  8  6  7  3 BY  3 1:34.0    5.80
 0 BUCKPASSER 120  9  7  7  6  4 BY  3 1:34.0    5.80
 2 DR FAGER-- 120  7  4  5  1  5 BY  3 1:34.0    4.00
 3 RIVA RIDGE 120  6  5  2  5  6 BY  4 1:34.1    5.00
 8 RUFFIAN--- 120  1  2  1  4  7 BY  4 1:34.1    5.00
 7 FOOLISH PL 120  2  1  8  9  8 BY  5 1:34.2   16.40
 4 SUE'S GIRL 120  5  9  9  8  9 BY  5 1:34.2   68.60

POST      WIN   PLACE      SHOW
   8   $19.60  $10.80     $3.40
   3            $6.00     $2.80
   4                      $3.00

READY?


1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 0        3453
READY
```

The Dynamic RAM...



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Text continued from page 142:

run the race as described by entering a carriage return, or can abort the race by typing anything before the carriage return is transmitted. If the race is not run, the program branches back to the action code selection.

Listing 2 shows the running of the race. A screen depicting the race is printed at various points. The number of screens printed for each race equals:

$$1 + \frac{(\text{distance in furlongs} + 1)}{2}$$

All fractions are truncated. The display was set up for use on a 24-line by 80-character terminal. Best results are obtained when running at 19,200 bps, causing the display to appear rapidly. For the sample run, the program was edited to show the track display only once, and to print all positions that would have been printed in the five individual displays. The "I" symbols represent the finish line and the ":" symbols indicate furlong markers.

The upper-righthand portion of the display represents the horses at the start of the race. If the markers are counted, you can see that the horses (depicted by numbers) are eight furlongs from the finish line. In the center of the track the horses are listed by name and post position, in order of finish. During the race, the display prints the names in racing order (first horse, second, third, etc). If twelve horses race, post positions 10 to 12 are represented by 0, A, and B, respectively. After the last display of the track is printed, a "?" appears. Any input or a return will cause the program to print the chart of the race.

The chart of the race is similar to newspaper reports that describe actual races. This chart shows the identification number, name, weight carried, post position, position at the start, half, stretch and finish, length behind the winner, and time and odds for each horse that participated in the running of the race. This is followed by the win, place, and show payoffs for the three horses finishing third or better. The computer asks if you are finished with this display by printing READY ?. Any input branches the program to the action code selection. Here a "0" is entered to end the race, and the program completes its execution by writing the newly created data to file RACE-D.

Listing 3 shows a second running of the program using the same data file: RACE-D. Here a maiden race is again selected, but the search covers all twelve identification numbers (0 to 11). This time every horse is selected except identification 1, Damascus, the winner of the first race shown. Rather than run this race, the word "kill" is entered.

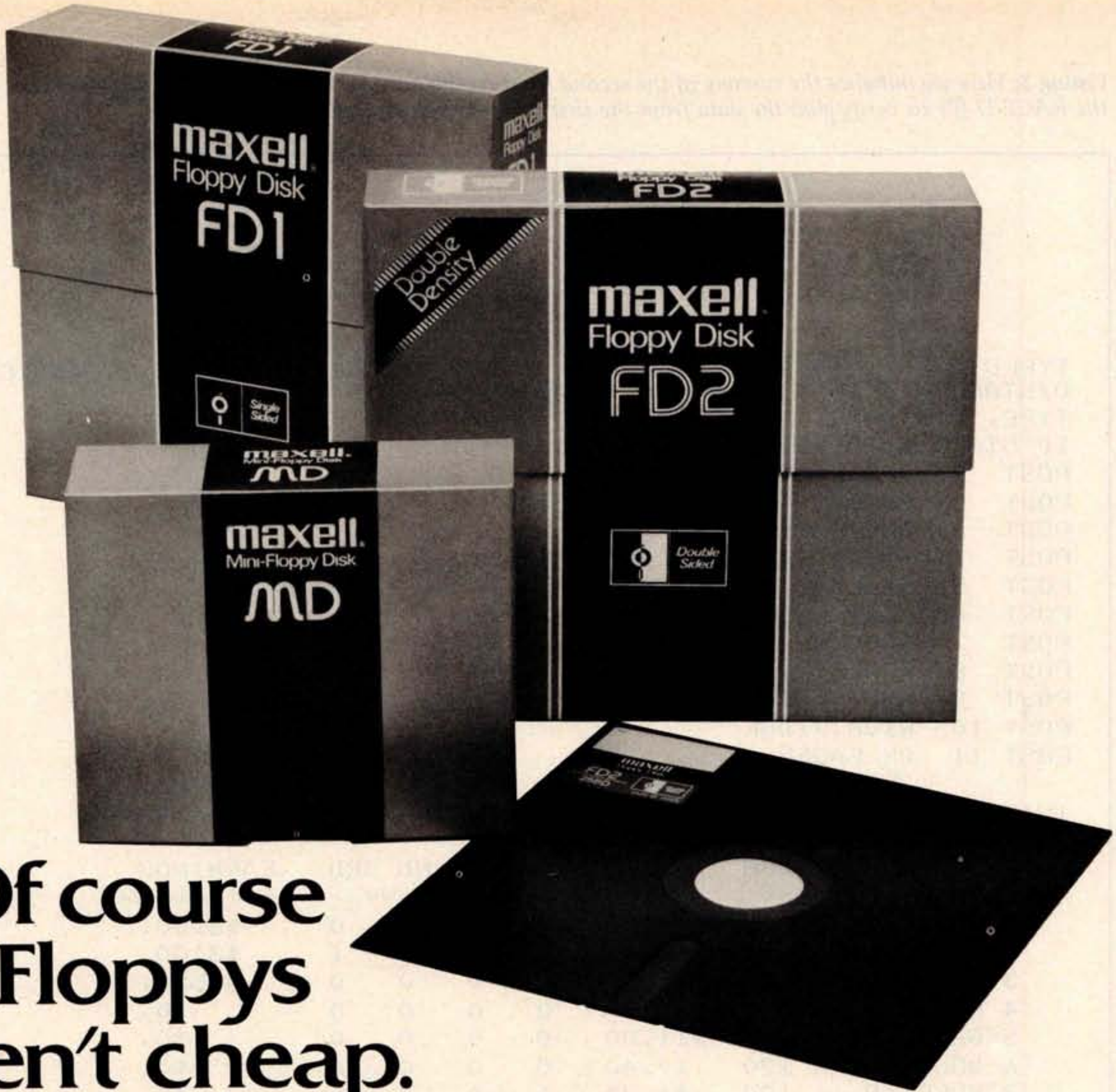
A "1" is selected as the next action code, and a list of the horses is again printed. This time, historical data is on file and is displayed.

Listing 4 shows the input for a conditioned race. For this type of race, a maximum earnings per race is requested. Only horses earning a particular amount or less per race are eligible to race. The maximum is set at $1000, and the search covers identification numbers 0 to 5. Three horses in the search area meet these conditions (this can be verified by examining listing 3). Therefore, the computer prints: TOO FEW HORSES (four is the minimum) and branches back to the action code selection. This time a handicap race for eight horses is selected and the computer chooses the eight horses who have no earnings.

In listing 5, a stake race is selected. Here, the user can choose between an automatic or a manual selection of horses. "YES" is input in response to the question: YES FOR AUTOMATIC SELECT?, and the program again branches to the automatic selection portion of the program. Again the user decides not to run this particular race. The bottom of this listing shows a stake race being set up without using the automatic selection process. After each post position number is printed, the user supplies a horse's identification number.

At this point, I turned off the printer and ran a number of races. All of the historical information for these races was again stored in file RACE-D. Listing 6 shows program RACE being executed, but this time a more adequate supply of historical data is available. Action code 1 is entered and the list of horses is displayed. Action code 2 is now entered for the first time. This code gives statistics for the individual horses. After the "2" is input, the computer asks: ID#?, and the user supplies the identifica-

Text continued on page 156



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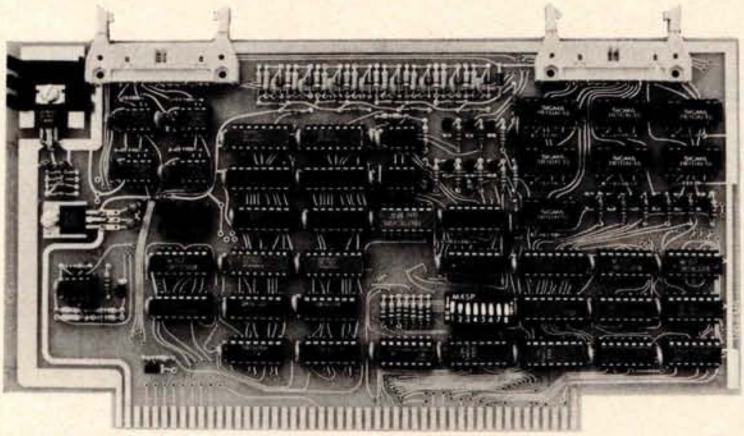
Listing 3: *Here we initialize the running of the second race. At this time we do not begin the race, but check for the current status of the RACE-D file to verify that the data from the first race has been stored.*

```
TYPES ARE 1=STAKES 2=ALLOWANCE 3=CONDITIONED 4=MAIDEN 5=HANDICAP 6=WORKOUT
DISTANCE= 6 TO 12 FURLONGS  MAXIMUM HORSES = 12
TYPE, DISTANCE, HORSES? 4,7,12
ID START & ID END SEARCH ? 0,11
POST  1  SECRETARIT
POST  2  FOREGO-----
POST  3  BUCKPASSER
POST  4  ROUND TABL
POST  5  GALLANT MA
POST  6  BOLD RULER
POST  7  RUFFIAN---
POST  8  FOOLISH PL
POST  9  SUE'S GIRL
POST 10  RIVA RIDGE
POST 11  DR FAGER--

THIS IS A 7 FURLONG MAIDEN   RACE WITH A PURSE OF $ 44000

POST NAME        WGH     ODDS  R# 1ST 2ND 3RD   EARNINGS
===========================================================
   1 SECRETARIT 120   $5.20   1   0   1   0      $6200.
   2 FOREGO---- 120   $7.40   1   0   0   1      $3100.
   3 BUCKPASSER 120   $7.40   1   0   0   0      $1550.
   4 ROUND TABL 120  $11.00   0   0   0   0         $0.
   5 GALLANT MA 120  $11.00   0   0   0   0         $0.
   6 BOLD RULER 120   $7.40   0   0   0   0         $0.
   7 RUFFIAN--- 120   $6.20   1   0   0   0         $0.
   8 FOOLISH PL 120  $20.00   1   0   0   0         $0.
   9 SUE'S GIRL 120  $83.00   1   0   0   0         $0.
  10 RIVA RIDGE 120   $6.20   1   0   0   0         $0.
  11 DR FAGER-- 120   $5.20   1   0   0   0         $0.

RETURN FOR RACE OR ANYTHING TO KILL ? KILL

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 1           3589

ID NAME          R#  1  2  3    $ WON ID NAME          R#  1  2  3    $ WON
============================================================================
 0 BUCKPASSER    1   0  0  0   $1550.  6 SECRETARIT  1  0  1  0  $6200.
 1 DAMASCUS---   1   1  0  0  $20150.  7 FOOLISH PL  1  0  0  0     $0.
 2 DR FAGER--    1   0  0  0      $0.  8 RUFFIAN---  1  0  0  0     $0.
 3 RIVA RIDGE    1   0  0  0      $0.  9 BOLD RULER  0  0  0  0     $0.
 4 SUE'S GIRL    1   0  0  0      $0. 10 GALLANT MA  0  0  0  0     $0.
 5 FOREGO-----   1   0  0  1   $3100. 11 ROUND TABL  0  0  0  0     $0.
READY TO RETURN ?
```

IDS Announces
S-100 Energy Management Module

The 100-EMM Energy Management Module provides temperature measurement at four separate locations indoors or out; monitors eight (8) doors, windows, or fire sensors; controls six external devices via relay or optoislator; and provides an intrusion alarm with battery backup (alarm operates even during primary power outages). Put the 100-EMM to use in your home or business and claim a 30% tax credit for the cost of your S-100 computer system including the 100-EMM. (Purchasing the 100-EMM can actually save you several times its cost in tax credits. Full instructions for filing are included in the 100-EMM manual.)



BUY THIS S-100 BOARD AND GET UP TO A 30% TAX CREDIT BASED ON THE COST OF YOUR COMPUTER SYSTEM!

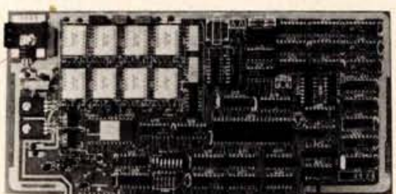
100-EMM Energy Management Module
Assembled and Tested **$395.00**
Kit **$345.00**

Options for 100-EMM:

CP-52 Cable Panel - Terminates two 26-conductor flat cables in 26 screwlugs. Use it for convenient interconnection of the 100-EMM to the "outside world". **$45.00**

CABL-26-STD 26-Conductor Flat Ribbon Cable - Four feet in length with connectors for 100-EMM and CP-52 above. **$35.00** Other lengths available on special order. Add **$1.00** per foot.

OTHER PRODUCTS FROM IDS. The most complete source of S-100 compatible modules for process control, data acquisition, energy management, and data communications.



88-MODEM S-100 ORIGINATE/ANSWER MODEM WITH AUTO-DIALER. Software selectable baudrate provides any baudrate from 66-600 baud. Provides 1.5 stop bits when operated in 5-bit code mode. Auto-answer programs available for CROMEMCO CDOS, CP/M, North Star Horizon and MDS, and Alpha Micro.

Assembled and Tested **$395.00** Kit **$245.00**

88-UFC UNIVERSAL FREQUENCY COUNTER
Four software selected inputs. Measure frequency from O-650 MHz and period from .luS to 1 Second. Extensive software included.

Assembled and Tested **$299.00** Kit **$199.00** Temperature-Compensated Crystal Oscillator option **$145.00**

88-SAI SYNCHRONOUS/ASYNCHRONOUS INTERFACE
The most versatile serial interface on the market. Computer access/control of all data and handshake lines and provision for masked interrupts, inversion of any input or output signal, and onboard baudrate generation for 110, 134.5, 150, 300, 600, 1200, 2400, 4800, 9600, and many other baud rates. Many more features.

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88-SPM TIME OF DAY CLOCK with battery backup. Set the clock with three out instructions: no delays! Programs included in North Star BASIC, CBASIC, and 8080 assembly language.

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88-RCB RELAY CONTROL BOARD
16 Relays on one board. Control appliances, production equipment, or even musical instruments (See BYTE Magazine Sept 1977 page 12)

Assembled and Tested **$299.00** Kit **$199.00**

INTERNATIONAL DATA SYSTEMS, INC.

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Dulles International Airport
Washington, DC 20041
Telephone **(703)661-8442**

Shipping Address:
400 West Service Road, Suite 130
Dulles International Airport
Washington, DC 20041 USA
TELEX 901112 IDS CTLY

Listing 4: *Listing of the input for a conditional race. Only three eligible horses are found in the search, too few for a race, so the computer subsequently prints TOO FEW HORSES. Next a request for the running of a handicapped race is entered. Here the computer selects eight horses who have no earnings.*

```
TYPES ARE 1=STAKES 2=ALLOWANCE 3=CONDITIONED 4=MAIDEN 5=HANDICAP 6=WORKOUT
DISTANCE= 6 TO 12 FURLONGS  MAXIMUM HORSES = 12
TYPE, DISTANCE, HORSES? 3,9,6
MAX $/RACE EARNED ? 1000
ID START & ID END SEARCH ? 0,5
POST  1  SUE'S GIRL
POST  2  RIVA RIDGE
POST  3  DR FAGER--

THIS IS A 9 FURLONG CONDIT.  RACE WITH A PURSE OF $ 17000

POST NAME      WGH    ODDS  R# 1ST 2ND 3RD   EARNINGS
========================================================
   1 SUE'S GIRL 120  $21.20   1   0   0   0        $0.
   2 RIVA RIDGE 120    $.40   1   0   0   0        $0.
   3 DR FAGER-- 120   $1.00   1   0   0   0        $0.

TOO FEW HORSES

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 3           3589

TYPES ARE 1=STAKES 2=ALLOWANCE 3=CONDITIONED 4=MAIDEN 5=HANDICAP 6=WORKOUT
DISTANCE= 6 TO 12 FURLONGS  MAXIMUM HORSES = 12
TYPE, DISTANCE, HORSES? 5,10,8
YES FOR AUTOMATIC SELECT. ? YES
ID START & ID END SEARCH ? 0,11
POST  1  ROUND TABL
POST  2  GALLANT MA
POST  3  BOLD RULER
POST  4  RUFFIAN---
POST  5  FOOLISH FL
POST  6  SUE'S GIRL
POST  7  RIVA RIDGE
POST  8  DR FAGER--

THIS IS A 10 FURLONG HANDICAP RACE WITH A PURSE OF $ 13000

POST NAME      WGH    ODDS  R# 1ST 2ND 3RD   EARNINGS
========================================================
   1 ROUND TABL 120   $4.80   0   0   0   0        $0.
   2 GALLANT MA 120   $3.40   0   0   0   0        $0.
   3 BOLD RULER 120   $8.00   0   0   0   0        $0.
   4 RUFFIAN--- 121   $8.00   1   0   0   0        $0.
   5 FOOLISH FL 119   $4.80   1   0   0   0        $0.
   6 SUE'S GIRL 118   $5.60   1   0   0   0        $0.
   7 RIVA RIDGE 121   $6.00   1   0   0   0        $0.
   8 DR FAGER-- 121   $8.00   1   0   0   0        $0.

RETURN FOR RACE OR ANYTHING TO KILL ?
```

The Place To Buy Computers

CROMEMCO Z-2H HARD DISK

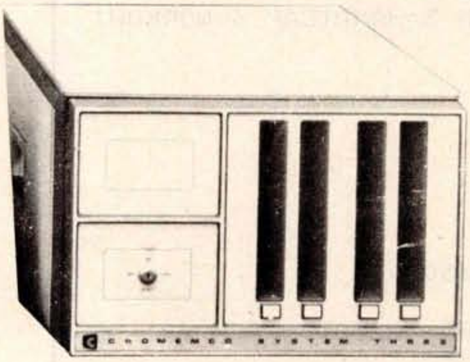
• Full 11-megabyte hard disk system • fast Z80A 4 MHz processor • two floppy disk drives • 64K RAM memory • RS232 special interface • printer interface • extensive software available

List $9995 . . .OUR PRICE ONLY **$8489**

CROMEMCO HDD

11/22 megabyte hard disk for use with existing systems. DMA controller, transfer rate of 5.6 megabytes/sec.

HDD-11, List $6995 . . OUR PRICE $ 5,939
HDD-22, List $11,995 10,189



CROMEMCO SYSTEM 3

— NOW DOUBLE THE CAPACITY! —

Features 4 MHz CPU, 64K of RAM, dual-sided PerSci 299B floppy disk drive (provision for installing a second 299B), RS232C interface, printer interface. All Cromemco systems are assembled and tested, ready to use.

With 64K of RAM, List $6990 ***$5890***

CROMEMCO SYSTEM 2

NOW DOUBLE THE CAPACITY
(with double-sided drives)

With 64K of RAM, two minifloppy disk drives, RS232 interface and printer interface board.

System 2 w/64K RAM, List $3990 . . . . . . $3390

CROMEMCO Z-2

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Z-2W, Assem., List $995 . . . . $845

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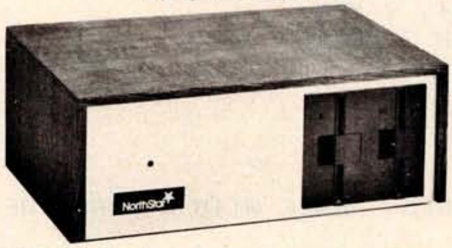
Above prices reflect a 2% cash discount (prepaid prior to shipment). Add 2% to these prices for credit cards, C.O.D., etc. Prices are f.o.b. shipping point. Prices are subject to change and offers subject to withdrawal without notice.

NORTH STAR HORIZON



HORIZON 1 KITS —

32K, Double Density, List $1849 . . 1684
32K, Quad Density, List $2049 . . . 1869

HORIZON 2 KITS —

32K, Double Density, List $2249 . . 2034
32K, Quad Density, List $2629 . . . 2359

Kits incl. 12 edge connectors, 2 serial ports, parallel port and extra drive cable. (Subject to availability and price changes.) Call or write for low prices on assembled units.

VECTOR MZ

Now 64K with Bank Select — Complete Peachtree Business Software Package also available — Call for details.

INTER SYSTEMS

(formerly ITHACA AUDIO)

The new series II CPO Board features a 4 MHz Z-80A CPU and a full feature front panel. 20-slot actively terminated motherboard, with 25-amp power supply (50/60 HZ operation, incl. 68 cfm fan).

DPS-1, List $1495 . . . . . OUR PRICE $1299

SD SYSTEMS

SDS-100, w/32K RAM, $6995. ONLY $5945
SDS-200, List $8995 7645

SUPERBRAIN®

By INTERTEC

Available with 32K, 48K & 64K

Totally self-contained in a single box; 32K, 48K, or 64K Version; Uses two Z-80 CPU's; Commercial-type terminal with 12" monitor (like the Intertube); Dual double-density minifloppies w/360 Kilobytes of storage capacity; I/O ports included; Expandable (if needed) with an external S-100 bus interface; Comes with CP/M™ operating system; extensive software support.

w/32K of RAM, List $2995 . . ONLY $2685
w/64K of RAM $2883

DYNABYTE

48K and 64K models, single and double density, dual mini disk (77 track), standard 8" and dual-sided 8" systems. ***SAVE 15%***

HEATH

WH-89 — All-in-one computer. Features two Z-80's, 16K to 48K. Call or write for prices.

RADIO SHACK TRS-80™

10% OFF

MiniMicroMart, Inc.

1618 James Street, Syracuse NY 13203 (315) 422-4467 TWX 710-541-0431

Circle 86 on inquiry card.

Listing 5: *An illustration of the automatic selection option provided in the running of the stake race. First the automatic selection process is chosen and the computer selects four entries, then the user decides to select each entry individually from the RACE-D file.*

```
TYPES ARE 1=STAKES 2=ALLOWANCE 3=CONDITIONED 4=MAIDEN 5=HANDICAP 6=WORKOUT
DISTANCE= 6 TO 12 FURLONGS  MAXIMUM HORSES = 12
TYPE, DISTANCE, HORSES? 1,6,4
YES FOR AUTOMATIC SELECT. ? YES
ID START & ID END SEARCH ? 0,11
POST  1  DAMASCUS--
POST  2  SECRETARIT
POST  3  FOREGO-----
POST  4  BUCKPASSER

THIS IS A 6 FURLONG STAKES   RACE WITH A PURSE OF $ 36000

POST NAME       WGH    ODDS  R# 1ST 2ND 3RD  EARNINGS
========================================================
   1 DAMASCUS-- 120   $8.00   1   1   0   0   $20150.
   2 SECRETARIT 120    $.60   1   0   1   0    $6200.
   3 FOREGO---- 120   $3.20   1   0   0   1    $3100.
   4 BUCKPASSER 120   $3.20   1   0   0   0    $1550.

RETURN FOR RACE OR ANYTHING TO KILL ? KILL

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 3          3589

TYPES ARE 1=STAKES 2=ALLOWANCE 3=CONDITIONED 4=MAIDEN 5=HANDICAP 6=WORKOUT
DISTANCE= 6 TO 12 FURLONGS  MAXIMUM HORSES = 12
TYPE, DISTANCE, HORSES? 1,6,4
YES FOR AUTOMATIC SELECT. ?
POST   1 ID#? 7
POST   2 ID#? 8
POST   3 ID#? 9
POST   4 ID#? 10

THIS IS A 6 FURLONG STAKES   RACE WITH A PURSE OF $ 35000

POST NAME       WGH    ODDS  R# 1ST 2ND 3RD  EARNINGS
========================================================
   1 FOOLISH PL 120   $9.00   1   0   0   0       $0.
   2 RUFFIAN--- 120    $.60   1   0   0   0       $0.
   3 BOLD RULER 120   $1.60   0   0   0   0       $0.
   4 GALLANT MA 120   $9.00   0   0   0   0       $0.

RETURN FOR RACE OR ANYTHING TO KILL ?
```

TIME after TIME

NEW!

TCU-68 $325
MOTOROLA MICROMODULE BUS Compatible
•Provides year, month, day, hour, minute and second.

BATTERY SUPPORTED CALENDAR CLOCKS

PDP-11*

TCU-100 • $495

- Provides month, day, hour, minute and second.
- Can interrupt on date/time, or periodic intervals.

TCU-150 • $460

- Provides year, month, day, hour, minute and second.
- Automatic leap year.
- Patches for RSX-11M, RT-11 FB/SJ VO2, VO3 and UNIX.

LSI-11/2*

TCU-50D • $325

- Provides month, day, hour, minute and second.
- Dual size board.
- Patches for RT-11 SJ/FB VO2, VO3B.

Lockheed SUE

TCU-200 • $550

- Provides year, month, day, hour, minute, second and milli-second.
- Interval interrupts between 1/1024 seconds and 64 seconds.

Computer Automation (Naked Mini)

TCU-310 • $385

- Provides year, month, day, hour, minute and second.

Multi-Bus**

TCU-410 • $325

- Provides year, month, day, hour, minute and second.
- SBC/BLC compatible.

HP 2100

TCU-2100 • $395

- Correct time restored after power failure.
- Compatible with the HP TBG card.

Serial Clock (RS 232 or 20 mA)

SLC-1 • $640

- Connects between any terminal and host computer.
- Provides date, time and more!

All Digital Pathways TCUs have on board NICAD batteries to maintain time and date during power down. Timing is provided by a crystal controlled oscillator. Prices are U.S. domestic single piece. Quantity discounts available.

For more information on these products, contact:
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Phone: (415) 493-5544

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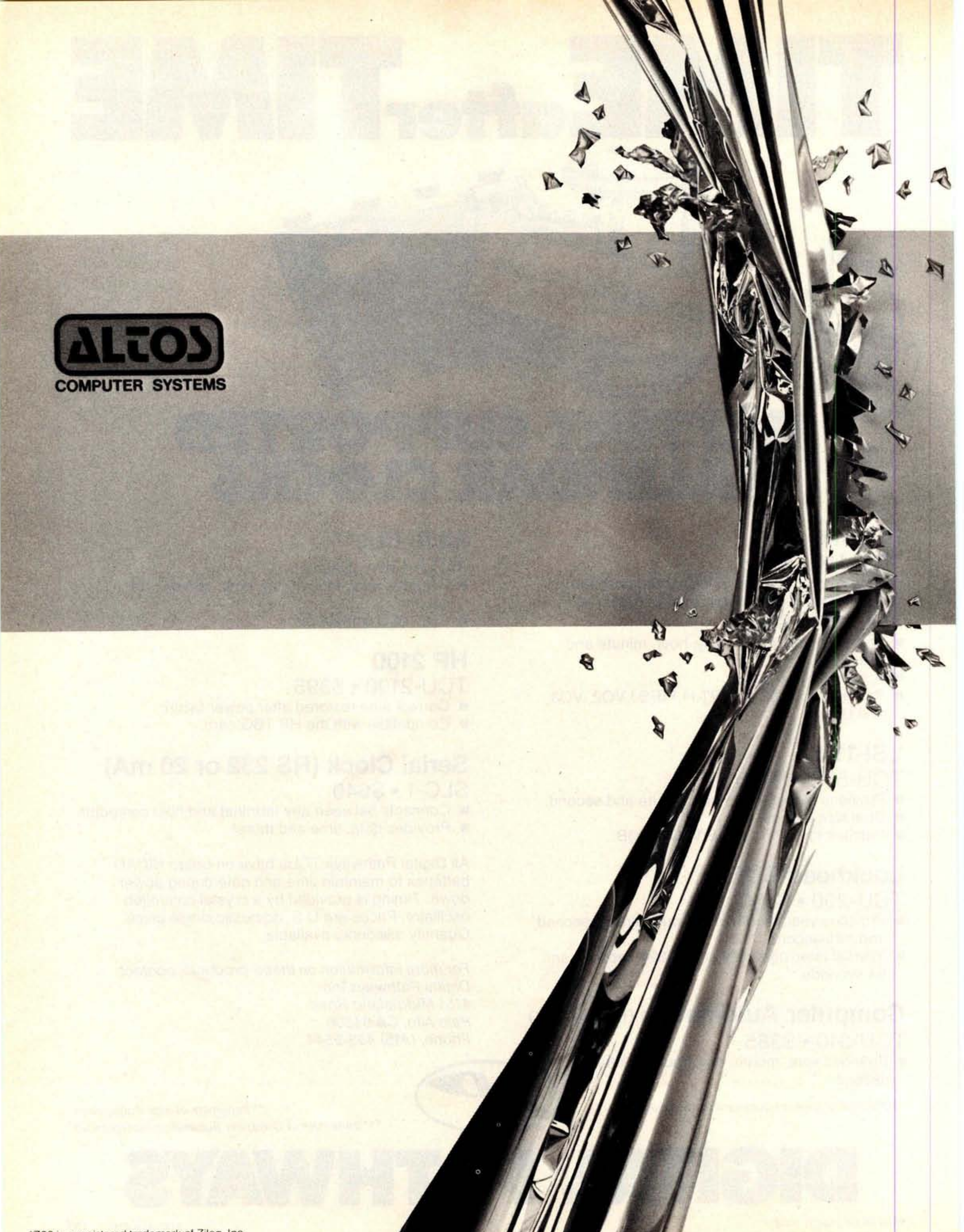
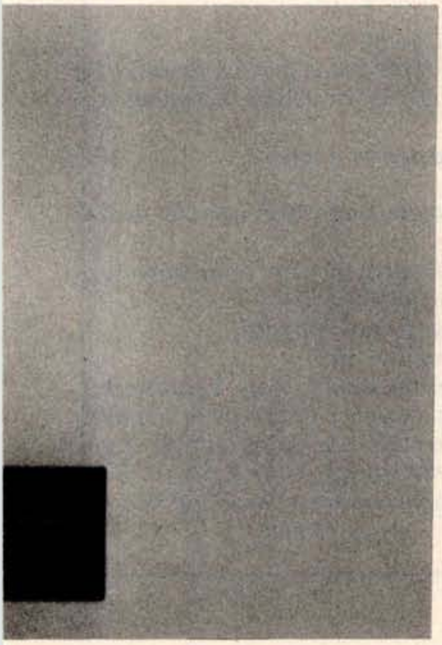
DIGITAL PATHWAYS

Circle 88 on inquiry card.


ALTOS
COMPUTER SYSTEMS



ALTOS BREAKS THE MICRO BARRIER.

Yesterday, microcomputer meant micro performance. Once you outgrew it, you had to step up to a mini. Which meant a big step up in price.

Today, there's the new Altos ACS8000-6 single-board microcomputer system.

It's the first system for the OEM, small businessman and personal user, that offers minicomputer performance and minicomputer storage capacities—at a microcomputer price.

MULTI-USER, WINCHESTER STORAGE, FLOPPY BACK UP: $14,260.

The new Altos ACS8000-6 is a highly advanced Z80* based microcomputer system with high-speed RAM, floppy disk and Winchester hard-disk controllers, DMA, six serial and two parallel I/O ports and the AMD 9511 floating point processor all on a single board. A typical four-user system configuration with two megabytes of Shugart floppy and 29.0 megabytes of Shugart Winchester storage, including CPU and 208K bytes of RAM, costs only $14,260—compared to $30,000 or more for a similar minicomputer system. And that adds up to mini performance at less than half the cost!

MULTI-USER EXECUTIVE SUPPORTS FOUR INDEPENDENT USERS RUNNING CP/M COMPATIBLE PROGRAMS.**

This revolutionary new microcomputer system features the MP/M** Multi-User Executive software program that's unique in two ways. It includes a multi-user CP/M capability and the ability to handle Winchester-type hard disks. The advanced Z80 operating program supports four independent CP/M compatible programs in any of six popular languages: BASIC, FORTRAN, COBOL, PASCAL, APL, C, and a large assortment of additional business application packages. MP/M is compatible with both the 1.4 and 2.0 versions of Digital Research's CP/M, which means programs based on either version can run under MP/M without modification.

With MP/M at the helm, your Altos ACS8000-6 system can support up to four simultaneous users with 48K bytes of RAM each plus 58 megabytes of Winchester storage and 4 megabytes of floppy back up. And that adds up to the first microcomputer to give you the power and performance of a minicomputer.

SINGLE-USER, HARD-DISK SYSTEMS START AT $9450.

The Altos ACS8000-6 series. It's a barrier breaker in every sense. Our entry-level, single-user, hard-disc system with floppy back up is priced under $10,000 and even our 4-user CP/M model is available for under $12,000. And all configurations are easily upgraded. For specific details about pricing or performance, call or write: Altos Computer Systems, 2360 Bering Drive, San Jose, CA (408) 946-6700. TELEX 171562 ALTOS SNA.

Circle 89 on inquiry card.

ALTOS
COMPUTER SYSTEMS

Horse Statistics

- *DAY :* *Each time a race is run a number is assigned in sequence from 0 to 99. This number is called the date. Note that only one hundred races can be run in the file storage space made available by the program.*
- *RACE T :* *The type of race.*
- *PURSE :* *The dollar purse value assigned to the race by the computer.*
- *#H :* *The number of horses that actually participated in the running of the race.*
- *DIS :* *The distance of the race in furlongs.*
- *TIME :* *The time that won the race. All times are given as minutes : seconds. fifths of seconds. In all horse racing a 0.2 equals 2/5 of a second not 2/10.*
- *WGH :* *The weight that the horse carried in pounds.*
- *P :* *Post position.*
- *S,H,S,F :* *The position of the horse at the start, half, stretch, and finish.*
- *L :* *How many lengths the horse lost the race by, or how many lengths the horse won by if it finished first.*
- *TIME :* *The time it took for the horse to run the race.*
- *ODDS :* *The odds of the horse winning the race.*
- *WINNER :* *Which horse won the race. In the sample runs, I had both twelve and forty horses as the number of horses available to run during a particular execution of the program. If a twelve-horse run is selected after a forty-horse run of the program, and past performances require a name of a horse not contained in the twelve, ------- is printed.*

Text continued from page 146:

tion number of the horse whose past performances are to be reviewed. In the sample run, "6" was entered and Secretariat's past performances are displayed. The information given, aside from the same data as supplied by action code 1, is explained in the text box at left.

In the case of Secretariat, his last ten races are printed, with the most recent appearing first. Ten is the maximum number of past performance races that are stored for each horse. If day 0 is examined for Secretariat, you will see that the data is identical to that shown in listing 2 for Secretariat. Listing 2 is the sample race that shows the running of the day 0 race.

What happens when a horse runs in its eleventh race? The least current race is dropped and the most recent race is added to the past performance file. Listing 7 shows this updating process for Secretariat.

That is it for the racing game. Before it can be used, however, program RACE-I (listing 13, race input) must be run to set up the file.

A 98-block file called RACE-D (or any name you choose) must be created before RACE-I is run. File RACE-D is created using the North Star disk operating system (DOS) and assigning a type 3 (the North Star code for a data file). Listing 8 shows the execution of RACE-I. This program always asks for the name of the data file first. Next, anything but a carriage return clears all of the historical data without removing the ratings and names of the horses on the file. The program execution then terminates. If a carriage return is entered now, the program enters the input/read mode. Here, horses' names and ratings can be entered, or the entire file can be read. To read the file a carriage return is entered again. Listing 8 shows the file used for the sample runs. If a return is not entered, you are in the input mode. To input, you enter an identification number between 0 and 39 (anything else ends the program), followed by a comma and the horse's name. Next you supply a class and six ratings, each separated by a comma.

The class is very important, and the number corresponds to the extra

Text continued on page 160

WHERE IS TARBELL?

ALABAMA

JACK RANDOLPH & ASSOCIATES INC
586 SHADES CREST ROAD
BIRMINGHAM 822-2339

JETT CONSULTING
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HUNTSVILLE 852-4364

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BYTE SHOP
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PLACENTIA 524-5380

BYTE SHOP
4 WEST MISSION
SANTA BARBARA 966-2638

AFFORDABLE COMPUTERS
3400 EL CAMINO REAL
SANTA CLARA 249-4221

BYTE SHOP
8038 CLAIREMONT MESA BLVD
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BYTE SHOP
2707 THOUSAND OAKS BLVD.
THOUSAND OAKS 497-9595

BYTE SHOP
14300 BEACH BLVD.
WESTMINSTER 894-9131

CAL BLU CORPORATION
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COMPUTER SYS & APPLICATIONS
P.O. BOX 3243
ORANGE 632-1228

COMPUTREND
2521 W. LA PALMA
ANAHEIM 533-3572

CYBERNITIC DATA SYSTEMS
1618 INGLIS LANE
SAN JOSE 925-6354

DCI COMPUTER SYSTEMS
4670 N. EL CAPITAN
FRESNO 266-9566

DEANS MUSIC CITY
82-704 MILES AVE.
INDIO 347-5245

DELTA PRODUCTS
1653 E. 28TH
SIGNAL HILL 595-7506

DIGITAL DELI
80 WEST EL CAMINO REAL
MOUNTAIN VIEW 961-2670

DYNATRON INTERNATIONAL COMPANY
18210 SHERMAN WAY
RESEDA 881-8700

ELECTRIC BRAIN
3038 NO. CEDAR AVE.
FRESNO 227-8479

ELECTROLABS
930 EMERSON AVE
PALO ALTO 321-5605

CRAIG ERICSSON
438 W. CYPRESS
GLENDALE 243-6251

ELECTRONIC SUPPLY
2486 3RD ST
RIVERSIDE 787-9220

EVERGREEN BUSINESS SERVICES
3365 B S. WHITE ROAD
SAN JOSE 274-8717

FORMULA INTERNATIONAL
12603 CRENSHAW BLVD
HAWTHORNE 973-1921

FRANKLIN SYSTEMS CORP
733 LAKEFIELD RD
WESTLAKE VILLAGE 496-1878

FUTRA CO.
3447 TORRANCE BLVD
TORRANCE 371-8138

HOBBYWORLD ELECTRONICS
19511 BUSINESS CENTER DR
NORTHRIDGE 886-9200

HOLLYWOOD SYSTEMS
9100 SUNSET BLVD SUITE 112
HOLLYWOOD 271-9726

INDUSTRIAL MICROSYSTEMS
628 ECKHOFF ST
ORANGE 633-0355

INTERNATIONAL SCIENTIFIC USA INC
1310 E. EDINGER SUITE F
SANTA ANA 834-9100

JADE COMPUTER PRODUCTS
13440 S. HAWTHORNE BLVD
HAWTHORNE 973-7330

KHALSA COMPUTER SYSTEMS INC
500 S. LAKE AVE.
PASADENA 684-3311

LANYON INC
7742 REDLANDS ST. SUITE H 3021
PLAYA DEL REY 821-0642

L. ELECTRONICS
410 BELL AVE.
SANTA ANA 593-4155

L.S. ENGINEERING
6701 DESOTO AVE #213
CANOGA PARK 992-1827

MICROBYTE COMPUTER STORE
2626 UNION AVE
SAN JOSE 377-4685

MICRO BUSINESS SYSTEMS INC
4563 MARMION WAY
LOS ANGELES 257-4444

MICROCOMPUTER BUSINESS SYTEMS
2084 B. WALSH AVE
SANTA CLARA 988-3059

MICROCOMPUTER CENTER
1211 SOUTH WESTERN AVE
ANAHEIM 527-5260

MICRO DA SYS
P.O. BOX 36051
LOS ANGELES 935-4555

BROWN DOG ENGINEERING
BOX 427
LOMITA 326-8482

MICROSUN COMPUTER CENTER
2989 N. MAIN ST.
WALNUT CREEK 933-6252

M C COMPUTERS
2008 WILSHIRE BLVD
SANTA MONICA 535-3006

SUPPORT SYSTEMS
2746 BENTON ST.
SANTA CLARA 247-0638

NEW HORIZONS
1618 BEACH BLVD #172
HUNTINGTON BEACH 926-8535

ORANGE COUNTY COMPUTER CENTER
1913 HARBOR BLVD.
COSTA MESA 646-0221

PCE ELECTRONICS
4782 DEWEY DRIVE
FAIR OAKS 966-2208

PRECISION COMPUTER SYSTEMS
1737 N. 1ST SUITE 580
SAN JOSE 279-8228

PROFESSIONAL DATA SYSTEMS
318 E. 18TH ST.
BAKERSFIELD 323-0891

SAS COMPUTER PRODUCTS INC
13766 SUNSET BLVD
PACIFIC PALISADES 459-5674

SUNNY SOUNDS
927-B EAST LAS TUNAS DR.
SAN GABRIEL 287-1811

SUNSHINE COMPUTER CO.
20710 S. LEAPWOOD AVE.
CARSON 327-2118

TECH-MART
19590 VENTURA BLVD.
TARZANA 344-0153

COLORADO

BYTE SHOP
3101 WALNUT STREET
BOULDER 444-6550

BYTE SHOP
3464 SOUTH ACOMA ST.
ENGLEWOOD 761-6232

COMPUTER TECHNOLOGY
6311 N. FEDERAL BLVD.
DENVER 427-4438

CONNECTICUT

OFFICE SERVICES OF HAMDEN INC.
965 DIXWELL AVE.
HAMDEN 624-9917

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DELAWARE MICROSYSTEMS
2535 DARTMOUTH WOODS RD.
WILMINGTON 738-3700

FLORIDA

APPLIED MICROCOMPUTER TECHNOLOGY
241 OLD DIRT ROAD
TALLAHASSEE 878-3385

DATA TECHNOLOGY ASSOCIATES INC
10445 S.W. 70TH AVE.
MIAMI 667-3410

DELTA ELECTRONICS INC.
2000 U.S. HI'WAY 441 EAST
LEESBURG 728-2478

DIGITAL MICROCOMPUTER SYSTEMS
927 BLANDING BLVD #4
ORANGEPARK 269-2002

MICROCOMPUTER TECHNOLOGY INC
1549 W. BRANDON BLVD
BRANDON 685-6714

GEORGIA

ADVANCED COMPUTER TECHNOLOGY
290 HILDEBRAND N.E.
ATLANTA 252-1094

ELECTROMAGNETIC SCIENCES INC
125 TECHNOLOGY PARK
NORCROSS 448-5770

HAWAII

MAHALO MICROSYSTEMS LTD.
355 ROYAL HAWAIIAN AVE
HONOLULU 922-2152

SMALL COMPUTER SYSTEMS
3140 WAIALAE AVE
HONOLULU 732-5246

ILLINOIS

BITS AND BYTES COMPUTER STORE
PO BOX G/292 W. 147TH ST.
POSEN 389-7112

CHAMPAIGN COMPUTER CO.
406 ELM ST.
MAHOMET 586-4131

BIES SYS. INC.
7037 WEST NORTH AVE
OAK PARK 386-3323

LILLIPUTE COMPUTER MART
4446 OAKTON ST.
SKOKIE 674-1383

MIDWEST MICROCOMPUTERS INC
708 S. MAIN ST.
LOMBARD 495-9889

WILCOX ENTERPRISES
25 W. 178 39TH ST
NAPERVILLE 420-8601

INDIANA

DIGITAL TECHNOLOGY
10 N 3RD
LAFAYETTE 423-2548

DATA DOMAIN
221 WEST DODDS
BLOOMINGTON 334-3607

DIGITAL SUPPLY
817 AGATHON DR.
EVANSVILLE

THE HOME COMPUTER CENTER
2115 EAST 62ND ST.
INDIANAPOLIS 251-6800

SMITH COMPUTER SYSTEMS
530 PIERCE AVE.
DYER 322-5461

KANSAS

COMPUTER CENTER
5815 JOHNSON DRIVE
MISSION 432-BYTE

COMPUTER SYSTEM DESIGN
906 N. MAIN
WICHITA 265-1120

LOUISIANA

GREAT SOUTHERN COMPUTER SYSTEMS
915 TALBOT
THIBODAUX 446-8432

BILL GULLEDGE
ROUTE 1 BOX 264-A
DOWNSVILLE 982-5610

MARYLAND

COMPUTERS ETC.
13A ALLEGHENY AVE.
TOWSON 296-0520

MASSACHUSETTS

THE COMPUTER MART INC
1395 MAIN ST ROUTE 117 AT 128
WALTHAM 899-4540

COMPUTER SHOP
288 NORFOLK ST.
CAMBRIDGE 661-2670

SCIENTIFIC CONSULTING SERVICES
35 LINDA AVE
FRAMINGHAM 926-4046

MICHIGAN

AMERICAN COMPUTER CENTER INC.
1800 WEST FOURTEEN MILE RD.
ROYAL OAK 576-0900

COMPUTER STORE OF DETROIT
4132 N. WOODWARD
ROYAL OAK 549-2870

GAW COMPUTERTRONICS
37727 AMRHEIN RD.
LIVONIA 464-0441

JRPSAN
GROUP K 4706 MORNINGSIDE DR. S.E.
GRAND RAPIDS 241-8336

UNITED MICROSYSTEMS CORP.
2601 S. STATE ST.
ANN ARBOR 668-6806

MINNESOTA

AGRI-ELECTRONICS INC
1061 E. CLIFF ROAD
BURNSVILLE 890-0?40

BROM MICROSYSTEMS ENGINEERING INC
3655 W. 6TH ST.
WINONA 452-7958

COMMERCIAL COMPUTER INC.
2200 W. 94TH AVE
MINNEAPOLIS 884-8003

COMPUTER DEPOT INC
7625 BUSHLAKE RD
MINNEAPOLIS 831-2088

MINNESOTA MICROSYSTEMS
514 CEDAR AVE
MINNEAPOLIS 338-5604

MISSISSIPPI

OXFORD SOFTWARE COMPANY
1125 JACKSON AVE
OXFORD 234-2226

MONTANA

CLIVUS MULTRUM
205 MEADOW ROAD
WHITEFISH 862-3854

NEBRASKA

OMAHA COMPUTER STORE
4540 S. 84TH ST.
OMAHA 592-3590

NEW JERSEY

CBS CONSOLIDATED
264 MALAPARDIS RD
MORRIS PLAINS 267-2653

COMPUTER EMPORIUM
BLDG 103 AVENUES OF COMMERCE
CHERRY HILL 667-7555

COMPUTER LAB OF NJ
141 ROUTE 46
BUDD LAKE 691-1984

COMPUTER MART OF NJ INC.
501 ROUTE 27
ISELIN 283-0600

COMPUTER SYSTEMS INTERNATIONAL
539 DURIE AVE
CLOSTER 767-7510

ELECTRO ANALYTIC SYSTEMS INC
448 RT 15 SOUTH
WHARTON 361-4300

S-100 INC.
7 WHITE PL.
CLARK 382-1318

NEW YORK

BYTE SHOP EAST
2721 HEMPSTEAD TRKE.
LEVITOWN 731-8116

COMPUTER SHOP OF SYRACUSE INC
3470 ERIE BLVD EAST
DEWITT 637-6208

COMPUTER MICROSYSTEMS
1311 NORTHERN BLVD.
MANHASSET 627-3640

MANAGEMENT COMPUTER SYSTEMS
86-16 SANTIAGO ST.
HOLLIS 479-7783

MINI MICRO MART
1618 JAMES
SYRACUSE 422-4467

OWENS ASSOCIATES
12 SCHUBERT ST
STATEN ISLAND 448-6283

NORTH CAROLINA

ALPHA DIGITAL SYSTEMS INC.
RT. 4 BOX 171 A
BOONE 264-7946

BYTE SHOP OF RALEIGH
1213 HILLSBOROUGH ST.
RALEIGH 833-0210

COMPUTER SHARING INC.
273 HAYWOOD ST.
ASHVILLE 253-2364

SOUTHERN DIGITAL SYSTEMS INC
VERNON PARK MALL SUITE 806A
KINSTON 527-4691

OHIO

CINCINNATI COMPUTER STORE
4816 INTERSTATE DR.
CINCINNATI 874-0600

COMPUTERLAND OF CLEVELAND
1288 SOM CENTER ROAD
MAYFIELD HEIGHTS 461-1200

COMPUTER MART
6310 LINWORTH ROAD
COLUMBUS 846-2966

DIGITAL AUTOMATION ASSOCIATES INC
735 HASKINS RD
BOWLING GREEN 352-6977

MIDWEST MICROCOMPUTERS
1671 TIMMY
HAMILTON 874-0600

OHIO MICROCOMPUTER SPECIALIST
1265 GRANDVIEW AVE
COLUMBUS 488-1849

QUASAR DATA PRODUCTS
3501 LAKEVIEW BLVD
STOW 779-9387

TEC MAR INC.
23414 GREENLAWN AVE.
BEECHWOOD 382-7599

OKLAHOMA

MICROLITHICS INC.
2918 N. MACARTHUR BLVD
OKLAHOMA CITY 947-5646

OREGON

BYTE SHOP BEAVERTON
3482 S.W. CEDAR HILLS BLVD.
BEAVERTON 223-3496

COMPUTERLAND OF PORTLAND
12020 S. WEST MAIN
TIGARD 642-3212

THE REAL OREGON COMPUTER CO. INC.
205 WEST TENTH ST.
EUGENE 484-1040

PENNSYLVANIA

ERIE COMPUTER COMPANY
1253 W. 8TH ST.
ERIE 454-7652

MARKETLINE SYSTEMS INC.
2337 PHILMONT AVE
HUNTINGDON VALLEY

SOUTH CAROLINA

BRK ELECTRONICS INC.
1811 HUNTINGTON PLACE
ROCK HILL 366-1329

THE BYTE SHOP 32
2018 GREEN ST.
COLUMBIA 771-7824

SOUTH DAKOTA

HAL CORPORATION
1425 COMET RD
SIOUX FALLS 332-4828

TENNESSEE

COMPUTER WORLD
625 MAIN ST.
NASHVILLE 255-8330

EASTERN MICROCOMPUTER STORES INC.
5613 KINGSTON PIKE
KNOXVILLE 584-8365

HOMESTEAD TECHNOLOGIES CORPORATION
2114 WEST END AVE
NASHVILLE 320-1883

TEXAS

ANDY ELECTRONICS CO. INC.
6319 LONG DRIVE
HOUSTON 641-0576

AUSTIN MICROPRODUCTS
C/O DAN DRUMMOND RT 3 BOX 87A
ROCKDALE 446-2248

COMPUTER MART OF WEST TEXAS
4622 28TH ST.
LUBBOCK 797-7550

THE COMPUTER STORE
3411 MARQUART SUITE 102
HOUSTON 522-7845

ELECTRONIC SPECIALTY CO.
4032 BELLAIRE BLVD.
HOUSTON 665-0477

HOUSTON COMPUTER MART
8029 GULF FREEWAY
HOUSTON 649-4188

INTEGRATED DATA SYSTEMS
6002 CERRITOS
HOUSTON 729-9160

MICROBYTE ABACUS
2212 CRAWFORD
HOUSTON 757-1128

THE MICRO STORE
634 S. CENTRAL EXPRESSWAY
RICHARDSON 231-1096

MICROSYSTEMS SERVICES INC.
5301 EVERHART SPACE H
CORPUS CHRISTI 855-4516

MICROTRONICS INC
P.O. BOX 985
DICKINSON 337-5112

RADIO HUT
201 LOCKWOOD
DALLAS 324-2829

RIBIGITAL ELECTRONIC CO
1423 WEST TERRELL ST
FORT WORTH 336-0777

THE K.A. COMPUTER STORE
9090 STEMMONS FWY
DALLAS 643-2667

YOUNG ELECTRONIC SERVICE
808 F. BROTHER'S BLVD
COLLEGE STATION 693-3462

UTAH

ARROW COMPUTER SERVICE
4154 S. 300 WEST
SALT LAKE CITY 268-0130

COMPUTERS + STUFF OF UTAH
1717 WEST CENTER ST.
PROVO 377-1717

VIRGINIA

COMPUTER PLUS
6120 FRANCONIA RD
ALEXANDRIA 751-1115

COMPUTER SYSTEMS STORE
1984 CHAIN BRIDGE RD.
MCLEAN 821-8333+821-8334

THE HOME COMPUTER CENTER
12588 WARWICK BLVD.
NEWPORT NEWS 827-3917

WASHINGTON

INNOVATIVE COMPUTING INC.
1135 LAKE ST. SOUTH SUITE 245
KIRKLAND 827-0731

NORTHWEST DATACOMM
13400 NORTHRUP WAY SUITE 19
BELLEVUE 641-0882

OLYMPIC COMPUTERS
418 S. LINCOLN
PORT ANGELES 457-3315

WEST VIRGINIA

THE COMPUTER CORNER INC
22 BEECHURST AVE
MORGANTOWN 293-5121

MORRIS ENTERPRISES
1 MAIN ST
OSAGE 599-5121

WISCONSIN

BYTE SHOP OF MILWAUKEE
6019 W. LAYTON AVE
GREENFIELD 278-6000

DHA INC.
545 MEADOW LN.
SHEBOYGAN FALLS 467-6006

MAGIC LANTERN COMPUTERS
3313 UNIVERSITY AVE
MADISON 233-2026

OUTSIDE U.S.

BYTRONIX MICROCOMPUTER LTD
83 WEST STREET
FARNHAM SURREY
GU97 N. ENGLAND

CANADIAN MICROCOMPUTER SYSTEMS
PO BOX 1154
BRANDON
MANITOBA CANADA R7A 6A5

COMPUTER CENTRE
9 DE-LA-BECHE STREET
SWANSEA
SOUTH WALES SA1 3EX
0792 460023

MICROBOARDS
1-7-1-1003 SAIWAI - CHO
CHIBA CITY
JAPAN 260
47 0427 (47) 3081

ORTHON COMPUTERS
12411 STONY PLAIN ROAD
EDMONTON - ALBERTA
CANADA T5N 3N3
403 448-2921

PAUL SCHENKER
PO BOX 176
ZURICH
SWITZERLAND 8044
213 473-3747

Circle 90 on inquiry card.

Listing 6: *RACE program execution, but this time with more historical data. Then a request for SECRETARIAT'S statistics is made.*

```
RANDOM NUM ? 43
# OF HORSES ? 40
FILE: RACE-D

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 1          1807

ID NAME        R#  1  2  3      $ WON ID NAME        R#  1  2  3       $ WON
==============================================================================
 0 BUCKPASSER  4   2  0  0   $82150. 20 RABBIT-----  0   0  0  0        $0.
 1 DAMASCUS--  3   1  0  1   $28650. 21 COL. BAY--   0   0  0  0        $0.
 2 DR FAGER--  5   1  0  1   $16900. 22 THE GEN---   0   0  0  0        $0.
 3 RIVA RIDGE  8   1  0  1   $18700. 23 THE ONE---   0   0  0  0        $0.
 4 SUE'S GIRL 10   0  0  0       $0. 24 ALL BUT ON   0   0  0  0        $0.
 5 FOREGO---- 10   0  4  2   $48300. 25 CAN DO----   0   0  0  0        $0.
 6 SECRETARIT 10   1  2  2   $38700. 26 DON'T SAY-   0   0  0  0        $0.
 7 FOOLISH PL 10   0  2  0   $11300. 27 PERSONALIT   0   0  0  0        $0.
 8 RUFFIAN---  7   2  0  0   $86450. 28 RUFF & RED   0   0  0  0        $0.
 9 BOLD RULER  5   1  0  1   $31450. 29 ----------   0   0  0  0        $0.
10 GALLANT MA  9   0  2  2   $34350. 30 ----------   0   0  0  0        $0.
11 ROUND TABL  9   1  0  0   $16050. 31 ----------   0   0  0  0        $0.
12 TIM TAM---  0   0  0  0       $0. 32 ----------   0   0  0  0        $0.
13 SWORD DANC  0   0  0  0       $0. 33 ----------   0   0  0  0        $0.
14 KELSO-----  0   0  0  0       $0. 34 ----------   0   0  0  0        $0.
15 CARRY BACK  0   0  0  0       $0. 35 ----------   0   0  0  0        $0.
16 CICADO----  0   0  0  0       $0. 36 ----------   0   0  0  0        $0.
17 NORTHERN D  0   0  0  0       $0. 37 ----------   0   0  0  0        $0.
18 MAN O'WAR-  0   0  0  0       $0. 38 ----------   0   0  0  0        $0.
19 SILKY SULL  0   0  0  0       $0. 39 ----------   0  .0  0  0        $0.
READY TO RETURN ?

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 2          1750

ID# ? 6
SECRETARIT 10 1 2 2 38700
DAY RACE T      PURSE-#H DIS   TIME WGH  P  S  H  S  F  L    TIME    ODDS WINNER
====================================================================================
  9 STAKES  $103000.-12 12F 2:24.4 120  4  5 11 11  9  5 2:25.4   4.60 RUFFIAN-
  8 ALLOW.   $85000.-12  6F 1: 7.3 120  5 11 10 10 10  5 1: 8.3   4.40 BUCKPASS
  7 CONDIT.  $30000.- 6 10F 1:59.3 120  1  2  1  4  1  0 1:59.3   1.60 SECRETAR
  6 MAIDEN   $20000.- 6  6F 1: 7.4 120  1  2  2  2  3  2 1: 8.1   1.60 ROUND TA
  5 MAIDEN   $24000.- 7  8F 1:33.1 120  1  4  1  3  4  4 1:34.0   2.40 RIVA RID
  4 MAIDEN   $30000.- 8  9F 1:46.3 120  1  6  4  7  6  4 1:47.1   3.00 RUFFIAN-
  3 MAIDEN   $31000.- 9  8F 1:33.4 120  1  5  7  8  8  8 1:35.2   3.60 BOLD RUL
  2 HANDICAP $20000.-10  7F 1:20.3 121 10  7  7  3  3  2 1:21.0  10.80 DR FAGER
  1 MAIDEN   $39000.-11  6F 1: 7.3 120  1  6  4  4  2  0 1: 7.3   4.20 BUCKPASS
  0 MAIDEN   $31000.- 9  8F 1:33.2 120  3  6  4  2  2  0 1:33.2   4.00 DAMASCUS
```

Circle 91 on inquiry card.

Listing 7: *Updating the file on SECRETARIAT. The least current race is dropped from the record and the most recent race is added to the past performance file.*

```
ID# ? 6
SECRETARIT 11 1 2 2 38700
DAY RACE T        PURSE-#H DIS   TIME WGH  F  S  H  S  F  L   TIME    ODDS WINNER
==================================================================================
 11 ALLOW.      $51000.-10  6F 1: 8.1 123 10  2  6  6  6  6 1: 9.2    2.00 DON'T SA
  9 STAKES     $103000.-12 12F 2:24.4 120  4  5 11 11  9  5 2:25.4    4.60 RUFFIAN-
  8 ALLOW.      $85000.-12  6F 1: 7.3 120  5 11 10 10 10  5 1: 8.3    4.40 BUCKPASS
  7 CONDIT.     $30000.- 6 10F 1:59.3 120  1  2  1  4  1  0 1:59.3    1.60 SECRETAR
  6 MAIDEN      $20000.- 6  6F 1: 7.4 120  1  2  2  2  3  2 1: 8.1    1.60 ROUND TA
  5 MAIDEN      $24000.- 7  8F 1:33.1 120  1  4  1  3  4  4 1:34.0    2.40 RIVA RID
  4 MAIDEN      $30000.- 8  9F 1:46.3 120  1  6  4  7  6  4 1:47.1    3.00 RUFFIAN-
  3 MAIDEN      $31000.- 9  8F 1:33.4 120  1  5  7  8  8  8 1:35.2    3.60 BOLD RUL
  2 HANDICAP    $20000.-10  7F 1:20.3 121 10  7  7  3  3  2 1:21.0   10.80 DR FAGER
  1 MAIDEN      $39000.-11  6F 1: 7.3 120  1  6  4  4  2  0 1: 7.3    4.20 BUCKPASS
```

Text continued from page 156:

lengths added to each one of the six ratings. The ratings are numbers between 1 and 13. The higher the rating, the faster the horse runs. The first rating sets the speed of the horse for the first two furlongs of a race; the second rating sets how fast the third and fourth furlongs are run, etc. Therefore, for a six-furlong race, only class and ratings 1, 2 and 3 are used. An eleven or twelve-furlong race utilizes class and all six ratings.

If you have a North Star disk, you are ready to simulate horse racing. If not, the following discussion will show you how to eliminate the files and reduce memory requirements.

File Structure

Before the file structure and the time requirements to manipulate files are discussed, program RACE will be described. Table 1 shows the key variables and functions by line numbers. As can be seen, almost everything is a subroutine. If you decide to remove a subroutine to save memory, I suggest reentering the first line of each routine to be eliminated as a RETURN, and deleting all other lines. This saves you from the task of looking for all references to the deleted subroutine. After eliminating a subroutine, testing will have to be done to ensure that variables still conform to print formats.

In listing 1, the program RACE was run with only twelve horses, and about 16,030 bytes of memory were required. With a forty-horse race (listing 6), 17,949 bytes are needed. In listing 9, I edited the program quickly to eliminate all file references. This version was run with only two horses and required only 11,917 bytes of memory. More memory can be saved by eliminating other subroutines.

This edited version of RACE does not require the use of program RACE-I, since all horses' names, classes and ratings are now data statements (listing 9 lines 1000 and 1001). You will notice, however, that the ratings are no longer numbers between 1 and 13. Program RACE-I converted the ratings 1 to 13 to the numbers shown in lines 1000 and 1001 of listing 9. If you examine lines 20 and 30 of listing 13, RACE-I, you can see the thirteen numbers into

Text continued on page 164

Listing 8: *Execution of the RACE-I program. You can enter the input mode to store any information in the file. Here we chose just to read the file.*

```
FILE : RACE-D
RETURN TO ENTER HORSES OR ANYTHING TO CLEAR FILE ? CLEAR
READY
RUN

FILE : RACE-D
RETURN TO ENTER HORSES OR ANYTHING TO CLEAR FILE ?
RETURN TO READ RATINGS OR ANYTHING TO INPUT ?
BUCKPASSER    2   12   12    9    9    9    9
DAMASCUS--    2   10   10    9    9    9    9
DR FAGER--    2   13   13    9    9    5    5
RIVA RIDGE    2   13   13    8    8    9    9
SUE'S GIRL    2    7    7    8    8    7    7
FOREGO----    2   12   12    9    9   10   10
SECRETARIT    2   13   13    9    9   10   10
FOOLISH PL    2    9    9    8    8    7    7
RUFFIAN---    2   13   13    8    8    7    7
BOLD RULER    2   12   12    9    9    5    5
GALLANT MA    2   10   10    9    9   10   10
ROUND TABL    2   10   10    9    9    8    8
TIM TAM---    2    9    9    9    9    9    9
SWORD DANC    2    9    9    8    8    9    9
KELSO-----    2   10   10    9    9   10   10
CARRY BACK    2    8    8    9    9    5    5
CICADO----    2    7    7    7    7    6    6
NORTHERN D    2   10   10    8    8    5    5
MAN O'WAR-    2   13   13    9    9   10   10
SILKY SULL    3    1    1   13   13   13   13
RABBIT----    2   13   13    1    1    1    1
COL. BAY--    0   13   12   11   10    9    8
THE GEN---    1   13   13   13    1    1    1
THE ONE---    0    1   13   13   13   13   13
ALL BUT ON    1    1    1   13   13    1    1
CAN DO----    1    2    2    6    6   10   10
DON'T SAY-    0    7    7    7    7    7    7
PERSONALIT    0    7    7    7    7    7    7
RUFF & RED    1    7    7    7    7    7    7
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
----------    0    0    0    0    0    0    0
READY
RUN

FILE : RACE-D
RETURN TO ENTER HORSES OR ANYTHING TO CLEAR FILE ?
RETURN TO READ RATINGS OR ANYTHING TO INPUT ? INPUT
ID, NAME ? 29,NAME IT
CLASS AND 6 RATINGS ? 0,12,12,6,6,6,6
RETURN TO READ RATINGS OR ANYTHING TO INPUT ? INPUT
ID, NAME ? 99,
READY
```

Key Variables

T$(864)	represent the track displayed
T1$(54)	54 blanks used in printing of the track's center
T3$(60)	60 blanks used to set track
N$(12)	the 12 horses' post positions for printing the track
M(12,6,4)	12 = the 12 horses that can be in a race 6 = the 6 individual ratings 4 = each rating broken into 5 possibilities
O(12)	the odds of each horse winning
H(U,11)	U = number of horses in the run 11 = 0 class 1-6 ratings 7 races run 8 firsts 9 seconds 10 thirds 11 earnings
H$(A)	horses' names
R(99,3)	99 represents the 100 races 3 = 0 type/distance/# horses 1 purse 2 winning time 3 race winner
R$(48)	types of races
A(12,9)	12 = twelve horses 9 = 0 ID of horse 1 weight 2 location of horse 3 what lane horse is in 4-7 position at the start, half, stretch, finish 8 length behind or ahead 9 time

Functions by Line Number (S = subroutine)

1 thru 35	Set variables and request historical file name
40 thru 65	Read historical file
70 thru 90	Select action code
5000 thru 5040S	Prints list of horses
6000 thru 6099S	Prints statistics (past performances)
7000 thru 7290S	Runs race
7300 thru 7360S	Prints results of race
7900 thru 7920S	Set what parts of each race will be placed in at the "start, half, stretch"
8000 thru 8040S	Clears track
8100 thru 8140S	Prints prerace list of horses with odds
8200 thru 8260S	Automatic selection of horses to be included in a race
9000 thru 9195S	Prints track
9300 thru 9350S	Sets the odds
9400 thru 9440S	Sets weights for allowance and handicap races
9500 thru 9530S	Calculates win, place, and show payoffs
9600 thru 9601S	Calculates times
9700 thru 9710S	Updates summary records
9800 thru 9825S	Updates individual records
9900 thru 9910S	Updates general race file to indicate what data is pertinent to each race date
9950 thru 9995	Writes all data to files and ends program

Table 1: *List of all key variables and functional routines used in the RACE program.*

File Structure

Type Code	Number of Records	x	Size of 1 Record	=	Total Bytes	Contains
1	100		20		2000	History of each racing date: variable R(99,3)
2	40		72		2880	Summary of historical data for each horse: variable H(U,11)
3	400		50		20000	Detail history of last 10 races run by each horse
	540		142		24880	or 98 blocks of 256 bytes

Organization of File

100 type 1 records

followed by 40 groupings of 1 type 2 record and 10 type 3 records

Table 2: *Detailed description of the file structure used to implement the horse race simulation.*

Text continued from page 160:

which ratings 1 thru 13 are converted. Therefore, the 51555 in line 1000 of listing 9 corresponds to rating 13: the thirteenth piece of data represented on lines 20 and 30 of RACE-I.

Table 2 details the file structure used. North Star BASIC allows you to read disk files by bit location. Records can therefore be of varying sizes and can be read sequentially or by random access. You must know what you are reading, or type errors (reading a string variable into a nonstring variable or vice versa) will occur and terminate the program.

In program RACE, the computer must always know the current race day, in order to update the proper race. This feature was added to save storage space. As detailed in table 1, variable R(99,3) carries the data common to each race, so individual past performance records for each horse need not carry this information. In order to accomplish this, an attempt is made to read the first 100 records of the file sequentially (lines 40 and 45 of listing 14, RACE program). As soon as a blank record is encountered, the read process is terminated and the computer assigns this point as the current race day.

Next, the computer reads only the summary information of the horses selected for the run. This is done by random-access read operations. The location of the summary record is always 2000 bytes + (identification number × 572 bytes). These operations are seen in lines 50 to 65 of listing 14. But why not read all information? The answer is memory limitations. Assuming a forty-horse run, an additional 20,000 bytes of memory would be required.

During the design of this program, a timing test program for disk reads and writes was developed. This was done to minimize execution times and to serve as a guide in writing future applications.

Listing 10 shows the output of this test and a sample run. The program prints its start time "7 31 37" (7 hours, 31 minutes, 37 seconds). The next time represents the time when ten new records are added to the file. The last time corresponds to when the program finishes reading the ten records five times each. These times are approximate, since the smallest

Text continued on page 172

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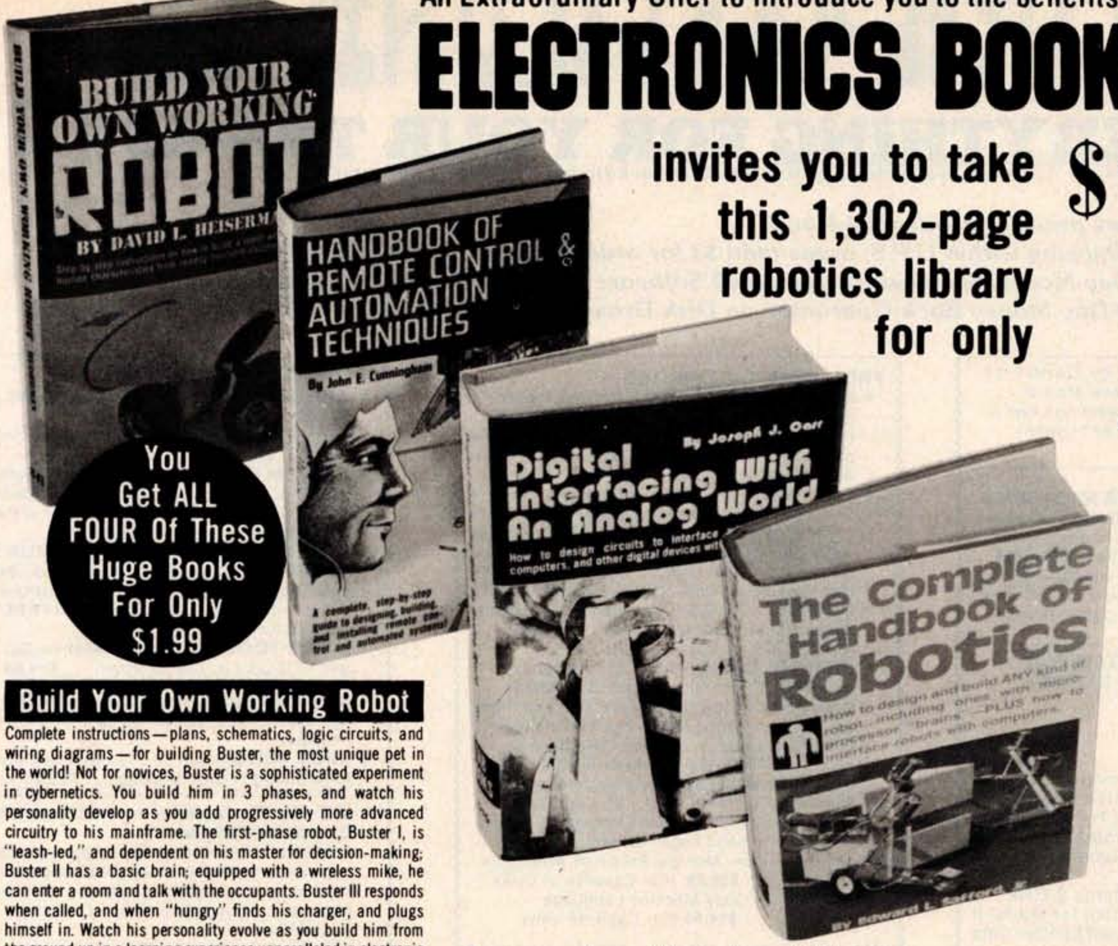

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Listing 9: *Section of code from the RACE program edited to eliminate all file references.*

```
LOAD RACE
READY
25
DEL 40,45
READY
EDIT 50
50 Y=A\FORA=OTO U\A1=(10*A)+1
EDIT 60
60 READ      H$(A1,A1+9),H(A,0),H(A,1),H(A,2),H(A,3),H(A,4),H(A,5)
65 READH(A,6)\NEXT
1000 DATA"FIRST DATA",1,51555,51555,51555,51555,51555,51555
EDIT 1000
1001 DATA"SECOND TRY",1,51555,51555,51555,51555,51555,51555
6000 RETURN
DEL 6010,6099
READY
7110
EDIT 8010
8010 FORZ=1TO15\T$=T3$+T$\NEXT\RETURN
DEL 8020,8140
READY
9000 RETURN
DEL 9001,9195
READY
9950 END
DEL 9960,9995
READY
RUN

RANDOM NUM ? 2
# OF HORSES ? 2

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 1          7839

ID NAME         R#  1  2  3     $ WON ID NAME          R#  1  2  3     $ WON
==================================================================================
 0 FIRST DATA   0   0  0  0      $0.   1 SECOND TRY  0   0  0  0       $0.
READY TO RETURN ?

1 FOR LIST OF HORSES
2 FOR STATISTICS
3 FOR RACE
0 TO END ? 3          7782

TYPES ARE 1=STAKES 2=ALLOWANCE 3=CONDITIONED 4=MAIDEN 5=HANDICAP 6=WORKOUT
DISTANCE= 6 TO 12 FURLONGS  MAXIMUM HORSES = 12
TYPE, DISTANCE, HORSES? 6,6,2
YES FOR AUTOMATIC SELECT. ? YES
ID START & ID END SEARCH ? 0,1
POST  1  SECOND TRY
POST  2  FIRST DATA
?

ID NAME          WT  P  S  H  S  F BY  L M:SS.F      ODDS
===============================================================
 0 FIRST DATA 120  2  1  2  2  1 BY  0 1: 8.0       .00
 1 SECOND TRY 120  1  2  1  1  2 BY  0 1: 8.0       .00

READY?
```

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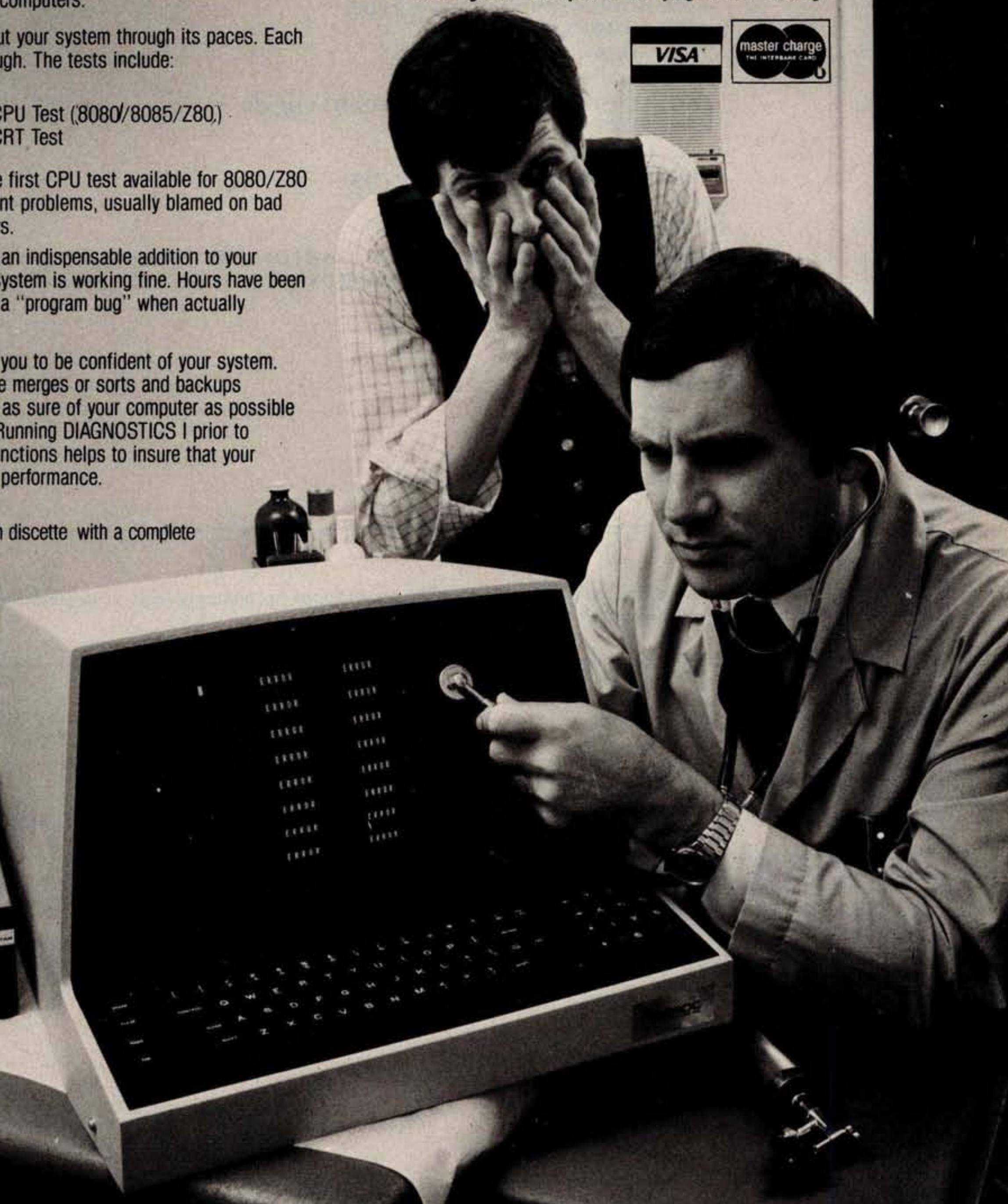

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Listing 10: *Listing of the timing test program for disk reads and writes.*

```
5 DIMV(12)
10 GOSUB 9857\!U1,U2,U3
20 OPEN#0,"A4,2"
30 FORA=1TO10
40 FORB=1TO9\C=(B-1)*60
50 READ#0%C,V(1)
60 FORD=2TO12\READ#0,V(D)\NEXT
70 C=C+60
80 WRITE#0%C,V(1)
90 FORD=2TO12\WRITE#0,V(D),NOENDMARK\NEXT\NEXT
100 C=0\WRITE#0%C,V(1)
110 FORD=2TO12\WRITE#0,V(D),NOENDMARK\NEXT
120 NEXT
130 GOSUB 9857\!U1,U2,U3
200 FORA=1TO5
210 FORB=0TO540STEP60
220 READ#0%B,V(1)
230 FORD=2TO12\READ#0,V(D)\NEXT
240 NEXT
245 NEXT
250 GOSUB 9857\!U1,U2,U3
260 !FREE(0)
270 END
9857 FORU=0TO7\U(U)=INP(168+U)\NEXT\U1=10*U(7)+U(6)
9858 U2=10*U(5)+U(1)\U3=10*U(2)+U(3)\RETURN
READY
RUN

 7 31 37
 7 32 21
 7 32 30
 18863
READY
```

Listing 11: *Some modifications of the previous listing. The use of loops for indexing read/write variables has been eliminated and, as a result, the program execution time is reduced.*

```
LOAD A2,2
READY
LINE 80
READY
50 READ#0%C,V(1),V(2),V(3),V(4),V(5),V(6),V(7),V(8),V(9),V(10),V(11),V(12)
60
80 WRITE#0%C,V(1),V(2),V(3),V(4),V(5),V(6),V(7)
90 WRITE#0,V(8),V(9),V(10),V(11),V(12),NOENDMARK:NEXT
100 C=0:WRITE#0%C,V(1),V(2),V(3),V(4),V(5),V(6),V(7)
110 WRITE#0,V(8),V(9),V(10),V(11),V(12),NOENDMARK
220 READ#0%B,V(1),V(2),V(3),V(4),V(5),V(6),V(7),V(8),V(9),V(10),V(11),V(12)
230
RUN

 7 47 0
 7 47 37
 7 47 43
 18715
READY
```

Listing 12: *This listing allows the record file to be updated without an excess of data manipulation. Records are maintained only for the most recent ten races. The last digit of the total races run by a horse is used as a pointer. When race number 11 occurs, the results are written into location 1, replacing race number 1 (old data). In this way we avoid shifting the entire record file every time a new race is run.*

```
LOAD A6,2
READY
40
50
70 C=(A-1)*60
90
100
210 FORC=ATOA+9:B=(A-1)*60:IFB>540THENB=B-540
RUN

  8 0 27
  8 0 30
  8 0 38
  18872
READY
LIST

5 DIMV(12)
10 GOSUB 9857\!U1,U2,U3
20 OPEN#0,"A4,2"
30 FORA=1TO10
70 C=(A-1)*60
80 WRITE#0%C,V(1),V(2),V(3),V(4),V(5),V(6),V(7)
110 WRITE#0,V(8),V(9),V(10),V(11),V(12),NOENDMARK
120 NEXT
130 GOSUB 9857\!U1,U2,U3
200 FORA=1TO5
210 FORC=ATOA+9\B=(A-1)*60\IFB>540THENB=B-540
220 READ#0%B,V(1),V(2),V(3),V(4),V(5),V(6),V(7),V(8),V(9),V(10),V(11),V(12)
240 NEXT
245 NEXT
250 GOSUB 9857\!U1,U2,U3
260 !FREE(0)
270 END
9857 FORU=0TO7\U(U)=INP(168+U)\NEXT\U1=10*U(7)+U(6)
9858 U2=10*U(5)+U(1)\U3=10*U(2)+U(3)\RETURN
READY
```

Text continued from page 164:

measurement of time is given in seconds. The procedure will be called method 1.

In listing 11, the program was edited to eliminate the use of loops in indexing read/write variables. This is called method 2 and is considerably faster than method 1.

In the racing game only the ten most current performance records for each horse are maintained. In the two tests already timed, this was done by keeping each record in a predetermined location. The most current record is always at a specified location followed by the next most current record, etc. This simplifies the read operations. However, each time a new record is added, the entire record file is shifted to accommodate for the addition of a new record, the new record is written in the first (most recent) position, and the record that was formerly in the tenth position is discarded.

Instead of employing this procedure, method 3 was formulated by additional editing shown in listing 12. The location of the oldest record is calculated, and the new record is placed in that location. For example, the last digit of the total races run by a horse is used as the pointer. If a horse has run one race, we write to location 1, location 2 for the second race, etc. When race number 11 occurs, it is written to location 1, replacing race 1 (the oldest). Race 12 replaces the second race, etc. This procedure reduces the number of disk writes required to update the file, but adds a calculation for all writes and reads.

Table 3 compares the three methods. Method 1 is the least effective, method 3 proves to be the best. Method 3 is a little slower than method 2 in reading files, but is far superior in writing disk files. Procedures similar to method 3 were employed in program RACE.

Aside from being entertaining, I hope that game RACE offers a few ideas in reducing program execution time and limiting the amount of data stored.■

	Method 1	Method 2	Method 3
Time in seconds:			
To write 10 new records	54	37	3
To read all records 5 times	9	6	8

Table 3: *A comparison of the three methods of record maintenance.*

Listing 13: *BASIC listing of the RACE-I program.*

```
READY
LIST
10 DIM R(13),D(6)
20 FORA=1TO13\READR(A)\NEXT
30 DATA45859599,40708595,35608090,30608090,30557590,25507085,20406080
40 DATA15305075,10254570,10204070,5153565,5153060,51555
50 OPEN#0,"RACE-D"
55 N$="----------"
56 GOTO200
57 INPUT"RETURN TO ENTER HORSES OR ANYTHING TO CLEAR FILE ? ",Z$
58 IFZ$<>""THEN200
60 INPUT"RETURN TO READ RATINGS OR ANYTHING TO INPUT ? ",Z$
62 IFZ$=""THEN300
68 INPUT"ID, NAME ? ",A,A$\IFA<0ORA>39THENEND\A$=A$+N$
70 INPUT"CLASS AND 6 RATINGS ? ",C,R1,R2,R3,R4,R5,R6
80 A=2000+(A*572)
90 WRITE#0%A,A$,C,R(R1),R(R2),R(R3),R(R4),R(R5),R(R6),NOENDMARK
100 GOTO60
200 FORA=0TO99\WRITE#0,I,I,I,I,NOENDMARK\NEXT
210 FORA=0TO39\B=2000+(A*572)+47\WRITE#0%B,I,I,I,I,I,NOENDMARK\NEXT\END
300 FORA=0TO39\B=2000+(A*572)
310 READ#0%B,A$,F,D(1),D(2),D(3),D(4),D(5),D(6)
320 FORB=1TO6\FORC=1TO13\IFD(B)=R(C)THENEXIT330\NEXT\GOTO335
330 D(B)=C
335 NEXT
340 !     A$,%5I,F,D(1),D(2),D(3),D(4),D(5),D(6)\NEXT\END
READY
```

Listing 14: *North Star BASIC listing of the RACE program for an 8080-based computer.*

```
1 INPUT"RANDOM NUM ? ",B\FORA=0TOB\C=RND(0)\NEXT
5 INPUT"# OF HORSES ? ",U\IFU/2<>INT(U/2)THENU=U+1
7 IF U<0ORU>40THEN5\A=U*10\U=U-1
10 DIMT$(864),T1$(54),T3$(60),N$(12),M(12,6,4),F(4),O(12),I(1,12),L(12)
15 F(1)=1000000\F(2)=10000\F(3)=100\F(4)=1
20 DIMH(U,11),H$(A),R(99,3),R$(48),A(12,?),K(12),P(4)
22 R$="STAKES  ALLOW.  CONDIT. MAIDEN  HANDICAPWORKOUT "
25 INPUT"FILE: ",M$\OPEN#0,M$
30 T2$="......"\LINE80\N$="1234567890AB"
35 P(1)=.65\P(2)=.2\P(3)=,1\P(4)=.05
40 FORA=0TO99\READ#0,R(A,0),R(A,1),R(A,2),R(A,3)\IFR(A,0)=0THENEXIT50
45 NEXT
50 Y=A\FORA=0TO U\A1=(10*A)+1\A2=(572*A)+2000
60 READ#0%A2,H$(A1,A1+9),H(A,0),H(A,1),H(A,2),H(A,3),H(A,4),H(A,5)
65 READ#0,H(A,6),H(A,7),H(A,8),H(A,9),H(A,10),H(A,11)\NEXT
70 !" "
75 !"1 FOR LIST OF HORSES"\!"2 FOR STATISTICS"\!"3 FOR RACE"
80 INPUT1"0 TO END ? ",A\!"          ",FREE(0)\IFA=0THEN9950\IFA>3THEN70\!""
90 IFA=1THENGOSUB5000\IFA=2THENGOSUB6000\IFA=3THENGOSUB7000\GOTO70
```

Listing 14 continued on next page

Listing 14 continued:

```
5000 !"ID NAME          R#  1  2  3    $ WON ID NAME          R#  1  2  3",
5010 !"      $ WON"\FORZ=1TO75\!"=",\NEXT\!""\Z5=INT(U/2)
5015 FORZ=0TOZ5\FORZ1=0TO1\Z2=Z\IFZ1=1THENZ2=Z2+Z5+1
5020 Z3=(Z2+1)*10\!%2I,Z2," ",
5030 !   H$(Z3-9,Z3),%3I,H(Z2,7),H(Z2,8),H(Z2,9),H(Z2,10),%$9F0,H(Z2,11),
5040 IFZ1=0THEN!" ",\NEXT\!""\NEXT\INPUT"READY TO RETURN ? ",Z$\RETURN
6000 INPUT"ID# ? ",V3\V4=(V3*10)+1
6010 !H$(V4,V4+9),\FORV4=7TO11\!H(V3,V4),\NEXT\!""\IFH(V3,7)=0THENRETURN
6020 !"DAY RACE T     PURSE-#H DIS   TIME WGH  P  S  H  S  F  L  ",
6025 !"TIME   ODDS WINNER"\FORV4=1TO79\!"=",\NEXT\!""
6040 V4=H(V3,7)\V5=V4-(INT(V4/10)*10)\IFV5=0THENV5=10\V5=V5-1
6050 FORV6=V5TOV5-9STEP-1\V=V6\IFV >-1THEN6070
6060 IFV4<11THENEXIT6099\V=V+10
6070 V=2000+(V3*572)+72+(V*50)
6080 READ#0%V,Z,Z1,Z2,Z3,Z4,Z5,Z6,Z7,Z8,Z9
6085 X1=R(Z,0)\X2=INT(X1/10000)\X1=X1-(10000*X2)\X3=INT(X1/100)\X4=X1-(100*X3)
6087 X5=8*X2\!%3I,Z," ",R$(X5-7,X5),%$8F0,R(Z,1),"-",%2I,X4,%3I,X3,"F",
6088 T=R(Z,2)\X3=(R(Z,3)*10)+1
6089       GOSUB9600\!%2I,T1,":",%2I,T2,".",%1I,T,%4I,Z1,%3I,Z2,Z3,Z4,Z5,Z6,Z7,
6091 T=Z8\GOSUB9600\!%2I,T1,":",%2I,T2,".",%1I,T," ",%6F2,Z9," ",
6094 IFX3+7>(U+1)*10THEN6096
6095 !H$(X3,X3+7),
6096 !""\NEXT
6099 RETURN
7000 !"TYPES ARE 1=STAKES 2=ALLOWANCE 3=CONDITIONED 4=MAIDEN",
7001 !" 5=HANDICAP 6=WORKOUT"
7002 !"DISTANCE= 6 TO 12 FURLONGS  MAXIMUM HORSES = 12"
7004 INPUT"TYPE, DISTANCE, HORSES? ",W,X2,X3
7010 IFW<>6ANDX3<4THEN7000
7020 IFX2<6ORX2>12ORX3<1ORX3>12THEN7000\X6=INT((X2+ 1)/2)
7022 IFW<1ORW>6THEN7000\I9=0\IFW=3ORW=4THENGOSUB8200
7025 IFI9=1THEN7030\INPUT"YES FOR AUTOMATIC SELECT. ? ",Z$
7027 IFZ$="YES"THENGOSUB8200
7030 FORX4=1TOX3\IFI9=1THEN7047\!"POST",%3I,X4,
7040 INPUT" ID#? ",V1\IFV1<0ORV1>UTHEN7040\GOTO7048
7047 V1=I(1,X4)\X5=(10*V1)+1\!"POST",%3I,X4,"   ",H$(X5,X5+9)
7048 A(X4,0)=V1\A(X4,1)=120
7050 FORX5=1TOX6\X8=H(V1,X5)\FORX7=1TO4
7060 M(X4,X5,X7)=INT(X8/F(X7))\X8=X8-(M(X4,X5,X7)*F(X7))
7064 IFM(X4,X5,X7-1)>M(X4,X5,X7)THENM(X4,X5,X7)=100
7068 X9=M(X4,X5,X7)-M(X4,X5,X7-1)\O(X4)=O(X4)+(X9*X7)
7070 NEXT\O(X4)=O(X4)+((100-M(X4,X5,4))*5)+(H(V1,0)*100)\NEXT
7080 X8=0\FORX7=1TOX3\X8=X8+O(X7)\NEXT
7082 X8=INT((X8/(X2*4))*(6-W)*.025)\U1=X8*1000
7090 K(X4)=X4\NEXT\IFW=2ORW=5 THENGOSUB9400\GOSUB9300
7100 GOSUB8000\X4=6\IFX3<6THENX4=X3\X5=0\IFX3>6THENX5=X3
7110 IFZ$<>""THENRETURN
7120 X7=2+(12*X2)\FORX8=1TOX4\X9=X7+((X8-1)*144)\IFX9>864THENX9=X9-864
7122 T$(X9,X9)=N$(X8,X8)\L(X8)=X9\NEXT
7125 X7=3+(12*X2)\FORX8=7TOX5\X9=X7+((X8-1)*144)\IFX9>864THENX9=X9-864
7126 IFX9>864THENX9=X9-864
7127 T$(X9,X9)=N$(X8,X8)\L(X8)=X9\NEXT
7130 FORX4=1TOX3\A(X4,2)=2+(12*X2)\K(X4)=X4\NEXT\GOSUB9000
7140 FORV=1TOX6\V1=1\IFV<>X6THEN7150\IF2*X6>X2THENV1=.5
7150 FORV2=1TOX3\V3=K(V2)\V4=INT(RND(0)*100)\V6=A(V3,0)
7160 FORV5=1TO4\IFM(V3,V,V5)>V4THENEXIT7180
7170 NEXT\V5=5
7180 V5=V5+19+H(V6,0)\IFV=X6THENV5=V5*V1\V5=V5+((120-A(V3,1))/X6)
7190 A(V3,2)=A(V3,2)-V5\Z9=A(V3,2)
7195 IFZ9>1THEN7200\Z9=Z9+144\GOTO7195
7200 A(V3,3)=0\FORV7=0TO720STEP144\V8=Z9+V7
```

Listing 14 continued on page 176

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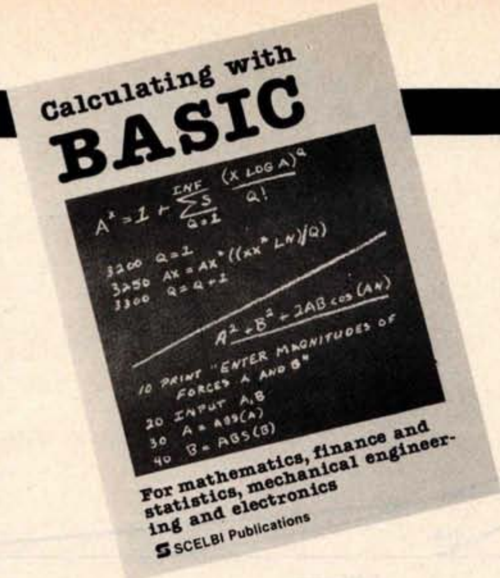
Listing 14 continued:

```
7210 IFT$(V8,V8)="."THENEXIT7250
7220 IFT$(V8,V8)=":"THENEXIT7250
7230 IFT$(V8,V8)="I"THENEXIT7250
7240 A(V3,3)=A(V3,3)-.1\NEXT\Z9=Z9+1\A(V3,2)=A(V3,2)-1\GOTO7195
7250 T$(V8,V8)=N$(V3,V3)\L(V2)=V8\NEXTV2
7260 V2=0\FORV3=1TOX3-1\V4=K(V3)\V5=K(V3+1)\V6=A(V4,2)+A(V4,3)
7270 V7=A(V5,2)+A(V5,3)\IFV6<=V7THEN7290
7280 V2=1\K(V3)=V5\K(V3+1)=V4
7290 NEXT\IFV2=1THEN7260\GOSUB9000\GOSUB7900\NEXT\INPUTZ$\GOSUB7300\RETURN
7300 FORZ=1TO3\!" "\NEXT\GOSUB9500
7303 !"ID NAME          WT  F  S  H  S  F.BY  L M:SS.F     ODDS"
7305 !"================================================================="
7310 FORZ=1TOX3\Z1=K(Z)\Z2=(1+A(Z1,0))*10\IFZ=1THENZ3=A(Z1,2)-.75
7320 Z4=INT(A(Z1,2)-Z3)\IFZ<>1THEN7330\Z4=K(2)\Z4=INT(A(Z4,2)-Z3)
7330 !%2I,A(Z1,0)," ",H$(Z2-9,Z2),%4I,A(Z1,1),%3I,Z1,
7340 !%3I,A(Z1,4),A(Z1,5),A(Z1,6),A(Z1,7)," BY",%3I,Z4,
7345 A(Z1,8)=Z4\T=INT(A(Z1,2)-.75)
7347 IFT<-100THENT=T+144\IFT<-100THEN7347\T=T+(65*X2)-48
7348 A(Z1,9)=T\GOSUB9600
7349 !%2I,T1,":",%2I,T2,".",%1I,T,%9F2,O(Z1)\Z1=A(Z1,0)
7350 IFW<>6THENGOSUB9700\Z1=K(Z)\O(Z1)=0\NEXT
7351 IF6=WTHEN7360\IFV2<2.1THENV2=2.1\IFV3<2.1THENV3=2.1\GOSUB9900
7352 IFV4<2.1THENV4=2.1\IFV5<2.1THENV5=2.1\IFV6<2.1THENV6=2.1
7353 !""\!"POST        WIN      PLACE       SHOW"
7354 !%4I,K(1),%$9F2,V1,V2,V3
7356 !%4I,K(2),"         ",%$9F2,V4,V5
7358 !%4I,K(3),"                    ",%$9F2,V6
7360 !""\INPUT"READY? ",Z$\!""\RETURN
7900 Z=0\IFV=1THENZ=4\IFV=X6-1THENZ=6\IFV=2THENZ=5
7910 IFV=X6THENZ=7\IFZ=0THENRETURN
7920 FORZ1=1TOX3\Z2=K(Z1)\A(Z2,Z)=Z1\IFV=2THENA(Z2,6)=Z1\NEXT\RETURN
8000 T3$="..............................................................................."
8010 FORZ=1TO15\T$=T3$+T$\NEXT
8020 FORZ=1TO133STEP12\T4$=":"\IFZ=1THENT4$="I"
8030 FORZ1=0TO720STEP144\Z2=Z1+Z\T$(Z2,Z2)=T4$\NEXT\NEXT
8040 FORZ=1TO12\A(Z,2)=0\A(Z,3)=0\NEXT
8100 !""\IFW=6THENU1=0\Z=W*8\!"THIS IS A",X2," FURLONG ",R$(Z-7,Z),
8105 !" RACE WITH A PURSE OF $",U1
8110 !""\!"POST NAME          WGH    ODDS  R# 1ST 2ND 3RD   EARNINGS"
8120     !"=================================================================="
8125 FORZ=1TOX3\Z1=A(Z,0)+1\Z2=Z1-1
8130 Z1=Z1*10\!%4I,Z," ",H$(Z1-9,Z1),%4I,A(Z,1),%$8F2,O(Z),
8132 !%4I,H(Z2,7),H(Z2,8),H(Z2,9),H(Z2,10),%$11F0,H(Z2,11)
8134 NEXT\IFX3>3ORW=6THEN8140\!""\!"TOO FEW HORSES"\Z$="K"\RETURN
8140     !""\INPUT"RETURN FOR RACE OR ANYTHING TO KILL ? ",Z$\RETURN
8200 IFW<>3THEN8202\INPUT"MAX $/RACE EARNED ? ",Z5
8202 INPUT"ID START & ID END SEARCH ? ",A,B\IFA>BTHEN8202
8203 IFA<0THEN8202\IFB>UTHEN8202
8205 FORZ=1TOX3\I(0,Z)=-999999\I(1,Z)=0\NEXT\Z4=0\I9=1
8210 FORZ=ATOB\IFH(Z,7)=0THEN8215\Z1=H(Z,11)/H(Z,7)\IFW=5THENZ1=0-Z1
8215 IFH(Z,8)>0ANDW=4THEN8260
8217 IFZ1>Z5ANDW=3THEN8260
8220 FORZ2=1TOX3\IFI(0,Z2)>Z1THEN8250
8230 FORZ3=X3TOZ2+1STEP-1\I(0,Z3)=I(0,Z3-1)\I(1,Z3)=I(1,Z3-1)\NEXT
8240 Z4=Z4+1\I(0,Z2)=Z1\I(1,Z2)=Z\EXIT8260
8250 NEXT
8260 NEXT\IFZ4<X3THENX3=Z4\RETURN
9000 FORZ=1TO11\!" "\NEXT
9001 FORZ=5TO-3STEP-1\Z1=Z*144\IFZ>-2THEN9008
9002 IFZ=-2THEN!"     ",T2$(1,2),
9004 IFZ=-3THEN!"   ",T2$(1,4),\GOTO9009
9008 !"        ",
```

```
9009 FORZ2=43TO47STEP2
9010 Z3=Z1+Z2+(144*((49-Z2)/2))\IFZ3>864THEN9020
9015 IFZ3<1THEN9020\!T$(Z3,Z3+1),\GOTO9030
9020 !"   ",
9030 NEXT\IFZ>-1THEN!T$(Z1+49,Z1+102),\IFZ<0THEN!T1$,
9032 IFZ=-2THEN!"    ",\IFZ=-3THEN!"      ",
9038 FORZ2=107TO103STEP-2
9040 Z3=Z1+Z2+(144*((109-Z2)/2))\IFZ3>864ORZ3<1THEN9050\!T$(Z3,Z3+1),
9050 NEXT\IFZ=-2THEN!T2$(1,2),\IFZ=-3THEN!T2$(1,4),\!" "\NEXT
9060 FORZ=42TO37STEP-1\FORZ1=720TO0STEP-144\Z2=Z+Z1\!T$(Z2,Z2),\NEXT
9062 Z4=43-Z\IFZ4>X3THEN9070\Z4=K(Z4)\Z5=A(Z4,0)
9064 Z6=(Z5+1)*10\!TAB(20),H$(Z6-9,Z6),"(#",%2I,Z4,")",
9066 Z4=49-Z\IFZ4>X3THEN9070\Z4=K(Z4)\Z5=A(Z4,0)
9068 Z6=(Z5+1)*10\!TAB(40),H$(Z6-9,Z6),"(#",%2I,Z4,")",
9070 !TAB(72),\FORZ1=0TO720STEP144\Z2=Z1+151-Z\!T$(Z2,Z2),\NEXT\!""\NEXT
9100 FORZ=-3TO5         \Z1=Z*144\IFZ>-2THEN9108
9102 IFZ=-2THEN!"       ",T2$(1,2),
9104 IFZ=-3THEN!"    ",T2$(1,4),\GOTO9109
9108 !"       ",
9109 FORZ2=36TO32STEP-2
9110 Z3=Z1+Z2+(144*((Z2-30)/2))\IFZ3>864THEN9120
9115 IFZ3<2THEN9120\!T$(Z3,Z3),T$(Z3-1,Z3-1),\GOTO9130
9120 !"  ",
9130 NEXT\IFZ<0THEN9150\FORZ2=30TO1STEP-1\Z3=Z2+Z1\!T$(Z3,Z3),\NEXT
9140 FORZ2=144TO121STEP-1\Z3=Z2+Z1\!T$(Z3,Z3),\NEXT
9150 IFO>ZTHEN!T1$,\IFZ=-2THEN!"    ",\IFZ=-3THEN!"      ",
9160 FORZ2=120TO116STEP-2\Z3=Z1+Z2+(144*((122-Z2)/2))
9170 IFZ3>864ORZ>Z3THEN9180\!T$(Z3,Z3),T$(Z3-1,Z3-1),
9180 NEXT\IFZ=-2THEN!T2$(1,2),\IFZ=-3THEN!T2$(1,4),
9190 IFZ<>5THEN!""\NEXT
9195 FORZ2=1TOX3\Z3=L(Z2)\T$(Z3,Z3)="."\NEXT\RETURN
9300 IFW=6THEN9350
9305 Z=99999\FORZ1=1TOX3\IFO(Z1)<ZTHENZ=O(Z1)\NEXT
9310Z2=0\Z=Z+ 20\FORZ1=1TOX3\O(Z1)=O(Z1)-Z\IFO(Z1)<20THENO(Z1)=20
9330 Z2=Z2+O(Z1)\NEXT\Z2=Z2*1.70\FORZ1=1TOX3\O(Z1)=INT((Z2/O(Z1))*2.5)
9340 O(Z1)=(O(Z1)/5)-1\IFO(Z1)<.20THENO(Z1)=.2\NEXT\RETURN
9350 FORZ1=1TOX3\O(Z1)=0\NEXT\RETURN
9400 Z2=0\FORZ1=1TOX3\Z2=Z2+O(Z1)\NEXT\Z2=Z2/X3
9420 FORZ1=1TOX3\Z3=INT(((O(Z1)-Z2)/100)+.5)\IFW=2THENZ3=INT(Z3*.5)
9430 IFZ3<-10THENZ3=-10\IFZ3>10THENZ3=10\O(Z1)=O(Z1)-(100*Z3)
9440 A(Z1,1)=120+Z3\NEXT\RETURN
9500 V7=K(1)\V1=O(V7)*2+2\V2=O(V7)+2\V3=O(V7)*.66+2\V3=INT((V3*20)/20)
9510 V3=V3*.20\V7=K(2)\V4=O(V7)+2\V5=O(V7)*.66+2\V5=INT((V5*20)/20)
9520 V5=V5*.2\V7=K(3)\V6=O(V7)*.66+2\V6=INT((V6*20)/20)\V6=V6*.2
9530 V3=V3+2\V5=V5+2\V6=V6+2\RETURN
9600 T1=INT(T/300)\T=T-(300*T1)\T2=INT(T/5)\T=T-(5*T2)\RETURN
9601 T1=INT(T/300)\T=V-(300*T1)\T2=INT(T/5)\T=T-(5*T2)\RETURN
9700 T3=H(Z1,7)+1\H(Z1,7)=T3\IFZ>3THEN9710\H(Z1,7+Z)=H(Z1,7+Z)+1
9710 IFZ>4THEN9800\H(Z1,11)=H(Z1,11)+(P(Z)*U1)
9800 T4=T3-(INT(T3/10)*10)\IFT4=0THENT4=10\T4=T4-1
9810 T5=2000+(572*Z1)+72+(T4*50)\Z1=K(Z)\Q=Z
9820WRITE#0%T5,Y,A(Z1,1),Z1,A(Z1,4),A(Z1,5),A(Z1,6),A(Z1,7),NOENDMARK
9825 WRITE#0%T5+35,A(Z1,8),A(Z1,9),O(Z1),NOENDMARK\RETURN
9900 R(Y,0)=(W*10000)+(X2*100)+X3\R(Y,1)=U1\T4=K(1)\R(Y,2)=A(T4,9)
9910 T4=K(1)\R(Y,3)=A(T4,0)\Y=Y+1\RETURN
9950 CLOSE#0\OPEN#0,M$
9960 FORA=0TO99\WRITE#0,R(A,0),R(A,1),R(A,2),R(A,3)
9970 IFR(A,0)=0THENEXIT9980\NEXT
9980 FORA=0TOU\A1=(572*A)+2000+47
9990 WRITE#0%A1,H(A,7),H(A,8),H(A,9),H(A,10),H(A,11),NOENDMARK\NEXT
9995 CLOSE#0\END
READY
$F
```



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Text continued from page 94:
in a real-time microcomputer music system.

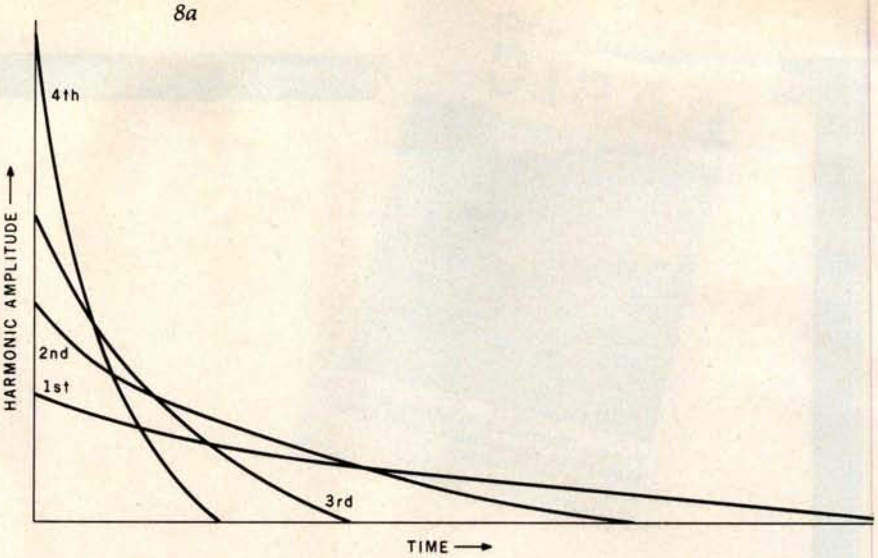
As before, we solve our problem by using a sequence of waveform tables to approximate the desired timbre envelope. In effect, we divide the time axis of the graph in figure 7b into a number of short intervals and compute a waveform table based on the average amplitude of each harmonic during the interval. If the waveform tables are used in sequence properly, the envelope sampling need not be uniform; sampling can be dense (closely spaced) during the attack and decay when harmonic amplitudes are changing rapidly, and sparse in between when things are fairly static.

Note that a single sequence of waveform tables implements both the overall amplitude envelope and the timbre envelope for a given instrument simulation. In fact, for lack of a better name, we will call a specific sequence of waveform tables an *instrument* and the specifications for computing them an *instrument specification*.

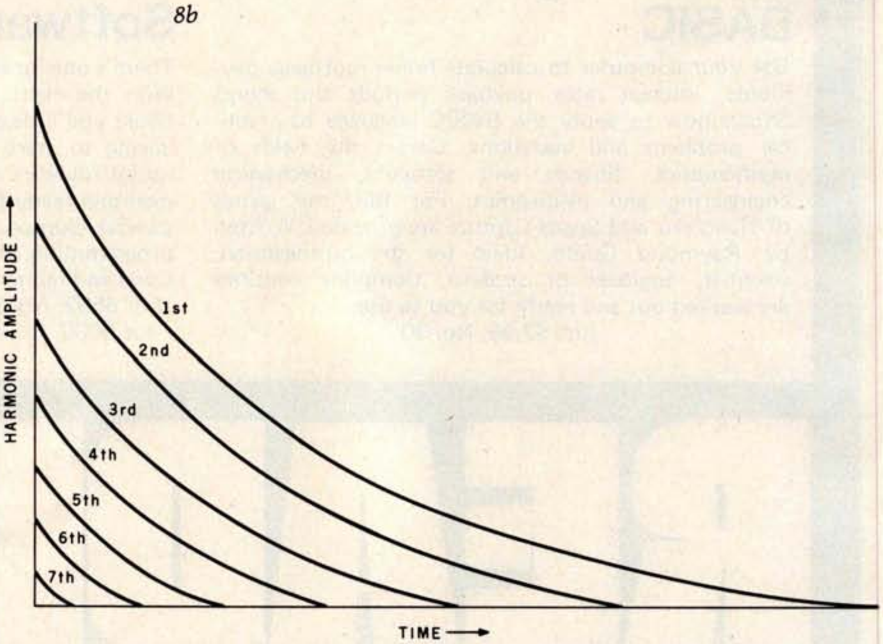
In actually setting up a waveform-sequencing routine, it is convenient to use a *waveform-sequence table*. This table is simply a list of numbers (typically with 256 entries), where each number corresponds to a waveform table (and is typically the page address of the table). While notes are being played, a *waveform-sequence pointer* moves at a uniform speed (about 100 increments per second) through the sequence table. Nonuniform sampling of the harmonic envelopes (dense or sparse at different times) is accomplished by varying the number of *duplicate* entries in the sequence table. It is even possible to define several different instruments using the same set of *waveform* tables simply by making a different *sequence* table for each instrument. One sequence, for example, could be simply the reverse of another.

Do not underestimate the importance or power of this additive-synthesis technique in producing realistic instrument sounds and interesting music. The graphs of figure 8 show some typical instrument characteristics. When these characteristics are incorporated into the software system to be described shortly, the instruments really sound plucked (figures 8a and 8b), struck (figure 8c), bowed

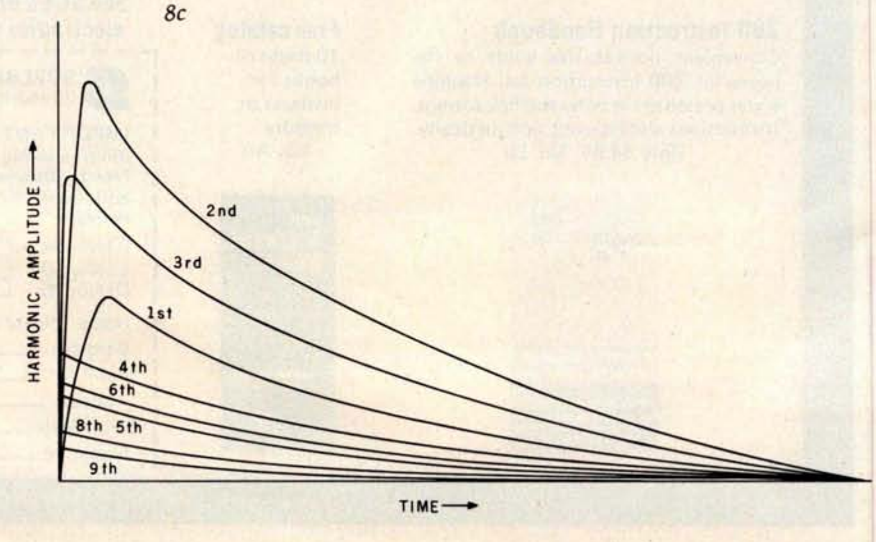
8a



8b



8c



(figure 8d), or blown (figure 8e).

The value of performing with a computer, however, lies in the concoction of new instruments such as those shown in figures 9 and 10.

The system I shall describe is sufficiently general and has sufficient correspondence between specifications and the actual sound produced that experimentation is encouraged. There is really nothing sacred about the sound of traditional instruments; they were mostly developed by trial and error, anyway. The real future of music lies in exploring the entire range of perceivable timbres, as well as in writing appropriate scores for various timbre groups.

Description of Music Software

In the remainder of this article, a music-playing program based on these principles will be described. The software is just a music interpreter that looks at compactly encoded music data in memory and carries out the specified tone-producing operations. In a complete music system, it is necessary to also have a music "compiler" that accepts a user-oriented "music language" and translates it into the format required by this interpreter.

Coding examples will be for the 6502 microprocessor. The maximum number of simultaneous voices is an arbitrary parameter that can be traded off against sample rate to the D/A converter. Using a clock frequency of 1 MHz on the 6502 processor, up to four voices are possible with an 8 kHz sample rate.

Basic Waveform-Scanning Code

The core of the program is the sound-generation routine that scans the waveform tables. I shall describe this routine, which is given in listing 4, first in its use with fixed waveform tables, that is, using rectangular envelopes. Then a description of an enhancement of it for waveform sequencing will follow.

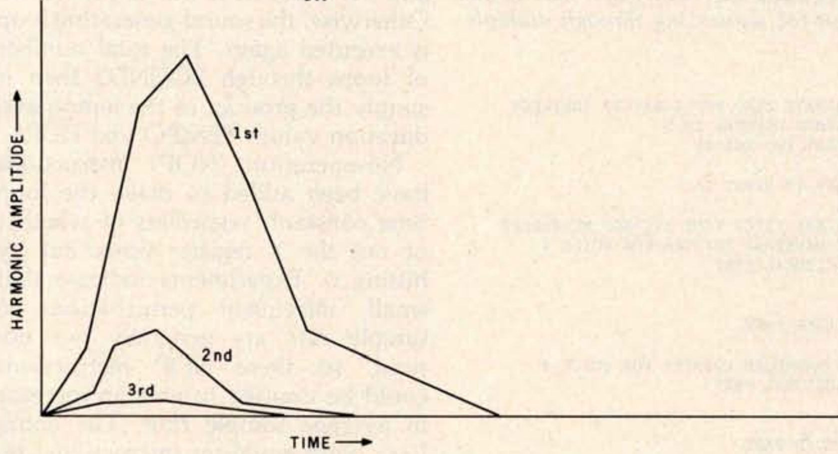
Before the waveform-scanning routine, SOUND, is called, ten parameters are established in memory by the calling routine. Four of these, the waveform-table pointers for each voice, are named WAVPT1 thru WAVPT4. The byte at WAVPTi+2 is the page number of the waveform table to be used for voice i. Four additional parameters, WAVIN1 thru WAVIN4, are the increments for the four waveform-table pointers. These pointer increments define the frequency for each of the four tones.

The last two parameters (TEMPO and DUR) are multiplied together to determine the duration, in sample periods, of sound generation before returning to the calling routine. DUR is normally used to specify the *relative* duration of the event while TEMPO specifies the overall speed of the event sequence. All of these parameters are kept in page 0 of memory for maximum speed of access.

In operation, the music-code interpreter sets up these ten parameters and calls SOUND for each musical event in the piece. An event is defined as the time between changes in the sound and is usually the duration of the shortest notes in a passage or chord. Since sound generation stops while the interpreter is setting up the next event, it is important that the interpreter be an efficient machine-language program was well.

Peering more deeply into the SOUND routine, we see that the value from location TEMPO is kept in the X register, DUR (the duration value) is left in memory, and the Y register is zeroed. In the 6502, the value of the Y register is added to indirect addresses, so "normal" indirect-address operation requires that Y contain 0.

8d



8e

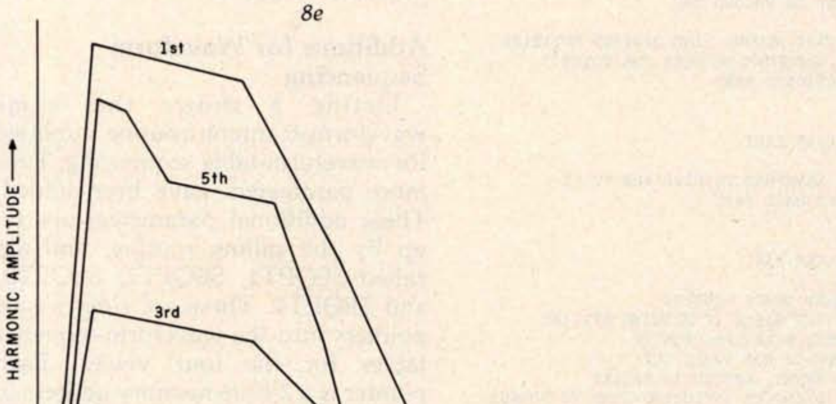


Figure 8: *Amplitude envelopes for harmonics present in notes produced by various types of instruments. (8a) First type of plucked-string instrument, a banjo, or a violin played pizzicato. (8b) Second type of plucked-string instrument, such as a lute or harpsichord. (8c) Struck-string instrument, such as a piano, in this case for the octave just below middle C at 261.6 Hz. (8d) Bowed-string instrument, such as a cello; for further data on this type, see reference 4. (8e) Blown reed or woodwind instrument, such as a clarinet; for further data on this type, see reference 5.*

We can see that during the loop starting at SOUND2 in listing 4, each of the pointer increments (WAVIN1, etc) is double-precision added to the corresponding waveform-table pointers (WAVPT1, etc). These are the integer and fractional parts of the pointers and increments. To save time, the initial state of the carry flag is ignored when the fractional parts are added together. (The state of the 6502 carry flag is always considered in an add instruction.)

The interesting part of the SOUND2 loop is the section which outputs samples that have been fetched from the waveform tables. In the top part of the loop, samples for voices 1 and 2 are averaged together and sent to one D/A converter while, later on, voices 3 and 4 are sent to another D/A converter. This stereo feature can be quite effective.

For monophonic output, the two D/A-converter addresses are simply made the same. Such action is actually an example of *time-division multiplexing*, another method of mixing simultaneous tones through a single D/A converter. The mixing actually takes place in the filter, due to its "hangover" effect between A-channel and B-channel samples in monophonic use.

Listing 4: *The basic waveform-scanning code for the 6502 microprocessor. This is the original version, which does not contain provision for sequencing through multiple waveform tables.*

```
0200 A000      SOUND:   LDY    #0              ; Y IS ALWAYS ZERO FOR STRAIGHT INDIRECT
0202 A600      SOUND1:  LDX    TEMPO           ; KEEP TEMPO COUNTER IN X
0204 18        SOUND2:  CLC                    ; ADD FIRST TWO VOICES
0205 B103               LDA    (WAVPT1+1),Y
0207 7106               ADC    (WAVPT2+1),Y ; AND SEND TO FIRST DAC
0209 6A                 RORA
020A 8D00FE             STA    DACA            ; **** START FIRST TIME DIVISON MULTIPLEX
020D A502               LDA    WAVPT1          ; UPDATE WAVEFORM POINTER FOR VOICE 1
020F 650E               ADC    WAVIN1          ;    FRACTIONAL PART
0211 8502               STA    WAVPT1
0213 A503               LDA    WAVPT1+1
0215 650F               ADC    WAVIN1+1        ;    INTEGER PART
0217 8503               STA    WAVPT1+1
0219 A505               LDA    WAVPT2          ; UPDATE WAVEFORM POINTER FOR VOICE 2
021B 6510               ADC    WAVIN2          ;    FRACTIONAL PART
021D 8505               STA    WAVPT2
021F A506               LDA    WAVPT2+1
0221 6511               ADC    WAVIN2+1        ;    INTEGER PART
0223 8506               STA    WAVPT2+1
0225 18                 CLC                    ; ADD SECOND TWO VOICES
0226 B109               LDA    (WAVPT3+1),Y
0228 710C               ADC    (WAVPT4+1),Y ; AND SEND TO SECOND DAC
022A 6A                 RORA
022B 8D02FE             STA    DACB            ; **** START SECOND TIME DIVISON MUTIPLEX
022E A508               LDA    WAVPT3          ; UPDATE WAVEFORM POINTER FOR VOICE 3
0230 6512               ADC    WAVIN3          ;    FRACTIONAL PART
0232 8508               STA    WAVPT3
0234 A509               LDA    WAVPT3+1
0236 6513               ADC    WAVIN3+1        ;    INTEGER PART
0238 8509               STA    WAVPT3+1
023A A50B               LDA    WAVPT4          ; UPDATE WAVEFORM POINTER FOR VOICE 4
023C 6514               ADC    WAVIN4          ;    FRACTIONAL PART
023E 850B               STA    WAVPT4
0240 A50C               LDA    WAVPT4+1
0242 6515               ADC    WAVIN4+1        ;    INTEGER PART
0244 850C               STA    WAVPT4+1
0246 CA                 DEX                    ; DECREMENT TEMPO COUNTER
0247 D005               BNE    SOUND3          ; GO TO TIME WASTE IF NOTHING SPECIAL
0249 C601               DEC    DUR             ; DECREMENT DURATION COUNTER
024B D0B5               BNE    SOUND1          ; CONTINUE IF NOT TIMED OUT
024D 60                 RTS                    ; END OF EVENT, RETURN TO CALLER
024E EA        SOUND3:  NOP                    ; WASTE 10 CLOCKS INCLUDING JUMP TO SOUND2
024F EA                 NOP
0250 4C5302             JMP    .+3
0253 4C0402             JMP    SOUND2

FE00           DACA     =      X'FE00          ; LEFT CHANNEL DAC  (MAKE DACA=DACB FOR MONO)
FE02           DACB     =      X'FE02          ; RIGHT CHANNEL DAC
0000 00        TEMPO:   .BYTE  0               ; TEMPO ARGUMENT FROM CALLER
0001 00        DUR:     .BYTE  0               ; DURATION ARGUMENT FROM CALLER
0002 000000    WAVPT1:  .BYTE  0,0,0           ; VOICE 1 WAVE TABLE POINTER  FRAC,INT,WAVE
0005 000000    WAVPT2:  .BYTE  0,0,0           ; VOICE 2
0008 000000    WAVPT3:  .BYTE  0,0,0           ; VOICE 3
000B 000000    WAVPT4:  .BYTE  0,0,0           ; VOICE 4
000E 0000      WAVIN1:  .BYTE  0,0             ; VOICE 1 POINTER INCREMENT   FRAC,INT
0010 0000      WAVIN2:  .BYTE  0,0             ; VOICE 2
0012 0000      WAVIN3:  .BYTE  0,0             ; VOICE 3
0014 0000      WAVIN4:  .BYTE  0,0             ; VOICE 4
```

Time-division multiplexing has the advantage of providing the equivalent of a 9-bit D/A converter and the disadvantage of requiring a better filter on the D/A converter. The rearrangement of processing tasks in the main loop is necessary so that the durations of the dwell time of A-channel and B-channel samples are approximately equal. Inequality in these durations leads to a volume inbalance when set up for monophonic output.

At the bottom of the SOUND2 loop, register X, which contains the TEMPO parameter, is decremented. If X becomes 0, it is reloaded from TEMPO and DUR is decremented directly in memory. If DUR also becomes 0, the sound event is over and the subroutine exits by a return. Otherwise, the sound-generating loop is executed again. The total number of loops through SOUND2 then is simply the product of the tempo and duration values TEMPO and DUR.

No-operation (NOP) instructions have been added to make the loop time constant, regardless of whether or not the X register times out by hitting 0. Experiments indicate that small, infrequent perturbations in sample rate are generally not noticed, so these NOP instructions could be omitted to give an increase in average sample rate. The entire loop (with equalizer instructions) requires 123 μs, which gives a sample rate of 8.13 kHz.

Additions for Waveform Sequencing

Listing 5 shows this same waveform-scanning routine modified for waveform-table sequencing. Four more parameters have been added. These additional parameters are set up by the calling routine, and are called SEQPT1, SEQPT2, SEQPT3, and SEQPT4. These are simply four pointers into the waveform-sequence tables for the four voices. Each pointer is a 2-byte memory address in which the upper byte (the page address of the sequence table) is normally constant and the lower byte is the pointer that scans through the sequence table.

The additional code for waveform-table sequencing is split into two sections. The first section of code accesses the four waveform-sequence tables and stores the data found into the page address parts of the

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waveform-table pointers (WAVPT1, etc). The second section of code increments the lower parts (byte addresses) of the sequence-table pointers (SEQPT1, etc). Both sections need to be executed only when index register X (which is initialized with the TEMPO parameter) underflows and is reinitialized; this typically occurs every 75 to 150 sample periods. On other passes through the waveform-scanning loop, time-wasting instructions of equivalent duration would need to be executed.

In the actual code of listing 5, we see that the sequence-table lookup instructions have been placed at the beginning of the loop at SOUND1; thus these instructions are guaranteed to be executed first thing when the routine is entered. This is necessary in case the calling routine has changed one of the sequence-table pointers, to assign a different instrument to a voice.

SOUND2 begins the waveform-table-lookup instructions, which are the same as before. At SOUND3, TEMPO (in index-register X) and the duration value DUR are decremented, while at SOUND4 the waveform-sequence-table pointers are incremented if X was decremented to zero. Note that the sequence-table-lookup instructions at SOUND1 are *not* executed until one sample period *after* the pointers are incremented, by virtue of control branching back to SOUND2 at the end of SOUND4, instead of to SOUND1. This in effect uses the instructions at SOUND1 as a time equalizer and greatly speeds up the routine.

Listing 5: *The advanced waveform-scanning code for the 6502. This version does contain provision for sequencing through multiple waveform tables. The code shown here was developed by Frank Covitz and Cliff Ashcraft.*

```
0200 A000      SOUND:   LDY   #0             ; Y IS ALWAYS ZERO FOR STRAIGHT INDIRECT
0202 A600               LDX   TEMPO          ; KEEP TEMPO COUNTER IN X
0204 B116      SOUND1:  LDA   (SEQPT1),Y     ; LOOKUP WAVEFORM PAGE NUMBER FOR VOICE 1
0206 8504               STA   WAVPT1+2       ; IN WAVEFORM SEQUENCE TABLE
0208 B118               LDA   (SEQPT2),Y     ; VOICE 2
020A 8507               STA   WAVPT2+2
020C B11A               LDA   (SEQPT3),Y     ; VOICE 3
020E 850A               STA   WAVPT3+2
0210 B11C               LDA   (SEQPT4),Y     ; VOICE 4
0212 850D               STA   WAVPT4+2
0214 18        SOUND2:  CLC                  ; ADD FIRST TWO VOICES
0215 B103               LDA   (WAVPT1+1),Y
0217 7106               ADC   (WAVPT2+1),Y   ; AND SEND TO FIRST DAC
0219 6A                 RORA
021A 8D00FE             STA   DACA           ; **** START FIRST TIME DIVISON MULTIPLEX
021D A502               LDA   WAVPT1         ; UPDATE WAVEFORM POINTER FOR VOICE 1
021F 650E               ADC   WAVIN1         ;    FRACTIONAL PART
0221 8502               STA   WAVPT1
0223 A503               LDA   WAVPT1+1
0225 650F               ADC   WAVIN1+1       ;    INTEGER PART
0227 8503               STA   WAVPT1+1
0229 A505               LDA   WAVPT2         ; UPDATE WAVEFORM POINTER FOR VOICE 2
022B 6510               ADC   WAVIN2         ;    FRACTIONAL PART
022D 8505               STA   WAVPT2
022F A506               LDA   WAVPT2+1
0231 6511               ADC   WAVIN2+1       ;    INTEGER PART
0233 8506               STA   WAVPT2+1
0235 18                 CLC                  ; ADD SECOND TWO VOICES
0236 B109               LDA   (WAVPT3+1),Y
0238 710C               ADC   (WAVPT4+1),Y   ; AND SEND TO SECOND DAC
023A 6A                 RORA
023B 8D02FE             STA   DACB           ; **** START SECOND TIME DIVISON MUTIPLEX
023E A508               LDA   WAVPT3         ; UPDATE WAVEFORM POINTER FOR VOICE 3
0240 6512               ADC   WAVIN3         ;    FRACTIONAL PART
0242 8508               STA   WAVPT3
0244 A509               LDA   WAVPT3+1
0246 6513               ADC   WAVIN3+1       ;    INTEGER PART
0248 8509               STA   WAVPT3+1
024A A50B               LDA   WAVPT4         ; UPDATE WAVEFORM POINTER FOR VOICE 4
024C 6514               ADC   WAVIN4         ;    FRACTIONAL PART
024E 850B               STA   WAVPT4
0250 A50C               LDA   WAVPT4+1
0252 6515               ADC   WAVIN4+1       ;    INTEGER PART
0254 850C               STA   WAVPT4+1
0256 CA        SOUND3:  DEX                  ; DECREMENT TEMPO COUNTER
0257 D0AB               BNE   SOUND1         ; REPEAT IF NOTHING SPECIAL
0259 C601               DEC   DUR            ; DECREMENT DURATION COUNTER
025B F00D               BEQ   SOUND5         ; JUMP OUT IF TIMED OUT
025D E616      SOUND4:  INC   SEQPT1         ; INCREMENT SEQUENCE TABLE POINTERS
025F E618               INC   SEQPT2
0261 E61A               INC   SEQPT3
0263 E61C               INC   SEQPT4
0265 A600               LDX   TEMPO          ; RESTORE TEMPO IN X
0267 4C1402             JMP   SOUND2         ; JUMP BACK INTO LOOP
026A 60        SOUND5:  RTS                  ; END OF EVENT, RETURN TO CALLER

0016 0000      SEQPT1:  .BYTE 0,0            ; VOICE 1 WAVEFORM SEQUENCE TABLE POINTER
0018 0000      SEQPT2:  .BYTE 0,0            ; VOICE 2 WAVEFORM SEQUENCE TABLE POINTER
001A 0000      SEQPT3:  .BYTE 0,0            ; VOICE 3 WAVEFORM SEQUENCE TABLE POINTER
001C 0000      SEQPT4:  .BYTE 0,0            ; VOICE 4 WAVEFORM SEQUENCE TABLE POINTER
```

As written, the sample period lasts for 145 processor clock pulses, which gives a sample rate of 6.89 kHz for four voices. If the routine is rewritten for instruction self-modification and put in page 0, the sample rate can be increased to 7.81 kHz (128 clock pulses), which is a much better match to the D/A converter filter designed for the earlier SOUND routine.

Higher-speed versions of the 6502, such as those found in Ohio Scientific, Atari, and Micro Technology processor boards, can give either higher sample rates or more voices, or both. For example, a 2 MHz 6502A could provide six voices with an 11-kHz sample rate, and a 3 MHz unit could provide eight voices at a 12.6 kHz rate, the same frequency response as an AM radio!

The use of waveform-sequence tables offers a great deal of flexibility in handling amplitude envelopes. To start a note with a given voice, its sequence-table pointer is reset to 0. To continue a note through several events (such as a half note in the bass continued during quarter notes and triplets in the treble), the music-code interpreter simply does not initialize the sequence-table pointer for the half note when entering the SOUND routine. The pointer then continues moving along the sequence table for continuity between events.

A problem may develop if a note is so long that the sequence pointer wraps around and starts over from the beginning. This can occur only for durations longer than a whole note and may be handled by backing the pointer up or switching to a different sequence table in which all entries are the same. In fact, it is possible to switch among sequence tables. One table is used for the attack, one for the steady state (sustain), and one for the decay. The steady-state sequence table could

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even be coded to cycle through several waveform tables and thus make possible a kind of vibrato. Separate sequence tables could also be used for different playing styles, such as legato, staccato, etc.

Music-Code Interpreter

The music-code interpreter is a program that looks at the encoded score in memory, sets up the parameters for the SOUND routine, and then calls SOUND for each encoded event. A music compiler, when written, translates a high-level music language into the binary-encoded form to be described.

Although such operations are usually done in a music compiler, this interpreter can also compute waveform and sequence tables from instrument specifications encoded in the score. An advantage of this capability is that instrument specifications can sometimes be recomputed on the fly during natural breaks in the music score, if a high-speed Fourier series routine is available.

In order to maximize the flexibility of the system while simplifying the interpreter, the score is encoded into two completely separate *strings* or arrays of 8-bit bytes. One of these is called the *command string,* and it consists of commands to the interpreter such as "Construct an instrument," "Set tempo," "Play a melody segment," "Stop," etc. The other string is called the *note string,* and it

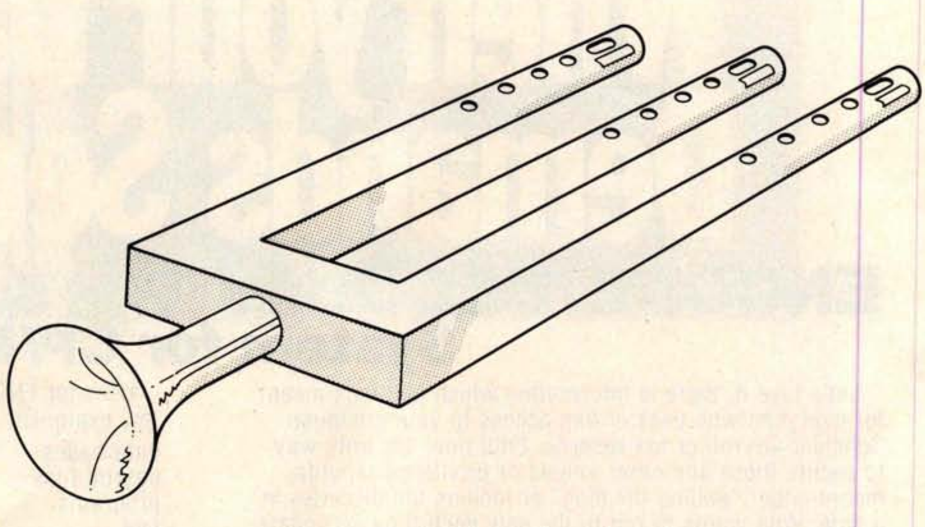


Figure 9a: *Artist's conception of the Glocken-flute, a hypothetical instrument, from a sketch by Cliff Ashcraft.*

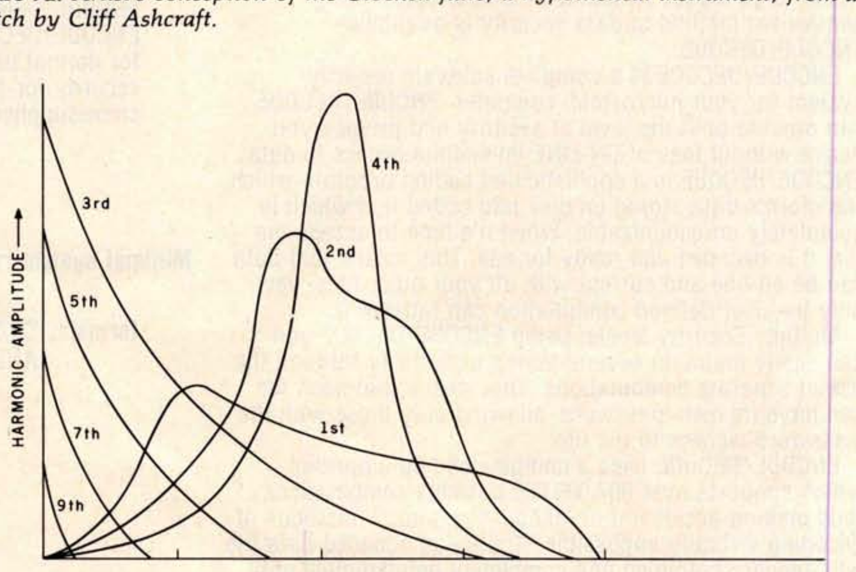
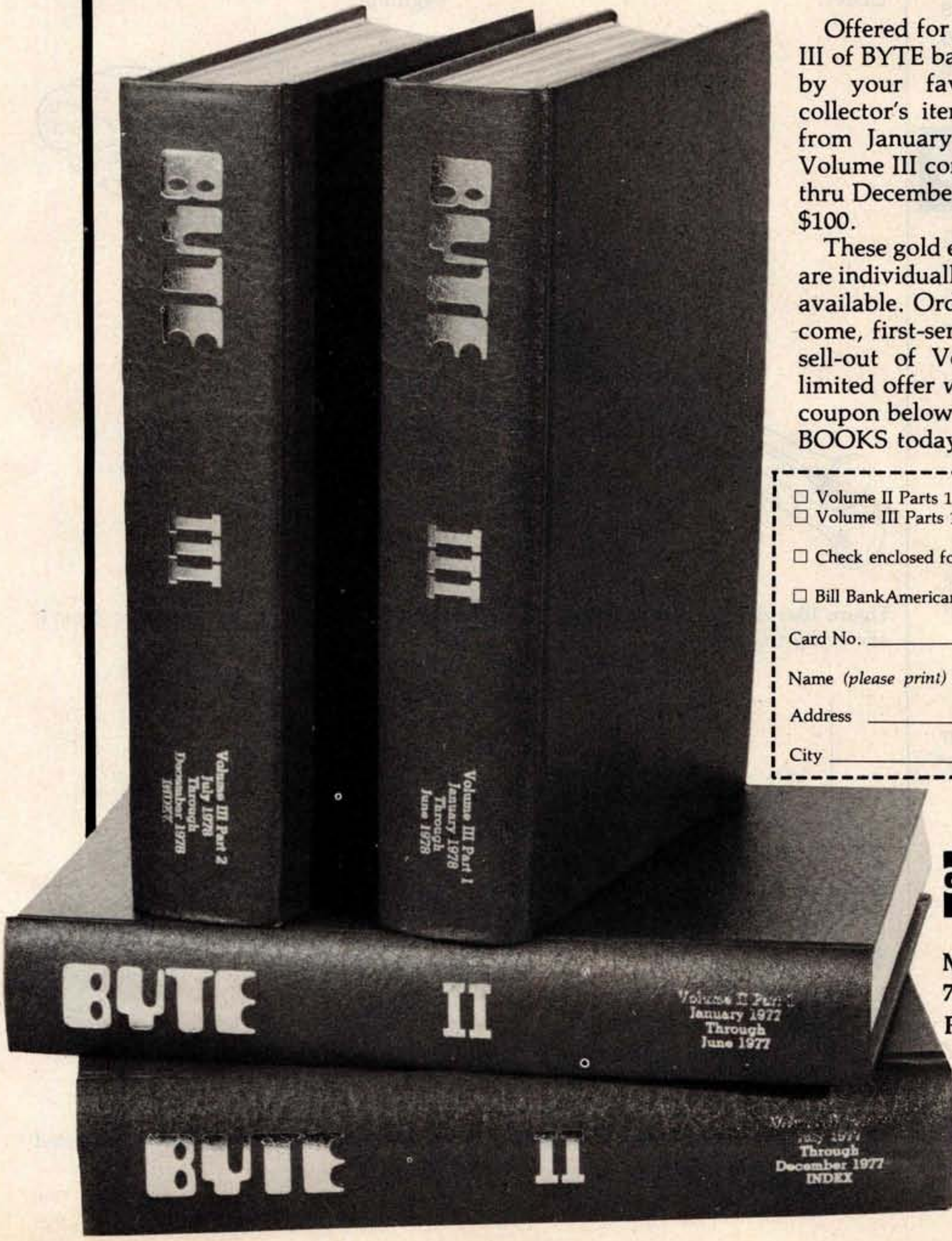


Figure 9b: *Amplitude envelopes for harmonics present in tones produced by the Glocken-flute.*

LIMITED EDITION



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contains the actual encoded notes.

Functions such as repetition of melody segments (for refrains and the like) are handled by coding multiple commands in the command string to play the same note-string segment. If intervening commands between occurrences have changed the tempo or instrument assignments, the same note-string segment will sound different when it is played again.

This double-string structure gives all of the power of jumps, repeats, and musical subroutines while avoiding the need for return-address saving, symbol tables, or look-ahead in either the interpreter or compiler. It also makes editing the strings easier.

Structure of the Note String

The format of the note string is quite simple, and consists of a sequence of *segments*. Each segment is a section of the score that can be treated as a unit. The command string determines the order in which the segments are actually played. Within a segment is coded a sequence of *events* where each event requires $N+1$ bytes, where N is the number of voices. The first byte of the event gives the duration of the event. The actual duration, in sample periods, is equal to the value of the duration byte multiplied by the current value stored in location TEMPO. A duration value of 0 signifies the end of the segment.

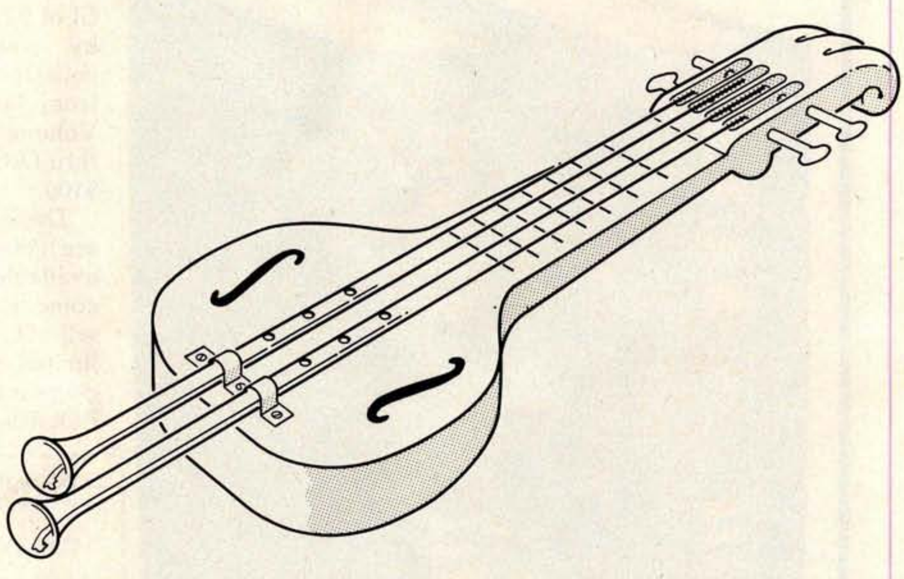

Figure 10a: *Artist's conception of the Blither, another hypothetical instrument, from a sketch by Cliff Ashcraft.*

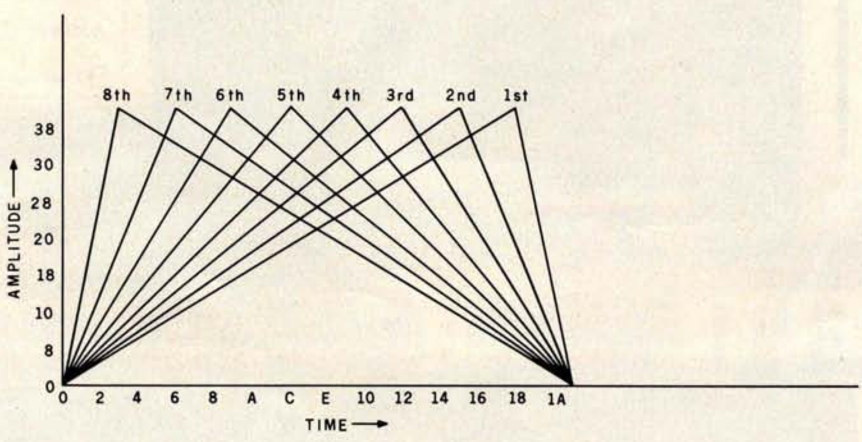

Figure 10b: *Amplitude envelopes for the Blither. Note the unusual symmetry exhibited by the envelopes.*

Succeeding bytes in the event segment give the pitches for each of the *N* voices. A command in the command string can alter *N*, if it is desired to save space when only a couple of voices are required for the segment. The pitch can be specified over a five-octave range that normally goes from C1 (32.7 Hz) to C6 (1046.5 Hz) and contains sixty-one pitch possibilities. The pitches can also be transposed up or down with an *offset* command for greater range.

Hexadecimal Op Code	Data Bytes	Operation Description
00 FF		End of command list, return to system monitor.
01 thru 0F	L,H	Play note segment starting at location given by address bytes H,L relative to beginning of note string. Version of SOUND used depends on op code. 01 = original SOUND routine, 02 = advanced SOUND routine.
10	I1,I2,I3,I4	Assign instrument I1, I2, etc to voice 1, voice 2, etc, respectively. Value of I1, I2, etc is page address of waveform-sequence table for the instrument, relative to origin of waveform memory.
11	T	Set TEMPO parameter to T.
12	N	Set number of active voices to N; inactive voices must be assigned to a silent instrument.
13	I,J	Establish pitch offset of J semitones for voice I. J is a signed integer. All offsets are initialized to zero.
14	L,H,...	Go to user-supplied subroutine at absolute address H,L. Command string pointer is pointing to the byte following H.
20	S	Create silent instrument at relative page address S and S + 1
21	S,N, H_i,W,A, W,A, ..., FF, ..., FF	Create a sequence of waveform tables. Start at relative page address S and occupy a total of N pages. H_i is harmonic number, 00 = noise, FF = end of command. W,A group defines a line segment for harmonic H_i; W = ending page address (relative to S) which is abcissa, and A = ending amplitude which is ordinate. Initial endpoint of first line segment for the harmonic is 0,0. W = FF = end of harmonic.
22	A,S,N, D1,D2,...,DN	Create a waveform-sequence table at A for waveform set computed with 21 op code using S and N. D1 is dwell time for waveform 1 in terms of waveform-sequence sample period, D2 is dwell time for waveform 2, etc. The sum of the D parameters should normally be 256.
23	A,S,N, DN,D(N − 1),...,D1	Same as 22, except waveform-sequence is backwards.
24	A,S,N,E	Create a waveform-sequence table at A for waveform set computed with 21 opcode using S and N. E is an exponential "stretch" factor. E = 0 gives a uniform sampling of the N waveforms. Positive E gives an increasing sample rate toward the end of the sequence table, while negative E gives a decreasing sample rate. The exponential scale factor is such that E = 16 gives a two-to-one stretch ratio, E = 32 a four-to-one ratio, etc.
25	A,S,N,E	Same as 24, except waveform sequence is backwards.

Table 1: *Instruction set of the command-code interpreter. The hexadecimal code in the leftmost column invokes the described operation. The op code is followed by one or more data bytes that give parameters for the specified operation. When execution of the interpreter begins, the memory addresses of the origin of the command string, note string, and waveform-table work areas are passed as parameters. All addresses in the command string are given relative to these origins.*

Six bits of the pitch-specification byte indicate the pitch within the five-octave range. The remaining two pitch bits specify how the amplitude envelope is to be handled. Currently, only one bit is used to specify one of the two states *begin note* (reset waveform-sequence pointer) and *continue note* (leave pointer alone), and the other bit is reserved for future use.

Structure of the Command String

The command string is organized as a list of commands that are simply executed in strict sequential order. An individual command consists of a *command code* byte followed by as many *data* bytes as the command needs. Table 1 gives a partial list of available commands. There is plenty of room for expansion as the music package evolves and matures. Many of the commands involve memory addresses such as the beginning of a note-string segment or the addresses of sequence and waveform tables. When the interpreter is entered, the addresses of the origins in memory of the command string, note string, and work area for waveform tables are given; all addresses in the command string are relative to the beginning of these areas. This allows score coding to be machine-independent.

Coding Instrument Definitions

Several of the available commands are used for "constructing instruments," which actually means computing the necessary waveform and sequence tables. The first step in construction is to cause a sequence of waveform tables to be computed by using the command code hexadecimal 21.

The *S* parameter is the page address (relative to the beginning of waveform memory) where the first waveform table will be stored. The *N* parameter is the total number of waveform pages that will be created. This is checked against succeeding line segment data to minimize the effect of errors. *S* and *N* also serve to uniquely identify the waveform sequence for other commands.

In order to simplify coding from

published instrument analyses (such as the quarterly installments of the the "Lexicon of Analyzed Tones" in the *Computer Music Journal*), the command processor will accept harmonic data in a line-segment form. The envelope of each harmonic is defined by a substring of bytes (H_i, $W,A,W,A,\ldots,FF$) where H_i is the actual harmonic number, and each W,A pair defines a point on the time-amplitude plane for that harmonic.

A is the amplitude value (an unsigned binary fraction), and W is the waveform number, which is proportional to time. The routine will linearly interpolate intermediate amplitude values from the previous W,A point to the current W,A point. The initial point is always 0,0. Of course, if you wish to directly specify the harmonic amplitude in each waveform table, then consecutive Ws from 0 to $N - 1$ with corresponding amplitudes could be coded. The end of the W,A sequence is denoted by a value for W equal to hexadecimal FF. At that point data for another harmonic could follow, or another hexadecimal FF value could be coded to end the waveform-computation command.

Note that if a harmonic amplitude is not specified for a waveform, then its amplitude is assumed to be 0. Presently the system sets the *phase* angles of all harmonics to 90° leading (negative sine waves), which minimizes attack clicks and allows the use of symmetry to double the waveform computation speed. The zeroeth harmonic is actually a source of white noise, which enhances the realism of some instruments and allows limited percussion effects.

COMMAND STRING		EXPLANATION
Relative Address	Code Bytes	
0000	20 00	Create a silent instrument for inactive voices at page 0 in waveform memory
0002	21 02 1B	Create a sequence of waveform tables for the Blither starting at page 2 in waveform memory, hexadecimal 1B waveforms
0005	01 18 3C 1B 00 FF	Fundamental, two line segments: 0,0 to 18,3C to 1B,0
000B	02 15 3C 1B 00 FF	2nd harmonic, two line segments: 0,0 to 15,3C to 1B,0
0011	03 12 3C 1B 00 FF	3rd harmonic, two line segments: 0,0 to 12,3C to 1B,0
0017	04 0F 3C 1B 00 FF	4th harmonic, two line segments: 0,0 to 0F,3C to 1B,0
001D	05 0C 3C 1B 00 FF	5th harmonic, two line segments: 0,0 to 0C,3C to 1B,0
0023	06 09 3C 1B 00 FF	6th harmonic, two line segments: 0,0 to 09,3C to 1B,0
0029	07 06 3C 1B 00 FF	7th harmonic, two line segments: 0,0 to 06,3C to 1B,0
002F	08 03 3C 1B 00 FF	8th harmonic, two line segments: 0,0 to 03,3C to 1B,0
0035	FF	End of command
0036	24 1D 02 1B F0	Create a waveform sequence table for the Blither at page 1D in waveform memory using an exponential stretch factor of −16.
003B	25 1E 02 1B 10	Create a reverse waveform sequence table at page 1E for the "Anti-Blither" using the same waveforms.
0040	12 02	Set number of active voices to 2.
0042	10 1D 1E 00 00	Voice 1 is Blither, voice 2 is Anti-Blither, voices 3 and 4 are silent.
0047	11 64	Set TEMPO to 100.
0049	02 00 00	Play note string segment at beginning of note string.
004C	02 00 00	Play the scale again.
004F	FF	End of command string, finished.

Table 2a: *An example of a command string. This command string plays a scale on the Blither using the note string of table 2b.*

Once the waveforms have been computed, the waveform-sequence table must be constructed. Since there are fewer waveforms than the 256-entry capacity of the table, there will be much duplication of entries.

The command indicated by hexadecimal 22 will construct a sequence table with an arbitrary time duration for each waveform. The A parameter specifies the memory page number where the sequence table will be stored, and the S,N pair identifies the set of waveforms the table is to address. The following N bytes gives the "dwell" time in terms of waveform-sequence-sample periods (in terms of audio sample periods each having the value set by TEMPO) for each of the N waveforms. Normally the sum of these bytes equals 256 so that the full length of the table addresses all of the waveforms. Using this command, arbitrary nonuniform sampling of the waveform tables may be specified. The command-sequence invoked by hexadecimal 23 is similar, except that the waveform tables are stepped through in reverse order.

For most instruments, the 24 command is appropriate, since only one parameter is needed to define how the sequence table is to be filled. A, S, and N are as before; and E is an "exponential stretch" factor. If E is set to 0, then uniform sampling is enabled, and the sequence table simply uses a duplication factor of $256/N$. If E is positive, then the sampling density increases (as the duplication factor decreases) toward the end of the table, which means that waveforms are sequenced faster at the end of the note than at the beginning. A negative E makes things happen faster at the beginning, which is the usual case for normal instruments.

E is scaled such that a value of

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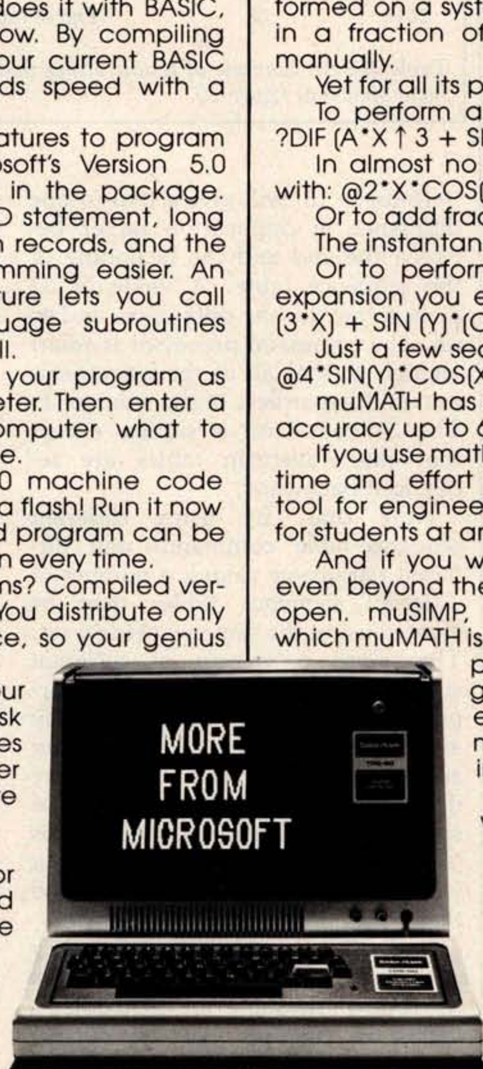
muMATH and muSIMP were written by The Soft Warehouse, Honolulu, Hawaii. Priced at $74.95, the package includes muMATH, muSIMP and a complete manual. It requires a Model I TRS-80 with 32K and single disk. muMATH for the Apple II Computer will be available later this year.



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MICROSOFT CONSUMER PRODUCTS

NOTE STRING		EXPLANATION
Relative Address	Code Bytes	
0000	40 19 0D	Blither plays quarter note C3, Anti-Blither plays C2, envelope starts at beginning.
0003	40 9B 8F	D3 and D2, continue envelope for tied notes.
0006	40 9D 91	E3 and E2, tied to first two notes
0009	40 1E 12	F3 and F2, restart envelope.
000C	40 A0 94	G3 and G2, continue envelope.
000F	40 A2 96	A3 and A2, continue envelope.
0012	40 24 18	B3 and B2, restart envelope.
0015	80 25 19	C4 and C3, half notes, tied to previous notes.
0018	00	End of note segment, return to command string.

Table 2b: *An example of a note string that plays a scale on the Blither, the instrument shown in figure 10.*

+16 (or −16) will give a two-to-one difference in duplication factor between the end and the beginning of the sequence table. A value of 32 gives a four-to-one difference, and so on. The command processor is smart enough so that all of the waveforms are used, regardless of the value of *E*. The 25 command is similar except that the waveform tables are sequenced backward.

Note that, by using different sequence-table commands and different parameter values, a number of different sequence tables may be created using the same waveform set. This gives a variety of different sounding instruments (it is often surprising how different sounding they are) with only 256 bytes required per additional instrument. There are doubtless many other methods of specifying waveform-sequence tables (such as provision for cycling waveforms to achieve vibrato), and there is ample room for expansion.

Probably the easiest way to verify an understanding of the preceding is to follow through an instrument-definition example. For simplicity, the Blither, whose analysis is shown in figure 10b, will be used. Table 2 gives a command sequence that can be used to define the instrument, assign it to a voice, and play a note-string segment with it.

Results

There are many other aspects of the interpreter too numerous to explain here. In general, the system gives very good results, even at the 6.9 kHz sample rate that the unoptimized SOUND routine provides. Over two dozen pieces of widely varying content have been coded by Frank and Cliff and played to audiences. The biggest hit has been "Dueling Banjos" from the movie *Deliverance*, which, after several iterations of the instrument definitions, produces quite realistic guitar and banjo sounds.

With relatively little effort, instrument definitions for cello, baritone horn, clarinet, mandolin, flute, zither, and even steel-drum band have been coded as well, and integrated into appropriate (and not so appropriate) musical scores. The piano has proved to be very difficult to imitate passably, but progress is being made by defining each octave as a separate instrument. The development of a sound-analysis program that runs on a 6502 microprocessor and produces data acceptable to the music interpreter will greatly aid the coding of additional existing instruments.

The biggest complaint from listeners has been the small but audible background-noise level which results from waveform-pointer truncation and, to a lesser extent, from waveform-table switching. In contrast, users of the system who attempt to encode melodies seem bothered most by the limited high-frequency response, which restricts the notes playable by instruments that have

rich harmonic spectra. By orchestrating the piece properly, it is possible to mask these shortcomings to some degree.

Evolution into a Non-Real-Time System

If the goal is production of music to be stored on audio media, it is possible to take the synthesizing process out of real time and thereby obtain a much higher-quality result. In particular, the sample rate may be made as high as desired and the noise level made inaudible (compared to the noise inherent in the recording medium) by eliminating the shortcuts necessary for real-time output. Multiplication and division can also be admitted if needed, and new features, such as a digital filtering, added.

The usual complaint about non-real-time systems is the lack of immediate audible feedback, which impedes the composition process. However, with this system, composition can be done in real-time mode with all the features available; then the music can be realized in non-real-time mode for a perfectly clean-sounding final result. This is not unlike common practice in word-processing centers (computerized typing pools) where a high-speed, dot-matrix proof printer is used for rapid draft output and a much slower letter-quality printer is used for the final copy.

In the past, a non-real-time music synthesis system was simply not practical on personal-computer hardware because the required volume of high-speed mass storage was unavailable. However, many of the systems entering today's market have the necessary disk-storage capacity and transfer rate to do an excellent job. It goes without saying that a system equipped with a hard disk drive is more than adequate, and a fair number of manufacturers have hard disk systems available for personal and small business computers. The typical storage capacity of 10 megabytes would hold in excess of 5 minutes of 12-bit sound at a 20 kHz sample rate, adequate for a typical record-album cut.

However, it is surprising to many people that floppy disks are also practical for music playback and, of course, they cost much less than a hard disk. An ordinary 8-inch, single-sided, single-density floppy-disk drive can attain an average transfer rate of 20 K bytes per second, and a disk in that drive can hold 315 K bytes of data if it is formatted properly. This translates into a 13.3 kHz sample rate with 12-bit samples, and into about 15 seconds of music per disk. With two drives and a carefully written waveform-sample-playback program, the idle disk drive can be manually loaded while the other is being read and thereby attain practically unlimited piece durations. Double-density disks could double the sample rate, and double-sided disks could double the duration per disk to 30 seconds of 25 kHz sample-rate, 12-bit sound!

The problem up until now has actually been the typical floppy-disk controller, which requires program intervention to transfer each byte of data to or from the disk. Newer disk controllers use direct memory access (DMA) for data transfers, which is a virtual necessity with the increasingly popular double-density formats anyway. With a DMA-type disk controller, it becomes possible to use an ordinary programmed-I/O D/A converter, although a D/A converter that employs direct-memory-access I/O transfer could simplify playback-programming further.

Conclusion

By now it should be apparent that a simple D/A converter really is the ultimate audio-output peripheral for a computer. Any kind of sound can be synthesized; it is simply a matter of programming. Future high-speed processors and reasonably priced hard disks will allow software systems having both a real-time "draft mode" and a high-quality "final mode" to be implemented on personal-computer hardware, thus giving the best of both worlds. This will in turn give the capability of professional-quality music synthesis to anyone with the creative desire to do it.■

The music interpreter that has been described is available from Micro Technology Unlimited, POB 4596, Manchester, NH 03108, in versions for the Commodore PET and for the KIM-1, SYM-1, and AIM-65 processors. Contact Micro Technology Unlimited about arrangements for Apple II, Atari, and Ohio Scientific machines. An audio demonstration tape of the system is available for $5.00. Also available is an 8-bit audio D/A converter with 6-pole 3.5 kHz filter and power amplifier.

The programs of listings 4 and 5 and the driving software described in the text were developed and coded by Frank Covitz and Cliff Ashcraft. Their addresses are:

Frank Covitz
Deer Hill Rd
Lebanon NJ 08833

Cliff Ashcraft
150 Mercer St
Hightstown NJ 08520.

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Program Those 2708s!

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Erasable programmable read-only memories (EPROMs) can be used to great advantage in many microcomputer applications. One of the stumbling blocks to more widespread hobbyist use of EPROMs has been the difficulty of programming them. Several companies offer programming services, but this can be time-consuming as well as expensive.

One of the first EPROMs to become available was the 1702 device, which is structured as 256 words by 8 bits. This EPROM is indeed difficult to program. All of its address and data lines must be switched at 50 V levels, requiring a multitude of level-shifting transistors, in addition to the timing logic. Although it is possible to construct a programmer for the 1702, it is certainly not simple.

Salvation for the hobbyist came with the Intel 2708 EPROM. This device sports 1 K words by 8 bits of memory, four times the capacity of the 1702. It requires power supplies of +5 V, +12 V, and −5 V. For read operation, all that is required is to supply the address lines with the desired memory address, and select the individual EPROM device by grounding the chip-select input. The outputs appear on the data lines.

The greatest advantage of this 2708-type memory is its program-

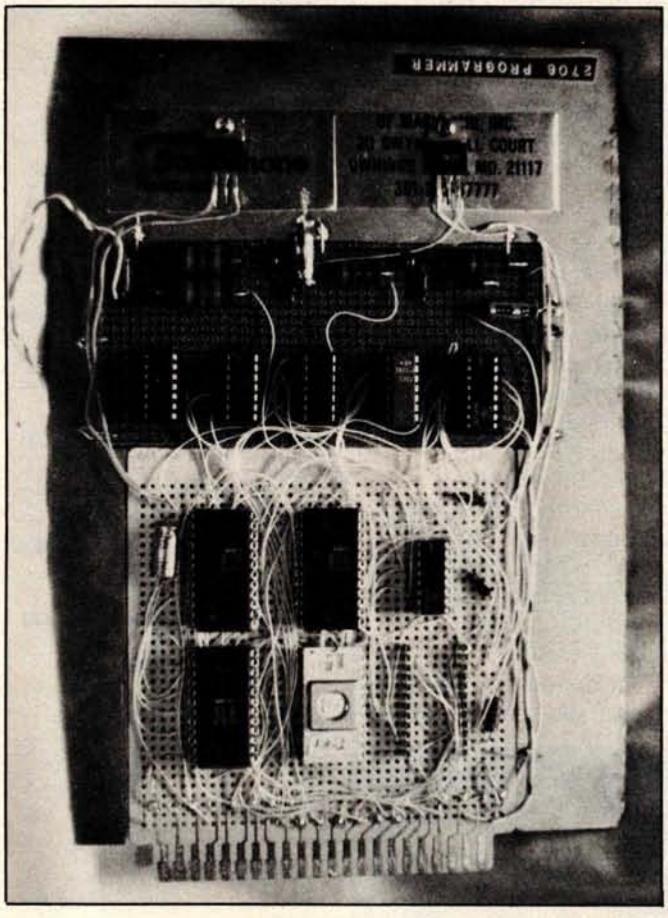

Photo 1: *Front side of the EPROM programming circuit board. Components may be identified from diagram of figure 4. A Radio Shack 44-pin card forms the base of the board, which has had other sections added to it. TO-220 packages at top are voltage regulators.*

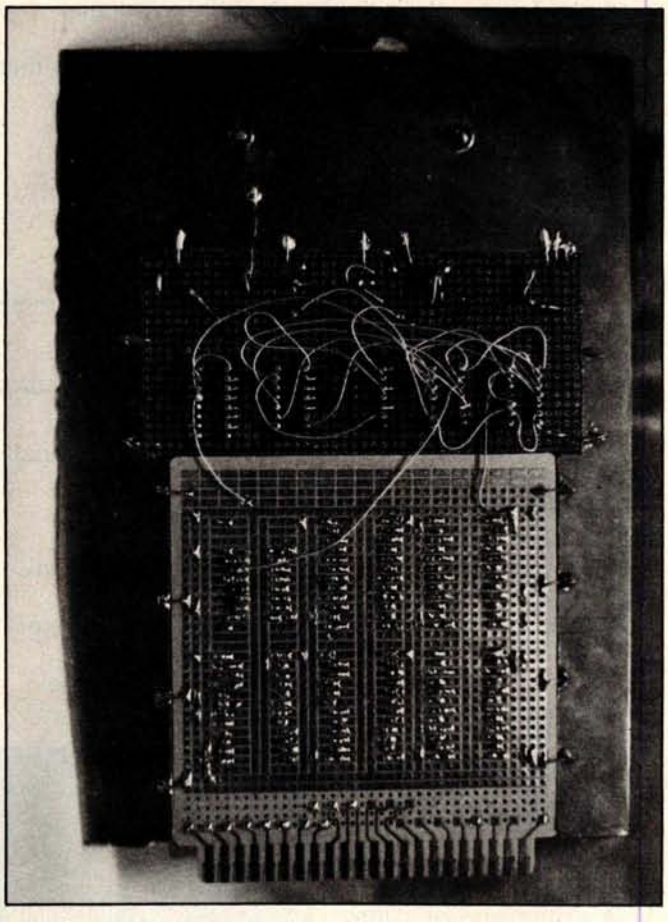

Photo 2: *The back side of the EPROM programming circuit board.* *The author wishes to thank Marc Leavey MD, WA3AJR for performing the photography.*

1a

1b

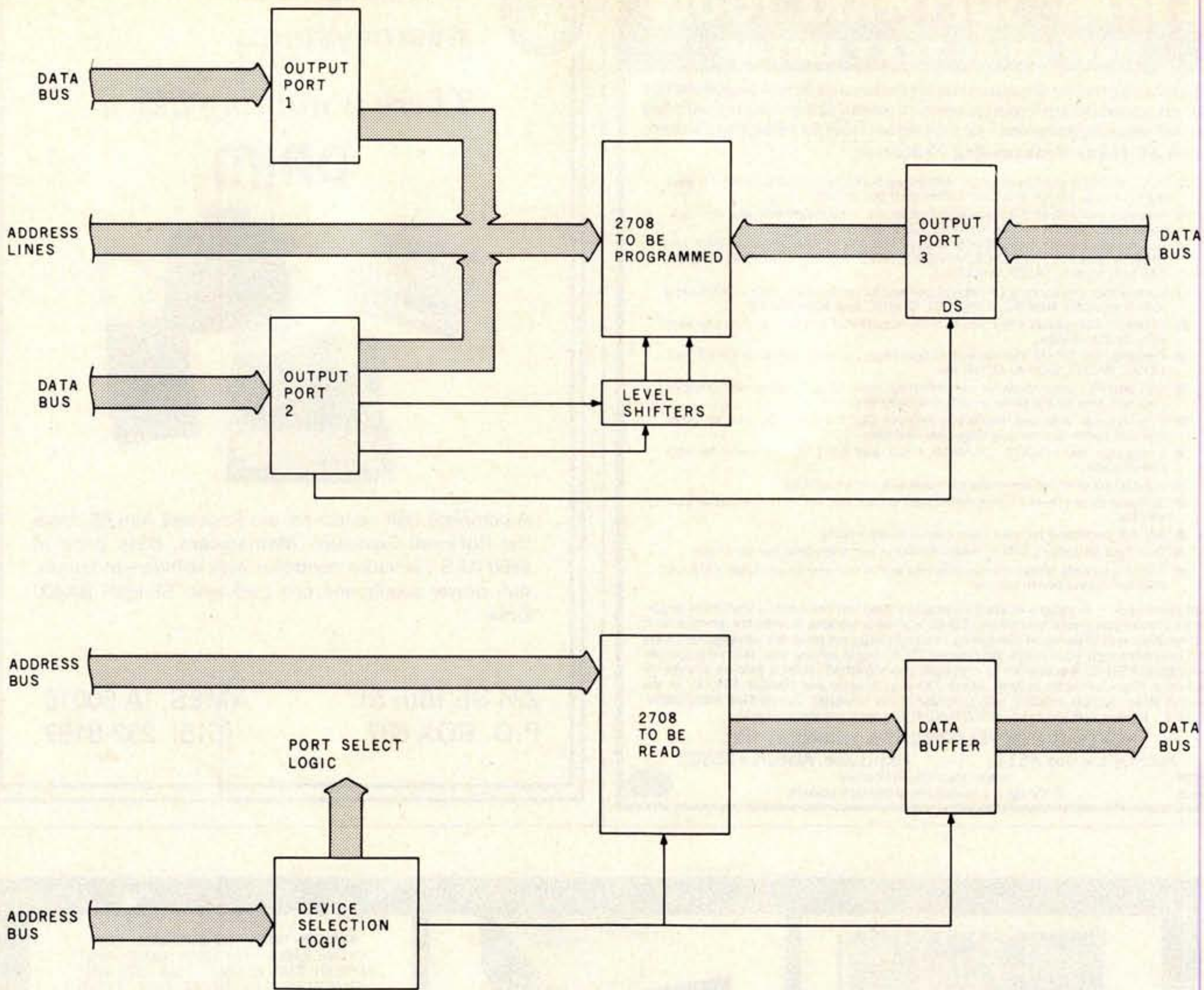

Figure 1: *Block diagrams of the 2708 EPROM programming circuit (1a) and 2708 reading circuit (1b).*

ming simplicity. All address and data lines need only be supplied with transistor-transistor logic (TTL) voltage levels. Two lines must be pulsed at nonTTL voltage levels. The write-enable line must be raised to +12 V, and the program pulse rises to +26 V.

After erasure with an ultraviolet lamp, all bits of the 2708 are in the logic 1 state. Programming consists of selectively changing the 1s to 0s. After the write-enable line is raised to +12 V, each byte is set up by applying the address and data information to the proper pins, and then pulsing the program input. The proper method is to sequence through all of the addresses many times. Each run through all addresses is called a *program loop*. The specifications of the 2708 device call for the number of program loops, multiplied by the duration of the program pulse, to form a total pulse time of at least 100 ms.

Microcomputer 2708 Programming

A simple way to accomplish the programming is to utilize a microcomputer system. With a small program routine, several output ports and some level shifters, it is easy to program the EPROM. Figure 1 shows the block diagram of the circuit I use in my 8080 system for the programming operation. Output port 1 and part of output port 2 supply the address to the 2708 device to be programmed. Output port 3 feeds the desired data to the 2708. Part of output port 2 and some level shifters provide the programming pulses for the device.

Each output port is an 8212 latch. The 8212 device is a general purpose I/O (input/output) port. The pin connections are shown in figure 2. The output of the latch is 3-state. If the mode input is high, the outputs are always enabled. When the device is selected by placing a low on $\overline{DS1}$ (active-low, device-select line) and a high on DS2 (active-high line), whatever data is present at the data input (DI) lines is latched and appears at the data output (DO) lines.

If the mode input is low, the outputs are in the high-impedance state until the device is selected. In this case, the data is latched by a signal on the strobe line. The 8212 places little loading on the data bus, and is quite suitable for the output ports used in this project.

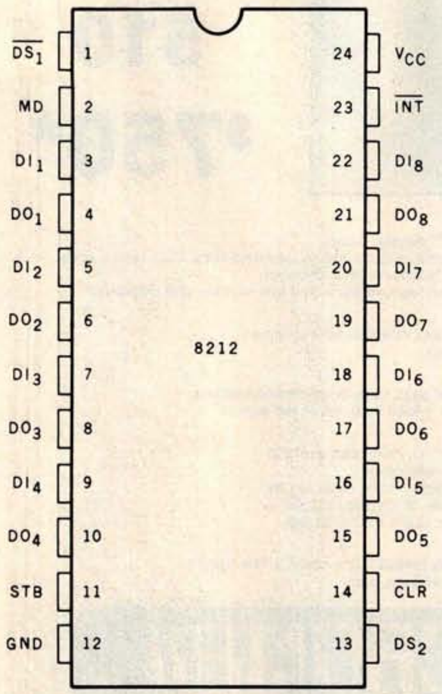

Figure 2: *Pin configuration of the 8212 integrated circuit. This device is an 8-bit I/O port latch. Three of them are used in the EPROM programming circuit.*

Number	Type	+5 V	GND	−5 V	+12 V
IC1	8212	24	12	—	—
IC2	2708	24	12	21	19
IC3	8212	24	12	—	—
IC4	8212	24	12	—	—
IC5	7404	14	7	—	—
IC6	7408	14	7	—	—
IC7	7404	14	7	—	—
IC8	7427	14	7	—	—
IC9	2708	24	12	21	19
IC10	8T97	16	8	—	—
IC11	8T97	16	8	—	—
IC12	7812	—	—	—	—
IC13	7805	—	—	—	—

Table 1: *Power supply connections for integrated circuits used in circuit of figure 3. IC12 and IC13 are voltage regulators.*

The schematic diagram of the programmer circuit is shown in figure 3. The 8212s IC1 and IC4 provide the address for the 2708 to be programmed. The mode input of these 8212s is high, causing the output lines to be always active. The 8212 IC3 provides the data byte to the 2708. The mode line is low, causing the outputs to be in the high-impedance state until the chip is selected. The reason for this is that the 2708 data lines are outputs until the 2708 is placed into the program mode.

Under program control, the 8212 latch IC3 provides data to the 2708. IC1 supplies the low 8 address lines, and is set up for hexadecimal output-port address 14. IC4 is at hexadecimal output port address 15.

Bits 0 and 1 (DO_1 and DO_2 on the output of IC4) supply address bits A8 and A9 for the 2708. Bit 7 from IC4 is the 2708 program pulse, bit 6 is the write-enable line, and bit 5 enables the data from the 8212 latch IC3. IC3 is set up for hexadecimal output-port address 16. The system reset pulse clears IC4, placing critical signals in the off mode.

To program a 2708, the integrated circuit package is placed into the program socket, and the circuit board is inserted into the 8080 mainframe. The 8080 system may then be powered up, and the program run. The 26 V power supply should be turned on just prior to supplying the address to the program.

It is important not to apply the high voltage before the system is powered up and reset. After programming, the sequence should be followed in reverse. The 26 V supply should be turned off, the computer turned off, the board unplugged, and the 2708 removed.

To read what has been written into EPROM, the device is plugged into the *read* socket. Hexadecimal address 0000 is used. If you already have an EPROM board which can read 2708s, then this portion of the circuit can be deleted. The inhibit line prevents the 2708 from being selected.

Construction

Construction will depend upon your particular system. My 8080-based system was built using 44-pin edge connectors. This permits the use

Text continued on page 206

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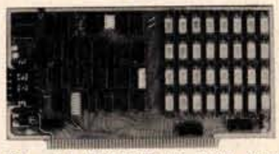

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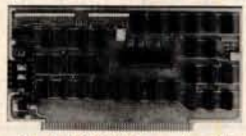

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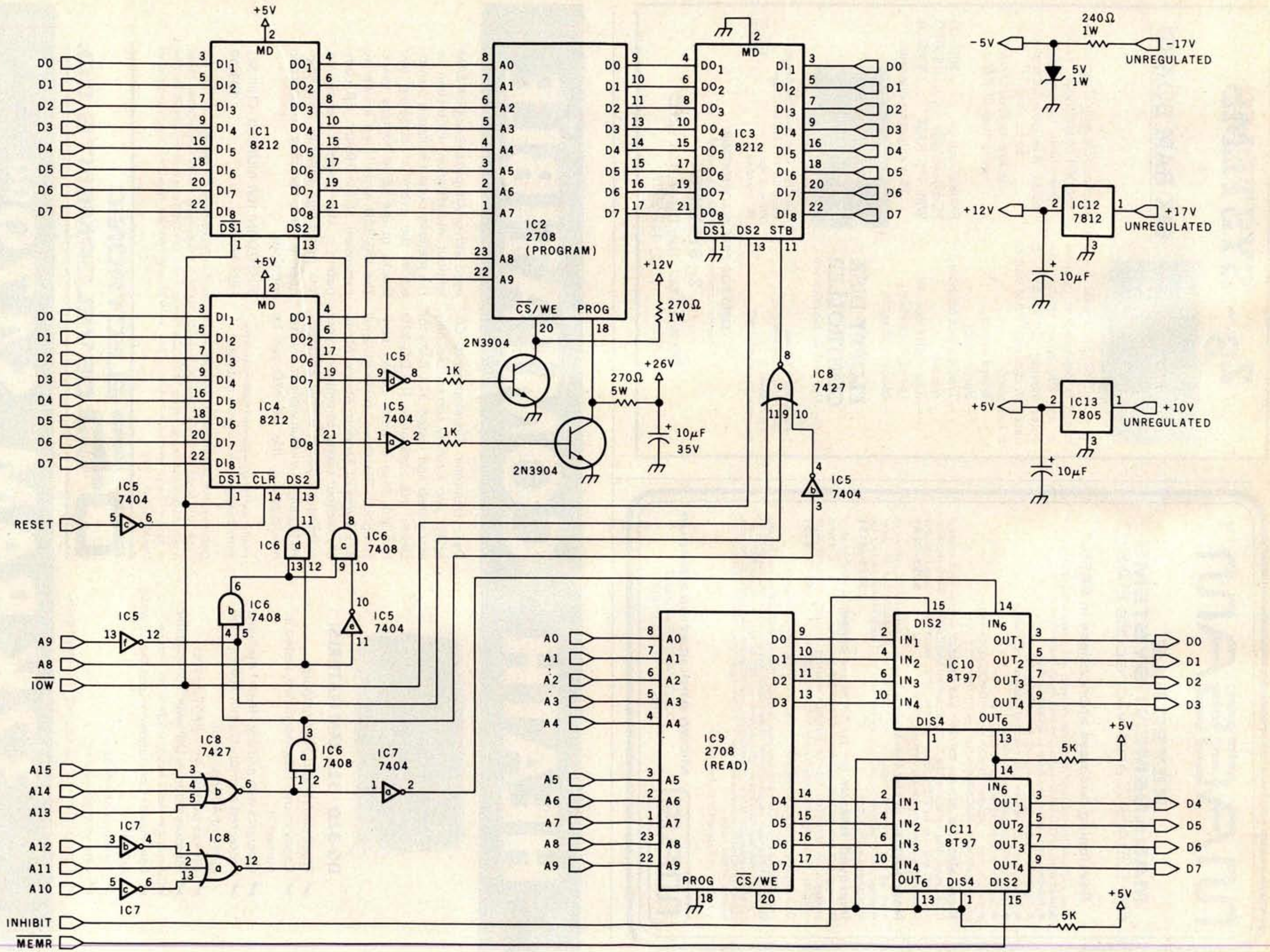

Figure 3: *Schematic diagram of the 2708 programming circuit. At right are shown voltage regulation schemes for power supplies.*

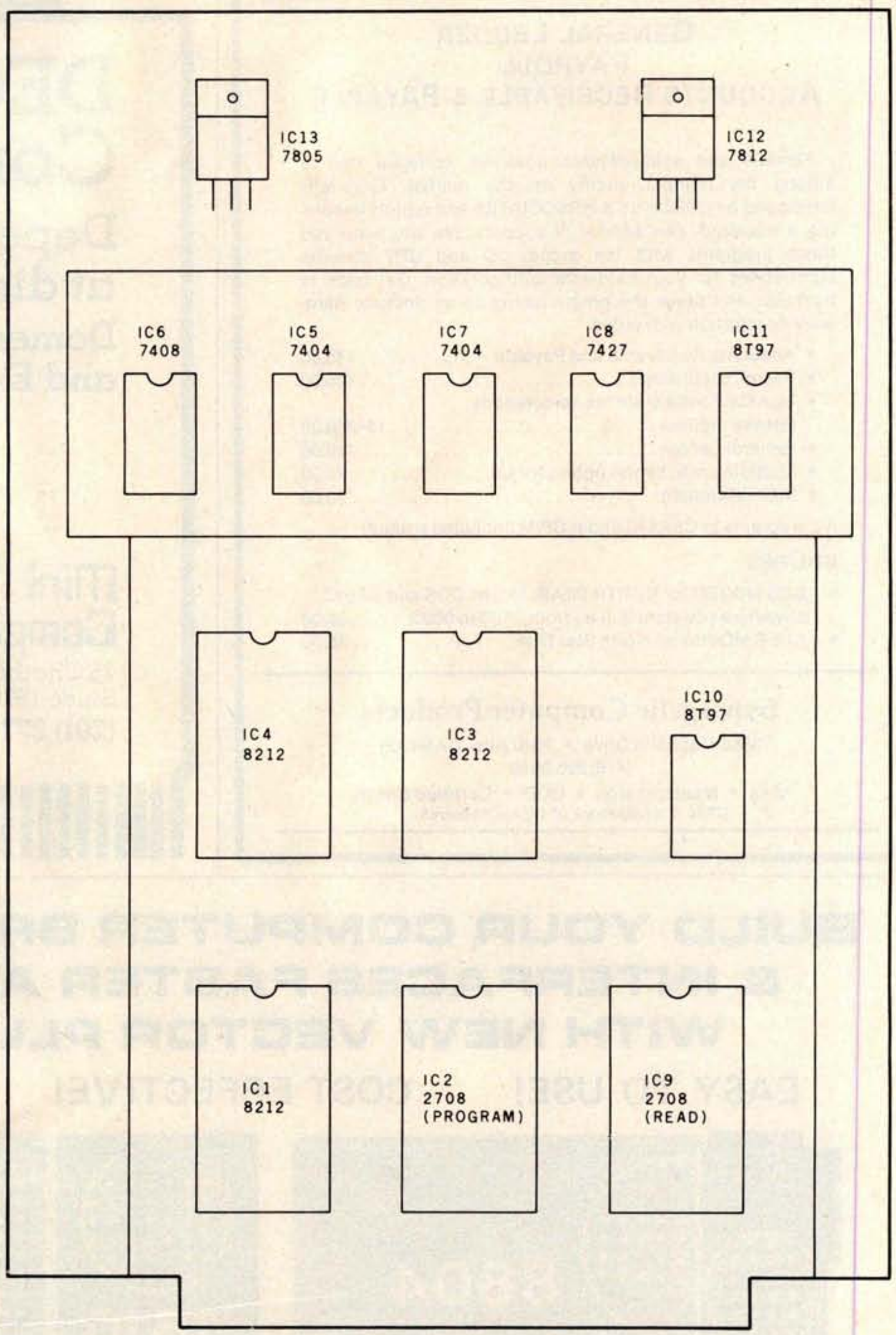

Figure 4: *Diagram of component placement on the circuit board. The board itself has been assembled from three sections.*

Text continued from page 202:

of inexpensive Radio Shack circuit boards. For the more conventional S-100 bus configuration, many wire-wrap boards are available. I used a combination of point-to-point wiring and wire-wrap. The layout is shown in figure 4. The only required voltage not commonly found in microcomputer systems is the +26 V. I connect a suitable power supply to the board when it is needed.

Programming Program

The program is set up as a subroutine (shown in listing 1). To satisfy the requirements for the 2708, I chose to go through 256 program loops, each lasting at least 0.5 ms. The subroutine MSG prints the message at ADMS, which asks for the address in memory where the data to be programmed into the 2708 is to be found. It is assumed that 1 K bytes of

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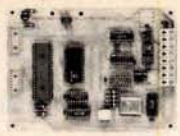

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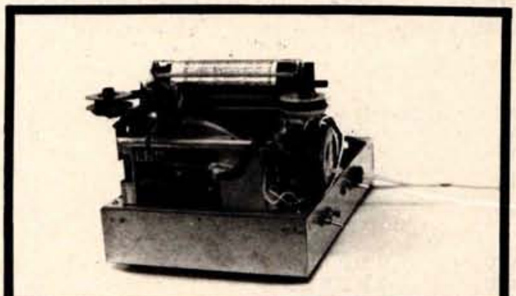

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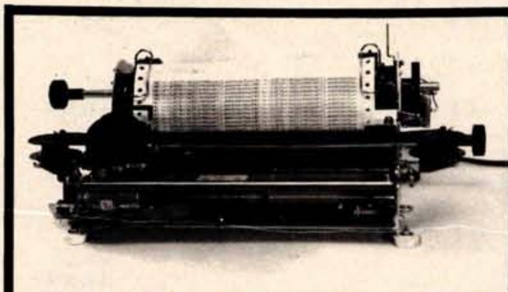

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Listing 1: *8080 subroutine for programming the 2708 EPROM using the circuit described in this article. With minor changes, this routine can be used to program 2716 devices also.*

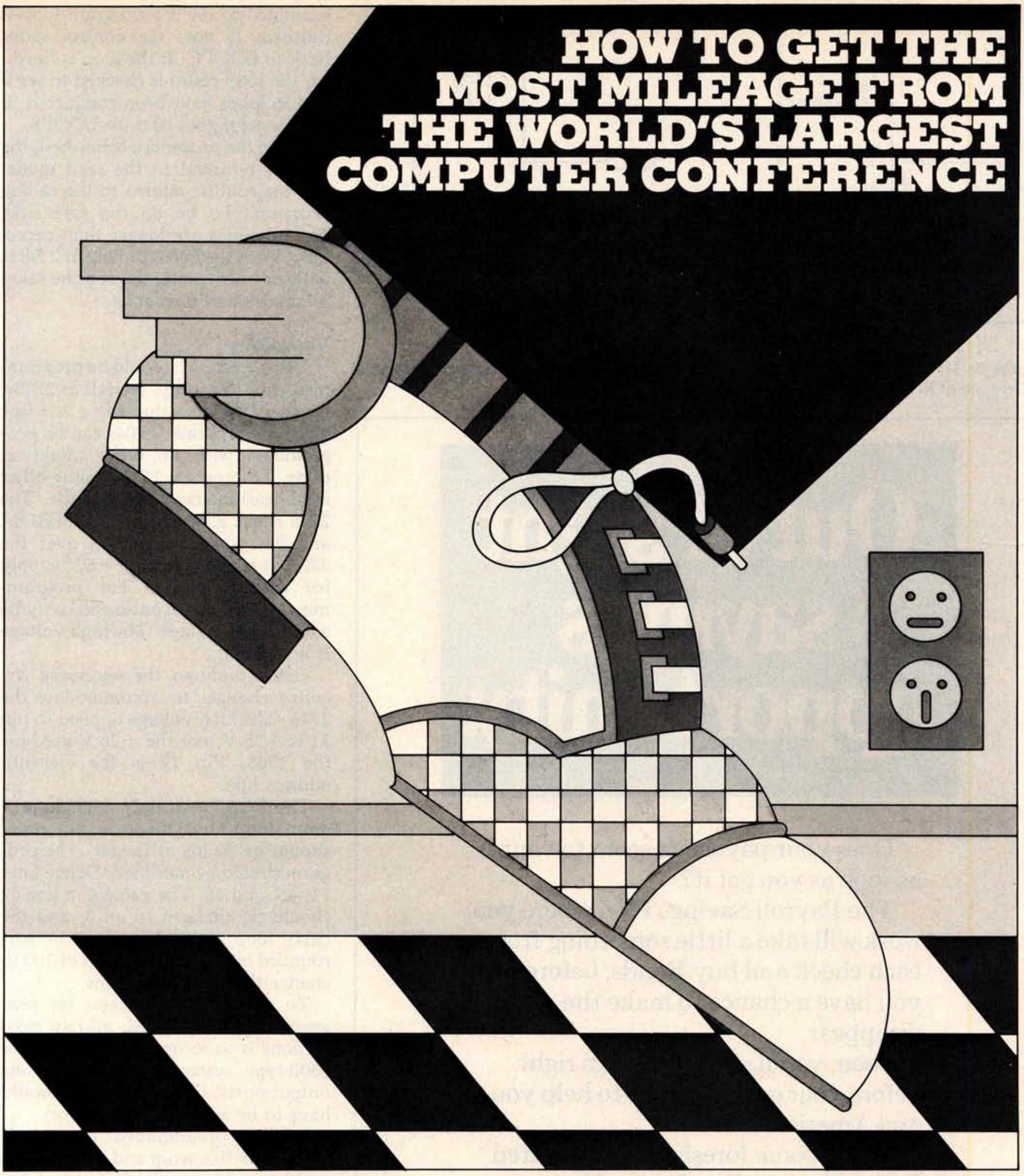
```
Address  Object Code   Label    Op Code  Operand     Comments
0000                            ; PROGRAM FOR PROGRAMMING 2708 PROMS
0000                            ; ROBERT GLASER, 11/77
0000                            ;
0000                            ;
0000                            ORG      0
0000     21 47 00               LXI      H,ADMS
0003     CD 79 ED               CALL     MSG
0006     CD 85 ED               CALL     GHXW
0009     EB                     XCHG                 ;START ADDR TO DE
000A     06 60                  MVI      B,60H
000C     0E 00                  MVI      C,0         ;LOOP COUNT
000E     21 00 00      LOOPS:   LXI      H,0
0011     7D            LOOPC:   MOV      A,L
0012     D3 14                  OUT      ADDL
0014     78                     MOV      A,B
0015     E6 FC                  ANI      0FCH
0017     B4                     ORA      H
0018     47                     MOV      B,A
0019     D3 15                  OUT      ADDH
001B     E5                     PUSH     H           ;SAVE PROGRAM ADDR
001C     19                     DAD      D           ;GET DATA ADDR
001D     7E                     MOV      A,M         ;GET DATA
001E     E1                     POP      H
001F     D3 16                  OUT      DATA
0021     00                     NOP
0022     00                     NOP
0023     00                     NOP
0024     00                     NOP
0025     00                     NOP
0026     78                     MOV      A,B
0027     F6 80                  ORI      80H
0029     D3 15                  OUT      ADDH        ;PROGRAM PULSE
002B     AF                     XRA      A
002C     3C            WAIT:    INR      A
002D     FE 2A                  CPI      42
002F     C2 2C 00               JNZ      WAIT        ;WAIT .5 MS
0032     78                     MOV      A,B
0033     E6 7F                  ANI      7FH
0035     47                     MOV      B A
0036     D3 15                  OUT      ADDH        ;REMOVE PROGRAM PULSE
0038     23                     INX      H
0039     3E 04                  MVI      A,4
003B     BC                     CMP      H
003C     C2 11 00               JNZ      LOOPC
003F     0C                     INR      C
0040     C2 0E 00               JNZ      LOOPS
0043     AF                     XRA      A
0044     D3 15                  OUT      ADDH        ;BACK TO READ MODE
0046     C9                     RET
0047                   ;
0047                   ;
0047                   ;
0047     41 44         ADMS:    DW       'DA
0049     44 52                  DW       'RD'
004B     3F 20                  DW       ' ?'
004D     00                     DB       0
004E                   ;
004E                   ;
004E                   ;
004E                   MSG:     EQU      0ED79H
004E                   GHXW:    EQU      0ED85H
004E                   ADDL:    EQU      14H
004E                   ADDH:    EQU      15H
004E                   DATA:    EQU      16H
%
```

data are to be written into the EPROM from that starting point. If the 2708 is to be only partially written, the unused portion of source memory should be filled with the hexadecimal value FF.

Subroutine GHXW gets the 16-bit value which is input in hexadecimal, and places it in register pair HL. The starting address is then moved to DE. Throughout the program this remains the same. Register pair HL contains the actual address applied to the 2708.

LOOPS (loop start) is the beginning of a program loop. At LOOPC (loop continue) the cycle begins. First the address is set up at ports ADDL and ADDH. The data is then fetched and output at the DATA port. Several no-operation instructions are included to guarantee the timing specifications of the 2708.

The program pulse is then applied, and a timing loop of 0.5 ms is entered at WAIT. The program pulse is removed, and the current address is



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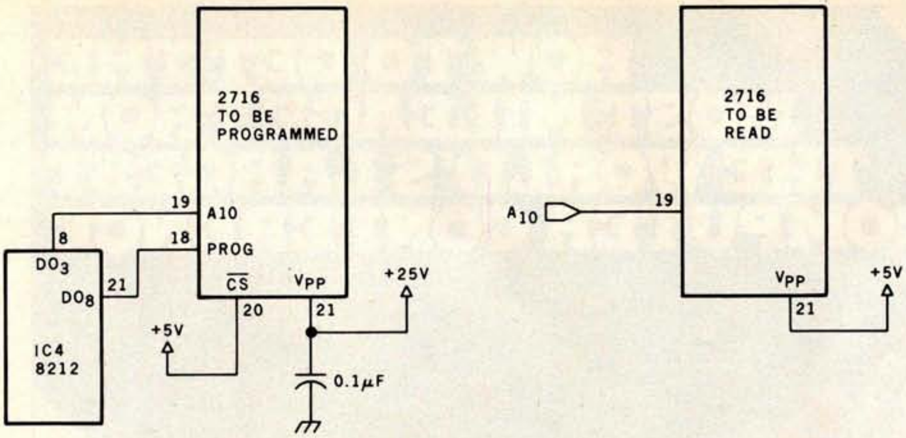


Figure 5: *Modifications to the circuit of figure 3 that enable the programming of the 2716-type EPROM. Modifications to the software are also necessary.*

examined to see if a program loop is finished. If not, the control loops back to LOOPC. If the loop is finished, the loop count is checked to see if all 256 loops have been completed. If not, control goes back to LOOPS.

When the procedure is finished, the 2708 is returned to the read mode, and the routine returns to the calling program. To be on the safe side, timing values are longer than necessary. With the 8080 running at 2 MHz with one wait state, the routine takes 3 minutes and 6 seconds.

Variations

Other EPROMs could be programmed with this setup, as well as 2708s. By changing the value 4 to a 2 in line 42 of the program, 2704s can be programmed with no other modifications. To program 2716s, some other modifications need to be made. The 2716 is a 2 K word by 8 bit EPROM and has some advantages over the 2708. It requires only a +5 V supply for read operation. For programming, the program pulse need only be a TTL level voltage. The high voltage is not pulsed.

Figure 5 shows the necessary circuitry changes to accommodate the 2716. The high voltage applied to pin 21 is +25 V, not the +26 V used for the 2708. Pin 19 is the eleventh address line.

The 2716 needs only a single program loop, but the program pulse should be 50 ms or longer. The program should be modified. Delete lines 11, 45, and 46. The value 4 in line 42 should be changed to an 8, and the delay loop at WAIT should be surrounded by an external loop of 100 to change the 0.5 ms to 50 ms.

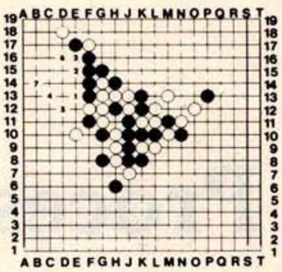
To use non8080 systems for programming the EPROM, all that need be done is to reconcile the buses. For 6800-type systems with no discrete output ports, the output ports would have to be addressed as memory.

I have programmed dozens of 2708s with this setup and have had no problems. My application has been with dedicated 8080 controllers. One such controller is used in the local amateur radio repeater to perform various functions. Many program versions were used in this application, since control and autopatch codes are all contained in the programmable read-only memory, which led to many program revisions. The 2708 programmer board was called upon many times. ■

GOMOKU

Can you find black's best move in the board position on the right?

Our program can. (Black plays on the points marked 1 thru 7).



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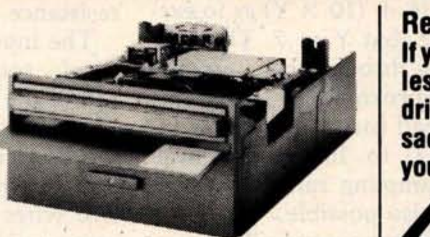

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There are at least three ways to get speech out of an Apple. The APPLE-TALKER program by Bob Bishop accepts voice from the cassette input, processes and stores the data, and then pokes it to the internal speaker. A second way is to use a voice synthesizer built on a plug-in card, such as the one made by Mountain Hardware. The third method is described in this article.

The references give the theory behind the methods of analog-to-digital (A/D), input, data storage, digital-to-analog (D/A), and output. They emphasize high sampling rates. Yes, it would be best to sample the input at 100 kHz and store it with 12-bit accuracy to create a high-fidelity computer. This is needed for music, but we are accustomed to sloppy speech. We can sample speech at 2000 Hz, store the data, and send it out to a 4-bit digital-to-analog converter. This reproduces speech which sounds very similar to that reproduced by a tape recorder!

Audio Input

The Apple has four game paddle inputs. These generate a count from 0 to 255 in response to a resistance from 0 to about 130 k ohms. The internal circuit shown in figure 1 has a 553 timer which discharges the 0.022 μF capacitor in response to a LDA $C070 instruction. Then a software counter runs while the capacitor is charged by the +5 V supply at a rate set by the paddle 0 resistance. When the capacitor reaches a trigger voltage, the 553 changes state and the counter stops. The program sequence used to create the counter is as follows:

label	mnemonic	operand	comment
	LDA	$C070	Discharge capacitor.
	LDY	#00	Initialize count.
	NOP		
	NOP		
READ	LDA	$C064	Check status of 553 timer.
	BPL	DONE	
	INY		
	BNE	READ	
	DEY		
DONE			

The execution time of this subroutine is a function of register Y. It takes the time $t = 16 + (10 \times Y)$ μs to execute. Suppose that Y = 7. Then the rate of cycling through the counter is $f = 1/t$ or approximately 11,600 Hz, minus overhead for storing the data. Speech at 100 to 1000 Hz is well within this sampling rate. Low fidelity music is also possible.

Figure 2 shows how to build a very simple amplifier that will convert an audio input into a variable resistance. The microphone should be a moving coil type. About 10 mV will be generated by the inexpensive microphones that used to be included with cassette recorders, or you can simply talk into a loudspeaker. The input capacitor should be 0.1 μF or more, nonpolarized. If the input capacitor is too small then it will block most of the input. The transistor is any NPN type out of a spare parts box (such as a 2N2222).

I used a 2 M ohm potentiometer for the base resistor. It will be adjusted later to allow for variations between transistors. You might want to include a 100 k ohm fixed resistance in series with the variable 2 M ohm resistance to prevent adjusting the base resistance to zero and destroying the transistor.

The base resistance allows a small current to flow that is amplified by the transistor to make a larger collector current. Both currents flow through the emitter to charge the internal 0.022 μF capacitor. Thus, the steady state of this imitation game paddle can be set by adjusting the base resistance. When you apply a small AC voltage from the microphone, the base current changes. This in turn changes the paddle's effective resistance.

The input circuit can be built on a 16-pin socket as suggested on page 118 of the *Apple II Reference Manual* (the red book). It is difficult to adjust the resistance R and capacitance if you do this. You can also connect two wires from pins 1 and 6 of the game paddle connector and build the amplifier on a breadboard.

Check out the amplifier in BASIC while running line 10 of listing 1 below. Adjust R to get a steady 7 or 8 paddle reading, for the fastest sampling. (Half of fifteen, for the 4-bit output to be used, equals the DC level before the you start talking.) A range of at least 4 units (8 is most desirable) change in PDL (0) caused by your speech is needed. Yell into the mike and hit control-C. You will get more gain by adjusting the base resistance to be larger, or by increasing the input capacitor value.

Text continued on page 216

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Listing 1: *Integer BASIC routines for testing the audio-input interface and manipulating the stored data. The routine starting on line 1000 produces a record of different numbers in the raw data. Note the minimum and maximum for later use. Lines 2000 thru 2080 scale the waveforms into the range 0 to 15. First, the minimum is subtracted from every data point to shift it down to 0. Then the wave is either clipped or compressed to bring the maximum down to 15. Lines 3000 thru 3050 send the audio data to the output trying all possible delays. The routine starting at line 4000 compresses the data by discarding every other data point. Lines 5000 thru 5040 show how to call the input subroutine.*

```
>LIST
   10 PRINT PDL (0): GOTO 10: REM  TEST THE INPUT AMPLIFIER
  900 REM
 1000 DIM N(80): REM  STUDY THE AUDIO DATA
 1010 FOR I=0 TO 80:N(I)=0: NEXT I
 1020 FOR I=2816 TO 12287: REM  AUDIO DATA AREA
 1030 X= PEEK (I):N(X)=N(X)+1: NEXT I
 1040 PRINT "I     N(I)    N(20+I)  N(40+I) N(60+I)"
 1050 FOR I=0 TO 19
 1060 PRINT I,N(I),N(20+I),N(40+I),N(60+I)
 1070 NEXT I: END
 1900 REM
 1990 REM  INPUT THE SPEECH DATA
 2000 FOR I=0 TO 80:N(I)=0: NEXT I
 2010 INPUT "MINIMUM DATA ",MIN
 2020 INPUT "MAX DATA ",MAX
 2030 FOR I=2816 TO 12287
 2040 X= PEEK (I)-MIN
 2050 X=X*15/(MAX-MIN): REM  COMPRESSING
 2060 IF X>15 THEN X=15: REM  CLIPPING
 2070 N(X)=N(X)+1: POKE I,X
 2080 NEXT I: GOTO 1040
 3000 INPUT "TURN ON AMPLIFIER AND PRESS RETURN.",A$
 3010 FOR DELAY=0  TO 255
 3020 PRINT DELAY
 3030 POKE 2561,0: POKE 2562,12
 3040 POKE 2612,DELAY: CALL 2560
 3050 NEXT DELAY: END
 3900 REM
 3990 REM  COMPRESS THE DATA BY DISCARDING HALF OF IT
 4000 X=(12287-2816)/2: REM  HALF OF DATA AREA
 4010 FOR I=1 TO X
 4020 POKE 2816+I, PEEK (2816+2*I)
 4030 NEXT I: END
 4900 REM
 5000 REM  CALL INPUT SUBROUTINE
 5010 INPUT "HIT RETURN WHEN READY TO TALK.",A$
 5020 POKE 2325,0: POKE 2326,11
 5030 POKE 2346,0: POKE 2339,48
 5040 POKE 2321,13: CALL 2304: END
```

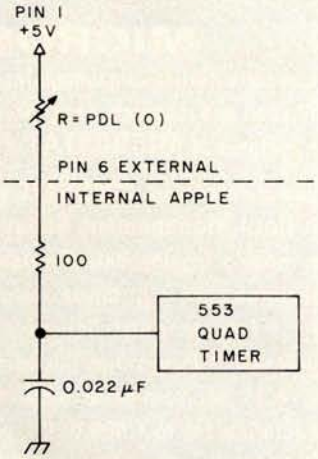

Figure 1: *A representation of the paddle-input system used by the Apple II computer.*

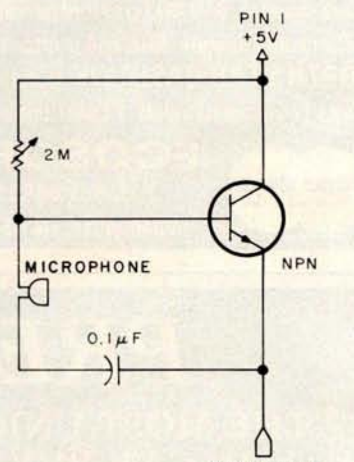

Figure 2: *A microphone and simple amplifier can be added to the Apple paddle connector and used to input audio information. The program in listing 2 is used with this circuit.*

Text continued from page 212:

BASIC cannot sample the game paddle fast enough to follow sounds. The program in listing 2 will do that. Hexadecimal locations 0900 thru 0912 loop indefinitely waiting for the user's initial voice input. When the paddle count reaches (THRESH + 1) (THRESH is threshold to start recording data), the rest of the program begins sensing and storing data. The user can insert a delay loop at hexadecimal 093E to wait between data points and get more (but lower quality) speech into memory.

A standard 16 K byte memory holds one or two words of good quality speech. You can adjust the base resistance in the amplifier to make a large steady PDL (0) value of 50 or more and thus sample the input more slowly. "Row, row, row your boat gently down the stream" will fit in, but the rest of the song might be too noisy if compressed into 16 K bytes.

Listing 2: *6502 assembly-language program to drive the audio-input interface. This reads the voice data from a microphone connected to a game paddle. The data is stored in locations START thru END. When ENDHI equals 48 (decimal), then LOMEM:12289 will put all BASIC work above the audio data area. There are several adjustable parameters: THRESH: threshold to start recording data. Should be 2 or 3 units above the steady state, no-speech PDL(0). STARTLO, STARTHI: start of the data storage area. ENDLO, ENDHI: = LOMEM − 1: end of audio area.*

```
0900-  AD 70 C0   LDA   $C070
0903-  A0 00      LDY   #$00
0905-  EA         NOP
0906-  EA         NOP
0907-  AD 64 C0   LDA   $C064
090A-  10 04      BPL   $0910
090C-  C8         INY
090D-  D0 F8      BNE   $0907
090F-  88         DEY
0910-  C0 10      CPY   #$10
0912-  30 EC      BMI   $0900
0914-  8C 00 0B   STY   $0B00
0917-  EE 15 09   INC   $0915
091A-  D0 03      BNE   $091F
091C-  EE 16 09   INC   $0916
091F-  AD 16 09   LDA   $0916
0922-  C9 30      CMP   #$30
0924-  30 08      BMI   $092E
0926-  AD 15 09   LDA   $0915
0929-  C9 00      CMP   #$00
092B-  D0 01      BNE   $092E
092D-  60         RTS
092E-  AD 70 C0   LDA   $C070
0931-  A0 00      LDY   #$00
0933-  EA         NOP
0934-  EA         NOP
0935-  AD 64 C0   LDA   $C064
0938-  10 04      BPL   $093E
093A-  C8         INY
093B-  D0 F8      BNE   $0935
093D-  88         DEY
093E-  4C 14 09   JMP   $0914
0941-  FF         ???
0942-  00         BRK
0943-  00         BRK
0944-  FF         ???
0945-  FF         ???
0946-  00         BRK
0947-  00         BRK
0948-  FF         ???
```

Processing

After the waveform data is stored in memory it can be easily improved, condensed, or distorted. Try the short programs in Tom O'Haver's article (see references). Keep in mind that the 4-bit output requires all data to be in the range 0 to 15.

The routines in listing 1 can be used to scale, compress, and output the data.

Output

The game connector has four annunciator outputs. These are compatible with the 4-bit digital-to-analog converter shown in figure 3. Build it on the socket that the input amplifier is connected to.

The idea of using a resistor network for digital-to-analog conversion is discussed by Hal Chamberlin (see references). The minimum resistance here is 5 k ohms so that the maximum current drawn from the annunciator outputs will be 1 mA. High-precision resistors are not necessary. The digital-to-analog conversion truncates the fifth bit, which introduces a 3% error. Five-percent tolerance resistors will do.

The capacitor in figure 3 filters out high-frequency noise. The noise comes from truncation to 4 bits, from delays between taking samples of the audio input, and from not changing all 4 bits of the digital output simultaneously. A larger capacitor on the output will filter out more noise, but it will also attenuate the signal, thus, you will have to turn up the amplifier's gain. A better low-pass filter would help.

The output software is shown in listing 3. It fetches a byte of waveform data, sends it to the digital-to-analog converter, increments and tests the memory pointer, waits for a delay, and then fetches another byte of data.

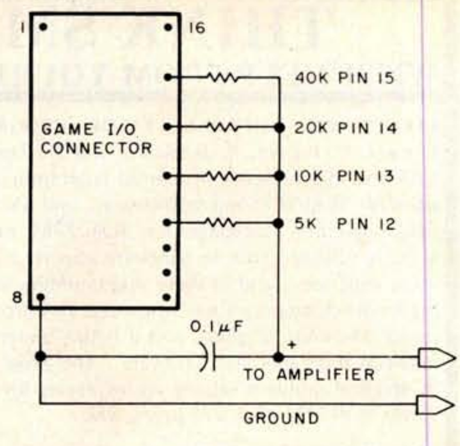

Figure 3: *This simple 4-bit digital-to-analog (D/A) converter, along with listing 3, is used to output information created by the circuit shown in figure 2 and the program shown in listing 2.*

Listing 3: *6502 assembly-language program that sends audio data to the 4-bit digital-to-analog (D/A) converter.*

```
*A00LL

0A00-  AD 00 0B   LDA   $0B00
0A03-  6A         ROR
0A04-  B0 05      BCS   $0A0B
0A06-  8D 58 C0   STA   $C058
0A09-  90 04      BCC   $0A0F
0A0B-  8D 59 C0   STA   $C059
0A0E-  EA         NOP
0A0F-  6A         ROR
0A10-  B0 05      BCS   $0A17
0A12-  8D 5A C0   STA   $C05A
0A15-  90 04      BCC   $0A1B
0A17-  8D 5B C0   STA   $C05B
0A1A-  EA         NOP
0A1B-  6A         ROR
0A1C-  B0 F5      BCS   $0A13
0A1E-  8D 5C C0   STA   $C05C
0A21-  90 04      BCC   $0A27
0A23-  8D 5D C0   STA   $C05D
0A26-  EA         NOP
0A27-  6A         ROR
0A28-  B0 05      BCS   $0A2F
0A2A-  8D 5E C0   STA   $C05E
0A2D-  90 04      BCC   $0A33
0A2F-  8D 5F C0   STA   $C05F
0A32-  EA         NOP
0A33-  A2 1E      LDX   #$1E
0A35-  CA         DEX
0A36-  D0 FD      BNE   $0A35
0A38-  EE 01 0A   INC   $0A01
0A3B-  D0 03      BNE   $0A40
0A3D-  EE 02 0A   INC   $0A02
0A40-  AD 02 0A   LDA   $0A02
0A43-  C9 30      CMP   #$30
0A45-  D0 05      BNE   $0A4C
0A47-  AD 01 0A   LDA   $0A01
0A4A-  C9 00      CMP   #$00
0A4C-  D0 B2      BNE   $0A00
0A4E-  60         RTS
0A4F-  00         BRK
0A50-  FF         ???
```

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Conclusion

The speech quality produced by this method is relatively good. Most music doesn't turn out very well when the high frequencies are filtered out. I tried "The Star Spangled Banner" from the article by Hal Chamberlin. The music was tolerable but my simple capacitor filter let through too much high-frequency noise (reference 3).

An 8-bit digital-to-analog converter can be built. I did so, but found that it resulted in no significant audible difference for speech. Such an option might be advantageous only if you are interested in high-fidelity music reproduction.

The main problem is the available memory which limits the amount of audio information that can be stored. Slower sampling can store more data, but this introduces too much noise when the sampling rate falls below 1000 to 2000 Hz. You can double up and store 2 units of data in 1 byte of memory. I have been able to get phonemes (eg: single letter sounds) compressed to 256 bytes of memory on the average.

The input routine in listing 2 could be improved. The routine now spends less time sampling low-amplitude inputs and more time sampling high-amplitude inputs. There should be another counter that waits during a variable interval depending on the input amplitude, which is indicated by register Y.

You can change the amplitude of the waveforms. Either divide all the data by 2 in BASIC, or insert an extra rotate right (ROR) instruction in the output routine just before the data gets to the digital-to-analog conversion section. The speech is still intelligible when it is cut down to 2 or 3 bits of data! A better output routine would have a parameter to choose full, ¾, ½, or ¼ amplitude. (Of course this won't work when the audio amplifier is a tape recorder with automatic level control.)

A minimum set of compressed phonemes needs about 10 K bytes (for 40 phonemes,each occupying 256 bytes) of memory. Room is left over for BASIC programs or extra phonemes. With variable pitch and amplitude, you can accent syllables in words. Variable pitch plus extra long vowels could effectively make a singing Apple! ■

Memory Locations Decimal	Hexadecimal	Usage
0-2047	000-07FF	System usage
2048-2303	0800-08FF	Blank
2304-2559	0900-09FF	Input subroutine
2560-2815	0A00-0AFF	Output subroutine
2816-LOMEM	0B00-LOMEM	Audio data storage
LOMEM-HIMEM		BASIC

Table 1: *Memory map for speech input and output routines.*

2a

Address Hexadecimal	Address Decimal	Variable Name	Suggested Value (Decimal)
0911	2321	THRESH	13
0915	2325	STARTLO	0
0916	2326	START HI	11
0923	2339	ENDHI	48 for 16 K bytes
092A	2346	ENDLO	0

2b

Address Hexadecimal	Address Decimal	Variable Name	Suggested Value (Decimal)
0A01	2561	STARTLO	0
0A02	2562	STARTHI	11
0A34	2612	DELAY	47

Table 2: *Tables of variable locations and values. Table 2a lists the location and suggested value of several constants that must be specified within listing 2; table 2b does the same for listing 3. In both cases, the constants are stored within the body of the listing.*

References

1. Chamberlin, Hal, "A Sampling of Techniques for the Computer Performance of Music," September 1977 BYTE, page 62.
2. Ciarcia, Steve, "Talk to Me," June 1978 BYTE, page 142.
3. Cross, Mark, "Apple Organ," a program based on reference 1.
4. O'Haver, Tom, "Audio Processing with a Microprocessor," June 1978 BYTE, page 166.

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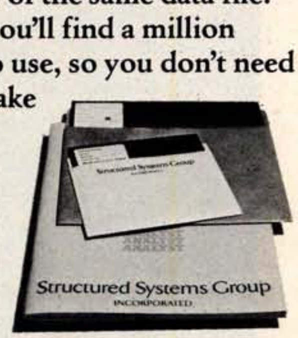

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BYTE's Bugs

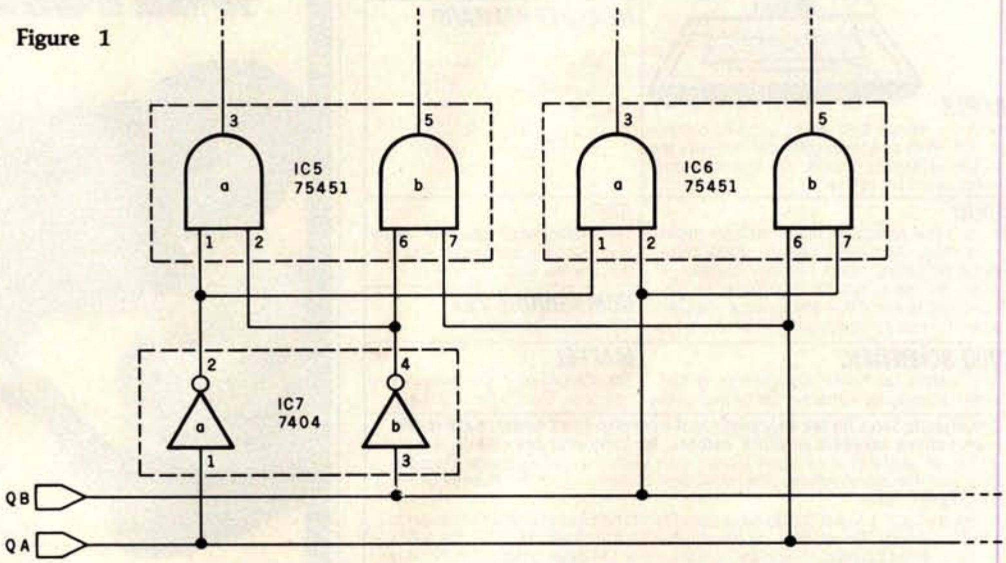
Schematic Decodes Improperly

An error marred a schematic diagram in William J Dally's article "Faster Audio Processing with a Microprocessor," on page 54 of the December 1979 BYTE. In figure 12 on page 75, two connections to a 7404 hex inverter are shown incorrectly. The correct connections are shown here as figure 1. A circuit built according to the published diagram would fail to decode the binary states 01 and 10 properly.

IC5b is supposed to decode the input 01. However, its inputs incorrectly come from the signals Q_A and $\overline{Q_A}$ in the published figure. The inputs to IC5b should come from the signals Q_A and Q_B. A similar situation exists for IC6a. Input for IC6a should come from Q_B and Q_A.

Thanks to Bob Werner of Solon, Iowa, for pointing out this problem. ■

Figure 1



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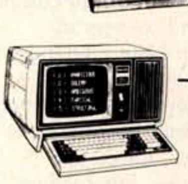

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Clubs and Newsletters

Another TRS-80 Users Group

The NASA/Bay Area TRS-80 Users Group meets the first Tuesday of each month in the Lockheed Bldg, L XI, Rm 2012, Space Park Dr, Nassau Bay TX. The dues are $5 per year. Contact Roy Cone, President, (713) 474-3847.

Computer Club in Finland

The "Mikrotietokoneyhdistys ry" translates into Microcomputer Hobbyists. This club has been in operation since June, 1977. Meetings are held bimonthly and are announced in the newsletter. The newsletter, *Microman*, is published six times a year. The club is interested in hardware and software related topics, and has a strong interest in advanced programming languages such as Pascal, ADA, APL and others. Their hardware interests include S-100 and IEEE-488 bus structures. The yearly dues for membership and the newsletter are 80 FIM or $20 US currency. Contact Mr Teuvo Aaltio, POB 250, SF-00121 Helsinki 12, FINLAND, (+358 0) 626 525.

The Financial Systems Report

The Financial Systems Report is a monthly newsletter that focuses on computer programs, products, and services relevant to the needs of the financial and tax consultant. Tax planning programs, financial modeling and forecasting systems, financial data bases, portable computers and telecommunication terminals, personal financial planning systems, microcomputers, and more will be covered in each issue. It is available for $60 per year from Syntax Corp, 4500 W 72nd Ter, POB 8137, Prairie Village KS 66208.

SYM-PHYSIS Newsletter

SYM-PHYSIS is a bimonthly newsletter published by the SYM Users Group, POB 315, Chico CA 95927. They welcome articles dealing with all aspects of the SYM-1 and its close relatives. The subscription rate for a six-issue volume is $9 in the US and $12.50 overseas. For more information, contact H R "Lux" Luxenberg at the above address.

PEEK (65)

PEEK(65), the unofficial Ohio Scientific users' journal, features a software exchange, PEEKs and POKEs, user equipment reviews, and bugs and fixes. Articles are welcome. Membership is $8 per year. Send inquiries to *PEEK(65)*, 62 Southgate Ave, Annapolis MD 21401.

Computers Anonymous

This club meets the first Sunday of each month. For complete information, contact Computers Anonymous, POB 263, Dalton MA 01226.

Albany Computer Society

The goal of this group is to serve as a forum for ideas and products of interest to computer hobbyists. The members are interested in anything pertaining to Sorcerers, Apples, Challengers, and TRS-80s. Meetings are held the second Saturday of each month at Albany Junior College and are open to the public. Contact Albany Computer Society, c/o Dr Donald Cook, 2400 Gillionville Rd, Albany GA 31707.

Join a Software Computer Club

Specify which computer you use and Ron Goodman will put you in contact with the right people. Apple, PET, Compucolor, Ohio Scientific, TRS-80, and other microcomputer users are welcome to join. For more information, contact Ron Goodman, 12702 Emelita St, N Hollywood CA 91607.

APL Newsletter

Personal APL News, written by the Rev Mokurai Cherlin and Shasta Abbey, covers hobby, educational, professional, and small-business uses of APL. The newsletter describes the use of APL as a programming language and as a mathematical notation and digital hardware design language. One feature is the resource directory, giving details of available APL hardware, software, services, and books. The cost is $1 in the US and Canada and $2 elsewhere. Send subscriptions and inquiries to *Personal APL News*, POB 1131, Mt Shasta CA 96067.

The Computer Club

The Computer Club offers an invitation to all computer users and owners in southern New England who wish to share their knowledge. The club meets once a month to discuss problems, ideas, and discoveries. For further details, contact The Computer Club, 6 Maureen Dr, Simsbury CT 06070.

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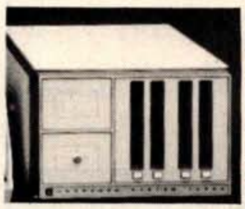

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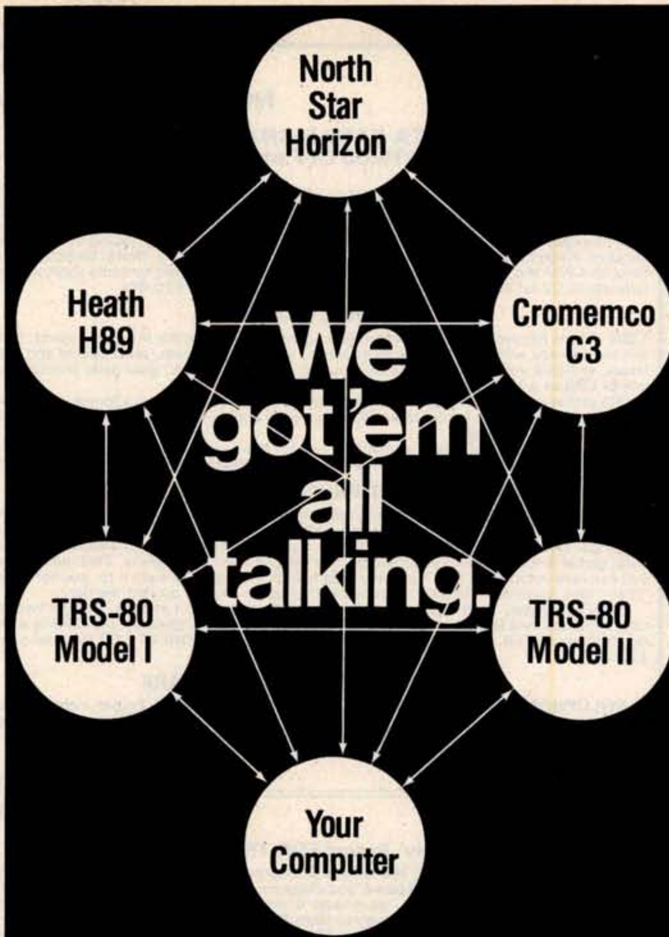

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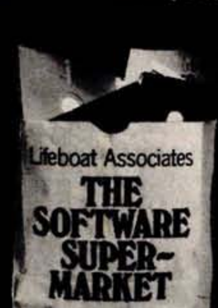

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1802 Software Newsletter

The 1802 Software Newsletter contains programs written in Tiny BASIC, BASIC, PILOT, CHIP-8, and other languages, and in assembly and hexadecimal object code. The newsletter averages fifteen pages per issue. Construction articles are included. The newsletter is for ELF, ELF II, Super ELF, VIP, VIP II, or homebrew 1802 systems. It is published monthly and costs $10 per year. Contact 1802, 19 French Cr, Regina, Saskatchewan S4R 6N3 CANADA.

The Computer Consultant

The Computer Consultant is published six times a year by Battery Lane Publications, POB 30214, Bethesda MD. The newsletter consists of short entries from computer consulting companies, including software design firms, training organizations, security consulting outfits, systems programmers, and other computer-related consulting companies. The subscription rate of $15 per year includes one free listing per issue.

TRS-80 Users Group in Maine

The Southern Maine TRS-80 Computer Club meets the first Tuesday of each month at 6:30 PM at the Maine Medical Center, Portland, Maine, in Classroom 2. Contact Douglas Stewart, 15 Mountain View Rd, Cape Elizabeth ME 04107.

An Apple Users Group in California

The Los Angeles Apple Users Group meets the first Friday of every month at 7:30 PM at the Allstate Savings Community Room, 8800 S Sepulveda Blvd, Los Angeles, California. Contact Philip A Wasson, 9513 Hindry Pl, Los Angeles CA 90045. ■

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Event Queue

Technical Programs, The Hartford Graduate Center, 275 Windsor St, Hartford CT 06120. These courses are aimed at technical professionals, and include such topics as computer system fundamentals, microprocessors, computer-aided graphics, solar energy systems, calculators, and more. Contact The Hartford Graduate Center for more information.

Datapro Research Corporation. Among the topics scheduled during the spring Datapro conferences are data communications, data base management systems, word processing, electronic mail, systems analysis and design, and many others. Contact Datapro, 1805 Underwood Blvd, Delran NJ 08075, for a schedule of the conferences.

Technology Transfer Institute. For a complete list of many courses being offered around the country during the spring of 1980, write to Technology Transfer Institute, POB 49765, Los Angeles CA 90049, or call (213) 476-9747.

Data Communications Conferences. These conferences will include symposia on local computer networks, European Data Communications Standards, understanding the components of data communications networks, data communications architecture, interfaces and protocols, and more. For a list of dates and further information, contact The McGraw-Hill Conference and Exposition Center, 1221 Avenue of the Americas, Rm 3677, New York NY 10020, or call (212) 997-4930.

APRIL 1980

April 1-2

Southeast Printed Circuits and Microelectronics Exposition, Sheraton-Twin Towers Convention Center, Orlando FL. This show is a specialized event devoted entirely to the packaging, production and testing of printed circuits, multilayers, semiconductor devices, and hybrids. The conferences are aimed at electronics specialists. Contact ISCM, 222 W Adams St, Chicago IL 60606.

April 9-11

The Practical APL Conference, Washington DC. This conference is addressed to business executives and systems designers. For more information, contact Joan Gurgold, STSC, 7 Holland Ave, White Plains NY 10603.

April 9-11

International Conference on Acoustics, Speech, and Signal Processing, Fairmont Hotel, Denver CO. The IEEE Acoustics, Speech and Signal Processing Society is sponsoring this conference devoted to experimental and theoretical aspects of signal processing, speech, and acoustics. For more information, contact IEEE, 1100 14th St, Denver CO 80202.

April 11-12

10th Annual Virginia Computer Users Conference. This conference is sponsored by the Virginia Tech Association for Computing Machinery (ACM) student chapter. The topics of discussion will be programming languages and system and personnel management. For more information, contact VCUC10, 562 McBryde Hall, VPI&SU, Blacksburg VA 24061.

April 12

Computer Fair, Scottish Rite Temple, 1895 Camino Del Rio South, San Diego CA. Exhibits and presentations of computers in education and the home are the highlights of this show which is sponsored by the San Diego Computer Society. For information, contact Richard Lindberg, POB 81537, San Diego CA 92138.

April 13-16

A Gateway to the Use of Computers in Education, Chase Park Plaza Hotel, St Louis MO. The purpose of this convention is to provide a forum for the exchange of information and ideas between individuals, to inform educators of developments in computer technology, and to expose participants to innovations in computing which can be utilized in the field of education.

Educators are encouraged

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to exhibit and make presentations of instructional microprocessor materials during the convention. Contact the Association for Educational Data Systems (AEDS), POB 951, Rolla MO 65401.

April 14-18

The 6th Annual Reliability Testing Institute, Ramada Inn, 404 N Freeway, Tucson AZ. The objective of the course is to provide reliability engineers, product assurance engineers, and managers with a working knowledge of analyzing component, equipment, and system performance, and failure data to determine the distributions of their times to failure, their failure rates, reliabilities, small sample size, and more. Three continuing education credits are offered. The price for the course is $495. Contact Dr Dimitri Kececioglu, Institute Director, Aerospace and Mechanical Engineering Dept, University of Arizona, Building 16, Tucson AZ 85721.

April 14-18

High-Speed Computer Organization, 6266 Boelter Hall, UCLA Extension, Los Angeles CA. This course is for computer designers, system architects, project leaders and managers. The course provides an understanding of the principles of high-speed computer organization and their use in cost-effective systems. Several designs for high-speed computers are presented and compared.

For more information, contact the UCLA Extension at POB 24901, Dept K, UCLA Extension, Los Angeles CA 90024.

April 19-20

Trenton Computer Festival, Trenton State College, Trenton NJ. Thirty speakers, user group demonstrations, conference sessions, and forums will be featured. The Trenton Conference has gained an excellent reputation in the past. This year it will cover computers in the home, education, medicine, music, and the arts. Admission is $5 for the two days. Contact Dr Allen Katz, Trenton State College, Hillwood Lakes, POB 940, Trenton NJ 08625, or Sol Libes, Amateur Computer Group of NJ, UCTI, 1776 Raritan Rd, Scotch Plains NJ 07076.

April 21-25

National Micrographics Association 29th Annual Conference and Exposition, Sheraton Center Hotel and Coliseum, New York NY. The theme for the show is "Focus on Productivity in Office Management." Highlighting the conference and exposition will be presentations and talks concerning the use in offices for computer systems and related items.

For more information, contact the Conference Dept, National Micrographics Association, 8719 Colesville Rd, Silver Spring MD 20910.

April 22-25

Spring DECUS US Symposium, Hyatt Regency O'Hare and the O'Hare Exhibition Center, Chicago IL. Exhibitions of Digital Equipment Corporation systems will be featured, along with special speakers and papers. Contact DECUS, Digital Equipment Computer Users Society, Attn: US Chapter, One Iron Way, MR2-3/E55, Marlboro MA 01752.

April 23-25

International DP Training Conference, Hyatt Regency, Chicago IL. The theme for this event will be "The 1980s: The Information Decade." The conference is a symposium for data processing experts and corporate training executives. For information, contact Deltak Inc, 1220 Kensington Rd, Oak Brook IL 60521.

April 26 and 30

The Computer-Aided Physician's Office, Academy of Medicine, 288 Bloor W, Toronto, Canada. The course will enable the private practitioner to evaluate the effectiveness of small computer systems and their potential to reduce or contain costs. The cost is $225 per day or $400 for both days. Contact Human Computing Resources Corp, 10 St Mary St, Toronto, Ontario, M4Y 1P9 CANADA.

April 27-30

The 17th Numerical Control Society Annual Meeting and Technical Conference, Hartford Civic Center, Hartford CT. This convention will offer technical sessions covering such areas as computer-aided design engineering, business management, tool design and graphics; computer-aided assembly, facilities planning, inventory control, and management information systems; numerical control in various areas; data base structure and management; and other educational programs. There is also a large exhibition being presented.

For more information, contact Numerical Control Society, 1800 Pickwick, Glenview IL 60025.

Circle 157 on inquiry card.

April 28-30
Managing Technical Programs and Projects, White Plains NY. For more information, contact the Institute for Advanced Professional Studies, One Gateway Ctr, Newton MA 02158.

April 30-May 2
Computerized Office Equipment Expo, O'Hare Exposition Center, Rosemont IL. The latest developments in computers, word processors, copiers/duplicators, telephone systems, and other business equipment will be featured. The seminars will cover guidelines on buying computer systems, telephone and copier systems, the use of word processors, and more. Contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606.

MAY 1980

May and June
Microprocessor Training Courses, Cudham Hall, Cudham, Sevenoaks, Kent, England. The courses being offered by the Sira Institute Ltd are microprocessor familiarization, microprocessor applications for the equipment user and for the manufacturer, and microprocessor-based equipment design and development. Write to Conference and Courses Unit at Sira Institute Ltd, South Hill, Chislehurst, Kent BR7 5EH ENGLAND.

May
IEEE Computer Society Conferences and Meetings. For a list of events, contact the Executive Secretary, Harry Hayman, POB 639, Silver Spring MD 20901, or phone (301) 439-7007.

May 5-11
Engineering, Science, and Public Policy, 16th Annual Meeting, Baltimore Convention Center, Baltimore MD. Companies from around the world and the US will be exhibiting. The conference is being sponsored by the American Institute of Aeronautics and Astronautics (AIAA). Contact Lawrence Craner, Director of Technical Displays, AIAA, 1290 Avenue of the Americas, New York NY 10019, or the Conference General Chairman, Laurence Adams at Martin Marietta Aerospace.

May 6-8
Micro/Expo 80, Centre International de Paris, Paris France. This is one of the leading shows in Europe for microcomputer users and manufacturers. Exhibits of new equipment, presentations, games, educational materials, and more will be featured. For more information, contact Sybex Inc, 2020 Milvia St, Berkeley CA 94704.

May 6-8
The 7th International Symposium on Computer Architecture, La Baule France. This symposium will consist of discussions and readings in the following areas: distributed architectures, special-purpose architectures, hardware description languages, fault-tolerant architectures, high-speed computers, control schema, evaluation of architecture performance, and more.

Contact, Daniel E Atkins, Dept of Electrical and Computer Engineering, University of Michigan, Ann Arbor MI 48109.

May 6-10
The 8th Annual Canadian Association for Information Science, Toronto, Canada. Technology, commodity, and rights are the themes of this conference. Topics will cover information in the marketplace, information transfer and policy issues, right to access, new information technologies and applications, and other subjects. For more information, contact the Program Chairman, Eighth Annual CAIS Conference, Technical Information Centre, Bell Northern Software Research, 12th floor, 522 University Ave, Toronto,Ontario M5G 1W7 CANADA.

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May 12-13

Data Communications, Worcester Polytechnic Institute, Worcester MA. This seminar is designed to help professionals develop an effective data communications system. Network design, requirements, software, diagnostics, and controls are some of the issues that will be covered. The fee is $375, which covers everything except hotels. For information, contact Office of Continuing Education, Worcester Polytechnic Institute, Worcester MA 01609.

May 13-15

Microprocessors: New Directions for Mankind, Albuquerque NM. This symposium will deal with a variety of microprocessor applications. It is part of the Ideas in Science and Electronics Show. Contact J Arlin Cooper, Div 2331, Sandia Laboratories, Albuquerque NM 87185.

May 13-15

Electro/80 Show and Convention, Hynes Auditorium and Boston Sheraton, Boston MA. This major show consists of presentations and exhibitions by manufacturers in the electronics and computer industries. Contact Electronic Conventions Inc, 99 N Sepulveda Blvd, El Segundo CA 90245.

May 13-16

The 9th Annual Conference of MUMPS Users Group, Islandia Hyatt House, San Diego CA. The meeting will bring together scientific, medical, and business professionals to discuss current research and application development in the use of MUMPS, a high-level language. Areas of participation include paper presentations, workshops and tutorials, and vendor exhibits. Contact Dr Jack Bowie, MUG 80 Program Chairman, The Mitre Corp, Mail Stop 641, 1820 Dolley Madison Blvd, McLean VA 22102.

May 14-16

Carnahan Conference on Crime Countermeasures, Carnahan House, Lexington KY. This conference is devoted to the application of engineering and science to law enforcement, security, and crime prevention. Emphasis will be on effective research and development in computer security.

Contact the Office of Continuing Education, College of Engineering, University of Kentucky, Lexington KY 40506.

May 19-22

1980 National Computer Conference, Anaheim Convention Center, Anaheim CA. The conference program will include more than 120 sessions covering computing careers and education, office automation, and auditing in the area of management; computers in earth resource management, human services, and word processing; programming languages, design techniques and methodology, and voice simulation and recognition in software; earth resources, education, women and minorities in the computing discipline, as well as social implications; microcomputers and minicomputers, computer architecture, and new concepts in memories.

For information, contact American Federation of Information Processing Societies Inc, 1815 N Lynn St, Arlington VA 22209.

May 21-22

The 2nd Clemson Small Computer Conference, Clemson University, Clemson SC. This conference will discuss applications in engineering, science, manufacturing, small business data processing, and education. Contact William J Barnett, Electrical and Computer Engineering Dept, Riggs Hall, Clemson University, Clemson SC 29631.

May 21-23

Business and Personal Computer Sales-Expo 80, Philadelphia Civic Center, Philadelphia PA. This show is aimed at a wide range of interests in business and other fields that use com-

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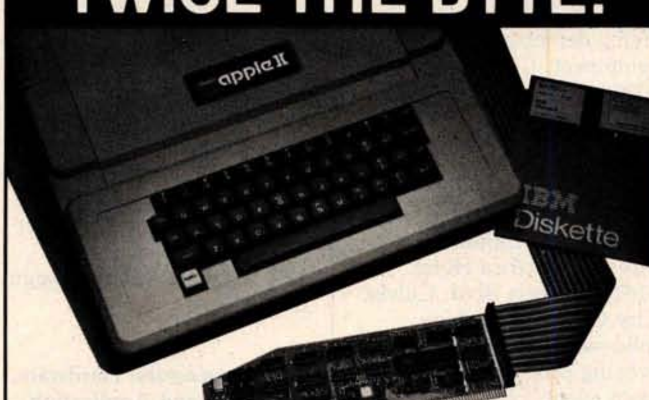

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puters and computer related products. Exhibitors will be giving demonstrations of equipment. Contact Produx 2000 Inc, Roosevelt Blvd and Mascher St, Philadelphia PA 19120.

May 23

The Digital Computer Association Annual Meeting, Pacifica Hotel, 6161 Centinela Blvd, Culver City CA. A slide show, followed by dinner and an evening program are the main events of the meeting. The price is $15 prepaid. Send reservations to Mary Rich, 731 Bayonne St, El Segundo CA 90245.

May 24-25

Amateur Radio and Computer Hobbyists Annual Convention, Cervantes Convention Center, St Louis MO. Speakers, presentations, equipment displays, and a flea market will be featured. For more information, contact the Gateway Amateur Radio Assocation Inc, POB 68, Marissa IL 62257.

JUNE 1980

June 2-5

The 9th Annual Symposium on Incremental Motion Control Systems and Devices, Ramada Inn, Champaign IL. Exhibition space is available for this conference. Contact Professor B C Kuo, POB 2772, Station A, Champaign IL 61820.

June 4-5

Microprocessors: Hardware, Software, and Application, Holiday Inn, Boston MA. This course is recommended for technical professionals who need an understanding of microprocessors in relation to their corporate and business careers. Contact Office of Continuing Education, Worcester Polytechnic Institute, Worcester MA 01609.

June 4-6

Salon de l'Ordinateur Computer Show, Place Bonaventure, Montreal, Canada. This exhibition will feature over eighty manufacturers' hardware and software.

For more information, contact Industrial Trade Shows of Canada, 36 Butterick Rd, Toronto, Ontario M8W 3Z8 CANADA.

June 9-13

Microcomputer Workshop, Carnegie-Mellon University, Pittsburgh PA. Engineers, research scientists, educators and managers will benefit from this course. It covers all aspects of microcomputers and software. Hands-on training will be provided. The tuition is $585 and housing can be arranged. Contact the Post College Professional Education, Carnegie-Mellon University, Pittsburgh PA 15213.

June 15-18

International Summer Consumer Electronics Show, McCormick Pl, McCormick Inn, and the Pick-Congress Hotel, Chicago IL. The Consumers Electronic Show (CES) will feature exhibits from many companies; seminars and discussions; and items ranging from television, tape recorders, telephones, translators, to computers, component systems, auto sound systems, and electronic games will be presented. Contact Consumer Electronics Shows, Two Illinois Center, Suite 1607, 233 N Michigan Ave, Chicago IL 60601.

June 17-19

Data Comm, Palais des Expositions, Geneva Switzerland. Data communications and distributed data processing are the main themes of this conference and exhibition. Software development and tools, computer languages, managing data communications systems, and definitions, concepts, and applications of data communications and distributed data processing are some of the topics that will be covered in the conference.

For more information, contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Suite 999, Chicago IL 60606.

June 18-21

Association for Computational Linguistics, University of Pennsylvania, Philadelphia PA. The meeting will cover theoretical and methodological problems of computational linguistics, speech acts, analysis of multisentence texts, dialog, machine translation and computational semantics. For further information contact Don Walker, Artificial Intelligence Center, SRI International, 333 Ravenswood Ave, Menlo Park, CA 94025.

June 20-22

The 5th Annual Computerfest, Franklin University, Columbus OH. Sponsored by the Midwest Affiliation of Computer Clubs, this is a gathering of interested hobbyists, professionals, and business-oriented computer users. Workshops and discussions are the main feature of the conference. Contact James Crowley, 4008 Rickenbacker Ave, Columbus OH 43213.

June 23-27

First World Conference on Transborder Data Flow Policies, Rome, Italy. Legal and social implications, economic dimensions, regulatory environment, interdependence caused by global communications, and assessing the status of data flow developments are some of the topics that will be covered in this forum. Write to the Intergovernmental Bureau for Informatics, POB 10253, 00144 Rome, ITALY.■

In order to gain optimum coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, 70 Main St, Peterborough NH 03458. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

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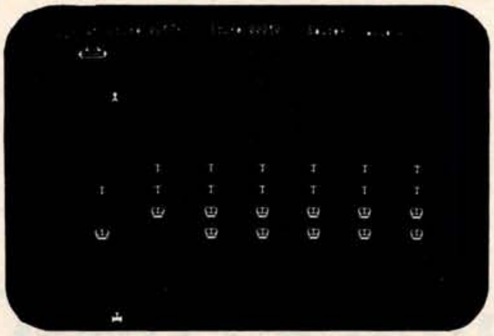

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The common 1702A, 2708, and 2716-type erasable programmable read-only memory devices (EPROMs) may be erased dozens of times and then reprogrammed, changing the internal bit pattern. The erasure is accomplished by exposing the silicon die to short-wavelength ultraviolet light through the quartz window. (The wavelength of the ultraviolet radiation in this instance is 2537 Å.) National Semiconductor's recommended integrated dose (intensity times exposure) is 6 Ws/cm^2 (Watt-seconds per square centimeter). They recommend also that the exposure be triple the time for erasure found empirically.

Light in the proper section of the ultraviolet spectrum for performing the erasure can be produced by several methods: molecular excitation, filtering of broad spectrum light, and fluorescence. The most economical way for generating a lot of ultraviolet light is by excitation, with or without filtering.

Common low-pressure fluorescent lamps excite mercury vapor to produce ultraviolet light. This light causes rare earth compounds on the tube walls to fluoresce in the visible spectrum.

Several companies manufacture a low-pressure mercury vapor tube without the fluorescent rare earth compounds. Such tubes emit a high-intensity, short wavelength ultraviolet light. As a bonus, they are easy to use, are relatively inexpensive, and have a long life (about 6000 hours). However, do not look at one while it is on. The light can damage your eyes.

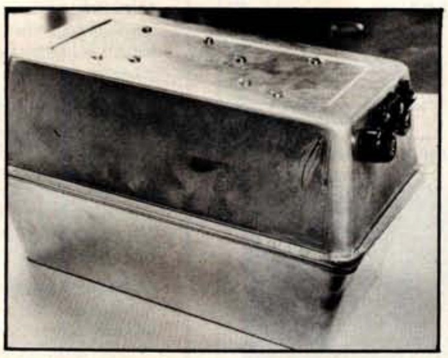

Photo 1: *The case for the EPROM eraser is made of two bread-baking tins hinged together with flexible material. Power supply components are mounted in one end of the upper tin.*

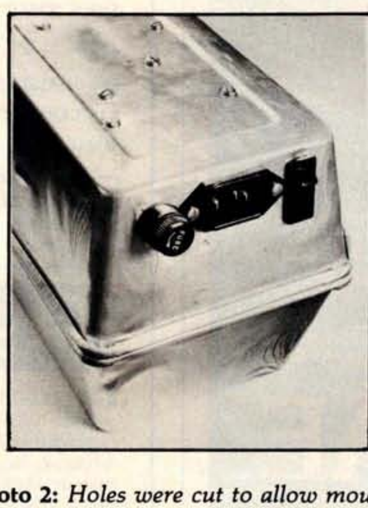

Photo 2: *Holes were cut to allow mounting of a fuse, a 3-prong connector, and a switch (with an internal neon pilot lamp).*

Construction

I set out to build an eraser for the erasable programmable read-only memories using one of the low-pressure, mercury-vapor ultraviolet tubes. As an enclosure for the device, I used two aluminum bread-baking tins with dimensions 24.5 by 14 by 7 cm (9⅝ by 5½ by 2¾ inches). I fastened the two tins together along the long side with a hinge made of flexible material. I cut holes in one end of the assembly to mount a fuse, a power switch, and a connector for power supply. Photo 1 shows the completed box; photo 2 shows a close view of the power control components mounted in their holes.

To provide strong support for the somewhat delicate ultraviolet lamp, I built a support for it on a piece of sheet aluminum cut to fit inside the bread tin with about 1.3 cm (one-half inch) clearance on each side. Two blocks of wood are attached by screws to the bottom of the tin and support the sheet of aluminum. The lamp tube is supported and raised about 2.5 cm (an inch or so) off the surface by a combination of standoff insulators and cable tie-down

devices. Photo 3 shows the tube mounted on its support structure.

Electrical power is supplied to the lamp through wires soldered to each of the miniature 2-pin contacts on the ends of the lamp. Because a potentially deadly voltage is present on the pins whenever the unit is plugged in, I insulated the pins thoroughly with heat-shrink tubing and silicone sealant. The wires were fed through holes in the aluminum baseplate/reflector.

Electrical Assembly

Figure 1 shows a schematic diagram of the electrical connections needed to operate the lamp. The remaining electrical components are mounted in the bread tin under the support plate of the lamp. The ballast and starter mechanism are secured to the tin with screws. The bread tins are connected to ground through the 3-conductor power cord; this is an important step to assure safety. Be sure that both halves of the case are grounded. Also, be careful to direct the hot side of the power line to the fuse and switch. An 82 k-ohm resistor limits the current in the circuit of the

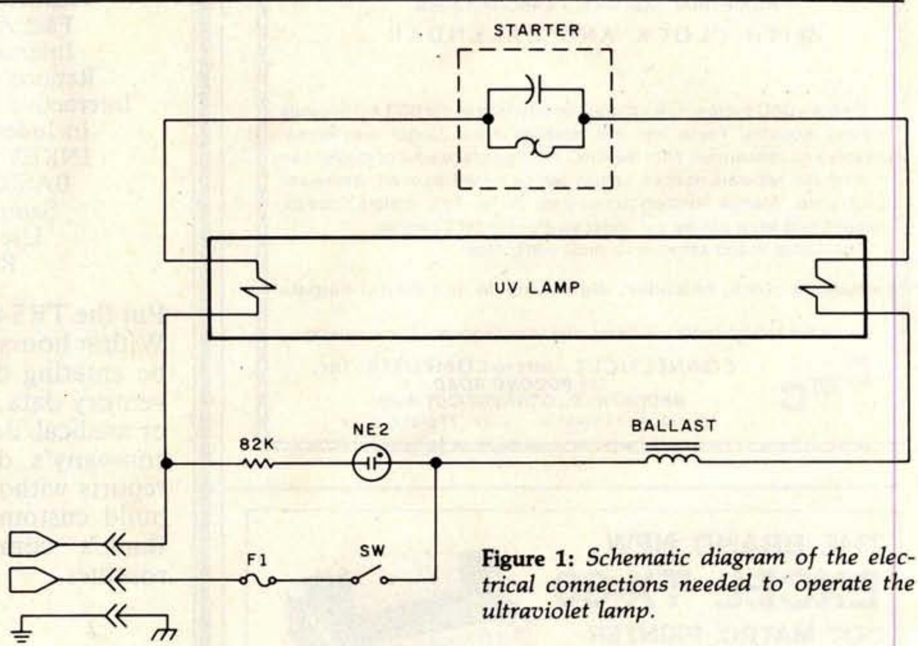

Figure 1: *Schematic diagram of the electrical connections needed to operate the ultraviolet lamp.*

1 F6T5/BLB	6 watt ultraviolet lamp
1 89G435 (General Electric)	4,6,8 watt ballast
1 FS-5	Fluorescent lamp starter 4,6 or 8 watt
1 #380 (Leviton)	Starter Socket
2 (9⅝ x 5½ x 2¾) aluminum bread tins	

Miscellaneous wire, hardware, hinges, switches, fuse, and IEC cord and socket.

Table 1: *List of parts needed to build this EPROM eraser.*

NE-2 pilot lamp in the switch. Photo 4 shows the components mounted in the bread tin among the baseplate supports.

I tested the device with a standard ohmmeter, checking for high resistance across the power plug. Having found this, I subjected the apparatus to a successful smoke test (that is, no smoke). I observed the starter takes 5 seconds or less to ignite the lamp in normal operation.

Conclusion

When operating the erasing device, it is a good idea to wrap opaque tape around the crack between the two bread tins. This should prevent possibly harmful ultraviolet radiation from leaking out and damaging your vision. Remember also, for safety's sake, that careful insulating of high voltage lines and grounding of all parts is very important.

I started to make a table of exposure indices for various erasable read-only memory devices, but I found that 30-minute exposure completely erased all bits in my tests, so I feel that this exposure interval is adequate.

In operation, the device is placed so that the lamp is in the upper half. The memory integrated circuits are placed in the empty lower half for exposure. An added benefit of this empty half is that it makes a convenient storage location for the detachable power cord between the times that you erase your memories. ■

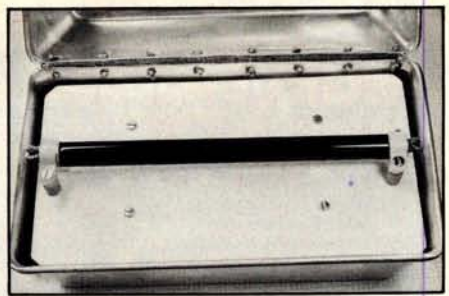

Photo 3: *The ultraviolet lamp tube is supported on its aluminum baseplate by insulating standoffs and cable ties.*

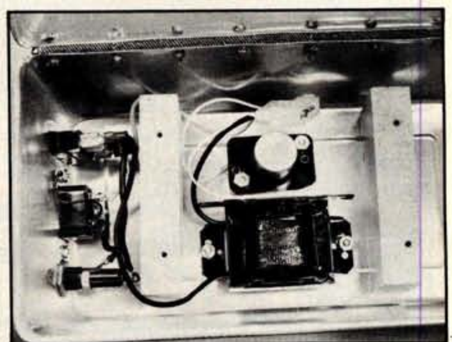

Photo 4: *Blocks of wood support the lamp baseplate. Between the blocks are mounted the lamp starter and ballast devices.*

Editor's Note

Ultraviolet light can damage your eyes, so it is important to avoid looking at a source of it while in operation. Observe due caution when operating the erasing device described in this article.

Over several cycles of programming and erasure, the necessary erasure exposure of certain EPROM devices can increase. Thus, over a period of time you may have to lengthen exposure times to obtain good results.

You may find more information about erasable read-only memory characteristics in "Program Your Next EROM in BASIC" by Steve Ciarcia (March 1978 BYTE, page 84), and "Zapper: A Computer Driven EROM Programmer" by G H Gable (December 1978 BYTE, page 100)....**RSS**

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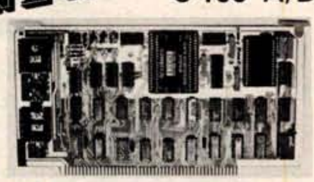

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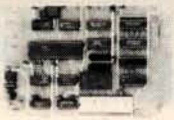

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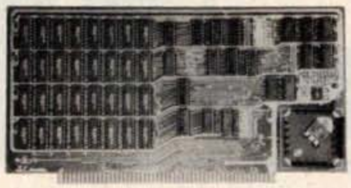

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Floppy-Disk Drives with 96 Tracks Per Inch

Micro Peripherals Inc is producing 5-inch floppy-disk drives that read and write 96 tracks per inch. When combined with double data density and double-sided read/write features, the units can store nearly one megabyte on a 5-inch floppy disk. The Models 91 and 92 disk drives are plug-compatible with existing systems. Disks recorded on the standard 48-track-per-inch format can be read on the 96-track-per-inch devices. The Model 91 can store 480 K bytes on a single side of a disk, and the Model 92 can store 960 K bytes using both sides of the disk. Both have an access time of 5 ms.

The head assembly for the Model 92 incorporates a fixed bottom head with a gimballed top head. This assembly provides more than three million in-contact passes of the media over a single track. An automatic disk positioning and ejector mechanism pre-positions the disk over the spindle hub before the clutch centering device is engaged. The units are available from Micro Peripherals Inc, 9754 Derring Ave, Chatsworth CA 91311. The prices are $450 for the Model 91 and $550 for the Model 92.

Circle 548 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgement the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first in first out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

Joystick Interface for TRS-80

This joystick interface plugs into the expansion interface of the TRS-80 with no modifications. Three sockets allow the use of one Fairchild or two Atari joysticks for single or two-person interactive games and input. Both types of joysticks can sense eight compass directions; additionally, the Atari includes one push button, and the Fairchild features push-pull and twisting actions. Each interface comes with a separate power supply, two games and instructions on programming the interface. The price is $65 plus $3.50 shipping and is available directly from Creative Software, POB 4030, Mountain View CA 94040.

Circle 549 on inquiry card.

TeleVideo Introduces Four Video Terminals

TeleVideo Inc has introduced four microprocessor-controlled video terminals that include uppercase and lowercase, a printer port, numeric pad, remote computer control, selectable transmission rates from 75 to 9600 bits per second (bps), editing and other functions, a serial RS-232C interface, and a 20 mA current loop. Editing and transmission functions are key-selectable and include character and line insert or delete, line and page erase, send-line, send-page, and tabbing. All models also offer reverse-video, underline, blinking and blanking, key-controllable conversational and block transmission modes, a built-in self-test, protected fields, switch-selectable parity, and a 240-character input buffer. The terminals provide a 12 by 10 dot matrix in a 24-line by 80-character per line format.

The 912B lists at $875, the 912C at $950, 920B at $945, and the 920C at $1030. For further information contact TeleVideo Inc, 3190 Coronado Dr, Santa Clara CA 95051.

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What's New?

PERIPHERALS

Digital Output Bar-Code Wand from Hewlett-Packard

The HEDS-3000 is a digital wand designed to scan bar codes and output a logic level pulse-width representation of the bars and spaces. The device can be used for portable data entry and as peripheral equipment for microcomputers. An analog amplifier, a digitizing circuit, and an output transistor provide TTL- and CMOS-compatible logic level output. The bar-code reader is a data entry alternative to the keyboard as a computer terminal accessory. It is priced at $99.50. Contact Hewlett-Packard Co, 1507 Page Mill Rd, Palo Alto CA 94304.

Circle 551 on inquiry card.

New Peripherals for the TI-99/4 Computer

An RS-232 interface for connecting serial peripherals to the TI-99/4 computer has been announced by Texas Instruments Inc, Consumer Relations, POB 53, Lubbock TX 79408. The interface converts the parallel data output of the TI-99/4 to a serial format. Using BASIC, the interface can be programmed for different data transmission speeds. Connection to the two serial ports is through standard 25-pin male DB-25 connectors. The suggested retail price is $225.

A disk drive controller and a 5-inch floppy-disk drive have also been developed for use with the system. The system can store up to 90 K bytes of memory, and up to 127 files may be defined. The controller can handle fixed and variable length records, and sequential and relative files. Controller software supplies disk utilities, including disk and file maintenance commands.

The controller has a suggested retail price of $300 and the drives are priced at $500 each.

TI also has designed a thermal printer for use with the TI-99/4. The printer prints 32 columns in a 5 by 7 dot matrix at 30 characters per second (cps). It prints two character sets, and has 32 predefined graphic symbols. The unit uses 8.8 cm (3.5 inch) thermal paper and retails for $400.

A telephone modem has been designed for the system and the new interface. The modem is priced at $225, and a software support package is priced at $45.

Circle 552 on inquiry card.

Graphics Drawing System for Apple II

The VersaWriter is a digitizer and software drawing package for the Apple II computer. When used as a pointer, the VersaWriter can direct movements of objects on the video screen for game playing or creating graphics. As a digitizer, the VersaWriter enters graphical data for analysis, flowcharts and diagrams. Drawings, architectural plans, schematics charts, and graphs can be created using the device. Sixteen commands control cursor movement, permit fill-in coloring, control horizontal and vertical scaling, centering on the screen, and more. The system consists of the VersaWriter drawing board and interface, software, calibration chart, and instruction manual. The drawing board plugs directly into the game port. An Apple II with 32 K bytes of memory and Applesoft read-only memory are required.

The normal retail price for the VersaWriter is $199, but a special price of $179.95 is offered while initial supplies last. For complete information, contact Rainbow Computing Inc, 9719 Reseda Blvd, Northridge CA 91324.

Circle 553 on inquiry card.

What's New?

PERIPHERALS

Rack-Mounted Alphanumeric Printer

Kontron Electronic Inc, 700 S Claremont St, San Mateo CA 94402, has introduced the rack-mounted Model 5019 Printer, which features a 64-character ASCII set. Character width is generated by control logic and can be changed during the printing. The unit prints up to 32 characters per line at up to two lines per second with a 5 by 7 dot matrix. A parallel or serial ASCII input or fully parallel binary-coded decimal (BCD) input mode may be selected. The printer measures 13.2 by 21 cm (5.22 by 8.39 inches) and costs $235.

Circle 554 on inquiry card.

Video Terminal Emulates Burroughs Terminals

The SRI/OP1-R microprocessor-based terminal can be configured to look like a Burroughs TD830, TD802, TD700 or a Teletype terminal using an 8 K byte programmable read-only memory-based emulator. The SRI/OP1-R offers asynchronous, TDI, or synchronous communication interfaces at speeds ranging from 300 to 9600 bits per second (bps), and can interface with printers, bar-code readers, and other peripherals. The terminal can also support concurrent background printing, using a separate polling address which enables users to concurrently perform on-line entry functions while it prints output reports. The terminal is priced at $2595 and is available from Systems Research Inc, 2400 Science Pky, Okemos MI 48864.

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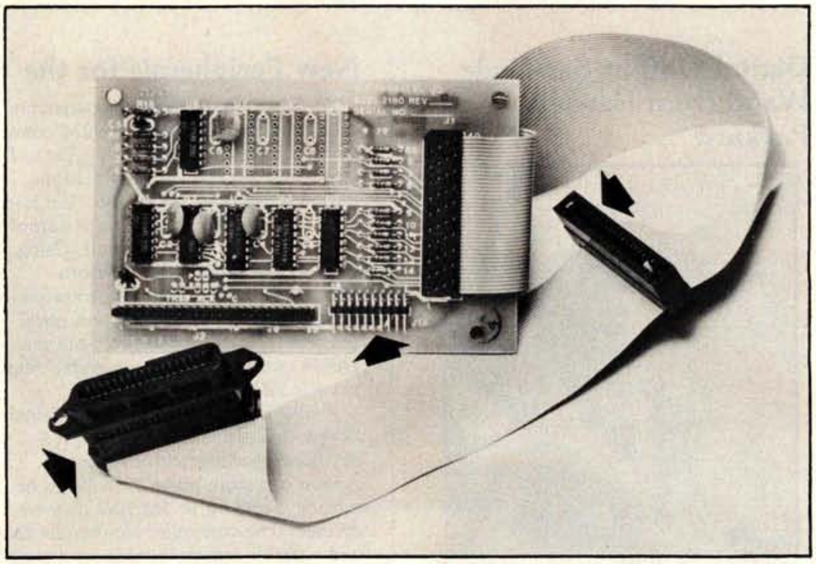


Comprint Offers an Enhanced Version of the 912: the Model 912-GP

The Comprint 912-GP electroresistive printer contains a feature that allows optional interfacing with nearly all of the microcomputers used in business, word processing, and personal applications, including the TRS-80 and the Apple II. The 912-GP is shipped with three separate connectors. The first is an Apple-compatible connector mounted on the board. Two additional connectors, one for the TRS-80 and the other for a Centronics-compatible port, are mounted on a flat ribbon cable attached to the board. The new printer provides a selection of four signals, which satisfy the requirements of most computers. This nonimpact printer prints at a speed of 225 characters per second on aluminized paper. It is priced under $1000. For additional information address Comprint, 340 E Middlefield Rd, Mountain View CA 94043.

Circle 556 on inquiry card.

Expansion Interface for The Imagination Machine

APF Electronics Inc, 444 Madison Ave, New York NY 10022, has announced Building Block, an expansion interface for their computer, The Imagination Machine. This interface is designed for interfacing printers, additional memory, modems, and floppy-disk drives. It includes a cartridge with a standard RS-232 port, which meets EIA RS-232 specifications. Eight data rates are selectable from 110 to 9600 bps. The suggested price for the Building Block is $199.95.

The 8 K byte programmable memory cartridge plugs into the interface and has a suggested retail price of $99.95. The floppy disk interface cartridge can drive two 5¼-inch floppy-disk drives and has a suggested price of $199.95. The D-100 5¼-inch floppy-disk drive has a storage capacity of 72 K bytes. It includes Shugart SA-400 compatibility, IBM formatting of 256 bytes per sector, and a built-in power supply. It retails for approximately $349.95. The P-40T 40-column thermal printer has a speed of two lines per second and a suggested price of $399.95. The TM-150 Modem transmits at 300 bps. It has originate and answer modes, and allows half- or full-duplex operation. An AC adapter is included for the package price of $199.95.

Circle 558 on inquiry card.

Dot-Matrix Impact Printer for Small Business and Home Computers

The Model 7000+ dot-matrix impact printer features 1.25 lines per second unidirectional printing, with a line speed of 1.25 lines per second. It accepts single- or multi-ply paper rolls from 2.4 cm to 9.6 cm (0.75 to 3.85 inches) wide, and prints an 8.2 cm (3.3 inch) line. Capacity is 40 columns at 12 characters per inch. The 7000+ printhead has a minimum life of 100 million characters, while the overall mechanism life of the unit is 10 million cycles. The printer interfaces include TRS-80 parallel, Apple parallel, RS-232C, PET IEEE, current loop, and others. The 7000+ accepts the full ASCII character set with uppercase and lowercase and can print in both a single- or a double-width font. The printer measures 18 cm high (6.5 inches) by 25.5 cm wide (10 inches) by 32.5 cm deep (12.5 inches). It is made by LRC, an Eaton company, Technical Research Park, Riverton WY 82501, and is priced at $389.

Circle 557 on inquiry card.

What's New?

SYSTEMS

ADDS Enters the Business Market with Modular Computer Systems

Applied Digital Data Systems Inc, 100 Marcus Blvd, Hauppauge NY 11787, has developed a modular microcomputer system for professional offices, agencies, retail stores, and other small businesses. The basic system, Multivision 1, contains an 8085 microprocessor running at 5 MHz, all input/output (I/O) and controller circuitry to operate the dual 5-inch floppy-disk drives, and a standard display terminal. Multivision 2 adds an 8-inch Winchester disk drive with either 5-megabyte or 10-megabyte storage. Multivision 3 supports up to four display terminals with up to 256 K bytes of programmable memory and three more terminal ports.

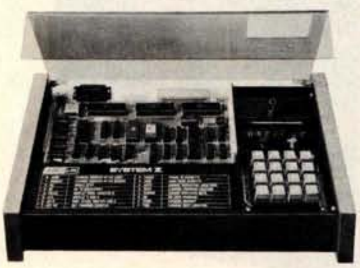
Some of the features of the central processing unit include: 256 bytes of nonvolatile (CMOS with battery power) memory for soft parameter control such as terminal data rates, stop bits, logging of diagnostic data, and applications use; direct memory access (DMA) capabilities for I/O to memory, memory to I/O, and memory-to-memory transfers. The unit also features 64 K bytes of dynamic programmable memory. All peripheral

and interrupt control uses I/O hardware.

ADDS produces a CP/M-compatible operating system, a BASIC compiler and interpreter with ISAM capabilities, business applications software, and word processing software. The price for the three Multivision systems are $3785, $7995, and $12,885, respectively.

Circle 513 on inquiry card.

The μ68 System X Microprocessor



Based on the Motorola 6800 microprocessor, System X was designed for technicians, engineers, and scientists. It can be used as a training system, or as a development tool by designers for circuit designs and interfacing for industrial control and software development. The unit includes an 86-pin card edge connector for the microprocessor board and another connector for the memory board and lab series board. It features total compatibility with the Motorola EXORcisor bus. The price for the system is $775, and it is available from ASCI Marketing Group, Suite 101, 27439 Holiday Ln, Perrysburg OH 43551.

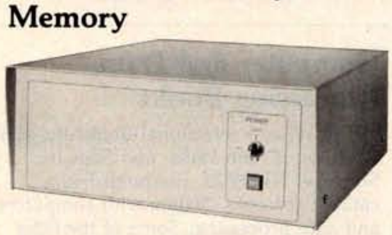
Circle 514 on inquiry card.

Single Board Microcomputer Uses 6809 Processor

The MIKUL 6809-3 is a single board computer that utilizes the Motorola MC6809 processor. The card includes two 6821 peripheral interface adapters, one 6840 programmable timer module, one 6850 asynchronous-communications interface adapter with RS-232C interface, 2 K bytes of static programmable memory with provision for battery backup, and sockets for four erasable programmable read-only memory (EPROM). The MIKUL 6809-3 is compatible with EXORciser and Micromodule buses. It is available for $425 from TL Industries, 2573 Tracy Rd, Northwood OH 43619.

Circle 515 on inquiry card.

S-100 Mainframe and Z80 Board with 64 K Bytes of Memory



CMC Marketing Corp, 10611 Harwin Dr, Suite 406, Houston TX 77036, has announced the Model 2018 Microcomputer Mainframe System. The system consists of an eighteen-slot S-100 bus motherboard and cabinet; a constant voltage transformer that provides for input voltages of 120 or 230 VAC; and a double-pole circuit breaker that protects the input power. Secondary voltages are rated at +8 VDC at 20 A and ± 16 VDC at 3.5 A.

The Model Z80/64 computer and memory card features a Z80 microprocessor and 64 K bytes of programmable memory, plus provisions for 2 K bytes of erasable programmable read-only memory and vectored interrupts. The board features transparent refresh and phantom memory, which allows programmable memory and read-only memory overlay. CMC Marketing Corp has also developed a controller board for double-density floppy-disk drives and is marketing software application programs for businesses.

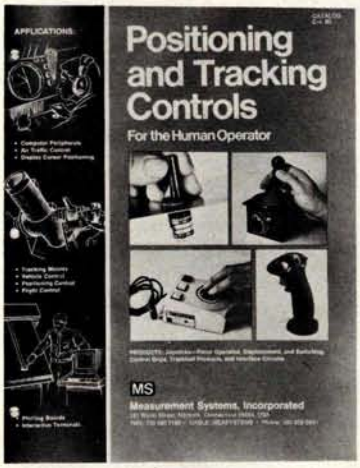
The price for the board is $1295. The price for the desktop mainframe $695.

Circle 516 on inquiry card.

What's New?

PUBLICATIONS

Positioning and Tracking Controls Catalog



Measurement Systems Inc, 121 Water St, Norwalk CT 06854, is publishing a sixteen-page catalog of positioning and tracking-control products. The controls in the catalog are used in computer peripherals, radar and other displays, and to position apparatus. The products include joysticks, trackballs, control grips, and interface electronic circuits. Contact the company for a copy of the catalog.

Circle 534 on inquiry card.

New Hardware Documentation from Ohio Scientific

Ohio Scientific (1333 S Chillicothe Rd, Aurora OH 44202) has introduced a line of paperback manuals documenting the boards used in OSI's computer systems. Each of the manuals, written by the Howard W Sams Company, contains schematics, labeled photographs with oscilloscope waveforms, integrated circuit pinout diagrams, parts lists including equivalent replacement parts by manufacturer, and other information. Two books are available now: the TM-100 *Servicing Data for Computer Boards 600 and 610, as used in Challenger Series Superboard II, Model C1P, and Model C1P-MF,* 36 pages, $7.95; and the TM-200 *Servicing Data for Computer Boards 502, 505, 527, 540, and 542, as used in Challenger Series Model C4P and C4P-MF,* 92 pages, $15.95. Both books are available from local Ohio Scientific dealers. Similar books for the remaining Ohio Scientific systems are being prepared.

Circle 535 on inquiry card.

Software for the TRS-80

Software Innovations Co, 320 Melbourne Rd, Great Neck NY 11021, has a catalog of their software for the TRS-80. The free catalog includes games and other programs for the 16 K Model II or 32 K floppy-disk system.

Circle 536 on inquiry card.

Programming the Z8000

Programming the Z8000, by Richard Mateosian, has been released by Sybex, 2344 Sixth St, Berkeley CA 94710. This book presents a detailed description of the Z8000 and is valuable to those interested in learning machine-language programming. The book covers input/output (I/O) techniques, peripheral components, utility programming examples, addressing modes, hardware organization, and a complete instruction set. Information on the engineering and applications of the Z8000 and instructions on writing programs are included. The price is $15.95.

Circle 537 on inquiry card.

Computer and Data Processing Books

The Wiley Professional Books-By-Mail Division of John Wiley and Sons Inc, Somerset NJ 08873, has published a catalog of books dealing with computers and data processing. Some of the titles are *Computer Networks and Their Protocols, Writing Interactive Compilers and Interpreters, On the Design of Stable Systems,* and *An Introduction to General Systems Thinking*. For a copy of the catalog and more information, contact the company.

Circle 538 on inquiry card.

How To Start Your Own Systems House

How To Start Your Own Systems House is a guide that covers most aspects of starting and operating a small-business computer company. Market selection and evaluation, industry application opportunities, equipment selection, evaluation of vendors, becoming a dealer and distributor, building a sales force, effective advertising, shows, product pricing, and equipment service are some of the subjects discussed. The book contains samples of contracts, proposals, agreements, advertising letters, and a complete business plan. The book is priced at $36 and is available from Essex Publishing, 285 Bloomfield Ave, Caldwell NJ 07006.

Circle 539 on inquiry card.

TRS-80 Interfacing

TRS-80 Interfacing, by Dr Jonathan Titus, explains a number of interfacing techniques that can be used with the TRS-80 Breadboard, a product that allows custom interfacing of peripherals to the TRS-80 computer. Schematic diagrams, software listings, and eighteen experiments are included. The book will enable users to acquire the tools needed to design interfaces and to write the necessary software for the TRS-80. The book is priced at $8.95, plus $1 shipping and handling. For further information, contact Group Technology Ltd, POB 87, Check VA 24072.

Circle 540 on inquiry card.

What's New?

MISCELLANEOUS

Addressable PET Printer Adapter

The ADA 1400 adapter drives a printer with an RS-232 interface from the PET IEEE-488 bus. The ADA 1400 is addressable, works with the Commodore disk, and prints uppercase and lowercase American Standard Code for Information Interchange (ASCII) characters. The PET IEEE type port is provided for daisy-chaining other devices. A cassette tape is included with programs for plot routines, data formatting and screen dumps. The ADA 1400 sells for $179 and includes a PET IEEE cable, RS-232 cable, power supply, case, instructions, and software. Contact Connecticut microCOMPUTER Inc, 150 Pocono Rd, Brookfield CT 06804.

Circle 541 on inquiry card.

General Ledger System for TRS-80 Model II

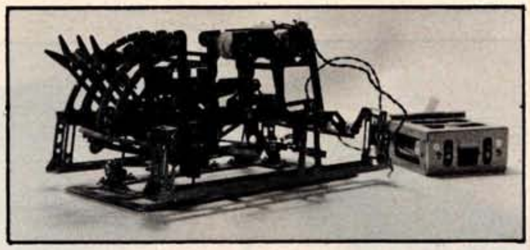
This general ledger system features unlimited inherent files, a year-to-year comparison on the income statement and the balance sheet, account transaction summary reports for up to a year, and automatic posting of retained earnings to user-defined accounts. The Cash Journal provides a cumulative listing of cash receipts and disbursements that result in permanent deposit records and cash register listings. Reports consist of trial balance, income statement, balance sheet, and special accounts report. Percentages to sales and prior year variances are also available. The price for the program is $249.95 and the package is available from Taranto and Associates, POB 6073, San Rafael CA 94903. Circle 542 on inquiry card.

Tiny Switcher

This 12.7 mm cube (0.5 inch) is an extremely small switching-mode power supply and the smallest of the μS family of switchers. The μS-A can operate from line voltages of 90 to 255 VAC at 47 thru 440 Hz, and it has 2500 V isolation from input to output. The AC input is transient-protected and DC voltages are protected from 1.5 to 15 VDC. Applications include powering low-power systems ranging from digital panel meters to smoke alarms, as well as charging nicad batteries. For more information, contact Microsource Corp, 7330 Rogers Ave, Chicago IL 60626. The original equipment manufacturers price is listed at $8.89 with a minimum factory order of $25 or cash/check with the order.

Circle 543 on inquiry card.

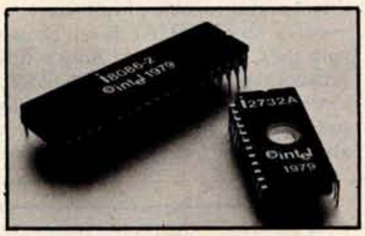
What Is It?



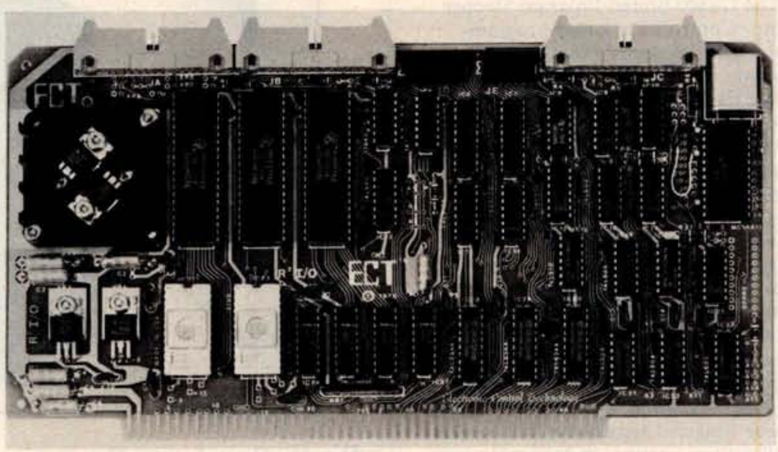
This unique item promises to be fun for the entire family. Designed for anyone between the ages of eight and eight and one-half, the unit comes replete with pieces of metal, wire, and a box for batteries. This specimen features a burned-out motor and two defunct batteries. Be the first to guess it — you win it. Send entries to Contest Editor, BYTE Publications, 70 Main St, Peterborough NH 03458.

Intel Develops the 8086-2 and the 2732A EPROM

Intel Corp, 3065 Bowers Ave, Santa Clara CA 95051, has announced the development of the 8086-2 microprocessor for the MCS-86 family of system components. The 8086-2 is a 16-bit, 8 MHz microprocessor that utilizes HMOS II technology. The 2732A 32 K bit erasable programmable read-only memory (EPROM) is a fourth-generation design based on HMOS-E technology. It operates at maximum access times down to 200 nanoseconds. Because of the speed of the 2732A, wait-states for program store memory references are not necessary using the 8086-2. Bipolar bus support, large-scale integration peripherals, and dynamic and static memory devices usable with the standard 5 MHz 8086 can also be used with the 8 MHz version. Additionally, the 8089 input/output processor can be used in 8086-2 systems, acting as a coprocessor in the system, executing input/output programs concurrently with the 8086 execution of the main program. The 8086-2 is currently priced at $200 in quantities of 100 and the 2732A EPROM is currently priced at $570.



Circle 545 on inquiry card.



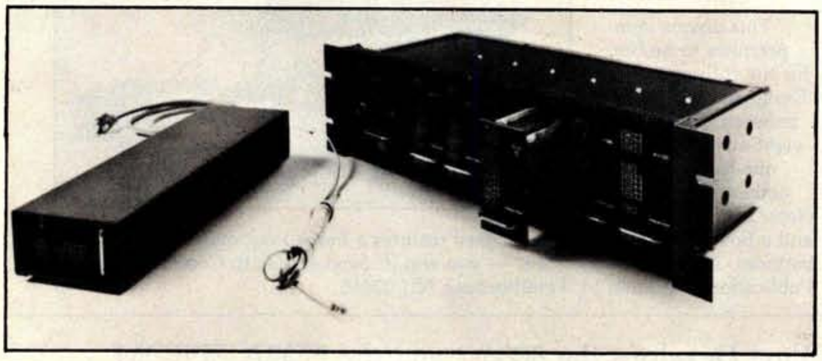
Memory and Input/Output Board

R^2I/O is an S-100 bus input/output (I/O) board with three serial I/O ports, one parallel I/O port, four status ports, 2 K bytes of read-only memory (ROM), and 2 K bytes of programmable memory. The board can be used as an interfacing device and as a computer control from a terminal keyboard with a ROM monitor containing executive commands and I/O routines. Data rates are selectable in the range of 75 to 9600 bits per second and the voltage levels of the serial I/O ports are RS-232 compatible. The price for the board is $295. For information contact Electronic Control Technology, 763 Ramsey Ave, Hillside NJ 07205.

Circle 546 on inquiry card.

What's New?

MISCELLANEOUS



Bell-Compatible, Low-Speed Modems Feature Integral DAA

Prentice Corporation is offering a family of modems that allow transmission of 300 bits per second (bps) asynchronous data over the dial-up switched telephone network without an external data-access arrangement (DAA). The family consists of the P103J Originate/Auto Answer, P113C Originate, and P113D Auto Answer modems. The modems have a standard RS-232C digital interface and a line interface defined by FCC Part 68. The modems provide half- or full-duplex transmission and reception of serial binary asynchronous data over two-wire, dial-up telephone facilities. An integral DAA allows connection of the modems to the telephone network by means of a modular jack. They also feature indicators that monitor up to nine conditions and parameters. The P103J is priced at $470; the P113C is priced at $385, and the P113D at $395. For information contact Prentice Corp, 795 San Antonio Rd, Palo Alto CA 94303.

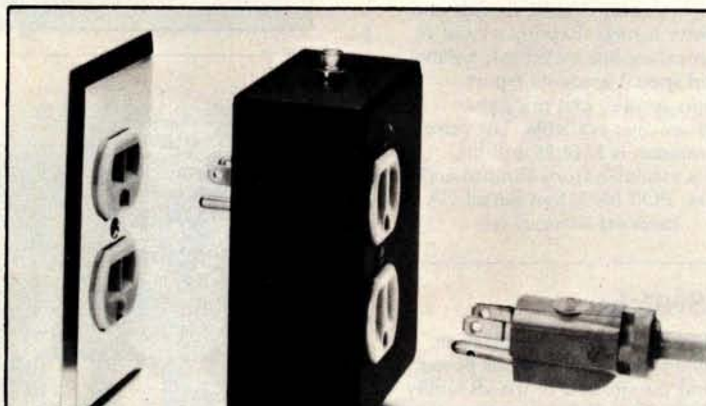
Circle 532 on inquiry card.

User-Programmable Integrated Circuit Controller for Stepper Motors

The CY500 Stored Program Stepper Motor Controller is a user-programmable NMOS device executing 22 separate function-oriented commands. When the CY500 is in the ASCII mode of operation, the instructions form a function-oriented language. In this mode, parameters are entered as ASCII decimal numbers. The CY500 can execute commands at once in the command mode, or store a sequence of commands and then run them as a program. This feature allows program looping using DO-WHILE instructions and program waits using WAIT-UNTIL instructions. Other instructions control single- or multi-step mode operation, full- or half-step operation, and more. Each step can be triggered separately, and control of direction, starting, and stopping may be done either via external hardware or via software control. Control of step rates up to 3500 steps per second is possible. Asynchronous communication with the CY500 may be achieved in serial or parallel fashion. The device uses a single +5 V power supply, and is priced at $95. For more information, contact Cybernetic Micro Systems, 445-203 S San Antonio Rd, Los Altos CA 94022. Circle 530 on inquiry card.

Disk-Drive Controller for the S-100 Bus

Cameo Data Systems Inc, 1626 Clementine St, Anaheim CA 92802, is shipping their DC-500S Cartridge Disk-Drive Controller for S-100 bus microcomputers. The controller will operate up to four 10 or 20 megabyte drives and is capable of full direct memory access (DMA). It can be used with the CDC Hawk and Ampex drives. Price of the controller alone is $1550, including cables and a CP/M-compatible software driver. Diagnostic software is also available. Circle 531 on inquiry card.



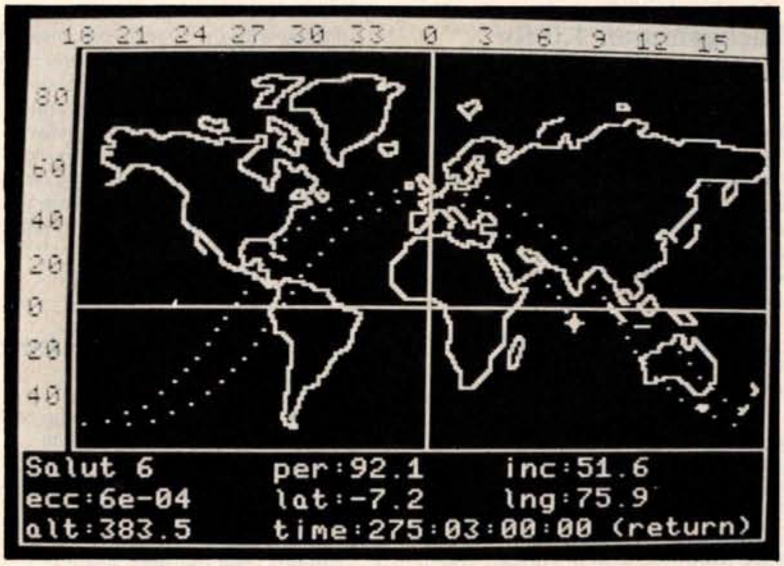
Protection from Power Surges

This power-surge-control device protects small computers as well as communications, medical and other electronic equipment from destructive voltage transients. The Surge Sentry 120 plugs into standard 120 VAC wall outlets to provide protection from transients. In operation, the SS-120 detects and quickly shunts short duration voltage surges. The device has a response time of less than 1 ns and a power dissipation capacity of 600,000 watts. A light-emitting diode lets the user know that the device is functioning properly. The unit is parallel with the power line so the SS-120 will not interrupt equipment operation if it malfunctions. The suggested price is $89.50 and it is available from R&K Enterprises, 643 S 6th St, San Jose CA 95112.

Circle 533 on inquiry card.

What's New?

SOFTWARE



Satellite Tracking Software

Sat Trak International produces satellite tracking software for beginners, professionals, or schools. The programs allow amateur radio operators to make azimuth, elevation, and range calculations for a one-week period in just a few minutes. Astronomers can compute the right ascension and declination of a synchronous satellite and quickly acquire it by telescope. All that is required for input are orbital parameters for each satellite, which are available from NASA at no cost.

FORTRAN and BASIC listing versions are $35. The full package on 5-inch disks for the TRS-80 and Apple II is $48.50. The cassette version costs $29.95. Contact Sat Trak International, c/o Computerland of Colorado Springs, 4543 Templeton Gap Rd, Colorado Springs CO 80909.

Circle 517 on inquiry card.

Inventory Control System for the TRS-80

INV-V is an inventory-control system for 32 K byte TRS-80 disk systems. It includes an order report which gives the inventory items at or below the safety levels along with associated order information, such as the order quantity, the vendor code, and the total amount in dollars. The system also indicates priority to order. The performance report measures the efficiency of the inventory system and the associated costs. Other reports include a data base lister and an end-of-year processor. A report writer allows users to specify unlimited report formats on line without any programming. Other features include form input, live keyboard, audit log, automatic page numbering, and simulated form feed. The package is priced at $99, including a program disk, a data disk, and a manual. For information, contact Micro Architect, 96 Dothan St, Arlington MA 02174.

Circle 518 on inquiry card.

Depreciation System for Small Businesses

The Depreciation System is a package of BASIC programs written for the North Star disk system that provide depreciation preparation aids for accounting services. The system allows users to create files of assets of past and future depreciation amounts. Standard methods of straight line, declining balance and sum of year-digits, and nonstandard depreciation methods can be used with the system. Some of the programs included are MDBLD, used to establish client files; MDADD, used to create new asset records; MDUPDT, used to modify existing asset records; MDDMP, for producing formatted listing of asset files; and MDSTAT, which is used to produce yearly summaries of depreciation. An average of 1300 assets can be stored on a double-density floppy disk.

The system is available from Business Computer Systems, 900 Roanoke Dr, Springfield IL 62702, for $100. The price includes a manual and program documentation.

Circle 519 on inquiry card.

Machine Language Utility Pac

The Machine Language Utility Pac is designed for the PET microcomputer. The package includes an extended monitor, a disassembler, hexadecimal-to-decimal conversion, screen dump onto a printer, a machine-code relocate, and a tape relocate, all written in machine code. Two extra programs, Renumber and Merge, are used with BASIC programs.

The package comes with a combination of a BASIC and a machine code program designed to relocate the utility pac to any amount of memory. It is priced at $29.95 from P S Software House, POB 966, Mishawaka IN 46544.

Circle 520 on inquiry card.

PSYCH-UP for SwTPC 6800 Systems

PSYCH-UP is a program that permits Flex 9.0 software to be run on SwTPC 6800 systems that have been upgraded with a Percom adapter module and PSYMON monitor for 6809 operation. PSYCH-UP resolves all Flex incompatibilities without hardware modifications. The software modification is accomplished using a two-drive SwTPC MF-68 floppy-disk system. Unmodified versions of both Flex 2.0 and Flex 9.0 are required. These are available from Technical Systems Consultants Company (TSC) or a TSC dealer. The program comes on a 5¼-inch floppy disk with instructions for $29.95. Contact Percom Data Co, 211 N Kirby, Garland TX 75042. Circle 521 on inquiry card.

What's New?

SOFTWARE

Verify Saved Programs on Apple Tape Systems

The Applesoft Tape Verifier will provide either an Apple II or an Apple II Plus computer with the ability to verify programs saved to cassette. The program remains resident in the computer as long as power is applied and the computer is in the Applesoft mode. The program costs $20 and is supplied on an Apple-compatible cassette. Contact Softsell Associates, 2022 79th St, Brooklyn NY 11214.

Circle 522 on inquiry card.

Machine Language Sorts for the TRS-80 Model II

A Generalized Subroutine Facility (GSF) is available for the TRS-80 Model II computer. Machine language functions in BASIC through USR calls include multi-key, multivariable in-memory sort; multi-key character string in-memory sort; USR peek and poke capability, both byte and word, fetch argument; compress and uncompress data; move blocks of data; and propagate across arrays. The system can sort 1000 elements in six seconds and can carry up to fifteen arrays together with multiple mixed ascending and descending keys. Sorts on multiple columns in character string sort mode can be done. The GSF is available from Racet computes, 702 Palmdale, Orange CA 92665, for $50 on a disk-operating system floppy disk.

Circle 523 on inquiry card.

Screen Editor for SS-50 Bus

Alford and Associates has developed a screen editing system, the SCREDITOR, for operation with Smoke Signal Broadcasting disk-operating system version 5.1X. The SCREDITOR provides fourteen edit commands and, in the screen editing mode, twenty-two screen operators are included. Dual-mode operation is provided, allowing the editing of source- and text-typed material whose lines must be exactly defined. The SCREDITOR operates with 16 by 64 or 24 by 80 character memory-mapped displays for the SS-50 bus. A manual is provided that explains how to modify the package. Keyboard definition, system input and output, and other aspects are user-alterable to meet special requirements. The system is priced at $99.95 and is available from Alford and Associates, POB 6743, Richmond VA 23230.

Circle 524 on inquiry card.

Backgammon 1.0 for North Star BASIC 3.6

GIGA, POB 1881, Chicago IL 60690, has released a Backgammon 1.0 for North Star users on disk for $15 or in a listing for $10. A player can compete against the computer at two levels, or against another player, or allow the computer to play itself. Output fits within a scrolling, 16 by 64 character display with the board represented at the left and playing information at the right. Features include legal move evaluation, end game scoring and optional display of computer move evaluations. Various playing options may be changed during play. Computer or player can double or generate dice rolls. Board positions can be saved or created for replay.

Circle 525 on inquiry card.

Advanced Statistical Analysis for the TRS-80

Radio Shack has available a series of programs designed for the analysis of data in business, education, medicine, government administration and other fields. Advanced Statistical Analysis may be used with Level II BASIC or Disk BASIC on a 16 K TRS-80. The system consists of a manual and 13 programs on cassette. Some of the programs supplied with the system are Tape Data Files, Disk Data Files, Random Sample, Descriptive Statistics, Histogram, Frequency Distribution, and Analysis of Variance. The package is sold at Radio Shack Computer Centers and other Radio Shack stores and dealers for $39.95. For more information, contact Radio Shack Computer Customer Services, 205 NW 7th St, Fort Worth TX 76106.

Circle 526 on inquiry card.

Data Base Manager for the TRS-80

The Data Manager accepts up to ten user-defined fields with up to 40 characters per field and a total of 255 characters per record. The program uses up to four disk drives on line, for as many as 320 K bytes of storage. Data Manager enables the user to create up to five "key" sort files for quick access of data. A utility program is provided to calculate the number of records possible. The program also supports the uppercase and lowercase modification, and printouts can be programmed to most formats and sent to line or serial printers. Background printing is provided for Centronics printers. The Data Base Manager is available from The Bottom Shelf Inc, POB 49104, Atlanta GA 30359. It is priced at $49.50.

Circle 527 on inquiry card.

Software Package for Pascal Programmable Graphics Computer System

Ramtek Corp, 2211 Lawson Ln, Santa Clara CA 95050, has introduced a graphics software package written in UCSD Pascal. Called GRAPHPRO, the package consists of a set of routines and procedures designed to facilitate programming on Ramtek's RM-6114 and RM-6113 graphics computer systems. Routines available include text with programmable font, rotating in 90-degree increments; windowing and clipping; scaling and translation; viewport capability; filled polygons in solid colors, programmable patterns, five standard marker symbols, with others programmable by the user; arcs and circles; and object overlay. Typical applications include business charts, process control, plotting, forecasting and modeling, and statistical analysis. The package is priced at $1750 for a one-time license fee.

Circle 528 on inquiry card.

The Postmaster Mailing List System

Lifeboat Associates, 2248 Broadway, New York NY 10024, is offering The Postmaster, a mailing-list management system. The Postmaster includes a batch entry facility and an optional reference field that allows users to segment the list by code and extract records based on any field. The system provides the option on an automatic "ID" field insertion. By keying in a name, a ten-character record identifier will be entered automatically to the reference field. This provides a reference number for each mail list record. Other features include a program to prepare and edit form letters and to record-sort based on any specified field using the Shell-Metzner sorting algorithm.

The program runs in over twenty different disk formats with CBASIC on all 8080 and Z80 computers using CP/M. The price of the system is $150. The manual alone is $15.

Circle 529 on inquiry card.

Now get OHIO SCIENTIFIC personal computer products with guaranteed, quick, mail order delivery.

ONLY $279

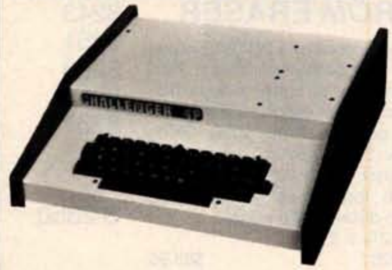
Ohio Scientific Superboard II

The first complete computer system on a board. Includes keyboard, video display and audio cassette interface. 8K BASIC-in-ROM; 4K RAM. Requires power supply +5V at 3 Amp.

"We heartily recommend Superboard II for the beginner who wants to get into microcomputers with a minimum cost. A real computer with full expandability."
POPULAR ELECTRONICS, MARCH, 1979

"The Superboard II is an excellent choice for the personal computer enthusiast on a budget."
BYTE, MAY, 1979

Ohio Scientific C4P Series.



The Challenger 4P. A 4-slot computer with one open slot. Highly sophisticated 16 color video display. 32 rows x 64 columns, upper and lower case. 8K BASIC-in-ROM 8K RAM. 200-20KHz programmable tone generator. AC remote interface. Expandable to 32K RAM and two mini-floppy drives. **$698.**

The Challenger 4P MF. Mini Floppy version of the 4P. Two to three times faster than competitors. More I/O built-in than any other in its class. 24K RAM. Real time clock. Modem interface. Printer interface. Foreground/Background operation and much, much more. **$1695.**

Ohio Scientific C1P Series.

The Challenger 1P. The best bargain in personal computer anywhere! 8K BASIC-in-ROM. 4K RAM. Cassette based with 53-key keyboard. B&W video display, 30 rows x 30 columns. Upper and lower case. **$349.** C1P with 8K RAM $399.

Ohio Scientific C1P MF. Mini-floppy version of the C1P. 8K BASIC-in-ROM, 12K RAM. Fully expandable. **$995.** C1P MF with 20K RAM and OS-65D software $1198.

Accessories

AC-3P 12" B/W monitor, TV	$ 125
AC-15P 12" Color monitor	$ 450
AC-16P 2-8 Axis Joysticks with cable	$ 39
AC-11P Answer/Originate 300 baud modem with cable	$ 199
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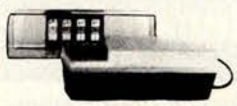

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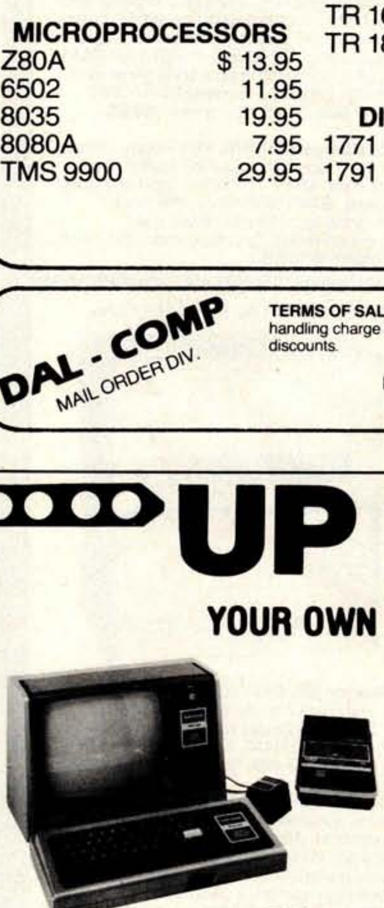

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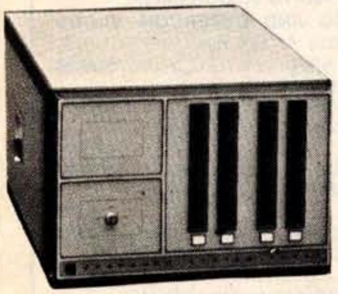

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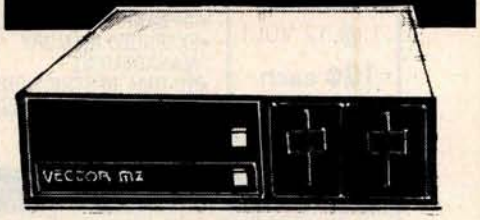

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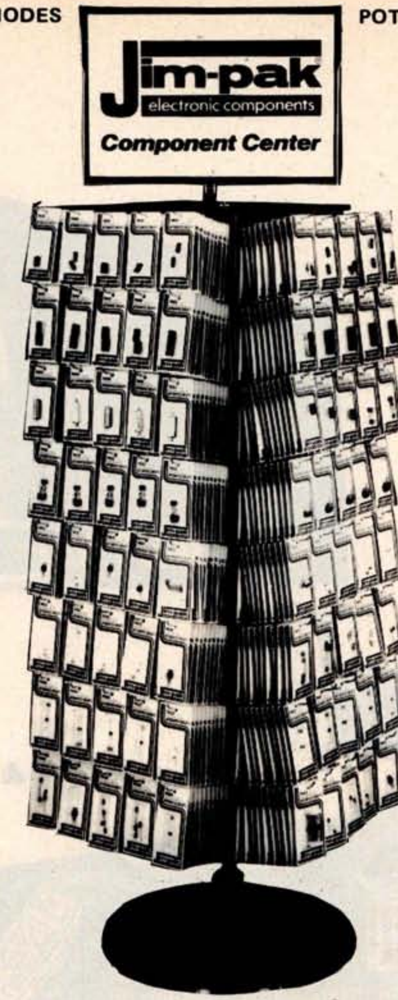

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M-530-1 . . . .
M-530-8 . . . .

—CAPACITORS—

. . . . Dipped . . . .
Tantalum
. . Polyester/Mylar. .
Miniature Aluminum Electrolytic Axial
. . . Ceramic Disc . .

—DIODES—

—TRANSISTORS—

—RESISTORS—
5% — 1/4 Watt
50 pc. Assortmts.

P.C. POTENTIOMETERS

—SWITCHES—
. . . . .Dip . . . . .
. . . .Toggle . . . .
. . . . Slide. . . . .
. . Pushbutton . . .

—CRYSTALS—

—CONNECTORS—

—HEAT SINKS—

—FUSEHOLDERS—

—TEST CLIPS—

—BOOKS—

—KITS—
. . . .Clocks . . . .
. .Thermometer . .
. . Stopwatch . . .
. Function Gen. . .
. Power Supplies. .
. 62-Key Encoded. . Keyboard
. . Hexadecimal . . Encoder Keyboard

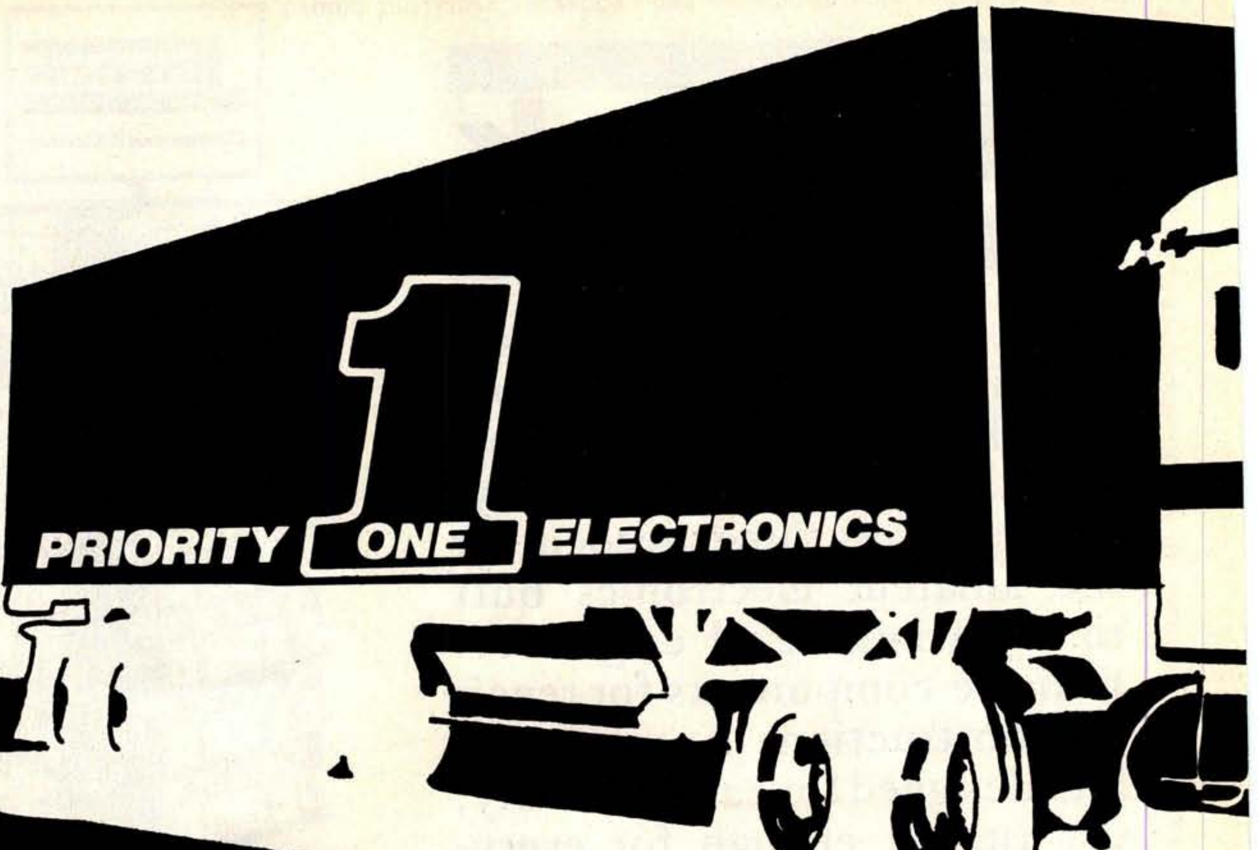
—DIP JUMPERS— AND CABLE ASSEMBLIES

—MISC.— ACCESSORIES

Ask your Distributor to stock Jim-pak electronic components today!

Call or write for distributor information:
JIM-PAK ELECTRONICS, 1355 Shoreway Road, Belmont, CA 94002 (415) 595-5936

Circle 205 on inquiry card.



CCS-M-XVI-M

The true 16K Static Ram module for S-100 bus systems. ASSEMBLED & TESTED --100% BURN IN - FEATURES: • Fully static • Uses popular 2114 static RAMS • +5 volt operation only • Bank Select available by bank port and bank byte • Phantom Line capability • Addressable in 4K blocks • 4K blocks can be addressed anywhere with in 64K in 4k increments. • Meets IEEE proposed S-100 signal standards • LED indicators for board selection and bank selection • FR-4 EPOXY PC boards • Solder masked on both sides • Silk screen of part number and part designator.

OUR PRICE

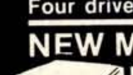
CCS-2016BA 450ns 2MHZ - Reg. Price $349.95 .... $279.95
CCS-2016BB 300ns 4MHZ - Reg. Price - $389.95 .... $309.00
CCS-2016BY Bare Board - only $29.95

The VISTA V-80 Disk Drive System

• 23% more storage capacity than TRS-80 • 120 day warranty • 40 track patch at NO CHARGE from VISTA

Single drive system $395.00
Two drive system $770.00
Four drive system $1450.00
Two drive cable $29.95
Four drive cable $39.95

NEW MS-230 DUAL TRACE MINISCOPE 30 MHz BANDWIDTH



1 NLS MS-230 30 MHZ Scope ... $598.15
2 NLS 41-141 10 to 1 Combo Probe $54.00
1 NLS 41-180 Deluxe Leather Case $45.00

LIST PRICE $697.15
MS 230 COMBO PRICE $547.15
SAVE $150.00

AUDIO RESPONSE™ DIGITAL DISPLAY

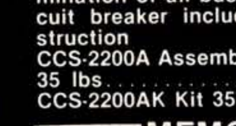
The ROAD RUNNER offers Audio Response...A new dimension in multimeters. Rapid checking of fuses, capacitors, diodes, resistors, transistors, LED's darlingtons...without looking at the meter. The <1V and<2V ranges cause sufficient voltage across the probe tips to forward bias diodes and transistors causing a continuous tone. Similarly, capacitors can be charged until the tone shuts off...thus the approximate value of the capacitor can be measured. The <1 ohm,<10 ohm, and<100 ohm ranges are used in threshold testing of resistors and making continuity tests of PCB's, wire wrap and solder connections, light bulbs, and transformer windings. In addition, the Audio Response function permits the monitoring of incoming digital pulses. The ROAD RUNNER ADMM ™ FEATURES • Six Functions • 29 Ranges • 0.5% Accuracy on DCV • 5 Range Audio Response Function • Color coded easy-to-read front panel and pushbuttons • Full Accessory Line Expands Capability • 0.5" LCD Display • Rugged Case for "Field Use" • RFI Shielded.

ONLY $139.00

WESTON-6100 Digital Multimeter .... @ $139.00
WESTON-6100C Leather Case @ $ 15.95
WES-9740-0279627 VHF RF Voltage Probe .... @ $ 63.00
WES-5768 AC Clamp-on Probe @ $ 57.75
WES-1961 RF Voltage Probe .. @ $ 29.00
WES-9395 50 KV Probe .... @ $ 38.75
WES-6100-AC 110V AC Adapter .... @ $ 15.00

NEW FROM SAMS BOOKS

192 PAGES TRS-80 .... $8.95



CALIFORNIA Computer Systems

• S-100 compatible • Industrial/commercial quality construction • Flip-top cover • Excellent cooling capability • 12 slot capability (uses model 2501A) • Input 105, 115, or 125 VAC • Output + 8 VDC20A, + – 16 VDC 4A • Active termination of all bus lines • Fan and circuit breaker included • Rugged construction

CCS-2200A Assembled & Tested 35 lbs. $399.95
CCS-2200AK Kit 35 lbs. $349.95

MEMORY MEMORY

2102LIPC
Low Power 450ns in lots of 20 ..... $1.10
2102AL-2
Low Power 250ns in lots of 20 ..... $1.25
2114-3L
1Kx4 300ns Low Power .... 8/$50.00
5257-3L
4Kx1 300ns Low Power .... 8/$55.00
2708
8K 450ns EPROM .... 8/$60.00-$8.50 ea.
2716
16K 5 Volt only EPROM
8/$248.00 .... $32.00 ea.

RS232 and "D" SUB-MINIATURE CONNECTORS *

P - Plug, Male Type S - Socket, Female Type - C - Cover, Hood

PART NO.	DESCRIPTION	PRICE 1-9	10-24	25-99
CND-DE9P	9 Pin Male	1.60	1.40	1.30
CND-DE9S	9 Pin Female	2.25	2.00	1.90
CND-DE9C	9 Pin Cover	1.50	1.35	1.20
CND-DA15P	15 Pin Male	2.35	2.15	2.00
CND-DA15S	15 Pin Female	3.25	3.10	2.90
CND-DA15C	15 Pin Cover	1.60	1.45	1.30
CND-DB25P	25 Pin Male	2.80	2.60	2.40
CND-DB25S	25 Pin Female	3.60	3.40	3.20
CND-DB51212-1	1 pc.Grey Hood	1.50	1.30	1.10
CND-DB110963-3	2 pc.Grey Hood	1.75	1.50	1.35
CND-DB1226-1A	2 pc.Black Hood	1.90	1.65	1.45

Circle 206 on inquiry card.

FLOPPY SYSTEMS

8" Siemens FDD120-8D All Siemens options included in this drive may be configured hard or soft and single or double density. We find this to be an extremely reliable drive. **$430.00**

Fully Shugart compatible.

5¼" BASF Magical Miniature Mini drive only 2/3 the size of others is reliable and durable and quickly gaining in popularity with our customers. Single or dual density fast access times **$259.00**

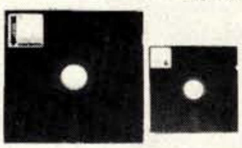
Tarbell... single density. A&T, $265 $265, kit, $179. A&T $219 w/ purch. of 2 drives. Tarbell double density, DMA, $399. Delta Double density, $399. Micromation double density w/programmable UART for RS-232 port $495. Sorrento Valley single density for Apple, $399.

Cable Kits For 8" Drives with 10' 50 cond. cable and connectors. Also power cable and connectors. Flat cable assem if you wish. For one drive 27.50, two 33.95, three 38.95

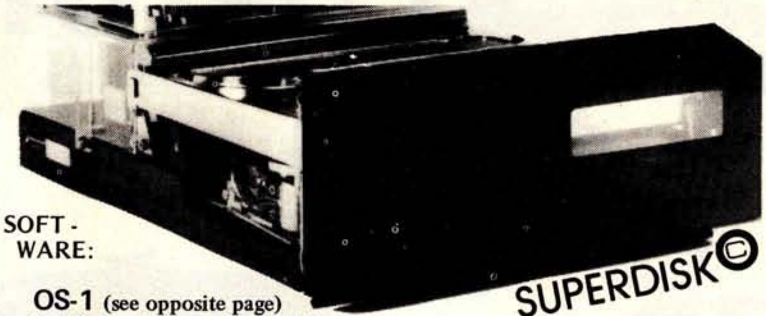
Cable Kits for 5¼" Drives as above, but 34 cond. For one drive **24.95**, two **29.95.**

"Power One" Model CP206 Power Supply adequate for at least two drives. 2.8A/24V 2.5A/5V, 0.5A/-5V beautiful quality. **$99.00**

CABINETS for FDD120 and 801R drives, or CP206 supply. Matte finish in mar resistant black epoxy paint and stacking design **29.95**



DISKETTES
(Mrx, Verbatim, Georgia Magnetics)
8" $39.95/10
5¼" $34.95/10



SOFT-WARE:

OS-1 (see opposite page)
Call for up to the minute pricing on S-100 DMA controller, LSI-11 controller, cabinetry, etc.

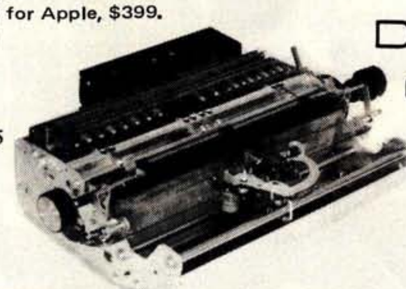
PS: OS-1 runs on the TRS-80, and can transform it from a toy computer to a real business machine !!!

10MBy DRIVE $3300

S-100 DMA CONTROL

POWER UNIT $395.00

For the first time in something like 10 years, a new STANDARD in removable media has evolved. Selected by Datapoint, and others who have not yet announced, this drive is beautifully simple and easy, if not trivial to maintain. 920kBy/sec. transfer rate, 3600 RPM 39 lbs and only 125 Watts.



Daisy Wheel Printers

Qume Sprint 3\45

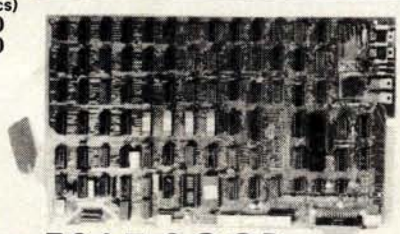
PRINTER (factory warr.)	**$1499.00**
POWER SUPPLY (Boschert)	**349.00**
(shown mounted on rear of printer)	
COMBINATION SPECIAL	**$1699.00**
Cases available	**200.00**
S-100 interface card	**149.00**

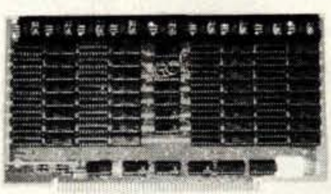
DATA DISPLAY MONITORS

Used 12" Sylvania monitors. Composite Video, 15 MHz, 120VAC. Rebuilt with NEW P39 anti-glare tube $119.00 New P4, 109.00, used P4 79.00. U-fix model, 10/$300.00

"OEM STYLE" as above, will fit any case. (Both versions serviced by qualified tech). Identical to above but subtract $12.00

Electrolabs
POB 6721, Stanford, CA 94305
415-321-5601 800-227-8266
Telex: 345567 (Electrolab Pla)
Visa MC Am. Exp.





STATIC RAM MEMORY, S-100

32K - $549.00 16K - $349.00

ESAT 200B

BI-LINGUAL 80x24 COMMUNICATING TERMINAL
Scrolling, full cursor, bell, 8x8 matrix, 110 - 19,200 baud, Dual Font Applications. Arabic & Hebrew, Multilingual Data Entry Forms Drawing, Music, & Switchyards. **$349.00**

Televideo 912B **($860.00)** **Televideo 920C** **($1020.00)**

New!

TELEVIDEO 912B
- Upper & lower case
- Adjustable baud rate
- 80 x 24
- Editing capabilities
- Printer port
- Second page memory & much much more

TELEVIDEO 920C
- Same features as 912B PLUS
- Line & character insert/delete
- Special function keys

"BACK TO SCHOOL" KEYBOARD SPECIAL

CHERRY "PRO" Keyboard $119.00
Streamlined Custom Enclosure $34.95
BOTH ONLY $134.95 !!!!!!!!!

SOCKET SPECIAL

"Won't Let Go"

Low Profile

Solder Tail

1 CENT/ Pin !! (0.75/1000's)

8 14 16 18 20 22 24 28 40

Circle 207 on inquiry card.

CP/M* Source Code – FREE! *when you purchase* **"OS-1"**

Electrolabs' new operating system for the Z-80 designed to have exactly the appearance of UNIX, including virtual I/O, "set TTY", a tree and a shell, filters and pipes PLUS total compatability with CP/M software!**

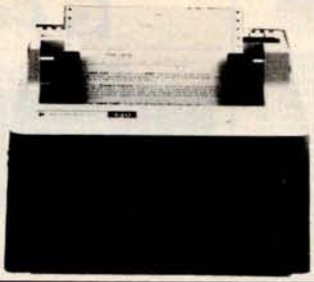
OS-1© FEATURES

(Because OS-1 is truly a comprehensive "OS", and not merely a file handling "DOS", we have changed the name from "Superdos" to "OS-1")

VIRTUAL I/O - copy with a single command between floppy and hard disk, or from TTY to printer to tape to disk... etc., etc. No messy I/O routines to write, & no awkward transfers.
SECURITY - 9 modes of file protection, user and login protection.
MULTI-USER - up to 256 passwords. (non-simultaneous users)
16MBy FILE SIZE - but no limit to no. of directories per device, thus allowing EASY implementation of gigantic storage devices.
"SET TTY" - for printer or crt: tabs, page width, buffer, cursor, UC/LC, fonts, formfeed, arbitrary control characters etc., etc.
"LOGIN" - automatically executes user selected programs and "set TTY".
OCCUPIES 12KBy - only 50% larger than CP/M, but 500% more features.
CP/M & CDOS COMPATABLE - your library is guaranteed to run!

*(Naturally, we are not giving away the version of CP/M written by Digital Research, Please pardon our pun, but they might object. What we ARE giving you is a greatly enhanced version of CP/M which resides on OS-1, and allows the user of OS-1 to run any and all of his programs, packages or system utilities which are already running on CP/M. We give you the source code at no charge so that you may modify any part of the CP/M to suit your own system requirements. At no charge, you also receive the enhancement allowing 4MBy files instead of 256K.)

OS-1 (with debugger, linker and screen oriented editor	**$199.00**
Update service, per year	**29.00**
Symbolic Debugger	**150.00**
MACRO-Assembler (Creates relocatable code)	**150.00**
"C" Compiler	**660.00**
FORTRAN Compiler	**100.00**
BASIC Compiler (very fast)	**350.00**



PAPER TIGER

IDS MODEL 440

- 8 Software Selectable Character Sizes
- Parallel & Serial Interface
- 98 ASCII Character set, upper & Lower case
- Forms length control
- Tractor Feed $949.00

Graphics option with 2K CRT screen buffer add $199.00

DYNAMIC DEVICES MODEM

- Acoustically coupled modem assembly set
- Asynchrous 0-300 Baud
- Switchable originate or answer modes
- Operates full or half duplex mode
- 15 minute assembly $149.95

SPRINGTIME IC SPECTACULAR

(While Supply Lasts)

MEMORY & EPROM

2114	$ 5.99
2114-2	6.99
pd 411	2.50
2107	2.00
4116 (set of 8, 16K, memory expansion for TRS-80, Apple, Exidy)	$69.00
2708	8.95
2716	35.00
2516	35.00
2732	95.00
8748-8	49.00
8755-8	49.00

CPU

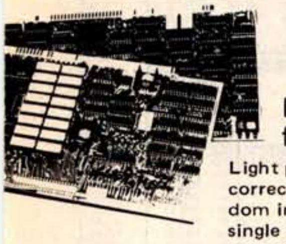
6502	6.25
Z-80	9.95
Z-80A	12.05
8080A	8.99
8085	22.00
8741	79.00

FLOPPY CONTROLLERS

1771	$26.95
1791	37.95
Pd372	39.00

MISCELLANEOUS (CALL US!!)

ELECTROLABS
POB 6721 Stanford, CA 94305
415-321-5601 800-227-8266
Telex: 345567 (Electrolab Pla)



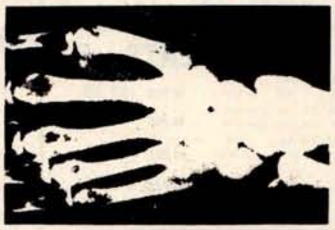
Graphics

High Resolution 480 x 512
for B&W and Color Imaging and Graphics

Light pen, A-D, D-A, TV synchro (needs no time base correction or adjustment with anything between random interface & NTSC commercial standard). T.V. single frame grabber ("snapshot"). Up to 1 Byte of atributions per pixel.

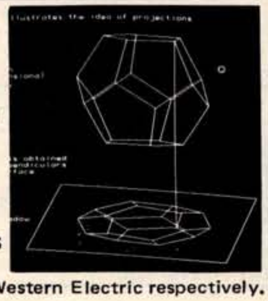
LSI-100 & S-100 applied to:

Graphic Presentation – such as computer generated animation & other graphic displays up to 256 colors & up to 256 b&w gray scales. **Image Analysis** – using built-in FRAME GRABBER, for medical image enhancement, contour analysis, & pattern recognition. **Commercial TV Tilting & Advertising** – using synchronization capability. **Interactive graphics** – using light pen accessory.



BASIC CONFIGURATION –
LSI-11 $1995. S-100 $1265.
For TRS-80/Exidy Add $595.00
Includes: Data Board - 32K (480 x 512 x 1 pixel) D-A 16 level video generator. Video Synchronization Circuitry. Address Control & Timing Board.

FEATURES – High speed. DMA or 2KBy window memory mapped interface. Full NTSC commercial color capability. Low power consumption. Excellent Software



Options – Accessories – Software
Options include: light pen, auxilliary outputs, text mode, memory and much more. Accessories include: b&w and color cameras and monitors. Software: "Plot" 2D or 3D, "Tilting", "Contour", "Image Enhancement", "Vector Curve Generation".

Call for price and details

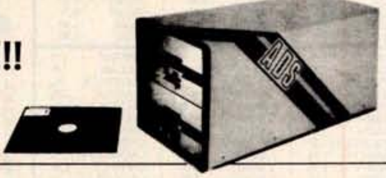
*CPM and **UNIX trademarks of Digital Research and Western Electric respectively.

MATCHMAKER TECHNOLOGY

TURNKEY DISK SUBSYSTEMS

DISK IS IN!!!

✓ SORCERER
✓ TRS-80
✓ APPLE
✓ HPIB
✓ PET



For those who wish to avoid the aggravation, fussing, irritation, annoyance etc., of assembling your own subsystem, plug in and GO!!!

APPLE

FEATURES:
- 2 8" Floppy DISK DRIVES (Single Sided)
- Color Coordinated Cabinet with Power Supply
- Expanded version of APPLE-DOS
- Single Density Disk Controller
- Full Cabling, Connectors + Documentation
- Assembled and Tested
- Plug In and GO!!!

OPTIONS:
- 2 8" Double Sided Drives (In place of Single Sided)
- 16K Internal Memory Expansion Kit 69.00

PET

Prices and specifications same as for APPLE except PET Operates via PET-DOS

TRS-80

Prices and specifications same as for SORCERER with following exceptions:
- Expansion Interface necessary
- Space for up to 48K plug-in dynamic memory on Controller Card
- Software package as above

SORCERER

FEATURES:
- 2 8" Single Sided Floppy Disk Drives
- Single and/or Double Density
- Color Coordinated Cabinet with Power Supply
- Full RS-232 Interface
- OS-1 Disk Operating System (Fully CP/M compatible) CP/M is a registered trademark of Digital Research
- Full Cabling, Connectors + Documentation
- Assembled and Tested
- One S-100 Slot available for Memory Expansion
- Plug In and GO!!!

OPTIONS:
- 2 8" Double Sided Drives (In place of Single Sided)
- 32K Dynamic RAM Memory Board, Assembled and Tested
- 16K Dynamic RAM Internal Memory Expansion Kit $ 69.00
- Deluxe Business Software package includes: C BASIC, WORD PROCESSING SOFTWARE, INTERACTIVE "Big 4": General Ledger, Accts. Payable, Accts. Rec. and Payroll
- 10 MBY Removeable Hard Disk – Call for Details

ANOTHER Fine Product brought to you exclusively by the folks at:

In California: 415-321-5601
Outside Cal: 800-227-8266

Electrolabs
POB 6721, Stanford, Ca. 94305

Worldwide:
TLX: 345567 Electrolabs PLA

Circle 207 on inquiry card.

BUY DIRECT FROM NCE/ CompuMart

Buy Direct from the Largest Commodore Dealer in the Country — NCE/CompuMart.

8K-Keyboard N	$795
16K-Keyboard B	$995
16K-Keyboard N	$995
32K-Keyboard B	$1,295
32K-Keyboard N	$1,295

B — large keyboard (graphics not on keys)
N — large keyboard with graphics symbols

SUPER SAVER. Thanks to Commodore their printer prices have been drastically reduced:

Commodore Printer (tractor feed) .... was $995 **NOW $795**
Commodore Printer (friction feed) .... was $849 **NOW $695**

2 Good reasons for buying your PET™ from CompuMart:

(1) $100 IN FREE ACCESSORIES WITH 16K or 32K PET.

When you buy a 16K or 32K PET, apply $100 toward PET accessories. FREE. Choose from the accessories listed below and indicate on your order that you have reduced the cost of your accessories by $100.

(2) FREE WITH PURCHASE OF ANY PET (Offer good until April 15, 1980)

A Texas Instruments' Hex/Octal Calculator ($60 Value), and a set of 6 PET Workbooks (Worth $36).

PET Accessories

Commodore Dual Floppy Disk Drive	$1,295.00
Second Cassette—from Commodore	$95.00
Commodore PET Service Kit	$30.00
Beeper—Tells when tape is loaded	$24.95
Petunia—Play music from PET	$29.95
Video Buffer—Attach another CRT	$29.95
Combo—Petunia abd Video Buffer	$49.95
TNW Bi-Dir.RS-232 printer S-face	$229.00
KIM 1 (A Single Board Computer from Commodore)	$179.00
PET TO IEEE Cable	$39.95
IEEE TO IEEE Cable	$49.95
KIM1 & Power Supply Package Special	$200.00

We have a complete inventory of Apple computers, peripherals, & software In-Stock for immediate delivery — Call us for prices.

$200 in FREE accessories with the purchase of a 48K Apple II reg. or Apple II plus.

16K Apple reg. or plus — $1,195 ($100 in ***free*** acces.)
32K Apple reg. or plus — $1,395 ($150 in ***free*** acces.)
48K Apple reg. or plus — $1,495 ($200 in ***free*** acces.)

Apple Accessories

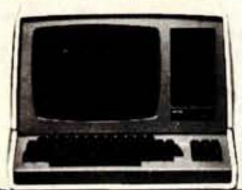
PASCAL	$495
Micromodem	$379
VisiCalc	$150
The Controller (Business Package)	SALE! $550
The Cashier (POS System)	SALE! $200
Integer BASIC ROM Card	$200
Centronics Printer Interface	$225
Disk and Controller	$595
Parallel Printer Card	$180
Communications Card	$225
Hi-Speed Serial Card	$195
Firmware Card	$200
NEW! AppleWriter Text Editor	$75

NEW FROM EXIDY
THE SORCERER II 48K COMPUTER

Z-80 Microprocessor. Full-sized keyboard • ROM PAC Programs • Microsoft BASIC • Powerful Graphics • Serial and Parallel I/O • Dual Cassette I/O Memory Internally Expandable • S-100 Expansion Options.
48K Sorcerer II $1,395

ZENITH

The All-In-One Computer



Save $300 off list on all Zenith Computers, $250 off the printer. Build a great system using both and save $550.

WH89 with 16K RAM	**list $2,295**	**SALE! $1,995**
WH89 with 32K RAM	**list $2,445**	**SALE! $2,145**
WH89 with 48K RAM	**list $2,595**	**SALE! $2,295**
Heath Printer	**list $895**	**SALE! $650**
16K Memory Expansion	**list $150**	**SALE! $110**
Dual-port Serial Interface		**$85**
HD05 Operating System		**$100**
Microsoft Basic		**$100**
WH17 Second Disk Drive		**$550**

Only limited quantities of the Computers and Printers are available. Order Now. (Offer good until April 15, 1980)

CENTRONICS PRINTERS

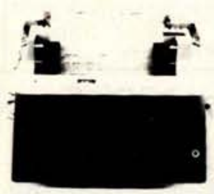
The 779-2 is a tractor feed printer designed for small business systems. Uses a 5x7 dot matrix to produce all 64 upper case ASCII characters. Centronics is the biggest name in printers and this is their most popular model. List. $1,245 .... SALE! $1,079

The New 730-1 parallel matrix printer is ideally suited for all personal and microcomputer systems. Standard Features include: 100 cps • 80 char./line • 3-way paper handling system • 7x7 dot matrix • 96 character ASCII • List $995 .... SALE! $695

The Perfect Printer for Small Business Systems

The Paper Tiger Printer From ROAR! Integral Data

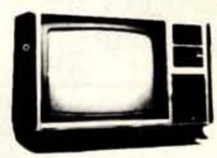
Standard features include: 4 character 8.3 to 16.5 cpi • 56 cps at 10 char. per in. • Selectable line spacing • 8 switch-selectable form sizes.



The IDS Graphics Option for the Paper Tiger allows full dot pattern control and includes an expanded 2048-byte buffer (a 256-byte buffer is standard).

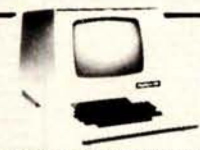
IDS Paper Tiger Printer $995
IDS Graphics Paper Tiger Printer $1,094

SPECIAL OFFER EXCLUSIVE FROM COMPUMART!



ZENITH COLOR VIDEO MONITOR

Beautiful Display Capabilities. Excellent for use with Apple, Atari, & Sorcerer Computers. This 13-inch monitor is Zenith's first color video display designed specifically for computers. Features include color and degaussing circuits.
Zenith Color Monitor $499.00



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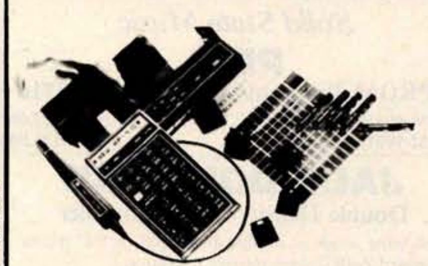

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HP-41C

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Features over 130 functions and offers up to 400 lines of program memory or 63 data storage registers — expandable to 319 registers or up to 2,000 lines. RPN Logic. Alpha-numeric capabilities let you communicate with the calculator in English. Customization features allow you to totally reassign the keyboard functions. Continuous memory....... **HP-41C Calculator $288.00**

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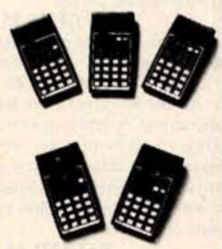

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Comes with:
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Atari 800 Computer System $995.95

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Uses standard ⅜ inch roll paper and ribbon
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UL approved
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Uses standard 5¼ inch diskettes
88K bytes storage per diskette
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Average data access time: 236 milliseconds
Power: AC adapter; UL approved
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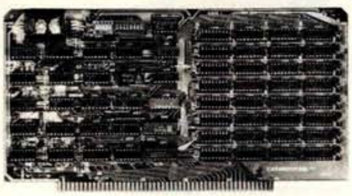

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Expandable to 64K Using 4116 RAMS

Interfaces with most popular S-100 boards
Bank selectable; PHANTOM provision
Draws only 5 watts fully populated
Designed to work with Z-80, 8080, and 8085 systems
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Kits come with sockets for full 64K
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Z-80A CPU with Serial I/O Port

This CPU can accomodate a 2708, 2716, or 2732 EPROM in SHADOW mode, allowing you to use a full 64K or RAM. The MWRITE signal is generated automatically if you use the board without a front panel. There's also an independent on-board USART to control the RS232 serial port at baud rates from 75 to 19,200.

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Double Density Disk Controller

Read/write single or **double density,** 8" or 5¼" drives
On board Z-80 insures reliable operation
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Density is software selectable
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New Disk Operating System

SDOS IS HERE

SDOS is a CP/M compatible operating system designed for the S.D. Sales Versafloppy I or II. It requires the SBC-100/Versafloppy board set and functions as a superset of CP/M, giving 19 additional functions including file attributes, disk label, and read/write logical blocks. It provides additional protection features, and is expandable to a multi-user real-time system.

SDOS sells for $200.00

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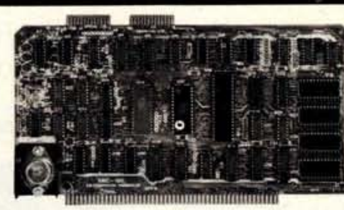

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SBC-100/200

2 or 4 MHz Single Board Computer

S-100 bus compatible Z-80 CPU
1K of on-board RAM
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One parallel and one serial I/O port
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Eight software selectable character sizes.
110, 300, 600, or 1200 baud.

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CP/M 2.0

Digital Research has done it again! This new release of their industry standard disk operating system is bound to be an even bigger hit than the original version. All of the fundamental file-size restrictions of release 1 have been eliminated, while maintaining full compatability with the earlier versions. This new release can be field-configured by the user for a single mini-disk up through a multiple drive hard-disk system with 128 megabyte capacity. Field configuration can be accomplished easily through use of the Macro Library (DISKDEF) provided with CP/M 2.0.

A powerful operating system for only........ $150.00

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Special Price for
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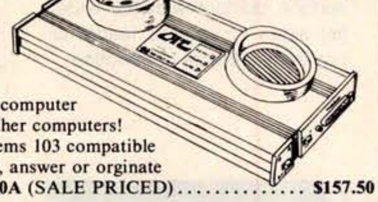

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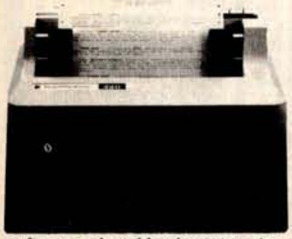


California Digital has resently researched the complete low cost printer market. It is our opinion that the IDS 440 Paper Tiger is, without doubt, the most versatile and offers the best value of any printer costing under $1,000.

This quality dot matrix printer incorporates such features as software selectable character size to allow print densities upto 132 characters per line. Full forms handling capabilities and tractor feed mechansim adjustable to 9.5". The Paper Tiger is engineered to accept either parallel or RS232 serial ASCII. 110/220V.50/60Hz.

***** $995.00 plus shipping *****

S-100 Mother Board

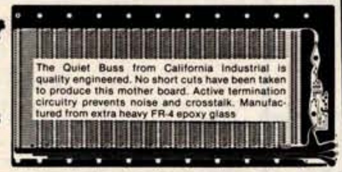
Quiet Buss

$29.95

8803-18

18 slot

IMSAI



TELETYPE® MODEL 43

4320 KEYBOARD

TTL .... AAA	$1050	
RS232 .... AAK	1150	plus shipping
Friction ... AAE	1100	
103 Modem AAB	1575	

Minidisk Drive for TRS-80

your choice

Lobo or Vista

$388.

Includes Interface Cable

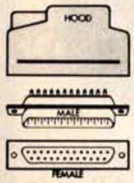
FREE PLASTIC LIBRARY CASE

with purchase of each box of .... Verbatim mini-diskettes. $5 value.

$24.95 BOX of 10

DISKETTES

CONNECTORS



your choice

DB25P male plug & hood

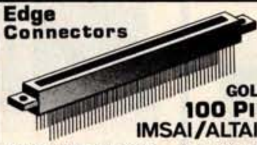
or

DB25S female

$3.25

Qty.	fe.	male	hd.
10	3.05	1.95	1.15
25	2.95	1.79	1.05
100	2.65	1.67	.95
500	2.25	1.60	.85
1K	1.97	1.37	.73

Edge Connectors



GOLD

100 PIN

IMSAI/ALTAIR

Imsai solder .125x.250	$2.95	3/$ 7.50
Imsai w/w .125 centers	$4.95	3/$13.00
Altair soldertail .140 row	$5.95	3/$15.00
SPECIALS		
22/44 Kim eyelet .156"	$1.95	3/$5.00
25/50 solder tab .156"	$1.09	3/$2.00
36/72 wide post w/w .156	$1.95	3/$5.00

SYSTEM X·10

It's not offen that California Digital ventures into the distribution of consumer products, but we have resently come accross a product that appears so unique that we just had to add it to our product line. This is the System X-10 manufactured by the BSR turntable company. This space age system will remotely control any light or appliance in your home or office. Command signals are transmitted from the command console over your existing wiring. From your bed or easy chair you can control up to 16 different electrical devices inside and outside your home. Use the System X-10 to control your stereo, television or any light fixture on the premises.

The modular system is available in the following components:

Ultrasonic Master Control Console $34.95
Battery Operated Ultrasonic Controller 19.95
Appliance Module, Lamp Module or Wall Switch....... 13.95

SPECIAL

APPLE II

16K MEMORY

COLOR • GRAPHICS • SOUND

$988

PLUS SHIPPING

Mfg. Sug. Retail.... $1195

Scotch Data Products

Authorized Distributor

		10 Pak	50+
740-0	IBM soft format.	$39.00	$3.50
740/2	Double side soft	65.00	6.00
741-0	Double density	53.00	4.90
743-0	Double/Double	70.00	6.60
740-32	8" Hard sector	39.00	3.50
744-(0)(10)(16)	5 1/4" mini	39.00	3.50
Library case for any above;		Add $3.00	
834 A	Data Cassette	5.50	
DC 100	Mini Cartridge	16.00	
DC 300	Data Cartridge	20.00	
920( )	Disk Cartridge	39.00	

Shugart Associates

SA800-R Floppy Disk Drive

The most cost effective way to store data processing information, when random recall is a prime factor. The SA800 is fully compatible with the IBM 3740 format. Write protect circuitry, low maintenance & Shugart quality.

$449.50

XEROX 800 WORD PROCESSING KEYBOARD ASCII ENCODED

This 77 key word processing keyboard was manufactured by Microswitch for use in the Xerox 800 word processing system.

The keyboard outputs a seven bit ASCII code along with an eighth bit that allows most keys to shift and double function as special characters. Extra large "Tab & Return" keys are designed into the layout of the keyboard to emulate the IBM Selectric. 17 illuminated keys serve for special word processing codes. The keyboard is equipped with two thumbwheel switches for defining line width.

Original Xerox acquisition over $400.00

California Digital USED price only $49.00

Excellent cond. Documentation included.

MEMORY

TRS-80
APPLE II
$65
16k memory (8) 4116's

Installation is simple. Anyone who has ever changed a spark plug should be able to up-grade his microcomputer.

How can California Digital offer these memory up-grade sets at 25% below our competition? Simple, we buy in volume, wholesale to dealers and sell the balance directly to owners of personal microsystems. These 16K dynamic memory circuits are factory prime and unconditionally guaranteed for one full year. NOW, before you change your mind, pick up the telephone and order your up-grade memory from California Digital. Add $3 for TRS80 jumpers.

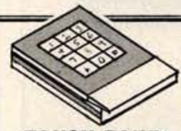
STATIC	1-31	32-99	100-5C	-999	1K+
21L02 450nS.	1.19	.99	.95	.90	.85
21L02 250nS.	1.49	1.39	1.25	*	*
2114 1Kx4 450	5.95	5.50	5.25	4.75	4.50
2114 1Kx4 300	8.95	8.50	8.00	*	*
4044 4Kx1 450	5.95	5.50	5.25	*	*
4044 4Kx1 250	9.95	9.50	9.00	*	*
4045 1Kx4 450	8.95	8.50	8.00	*	*
4045 1Kx4 250	9.95	9.50	9.00	*	*
5257 low pow.	5.95	5.50	5.00	4.80	4.60

SPECIAL CIRCUITS

Z80A 4 MHz.	24.95	AY5-1013A UART	4.95
8080A CPU	9.95	Floppy Disc Controllers	
8085	22.50	WD 1771 single D.	39.95
8086 Intel 16 bits	85.00	WD 1781 Double D	65.00
TMS 9900 16 bits	49.95	WD 1791 D/D 3740	*

EPROMS		1-15	16-63	64+
1702A	2K	4.95	4.50	4.00
2708	8K	9.95	9.50	9.00
2716 5v	16K	29.95	27.50	*
2716 TI		24.88	20.00	*
2532		85.00	*	*

TOUCH TONE® Speaker Phone



The Voicecaster simply plugs into your existing phone wall jack. The twelve button pad creates standard Touch Tone frequencies. Unique electronic circuitry eliminates that hollow sound that you have heard on other systems.

Original retail price $295.

Please consult your local telephone company to determine if a line protection device is required in your community.

Dial units also available.

$49

Factory Liquidation

ACOUSTIC MODEM

The Omnitec model 701 Modem connects the RS-232 serial port of your computer or peripheral device acoustically to your telephone line.

Place the telephones handset into cradle of the modem, instantly your computer system has access to the world of digital information.

Half and full duplex ability.

$89

USED

Regent® 25

Through years of research the ADDS Corporation has evolved a low maintenance, extremely durable CRT terminal capable of withstanding an abusive 24 hour duty cycle. The Regent 25 features Intel 8085 microprocessor controlled circuitry along with the Cherry Switch long-life capacitance keyboard.

18 key cursor and numeric pad doubles to allow for user definable special functions. True descending lower case characters along with a fully addressable cursor makes the Regent 25 the ideal word processing terminal.

High-resolution screen is capable of displaying 96 upper and lower case ASCII characters and 32 control codes. This terminal is switch selectable to display six European languages.

At $850 (plus shipping) the Regent 25 offers the best value in todays CRT terminal market. Additional data upon request.

MINIATURE SWITCHES

your choice

	10	50	100	1k
$.98	$.88	.81	.73	.66

SPDT Miniature Toggles

7101 C&K	ON-NONE-ON
7107 jbt	ON-OFF(mnt.ON)
7108 CK	ON-(moment ON)
7103 CK	ON OFF ON
Rotary	3P-4-Pos.
Rotary	3P-6-Pos.
Push B (N.O.)	$.39ea. 4/$1

DIP Switch

	10	25	100	1K
$1.29 ea.	$1.19	1.09	.97	.83

specify 4, 7 or 8 pos.

SPST

PORTABLE DATA ENTRY SYSTEM

$139.50

These used data terminals were originally designed for chain store inventory control and order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered into the recorder, the main warehouse is telephoned, the handset is placed in the acoustic coupler and all the recorded information is transmitted back to the master computer. With a little imagination and one of these portable entry systems, you should be able to exchange programs and computer information with associates across the country. All units were removed from service in working condition. Original cost $2,500. Each system comes complete with:

- Portable Cassette Drive Unit
- Removable Entry Keyboard with LED Display
- Five Gould "D" NiCads
- Acoustical Coupler
- Battery Charger
- DB25 Cable
- Shoulder starp
- Full Documentation

DISCOUNT Wire Wrap Center

IC SOCKETS

pin	wire wrap ea.	25	50	low profile ea.	25	50
8	—	—	—	17¢	16	15
14	37¢	36	35	18	17	16
16	38	37	36	19	18	17
24	99	93	85	36	35	34
40	169	155	139	63	60	58

KYNAR WIRE WRAP

50ft. $.98

500	1,000	11,000
$9.	$15.	$105.

$29.95 BW630

OK HOBBY WRAP-30 wire wrap & strip tool

$5.45

(213) 679-9001

VISA   master charge

All merchandise sold by California Digital is premium grade. Sorry, no COD's. Orders are shipped the same day received. California residents add 6%. Foreign orders add 10%. Orders over $25, when accompanied by payment, are shipped at our expense. Otherwise, please add $2.

Circle 212 on inquiry card.

HEX ENCODED KEYBOARD

Four onboard LEDs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only $15.00 Part No. HEX-3, with parts $49.95 Part No. HEX- 3A. 44 pin edge connector $4.00 Part No. 44P.

ASCII TO CORRESPONDENCE CODE CONVERTER

This bidirectional board is a direct replacement for the board inside the Trendata 1000 terminal. The on board connector provides RS-232 serial in and out. Sold only as an assembled and tested unit for $249.95. Part No. TA 1000C

T.V. INTERFACE

• Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple • Power required is 12 volts AC C.T., or +5 volts DC • Board only $7.60 part No. 107, with parts $13.50 Part No. 107A

TAPE INTERFACE

• Converts a low cost tape recorder to a digital recorder • Works up to 1200 baud • Digital in and out are TTL-serial • Output of board connects to mic. in of recorder • Earphone of recorder connects to input on board • No coils • Requires +5 volts, low power drain • Board only $7.60 Part No. 111, with parts $29.95 Part No. 111A

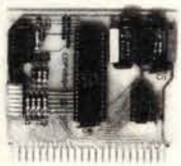
ASCII KEYBOARD

53 Keys popular ASR-33 format • Rugged G-10 P.C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5, -12 volts. $59.95 Kit.

T.V. TYPEWRITER

• Stand alone TVT • 32 char/line, 16 lines, modifications for 64 char/line included • Parallel ASCII (TTL) input • Video output • 1K on board memory • Output for computer controlled curser • Auto scroll • Non-destructive curser • Curser inputs: up, down, left, right, home, EOL, EOS • Scroll up, down • Requires +5 volts at 1.5 amps, and -12 volts at 30 mA • All 7400, TTL chips • Char. gen. 2513 • Upper case only • Board only $39.00 Part No. 106, with parts $145.00 Part No. 106A

UART & BAUD RATE GENERATOR



• Converts serial to parallel and parallel to serial • Low cost on board baud rate generator • Baud rates: 110, 150, 300, 600, 1200, and 2400 • Low power drain +5 volts and -12 volts required • TTL compatible • All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity. • All connections go to a 44 pin gold plated edge connector • Board only $12.00 Part No. 101, with parts $35.00 Part No. 101A, 44 pin edge connector $4.00 Part No. 44P

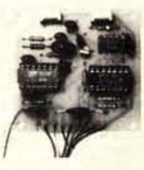
ASCII KEYBOARD

TTL & DTL compatible • Full 67 key array • Full 128 character ASCII output • Positive logic with outputs resting low • Data Strobe • Five user-definable spare keys • Standard 22 pin dual card edge connector • Requires +5VDC, 325 mA. Assembled & Tested. Cherry Pro Part No. P70-05AB. $119.95.

SOROC IQ 120

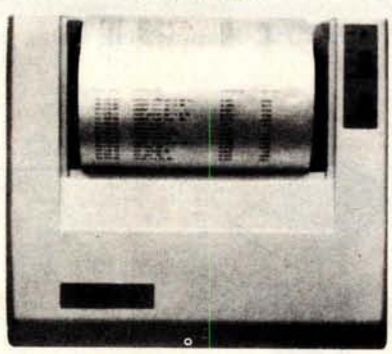
Upper/lower case display • Numeric keypad & cursor keys • Protected fields, ½ intensity display • RS 232 interface & aux. port. IQ120—$799.95 • IQ140 Detachable keyboard—$1199.95

MODEM



• Type 103 • Full or half duplex • Works up to 300 baud • Originate or Answer • Serial TTL input and output • connect 8 Ω speaker and crystal mic. directly to board • Requires +5 volts • Board only $7.60 Part No. 109, with parts $29.95 Part No. 109A.

COMPRINT PRINTER



Printing Characteristics: 225 characters/second (170 lines/minute) throughput • 9 horizontal x 12 vertical matrix • 96 ASCII character set with upper and true lower case • 80 characters/line • 5.8 lines/inch
Buffer Memory: standard 256 bytes; • optional; 2,048 bytes (buffer memory option designated as Model 912-2K), add $149.95.
Paper Requirements: electrosensitive type (aluminum coated) • 8-1/2 inch width • 3.7 inch max. (300 ft.) roll diameter.
Model 912-S Interfacing: serial interface RS232 and 20 mA current loop • BAUD rates 110, 150, 300, 600, 1200, 2400 and 4800 are strap selectable.
Model 912-P Interfacing: parallel interface, IEEE-488 and 8 bit parallel (strobe/acknowledge). Model 912-S, Part No. CPIA, 32118, $579.95. Model 912-P, Part No. CPIA, 32117, $559.95.

RS-32/TTL INTERFACE

• Converts TTL to RS-232, and converts RS-232 to TTL • Two separate circuits • Requires -12 and +12 volts • All connections go to a 10 pin edge connector, kit $9.95 Part No. 232A 10 Pin edge connector $3.00 part No. 10P.

COMPUCOLOR II

With reg. keyboard
MOD3 8K $1595.95
MOD4 16K $1695.95
MOD5 32K $1995.95
Now includes $250 more, worth of software and accessories with 101 key option add $134.95 with 117 key option add $179.95

44 BUS MOTHER BOARD

Has provisions for ten 44 pin (.156) connectors, spaced 3/4 of an inch apart. Pin 20 is connected to X, and 22 is connected to Z for power and ground. All the other pins are connected in parallel. This board also has provisions for bypass capacitors. Board cost $15.00 Part No. 102. Connectors $3.00 each Part No. 44WP.

RS-232/20mA INTERFACE

This board has two passive, opto-isolated circuits. One converts RS-232 to 20mA, the other converts 20mA to RS-232. All connections go to a 10 pin edge connector. Requires +12 and -12 volts. Board only $9.95, part no. 7901, with parts $14.95 Part No. 7901A.

DC POWER SUPPLY

• Board supplies a regulated +5 volts at 3 amps., +12, -12, and -5 volts at 1 amp. • Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps. • Board only $12.50 Part No. 6085, with parts excluding transformers $42.50 Part No. 6085A

To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U.S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800

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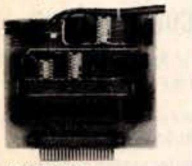
Circle 213 on inquiry card.

TRS-80 SERIAL I/O

• Can input into basic • Can use LLIST and LPRINT to output, or output continuously • RS-232 compatible • Can be used with or without the expansion bus • On board switch selectable baud rates of 110, 150, 300, 600, 1200, 2400, parity or no parity odd or even, 5 to 8 data bits, and 1 or 2 stop bits. D.T.R. line • Requires +5, -12 VDC • Board only $19.95 Part No. 8010, with parts $59.95 Part No. 8010A, assembled $79.95 Part No. 8010 C. No connectors provided, see below.



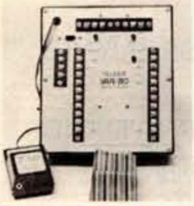
EIA/RS-232 connector Part No. DB25P $6.00, with 9', 8 conductor cable $10.95 Part No. DB25P9.

3' ribbon cable with attached connectors to fit TRS-80 and our serial board $19.95 Part No. 3CAB40.

COMPUCRUISE

$129.95; with cruise control $169.95

THE TELESIS VAR-80 INTERFACE UNIT



For the TRS-80 with Level II Basic • Provides 8 outputs • Provides 8 inputs • 2 ft. of interconnecting cable w/connector • Plugs directly into TRS-80 • Power supply provided • Assembled and tested. Part No. VAR80, Introductory price $109.95.

GAME PADDLES & SOUND

Includes: 2 game paddles, interface, software, speaker, power supply, full documentation including: schematics, theory of operation, and user guide; plus 2 games on cassette (Pong and Starship War). $79.95 Complete Part No. 7922C

DIGICOM DATA PRODUCTS INC. Series 312 Acoustic Coupler

300 BAUD Originate, Part No. AC3122, $219.95. 300 BAUD Answer, Part No. AC3122, $219.95. 300 BAUD Answer/Originate, Part No. AC3123, $229.95.

LIGHT-PEN For Your TRS-80

Your TRS-80 Light-Pen is a carefully engineered instrument and with the proper care will give satisfactory use and many years of service. Part No. TRS80LP $24.95.

SYSTEM EXPANSION from LNW Research

• Serial RS232C/20 mA I/O • Floppy controller • 32K bytes memory • Parallel printer port • Dual cassette port • Real-time clock • Screen printer bus • Onboard power supply • Software compatible • Solder mask, silk screen. PC board and user manual, Part No. LNW80, $69.95.

DISKETTES

Box of 10, 5" $29.95, 8" $39.95.
Plastic box, holds 10 diskettes, 5" - $4.50, 8" - $6.50.

16K RAMS

For the Apple, TRS-80 or Pet $8 each Part No. 4116/2117.

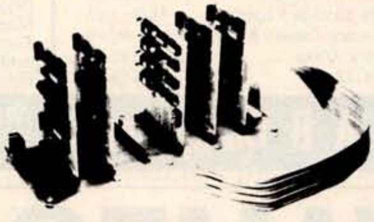
LEEDEX MONITOR

12" Black and White • 12 MHz Bandwidth • Handsome Plastic Case • $139.00

S-100 INTERFACE

AN S-100 bus Adapter—Motherboard for the TRS-80. Kit, Part No. HUH81DLXK, $295.95. Assembeled, Part No. HUH81DLXA, $375.95.

NOW! A FULL SUPPORT SYSTEM FOR TRS-80



• 32K of RAM • EPROM firmware • Disk control • Data acquisition • Parallel I/O • Serial I/O • Plug into GPA's Motherboard. GPA's quality design includes • 6-44 pin edge connectors • +5V, -5V, +12V, -12V external power supply required • Active termination. The Motherboard, Part No. GPA80, is only $149.95.

TAKE ADVANTAGE OF GPA-EXPANSION CARDS FOR THE GPA80

Memory cards: Now with Fortran compilers available for your TRS-80, additional expansion memory is a must! Card with sockets only, Part No. GPA801, $119.95. Card with 16K of 4116 Dynamic Ram, Part No. GPA802, $224.95. Card with 32K of 4116 Dynamic Ram, Part No. GPA803, $329.95. All cards come equipped with sockets to accomodate 32K of Ram.
EPROM firmware card. Put those valuable subroutines in firmware. Don't waste time loading and unloading tapes and disks. For 2708 or 2716 EPROMS, Part No. GPA806, $79.95.
Serial I/O card. Here's what you've been asking for, a full serial terminal interface, with RS-232C or 20 mA. Current loop. Input/output capabilities. Part No. GPA807, $79.95.
Parallel I/O Card. Control functions in the outside world, monitor and store real time events. Two parallel output ports. Dip switches select ports (0-254). Part No. GPA808, $79.95.

FLOPPY DISK STORAGE BINDER

Three-ring binder comes with ten transparent plastic sleeves which accommodate either twenty, five-inch or ten, eight-inch floppy disks. Binder & 10 holders $14.95 Part No. 8800; Extra holders 95¢ each. Part No. 800.

DIGITAL CASSETTE

5 min. each side. Box of 10 $9.95. Part No. C-5.

DISK JACKET™

Holds two 5-1/4 inch diskettes and will fit any standard three ring binder. $9.95/10 Pack.

TRENDCOM PRINTER

• 40 characters per second • 4-7/16 inch wide thermal paper • Graphics (TRENDCOM 100): 480 sevendot print postions per line. TRENDCOM 100, Part No. TRC0100, $495.95. TRENDCOM 200, Part No. TRC0200, $375.95. **Interface** for TRS-80, Part No. T80A $45.95. For Apple II, Part No. TRCAII, $75.95. For PET, NO. TRCP2, $79.95. For Scoccerer, TRCSR1 $45.95.

SARGON: A Computer Chess Program

Features the complete program that won the 1978 West Coast Computer Faire Tournament. Part No. 00603 — TRS-80 Level II; Part No. 00604 — Apple II (24K). $19.95

SOUND EFFECTS AND MUSIC FOR YOUR COMPUTER

SOUNDWARE is a complete system. It includes a speaker/amplifier unit with volume control, earphone jack, and connectors. It boasts excellent tone quality yet is small and convenient to use. Add batteries, plug it in, and play. One year warranty. SOUNDWARE package (includes INTRO to SOUNDWARE programs) PET (8K), Part No. 20003, $29.95. TRS-80 Level II (16K), Part No. 20002, $29.95. Compucolor II (8K), Part No. 20001, $39.95. INTRO to SOUNDWARE programs only PET and TRS-80, Part No. 20005, $14.95. Compucolor II Part No. 20006, $19.95.

To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U. S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U. S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800

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Circle 213 on inquiry card.

Circle 214 on inquiry card.

FREE! Up to $170 in merchandise with purchase of one of following PET-CBM items ! ! !

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Leedex Video 100 12" Monitor	$ 119.00
Heath WH19 Terminal (factory asm.)	$ 770.00
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PET SPECIALS		*FREE
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PET 32B 32K full size business keyboard	$1295	**$170**
PET 8N 8K full size graphics keyboard	$ 795	**$100**
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PET 2022 Tractor Feed Printer	$ 795	**$100**
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Buy 2 PET Computers, get 1 FREE

*Free Merchandise with Purchase of PET-CBM Item.

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SYM Assembler in ROM	$ 85
SEA-16 New 16K Static RAM	$325
Seawell Motherboard - 4K RAM Space	$139
KTM-2/80 Synertek Video Board	$349
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TIS PET Workbooks - set of 6	$ 21.50
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Cassettes (all tapes guaranteed) AGFA PE611 Premium quality, high out put lownoise in 5 screw housing with labels:

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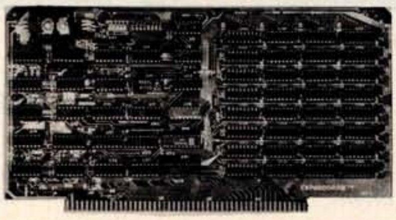

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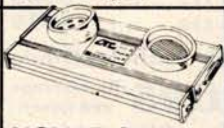

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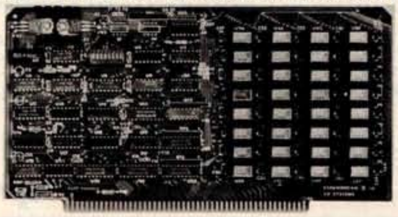

SD Systems' ExpandoRAM II is a dynamic RAM board with capacities from 16K bytes (4116) to 256K bytes (4164). It operates on the industry S-100 Bus. The design allows 8 boards to operate from the same S-100 Bus. The ExpandoRAM II is compatible with most S-100 CPU's based on the Z80 microprocessor.

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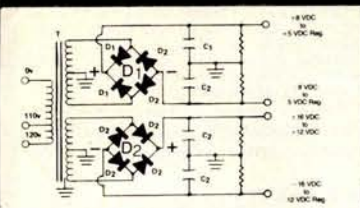

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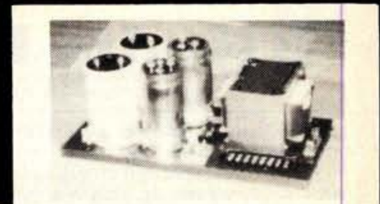

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T_3	3	0V, 110V, 120V	2×9A	2×2.5A	2×2.5A	3¾"×4⅜"×3⅛"	29.95
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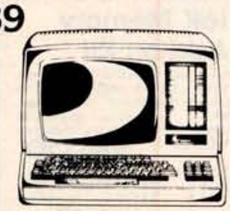

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BRAND: SULLINS: U.L Reg.					
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129875	50/100 W/W Imsai	.250	5.25	4.75	4.20
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12790	40/80 W/W	.250	6.30	5.65	5.00
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10280	25/50 S/E TRS 80	.140	4.50	4.05	3.60
10175	20/40 S/E TRS 80	.140	5.85	5.35	4.75
10180	20/40 W/W TRS 80	.200	3.30	3.00	2.15
10190	20/40 S/T TRS 80	.140	3.20	2.90	2.55
10485	36/72 S/E Vector	.140	5.50	4.90	4.40
10490	36/72 W/E Vector	.200	5.80	5.25	4.65
10500	36/72 S/T Vector	.140	5.70	4.20	4.60
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10540	40/80 W/W PET	.200	6.00	5.40	4.80
10550	40/80 S/T PET	.140	5.80	5.25	4.65
10585	43/86 S/E COS/ELF	.140	6.95	6.25	5.55
10605	43/86 S/T COS/ELF	.140	6.60	5.95	5.30
10595	43/86 W/W COS/ELF	.200	6.90	6.20	5.95
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15110	6/12 S/T PET/NSC	.140	1.85	1.65	1.50
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15175	6/- S/E Sgle Row	- -	1.70	1.50	1.30
15270	10/20 S/E	.140	2.15	1.95	1.70
15275	10/20 S/T	.140	2.00	1.85	1.60
15435	12/24 S/E PET	.140	2.60	2.35	2.10
15440	12/24 S/T PET	.140	2.65	2.40	2.15
15445	12/24 S/T PET	.200	2.75	2.50	2.20
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15510	15/30 S/T GRI Key	.140	2.40	2.15	2.95
15515	15/30 W/W GRI Key	.200	2.60	2.35	2.10
15600	18/36 S/E	.140	3.35	3.05	2.70
15610	18/36 S/T	.140	3.00	2.70	2.40
15615	18/36 W/W	.200	3.60	3.20	2.90
15700	22/44 S/E KIM/VEC	.140	2.98	2.90	2.75
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15875	25/50 S/E	.140	4.65	4.20	3.75
15880	25/50 S/T	.140	4.55	4.10	3.65
15885	25/50 W/W	.200	4.85	4.35	3.90
16115	36/72 S/E	.140	6.50	5.85	5.20
16120	36/72 S/T	.140	6.55	5.90	5.25
16125	36/72 W/W	.200	6.75	6.10	5.40
16145	36/72 S/T	.200	6.50	5.85	5.20
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16240	43/86 W/W Mot 6800	.200	7.80	7.05	6.25
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DE	9S	Female	2.25ea.	2.00ea.	1.90ea.
DE	110963-1	2 pc. Grey Hood.	1.50ea.	1.35ea.	1.20ea.
DA	15P	Male	2.35ea.	2.15ea.	2.00ea.
DA	15S	Female	3.25ea.	3.10ea.	2.90ea.
DA	51211-1	1. pc. Grey Hood	1.40ea.	1.20ea.	1.15ea.
DA	51226-1	2 pc. Black Hood	2.50ea.	2.25ea.	2.00ea.
DA	110963-2	2 pc. Grey Hood	1.60ea.	1.35ea.	1.30ea.
DB	25P	Male	2.80ea.	2.60ea.	2.40ea.
DB	25S	Female	3.60ea.	3.40ea.	3.20ea.
DB	51212-1	1 pc. Grey Hood	1.50ea.	1.30ea.	1.10ea.
DB	51226-1	2 pc. Black Hood	1.90ea.	1.65ea.	1.45ea.
DB	110963-3	2 pc. Grey Hood	1.75ea.	1.50ea.	1.35ea.
DC	37P	Male	4.20ea.	4.00ea.	3.70ea.
DC	37S	Female	6.00ea.	5.75ea.	5.50ea.
DC	110963-4	2 pc. Grey Hood	2.25ea.	2.00ea.	1.75ea.
DD	50P	Male	5.50ea.	5.10ea.	4.75ea.
DD	50S	Female	9.40ea.	8.60ea.	8.00ea.
DD	51216-1	1 pc. Grey Hood	2.40ea.	2.20ea.	2. 00ea.
DD	110963-5	2 pc. Grey Hood	2.60ea.	2.40ea.	2.10ea.
D	20418-2	Hardware Set (1 Hood Set)	.90ea.	.80ea.	.70ea.

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2147	40 Cond. Cable 10 ft. length	12 oz.	$16.00
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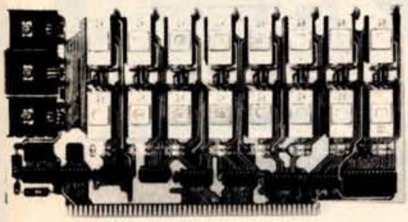
16K EPROM CARD-S 100 BUSS



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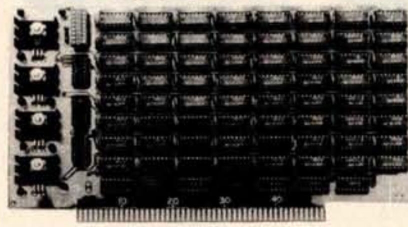

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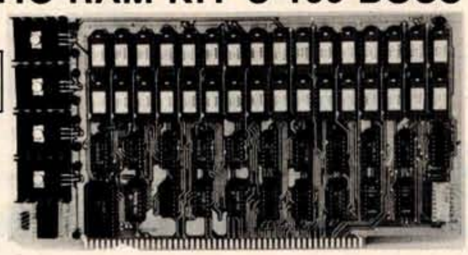

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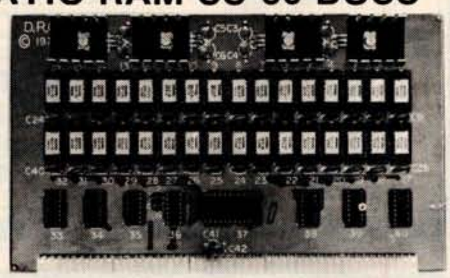

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5. All Parts and Sockets included
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1802/S-100 expandable to 32K, Hidden refresh w/clocks up to 4 MHz w/no wait states Addl. 16K RAM **$79.00.**

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Quest, the leader in inexpensive 1802 systems announces another first. Quest is the first company worldwide to ship a **full size Basic** for 1802 systems. A complete function **Super Basic** by **Ron Cenker** including floating point capability with scientific notation (number range $\pm .17E^{38}$), 32 bit integer ± 2 billion; Multi dim arrays; String arrays; String manipulation; Cassette I/O, Save and load, Basic, Data and machine language programs; and over 75 Statements, Functions and Operators.

Easily adaptable on most 1802 systems. Requires 12K RAM minimum for Basic and user programs. Cassette version in stock now. ROM versions coming soon with exchange privilege allowing some credit for cassette version.

Super Basic on Cassette **$40.00**

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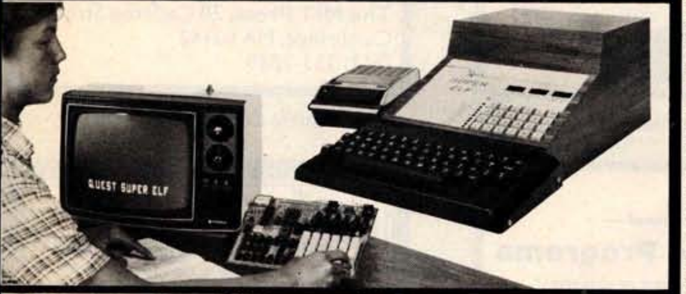

RCA Cosmac Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded with additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

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The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during** and **after** executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

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Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** Expansion Cabinet with room for 4 S-100 boards **$41.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested.

Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year. Issues 1-12 bound $16.50.

Tiny Basic Cassette **$10.00,** on ROM **$38.00,** original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50.** Games and Music **$3.00,** Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface**. Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf**. The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed.** EPROM can be used for the monitor and Tiny Basic or other purposes.

A 1K Super ROM Monitor $19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. The Super Monitor is written with subroutines allowing users to take advantage of monitor functions simply by calling them up. Improvements and revisions are easily done with the monitor. If you have the **Super Expansion Board** and **Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports** with **full handshake**. They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $15.25 for easy connection between the **Super Elf** and the **Super Expansion Board.**

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7420N	.18
7422N	.39
7430N	.20
7442N	.50
7445N	.69
7447N	.60
7448N	.69
7450N	.18
7474N	.35
7475N	.49
7485N	.88
7489N	1.85
7490N	.43
7492N	.43
7493N	.43
7495N	.69
74100N	.90
74107N	.35
74121N	.34
74123N	.59
74125N	.45
74145N	.69
74150N	.95
74151N	.69
74154N	1.00
74157N	.69
74161N	.87
74162N	.87
74163N	.87
74174N	.96
74175N	.90
74190N	1.15
74192N	.87
74193N	.85
74221N	2.00
74298N	1.65
74365N	.66
74366N	.66
74367N	.66

74LS00 TTL	
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74LS02N	.35
74LS04N	.35
74LS05N	.35
74LS08N	.35
74LS10N	.35
74LS13N	.55
74LS14N	1.10
74LS20N	.35
74LS22N	.35
74LS28N	.41
74LS30N	.35
74LS33N	.75
74LS38N	.55
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74LS75N	1.00
74LS90N	.85
74LS93N	.70
74LS95N	1.10
74LS107N	.45
74LS112N	.45
74LS113N	.35
74LS132N	.89
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74LS155N	.85
74LS157N	.85
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LM340K-24	1.35
LM340T-5	1.25
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CD4046	1.67
CD4049	.45
CD4050	.49
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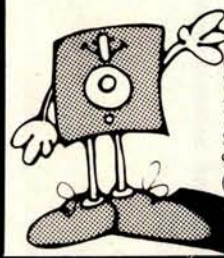

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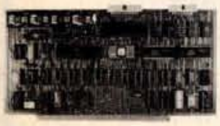

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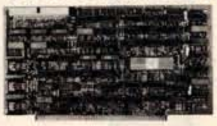

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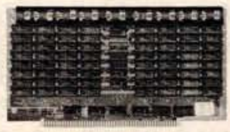

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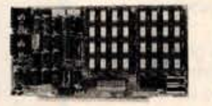

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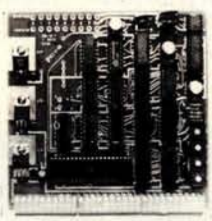

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UNCLASSIFIED POLICY: *Readers who are soliciting or giving advice, or who have equipment to buy, sell or swap should send in a clearly typed notice to that effect. To be considered for publication, an advertisement must be clearly noncommercial, typed double spaced on plain white paper, contain 75 words or less, and include complete name and address information.*

These notices are free of charge and will be printed one time only on a space available basis. Notices can be accepted from individuals or bona fide computer users clubs only. We can engage in no correspondence on these and your confirmation of placement is appearance in an issue of BYTE.

Please note that it may take three or four months for an ad to appear in the magazine.

FOR SALE: SOL-20 with 32 K programmable memory, dual North Star disk drives with power supply, and cabinets. Completely operational. With North Star disk operating system, BASIC, and many disks full of programs. $2700. Clifford C Anthony, (301) 863-8468.

FOR SALE: B & K oscilloscope Model #1471, 15 MHz bandwidth; $500. Optical paper-tape reader; $25. Richie, (305) 553-4326 after 5 PM.

FOR SALE: Percom disk SwTPC compatible controller board with cable, MDOS-PLUS operating system in programmable read-only memory (no booting), plus TSC Edit and Text Processor with Touchup, Microsoft G2-Standard BASIC, Microware ABASIC compiler, and all disk utility programs on two minifloppies. All hardware $200 firm; software free with purchase. Just add Percom disk drive for $375 for complete disk system. M B Scudiere, 100 Ceder Ln, Oak Ridge TN 37830, (615) 482-1355.

FOR SALE: Save $500 on iCOM disk controller for one to four disk drives. IBM 3740 compatible. Use with Shugart, Siemens, Pertec, . . floppy-disk drives. With manual containing S-100 and 6800 interface instructions. Just checked out by factory. Cost $850, only $250. Okidata 110 cps commercial quality printer with full options including pressure and tractor feed and self-test. Like new, just rebuilt by factory. With RS-232 interface, only $850. PT factory assembled S-100 bus 8 K programmable memory, $85. H H Hayden, POB 1275, Socorro NM 87801.

FOR SALE: KIM-1 microcomputer including all documentation, $100. Electronic Systems 32 by 32-character video board, $75. Cyclic redundancy check ASCII (uppercase) keyboard, $25. All postpaid. Kerch Holt, 115 High St, Bath ME 04530, (207) 443-3588.

FOR SALE: Two 8 K static programmable-memory boards by Base 2 and IMS respectively. One music board by Newtech. All for $325. Assembled and manuals included. Call after 6 PM. James Chen, (213) 363-4593.

FOR SALE: I have two Rockwell AIM-65 microcomputers to sell. They are in their original cartons unopened. The 1 K is being offered for $325 and the 4 K for $425. I will ship these units UPS and will pay postage. Alfred F Stahler, 5521 Big Oak Dr, San Jose CA 95129, (408) 252-4219.

FOR SALE: IMSAI MIO board with modifications to make it work, two parallel ports, serial port, Tarbell cassette port, software drivers, serial port untested. Two IMSAI 4 K programmable-memory boards, one Godbout 8 K Econoram board, 62-key ASCII keyboard in dress enclosure. Make offer on any or all. Roy Turner, 14407 Broadgreen, Houston TX 77079, (713) 497-5849.

FOR SALE: Fairchild/Veras (44-pin bus) Micro System boards. One processor, one mother board, and two 4 K static memory boards. All expertly assembled, tested, and socketed. Much documentation, hardware, software, assembly manuals, and 4 K BASIC included. First $200 takes all or best offer. Also, OAE OP-80 paper-tape reader (solid-state) 0 thru 5000 cps. Interfaces to any 8-bit parallel port. Assembled and working. Supplied with full documentation. $55. Paul Ramos, 100 Middle St, Woburn MA 01801, (617) 935-3758.

WANTED: Development system for Intel 8048 and/or 8080 microprocessors. Prefer Model 230 Intellec Series II, but will consider any model. Also interested in any extras (ie: ICE, or what have you). Reed Hannebaum, 6821 Birdie Ln, St Louis MO 63129.

FOR SALE: One IMSAI 32 K programmable-memory board, $500. Never used, but was working at 2 MHz when bought. Quitting microcomputing. J Phillips, 3435 N 75th Dr, Phoenix AZ 85033.

FOR SALE: BYTE magazines, March 1977 thru September 1978. Make me an offer. Dick Neish, 904 Marday, Sioux Falls SD 57103.

FOR SALE: North Star computer. Piecemeal or package. Memory, processor, single-density drive. D Montano, 13 Macfarlan St, Hawthorne NJ 07506.

FOR SALE: Expanded KIM system: two 8 K programmable-memory boards, 2 K erasable-programmable read-only memory S-100 mother board, separate 64 by 16 television typewriter, fast tape input/output (I/O), books, much software; all for $400. Fred Monsour, 309 Camellia Dr, Charlottesville VA 22903, (804) 977-8077.

FOR SALE: BYTE, November 1976 thru December 1978, twenty-six issues, $25. *Interface Age*, February 1977 thru December 1978, twenty-two issues, $21. *Kilobaud*, June 1978 thru December 1978, seven issues, $6. Or all for $50 FOB. R Mendelson, 27 Somerset Pl, Murray Hill NJ 07974, (201) 464-5244.

FOR SALE: PET computer, 8 K programmable memory, includes five prerecorded tapes, all in perfect working condition. $650. Stan Prokop, 4330-B 2nd Ave, Ft Knox KY 40121, (502) 624-8650.

FOR SALE: Intel SDK-85 SBC system, completely assembled with extra 8155 wired in, instruction book, assembly manual, MCS-85 users manual. See article in January 1979 BYTE, page 60. Asking $260, you pay shipping. Sam Stickle, 651 E Travis Blvd #14, Fairfield CA 94533, (707) 422-4850.

FOR SALE: Quitting hobby. All test equipment, integrated circuits, transistors, capacitors, resistors, etc must go. Send SASE for list and prices. Steve Pang, 99-709 Hoio St, Aiea HI 96701.

FOR SALE: E and L MMD-1 8080A Mini/Micro computer with one MI interface board. An excellent tutorial system. 2.5 K programmable memory, monitor and D-Bug in programmable read-only memory, octal keyboard entry, tape cassette interface, and serial input/output (I/O) for teletype or monitor. A-1 condition. $395. Don Woods, 12012 Pebblebrook Ln, Carmel IN 46032, (317) 846-8388.

FOR SALE: Factory assembled ELF-II in almost new condition. Includes power supply, user manuals, light pen, speaker interface, and other information. Worth about $170, sell for $150. Tom Court, 8745 Greenway Ave S, Cottage Grove MN 55016, (612) 459-4340.

FOR SALE: PolyMorphic 88 system: 8080 processor, 24 K programmable memory, 300 bps and 1200 bps cassette interface with Superscope recorder, serial printer interface board, Javelin video monitor, and keyboard. Excellent condition, runs great. Includes hardware/software manuals, BASIC, Assembler, and Disassembler programs. $1500 or best offer. J Comer, 221 Reynolds Rd, Raleigh NC 27609, (919) 781-3072.

FOR SALE: Teletypes: ASR33 ($450), KSR33 ($375), KSR35 ($550); high-speed teletype line printer ($285), high-speed paper punch ($135), INVAC paper punch ($60). Will consider trade for memory, video, or other S-100 boards. Shipping extra, call for condition. Jim, (509) 547-8745 evenings.

GENEALOGY: I am using a microcomputer to help bring order out of chaos in my collected documentation of several thousand ancestors. I would like to be able to store, file, sort, retrieve, and cross-reference genealogical data. I would also like to be able to have pedigree, individual, and family group printouts, as well as indexes. I would like to hear from others having a similar interest (it also has relevance to tracing genetic dis- [illegible]ers and there are other analogs), so that a network of in[illegible]ation could be pooled and shared. Clifton M Howard, 5[illegible] Orden Rd, Harrington Park NJ 07640.

PROGRAM EXCHANGE: The Craig County Public Schools have placed Level II TRS-80s in pilot programs in elementary and secondary schools. These machines are being used with computer-assisted instruction (CAI) programs and educational programs. Because of an apparent scarcity of CAI programs, K-12, school personnel and advanced secondary students are developing such programs. This process is quite slow, however, when the ultimate objective is to offer CAI in a variety of subjects at all grade levels. We would be glad to contact schools and/or individuals interested in exchanging programs which they have developed. Earl R Savage, Craig County Public Schools, POB 245, New Castle VA 24127.

FOR SALE: PolyMorphic Systems Poly 88 computer system including: 8080A processor board, 16 K memory board, video interface board (memory-mapped with graphics), mainframe with input/output (I/O) amp power supply, keyboard, modified TV, cassette interface, and all documentation. BASIC, Assembler software on tape. 1.5 years old. $1100 or best offer. Joel Cardon, 4 University Hill Way, Logan UT 84321, (801) 752-5516 after 7 PM.

FOR SALE: AIM-65 microcomputer with built-in printer, full ASCII keyboard, and 20-character alphanumeric display. Interfaces to two audio cassette recorders and 20 mA loop teletypewriter. Unit includes $75 4 K programmable memory option and $85 Assembler read-only memory option. Original price of complete system purchased 6/79 was $535. Asking $450. Bob Findley, 5 Marvin Pl, Bethel CT 06801, (203) 792-9945.

WANTED: NOVA Assembler Manual, DGC 093-000017 and/or Assembler punched tape program for NOVA. R A May, 306 Ferguson Ave, Elizabethton TN 37643.

FOR SALE: L/S ADM 31 video display. N/S Horizon processor, 32 K programmable memory, two double-density disks. T/I Omni 810 printer. P Mundy, 49 E 12 St #3F, New York NY 10003.

FOR SALE: Diablo series 30, 2.5 megabytes disk drives, compatible with many processor interfaces: Texas Instruments, Interdata, Data General, DEC, etc. $995 for drive. $110 for power supply which will power two disk drives. Jon Shechter, 556 Rutherford Dr, Seaford NY 11783, (516) 796-8683.

Ciarcia Wins Three in a Row

Steve Ciarcia has won the BOMB for the third consecutive month. He will receive a $100 check for his January article, "Computerize a Home." Our congratulations go to Steve for an excellent job. Second place was a tie between John Gibson and Edward Joyce for their respective articles, "A Computer-Controlled Light Dimmer, Part I: Design," and "Telephone Dialing by Computer." Ken Skier's article on "Indirect Addressing for the 6502" placed third.

The first place article was 2 standard deviations above the mean, and the two second place articles placed 0.8 standard deviations above the mean.■

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*To get further information on the products advertised in BYTE, fill out the reader service card with your name and address. Then circle the appropriate numbers for the advertisers you select from the list. Add a 15-cent stamp to the card, then drop it in the mail. Not only do you gain information, but our advertisers are encouraged to use the marketplace provided by BYTE. This helps us bring you a bigger BYTE. *Correspond directly with company.*

BOMB BYTE's Ongoing Monitor Box

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Get the most out of your microcomputer with Graham-Dorian Business software.

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Programs are compatible with most major computers using CP/M disk operating systems, and come in standard 8" or on various mini-floppy disks. Each package contains the software program in INT and BAS file form plus a user's manual and hard copy source listing. Graham-Dorian stands behind dealers with technical advice when needed.

Yes, there's a world of difference in business software. Count on Graham-Dorian for more per-package capabilities and more packages. (With new ones added every few months.)

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Ask your dealer for a demonstration soon.

There's A World of Difference

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211 North Broadway / Wichita, KS 67202 / (316) 265-8633

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The home computer you thought was years away is here.

C8P DF $2,597

Ohio Scientific's top of the line personal computer, the C8P DF. This system incorporates the most advanced technology now available in standard configurations and add-on options. The C8P DF has full capabilities as a personal computer, a small business computer, a home monitoring security system and an advanced process controller.

Personal Computer Features

The C8P DF features ultra-fast program execution. The standard model is twice as fast as other personal computers such as the Apple II and PET. The computer system is available with a GT option which nearly doubles the speed again, making it comparable to high end mini-computer systems. High speed execution makes elaborate video animation possible as well as other I/O functions which until now, have not been possible. The C8P DF features Ohio Scientific's 32 x 64 character display with graphics and gaming elements for an effective resolution of 256 x 512 points and up to 16 colors. Other features for personal use include a programmable tone generator from 200 to 20KHz and an 8 bit companding digital to analog converter for music and voice output, 2-8 axis joystick interfaces, and 2-10 key pad interfaces. Hundreds of personal applications, games and educational software packages are currently available for use with the C8P DF.

Business Applications

The C8P DF utilizes full size 8" floppy disks and is compatible with Ohio Scientific's advanced small business operating system, OS-65U and two types of information management systems, OS-MDMS and OS-DMS. The computer system comes standard with a high-speed printer interface and a modem interface. It features a full 53-key ASCII keyboard as well as 2048 character display with upper and lower case for business and word processing applications.

Home Control

The C8P DF has the most advanced home monitoring and control capabilities ever offered in a computer system. It incorporates a real time clock and a unique FOREGROUND/BACKGROUND operating system which allows the computer to function with normal BASIC programs at the same time it is monitoring external devices. The C8P DF comes standard with an AC remote control interface which allows it to control a wide range of AC appliances and lights remotely without wiring and an interface for home security systems which monitors fire, intrusion, car theft, water levels and freezer temperature, all without messy wiring. In addition, the C8P DF can accept Ohio Scientific's Votrax voice I/O board and/or Ohio Scientific's new universal telephone interface (UTI). The telephone interface connects the computer to any touch-tone or rotary dial telephone line. The computer system is able to answer calls, initiate calls and communicate via touch-tone signals, voice output or 300 baud modem signals. It can accept and decode touch-tone signals, 300 baud modem signals and record incoming voice messages. These features collectively give the C8P DF capabilities to monitor and control home functions with almost human-like capabilities.

Process Controller

The C8P DF incorporates a real time clock, FOREGROUND/BACKGROUND operation and 16 parallel I/O lines. Additionally a universal accessory BUS connector is accessible at the back of the computer to plug in additional 48 lines of parallel I/O and/or a complete analog signal I/O board with A/D and D/A and multiplexers.

Clearly, the C8P DF beats all existing small computers in conventional specifications plus it has capabilities far beyond any other computer system on the market today.

C8P DF is an 8-slot mainframe class computer with 32K static RAM, dual 8" floppies, and several open slots for expansion.

C8P $895

Or get started with a C8P with cassette interface, 8K BASIC-in-ROM which includes most of the features of the C8P DF except the real time clock, 16 parallel I/O lines, home security interface and accessory BUS. It comes with 8K static RAM and Ohio Scientific's ultra-fast 8K BASIC-in-ROM. It can be expanded to a C8P DF later. Base price $895. Virtually all the programs available on disk are also available for the C8P cassette system on audio cassette.

Computers come with keyboards and floppies where specified. Other equipment shown is optional.

For literature and the name of your local dealer, CALL 1-800-321-6850 TOLL FREE.

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