creative computing

June 1980
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Special Computer Graphics and Music Issue

14 Graphics Articles: Polar Plots, 3-D Graphics, Animation, Graphic Mazes, A Shape Maker, Poke Graphics, Cartoons, Motion Simulation, Inside Space Invaders

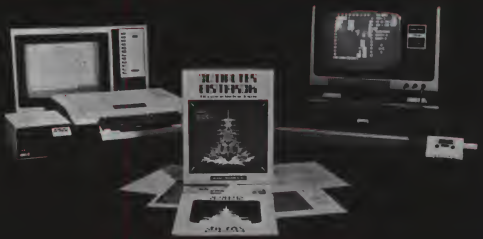
7 Music Articles: Digital Audio—Records and Components, Digital Enhancement of Old Recordings, Computer-Aided Sight Reading, Design of a Synthesizer

Reviews: Line printers, Percom Microdos, VersaWriter, Comprint 912, Heathkit Organ, Pet Music Box, Atari 800

Stock Option Maneuvers

Columns for Atari, TRS-80

INTRODUCING A GREAT WARGAME FOR TWO GREAT HOME COMPUTERS.



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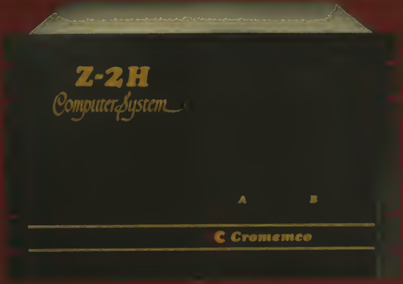

Low-cost hard disk computers are here and field proven

11 megabytes of hard disk and 64 kilobytes of fast RAM in a Z80A computer for under $10K. Two floppy drives, too. Naturally, it's from Cromemco.

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Last summer we told you this new Z-2H would be a smash. And it is. So see it at your dealer's now. Have him put you in touch with a user—there are lots of them because Cromemco has been delivering for months. See for yourself how pleased our users are.

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CIRCLE 130 ON READER SERVICE CARD

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CIRCLE 170 ON READER SERVICE CARD

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The Cover

The cover combines two elements. The logo is by Metacolor, 855 Sansome St., San Francisco, CA 94111 and is one of many ways of enhancing a black and white image available from Metacolor.

The illustration of little "men" is by David Willardson (©1977, Paper Moon Graphics, Inc.). It was done on a CG Series Computer by Chromatics, Inc., 3923 Oakcliff Industrial Court, Atlanta, GA 30340. The Chromatics CG Series use a Z80 with 512 x 512 graphics resolution and many advanced graphics features.

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et cetera

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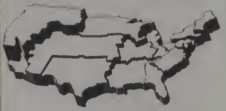
Computer Graphics Week '80

The Harvard Laboratory for Computer Graphics and Spatial Analysis will sponsor a week of intensive education about practical computer graphics—hardware, software and data bases. There are two major facuses: computer mapping and management graphics. The program will cover management graphics as a means of data reduction, the integration of graphical capabilities in data base management systems, how to design a graphics presentation, the presentation of graphical information in time and space and many other topics.

Dates are July 27-August 1, 1980 in Cambridge, Mass. Write Laboratory for Computer Graphics, Harvard University, 48 Quincy Street, Cambridge, MA 02138.

The Laboratory has also just announced five new volumes in the 11-volume set, "The Harvard Computer Mapping Collection." The new volumes include (7) "Management's Use of Maps," (8) "Cartographic and Statistical Data Bases and Mapping Software," (9) "Computer Graphics Hardware," (10) "Computer Mapping of Natural Resources and



Three-dimensional PRISM map.

the Environment including applicatons of satellite-derived data," and (11) "Urban, Regional, and State Government Applications of Computer Mapping plus computer mapping in education." The first volume ordered costs $50; additional ones are $35 each. For a complete catalog, write to the address above.

PET Break

Greg Yob will be enjoying a brief respite from these pages. For those of you who look forward to the support of the monthly PET column, don't despair! It will not be a permanent lapse, just a temporary break which should last only a month or two.

Commodore Van Program

Does anyone remember the EduVan program of Digital Equipment that I started back in 1972-73? Several PDP-8's and terminals lived in a Dodge van and rotated around to sales offices throughout the country. Seems that Commodore has revived the idea (sorry, no photo), and has loaded a van with 20 PETS, 2 disks and 2 printers. The van goes to a school district for 1 to 5 days. Plans call for seven vans throughout the country, but for now there is just one making the rounds on the West Coast.

For more information contact Glen Baylor, Commodore Business Machines, 3330 Scott Blvd., Santa Clara, CA 95050.

—DHA

Corrections

Several readers have contacted us about problems in the GROW program published in our January 1980 issue. Mr. Peter Scargill of Tyne & Wear, Great Britain, provided the following correction:

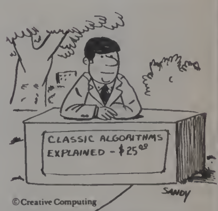
5070 IF INSTR(I$,S$) = 0 then 5030.

The contents of the DEFAULT file should be:

EXTEND
—
X
—
QUIT
—
Q
—

The contents of the INIT file should be:

WELCOME TO GROW
—
HELP
—
PI CAN'T HELP YOU.. YOU'LL HAVE TO STUDY THE PROGRAM
—



There are two corrections that need to be made to the Readability Program (Mar'80).

First, line 170 should be:

170 IF STR(T$(C),K,1) " " THEN 185

This correction must be made because the computer counts words by looking for spaces. There is no problem unless the person typing the passage double spaces at the end of a sentence or between words.

Second, add line 225 225 L = Q

This statement must be added so the computer will know exactly where the 100th word ends in the last line of the passage. Without this statement only the first character of the last line is examined when counting syllables. This correction could also be made by one of the following methods:

Change line 230 to read:
230 L = Q:GOTO 430
Change line 220 by adding:
:L = Q to the end.

CIRCLE 177 ON READER SERVICE CARD

Input/Output

Sorcerer as a Terminal

Dear Editor:

The Sorcerer's serial data cable (Exidy part number DP4005) is not enough to connect an acoustic coupler to the Sorcerer computer. It has no RS (request to send) line which is essential to the communication between a terminal and a host computer.

There is a +12 volts pin (#9) on the Sorcerer's serial interface, so I connected it to the #4 pin (RS) pin of an acoustic coupler with wire and 1K (1/4 W) resister. By this modification I succeeded in using the Sorcerer as a computer terminal.

Also, the Sorcerer dumb terminal program (supplied on cassette) has two defects. First, it doesn't select parity, the number of stop bits and the number of bits per character. Second, when the number of received characters per line from a host computer exceeds 64, the rest of the line is not printed on the CRT screen. But one can easily correct these defects by inserting some machine instructions.

Kazuo Nakamura
5-2-1-1402 Oji Kita-ku,
Tokyo, JAPAN 114

Computer Aided Life Journey

Dear Editor:

I would like to tell you about myself and my situation. About two months ago I purchased my first computer. It was the Commodore PET 2001, 16K, with their Model 2040 floppy disk drive and Tractor Feed printer. This setup has totally changed the course of my life.

Since birth thirty-five years ago, I have been disabled with a muscle weakness. This malady has provided me enough muscular strength to feed myself, dial a touch-tone phone, and type on a keyboard as I am doing now. Prior to the purchase of my PET there was limited choice of interests within my physical realm. Computers afford me the needed stimuli which were missing.

I now have an unending road of pursuit to look forward to. Quite a gratifying mode of incentive.

It is my hope that I can somehow get in touch with people doing work with the severely disabled and their specific needs. I would then be able to acquire information vital to progress in my search for an environment more conducive to my needs. Computer technology represents my emergence as an outwardly productive person. If it were not for computer technology and the descending prices, this letter (with editing capabilities galore and effort-free printout) would have been impossible. I trust you will assist me with any suggestions you may have. Also feel free to give my number and name to any person you may deem responsible. Please feel free to call (215) 276-0696.

May Peace and good health be with you and yours.

Barry L. Giordano
6035 Park Avenue
Philadelphia, PA 19141

No Cost Way to Share Disk and Printer with a Dozen PETS

Dear Editor:

Teachers, computing laboratory instructors, anyone who is involved with groups operating several computers within several meters of each other—here is a peripheral bonanza that can't be beat. At *no* additional hardware *or* software cost (beyond that of the obviously needed cables) it is possible to share *one* printer and *one* disk drive amongst many PETs. Each user will have access to the peripheral in exactly the same way they would if the peripherals were connected exclusively to their computer; as long as no more than one user at a time accesses the devices (both devices must be free).

This is a limitation, but in fact it is not a serious one in most teaching or small business situations, where most accesses are just to LOAD or SAVE files. The penalty for failing to find out if both devices are available will be a couple of aborted operations which can be disconcerting. However, considering that you can provide access to a disk and a printer for a dozen PETs at 1/12 the regular cost, checking for availability is a most reasonable constraint. Note that by appropriate applications programming, it is possible to have some terminals examining data generated by other terminals making many small business multi-terminal applications quite practical. (Care must be taken in doing this.)

The mechanics are so simple that it is amazing it has not been widely publicized before this.

1 Simply connect one PET to the disk drive, using the standard PET/IEEE cable.
2 Connect the printer by plugging the IEEE/IEEE cable to it and to the extension socket on the previously connected cable.
3 Using standard PET/IEEE cables connect the remaining PETs into any convenient extension socket on any of the other cables.

That's it! Turn on your PETs and the peripherals and they are all in business. As long as each user makes sure no one else is using either peripheral (place them so they can be easily seen and heard by all users), the IEEE system incorporated into the PET lets each computer think it is a controller in exclusive command of the peripherals. We have only tried this with four (4) PETs connected at the same time, but as long as the overall capacitance limit of the cables (available in 1,2,4,8,16 meters) is observed, it should be possible to connect up to 13 PETs, a printer and a disk drive (for a total of 15 devices).

Obviously extended capabilities are possible, but nothing can beat this price. (We are working on hardware and software facilities that would signal the user that the peripherals are in use, or that would inhibit access if the peripherals were in use, etc.)

Full credit for this startling discovery belongs, not to the author, but to Dick McLemore and Earl Hicks who work in

The Microsoft Z-80 SoftCard. Leading a Whole New Lineup for Your Apple II.

[illegible]

Starting with Two Software Standards. [illegible]

[illegible]

More Power Down the Line. [illegible] Microsoft's FORTRAN, COBOL, BASIC Compiler and Assembly Language Development System. All are available separately to run with the SoftCard system.

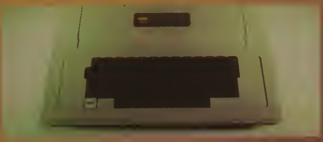
And the whole host of CP/M-based business, scientific and educational applications can be easily transferred to your Apple with SoftCard.

The Microsoft Z-80 SoftCard is compatible with most every Apple product from the Apple II to the Apple II Plus, Language Card and peripherals. Independent peripherals for the Apple are supported as well. The SoftCard package requires a system with 48K and a disk drive.

Line up a SoftCard demonstration at your Microsoft Consumer Products dealer today. They'll be glad to show you how the Z-80 SoftCard and your Apple computer combine to form a system that can't be beat for either practicality or pure pleasure by any personal computer available today. Or give us a call, 206/454-1315, for more information.

But act quickly. At the low price of $349 for SoftCard, CP/M, Microsoft BASIC and complete documentation, you may have to stand in line to get one!

*Apple II is a trademark of Apple Computer, Inc.
CP/M is a registered trademark of Digital Research



MICROSOFT
CONSUMER PRODUCTS

CIRCLE 159 ON READER SERVICE CARD

I/O, cont'd...

the Autonetics Computing Technology Group of Rockwell International. Credit for the capability must obviously go to Commodore for incorporating the IEEE bus into the PET's design. Thank you Commodore, Dick and Earl.

G. E. Eversole
1417 11th Street
Manhattan Beach, CA 90266

More Error Trapping Input

Dear Editor:

Mike Summers and John Willett have written (February 1980), a very nice introductory article on error trapping i.e., programming to handle inputs which are not appropriate but which could certainly be entered by a user of the program. I would like to add to their discussion, which was focused on the TRS-80, a few comments applying specifically to the Apple II, and which would apply to other computers having relevant features that are similar.

First, Summers and Willett give a simple routine to scan an input string for the presence of a specified character. Their suggested modification of it—checking the ASC of substrings rather than checking equality with the stated character as a string—is dangerous, because the input string could be empty (if user merely pressed Return key), and calling for ASC of the empty string generates an error on the Apple. One should first check to see if the string is empty before using this routine—possibly allowing an empty response to produce a complete list of options, or return to a neutral point in the program.

Second, in Applesoft, interpreter-generated error messages (such as refusal to take letters on a numerical input, or resulting from entry of a value like "/E1000") can be avoided altogether by using an ONERR GOTO...before the INPUT step. The ONERR can feed to an error message already in the program for other purposes, or it can go to a separate routine where the error will be analyzed according to type (the code number returned by Applesoft), with corresponding treatment.

Third, in page-display programs, the page presentation can be protected from being over-written by user inputs and error messages, simply by setting a small text window and locating the cursor there, before an INPUT is requested. With a one-line window, the input line (and any interpreter-generated message) will clear automatically; the program can then return to full-screen window, reprinting the input if desired, and putting messages wherever appropriate.

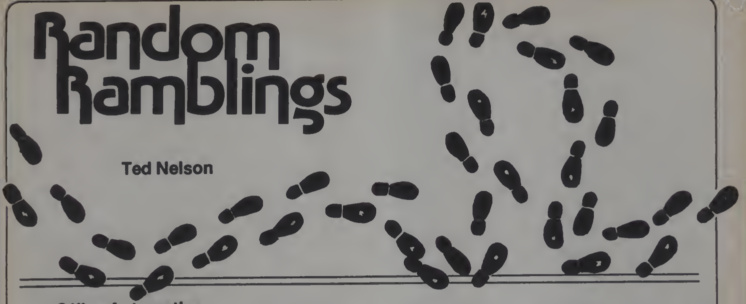
Fourth, for sophisticated applications, other approaches can be used. For example, if I want an input consisting of precisely two letters from some list of letters, plus an integer from 1 to 4095, I can use repeated GETs to get response characters one by one, checking each for appropriateness, printing it out if OK; if not OK, the program can beep and provide an error message, to be cleared either after a time delay or after the next keypress. By using multiple tables of permitted letters and numbers, the same routine can be used to get legitimate responses for a variety of specific items in one program. This method offers essentially complete protection against unwanted inputs and over-writing: even escape or control characters cannot hurt the program, though, of course, Reset will make problems.

Finally, there is no software defense against the Apple's Reset key. This suggests that a good user-oriented program should have at least one safe, neutral entry point, such as "GO TO 5000," to be used after accidental reset to re-enter the program with essentially no data loss. This feature is also quite handy when one is debugging a program!

Robin Ault
Concolor Allied Technical Services
45 Dexter Road
Newtonville, MA 02160

Random Ramblings

Ted Nelson



Office Automation Conference

Here comes the Office Of the Future. OOF, indeed. Never has so assorted a congregation sought so unknown, dubious and uncertain an object—at least, not since a collection of preoccupied fools hunted for the Snark in Lewis Carroll's poetic fable.

AFIPS, that doughty non-profit, tried to be a prophet this time, with their early-March "Office Automation" conference. Many hotshots came, but the attendees may have included more competitors than customers.

One good thing: this was the first computer-type conference I've ever seen that had a decent turnout of women—I'd say 20% or 30%. And a lot of them were smart; the ones in the booth weren't just the usual hired bodies saying "You'll have to ask the salesman." A nice change. (Indeed, a woman, Patricia Seybold, was the star of the Conference. She and her father edit the two Seybold Reports—his on computer typesetting, hers on Word Processing, and she is one of the few people who know which way is up.)

There was much Snark Hunting at the conference sessions: everybody had a different idea of what the office of the future was about, and how central was his own specialty. Personnel managers and interior decorators explained how the Office of the Future would revolve around the personnel-management function and well-done interior decoration (respectively).

There was little surprising on the exhibit floor. The main product, from any number of vendors, was the Word Processor for about $15,000—with screen, keyboard, two floppies and daisywheel printer. Most of them offered "communication capability"—sorry, with our equipment oniy... (There were S-100 machines on the floor, and S-50s. But nary an Apple or Ohio Scientific. I kind of wonder why not; but next year it should be different.)

Of course, a Word Processor is only a disguised computer that perpetually runs a program for text editing. But the little old lady in Dubuque will never know that. There's no explaining it, ever. At least, that seems to be the fundamental principle of the office automation industry. Sigh.

Everybody had a different idea of what the office of the future was about, and how central was his own specialty.

One company that knows what it's doing in this area is Exxon. Besides the Qyx daisy-wheel (with hidden computer, and options, and options), Exxon has acquired the Vydec as its top-of-the-line word processor. In addition to which, another little Exxon subsidiary was selling very nice liquid-crystal text displays for one line of characters.

The Brooding Presence Of Xerox

The main company at this conference was Xerox, both on the floor and in the sessions. (The phrase "Office of the Future" is essentially their phrase, though what it means to the corporate management back in Rochester—where Paper Copies have been the center of the company's thinking since 1964—is by no means obvious to us computer freaks.)

For those of you who came in late, Xerox Palo Alto Research Center, or PARC, is the high-octane research tank where the hottest work is going on. They're best known, perhaps, for Alan Kay's Smalltalk language *(see review of West Coast Computer Faire);* but there they build the Alto, the hotshot computer with super graphics screen. We all thought the Alto was a research machine, until it was recently revealed that they've been installed at the White House, the Senate, the Congress and the CIA.

Xerox was in the sessions with hot stuff. For instance, Ira Goldstein of Xerox PARC described his PIE system, which runs on a super-Alto called the Dorado, and allows the same material to be organized by multiple researchers according to their respective viewpoints. (I was pleased to hear him compare it to the lengendary Xanadu System (TM), more of which will be heard in these pages.)

The Xerox pavilion on the exhibit floor supposedly featured the Ethernet, an extremely important development. The exhibit had a magician, literally, but not much information. Repeated inquiries led to an individual named Ted Rubin, who *knew* about Ethernet, but was not authorized to tell me very much.

Fortunately I already knew that Ethernet was the system worked out at Xerox PARC for interconnecting computers and other devices promiscuously. It's basically a video cable with magic boxes that eliminate

Ramblings, cont'd...

arguments over which device gets to use the video cable at a given instant. A device looks at the cable and, finding it empty, begins transmitting; if two devices do this at the same time, they both back off and wait a random interval. Simple and straightforward.

Ethernet is to be the fundamental transmission line of Xerox's OOF. Hundreds of computers and terminals—the distinction is of course becoming blurred—can be put on an Ethernet line.

But Xerox is not just selling cables and plugs. You can't buy an Ethernet yet, and when you can, you must buy a "File Server" with it. Now, the File Server is Xerox's new term for a back-end document storage machine—a computer that holds documents and provides them to the other devices. When I pressed Mr. Rubin on the characteristics of the File Server, he was apologetically vague. (I am unable, indeed, to distinguish in my notes between what he said, what he hinted, what he allowed me to conclude, and what I merely decided. In all respects, he did not say or hint much.) How big would storage be? Big. My conclusion is "probably hundreds of megabytes on the initial offering," but that is conjecture.

A more interesting question about the File Server: How big a document will it hold? I got the impression that a document could be as big as all storage. This could be fun to see.

Three very interesting new machines were offered in the Xerox exhibit, all explicitly compatible with the as-yet-unavailable Ethernet. The 850 whatsit has a screen and a keyboard. You can use it for word processing, but you're not allowed to program it—except in FDL, or Forms Description Language, which lets you design business forms right on the high-resolution, Alto-like screen. Then when you're done, the forms (blank or filled in) can whip right off the 9700 *printer* (xerographic, naturally), which is connected to it by the Ethernet.

You say you like that word processor, or whatever it is, but you want to program it? Step right up. The 860 is just like the 850—screen, keyboard, table, floppies—except that you can program it. It has about the same multi-typefont hi-res screen as the Alto. But is it an Alto? Can you program it in Smalltalk? No, *Basic*. But at fifteen thousand bucks it made all the other word processors at that price look sick.

"We don't sell the Alto," Rubin said when I asked. I suppose you *give* it to the White House and CIA.

At the cocktail party I met a young couple who were responsible for the Altos at the House and Senate. They complained about having to call Xerox PARC when something went wrong.

One of the luncheon speeches was by Richard Harden of the White House, saying pleasant general things about their need for computers. I asked him afterwards what he used *his* Alto for, and did he program in Smalltalk? No, he just used it for a Word Processor and to keep his schedule on.

Gee. I asked what program he used for scheduling. He said he just did his schedules on the Word Processing program. Ah, the wonders of technology.

The Xerox exhibit had a magician but not much information.

Speaking of wonderment, IBM had a new product there. They have taken a clear and simple idea and made it devilishly ibmish.

The IBM Document Box

IBM's special new offering is the 5520 "Electronic Document Distribution System." It is, of course, a computer in disguise, but in the psychological sense it is a Giant Word Processor: that is, something in there runs it according to some sort of plan, but you can't change the program.

It's from the General System Division, in Atlanta, and in a way represents the increasing hidden conflict among IBM's divisions.

(The great expansion phase of IBM took place when nobody had computers, and their sleek salesmen seemed to have all the answers. Now all the easy customers have been taken, and the remaining prospects have gotten sophisticated, and so to maintain IBM's traditional rate of growth they must now aggressively find new areas which *don't conflict with the old ones*. This is going to be extremely difficult, and this is why I do not consider IBM a growth stock.)

Anyway, the 5520 Electronic Document Distribution System comes in four models, called, not astonishingly, the 20, 30, 40 and 50. They offer on-line storage from 29 to 165 megabytes, plus two (!) removable diskettes. The 5520 can have up to 16 (?) communication lines and up to 18 (!) work stations.

The system, explained the salesman, is "optimized to text." It uses a new code, called WORD PROCESSING EBCDIC! This concept gives special status to carrier-return codes and required hyphens (as in "state-of-the-art"), and allows users to *control easily what effect these special characters are to have.* An original conception, that: a whole new internal code just so there can be different kinds of formatting.

Now, perhaps you were wondering if this device will communicate with other devices. Why, sure, via the special unique IBM incantations. It can communicate with another of its kind, via "SNA/SDLC"; to a bisync device; or to a 370 "host" via SNA/SDLC (but requiring special host programming).

The salesman explained briefly that the system had been carefully thought out with respect to access, format, authorship, privacy and retention. Each of these concepts had its own formalities and subclassifications.

This, then, was IBM's equivalent of Xerox's File Server: complicated, restricted, obtuse in conception and able to deal with other devices—even their own—only through a megilla at the other end. As distinct from Xerox's sweeping, clearminded, uncluttered offering. (You could even put Ataris and Apples on an Ethernet. Damn good idea, too.)

Anyway, IBM's Document Dissemination System terminals are nice-looking.

West Coast Computer Faire

Here we go! California, Garden of semiconductors! In from the sunlight we come, and here are the crowds and noises, jillions of uptight and overweight people wandering around to the din of croaks and tootles from many computer loudspeakers. Upstairs are the classy, corporate-image exhibits; downstairs are the mom-and-pop firms and, for the chipmonks, the great greasy components bazaar.

While other machines were there in force—S-100s, and TRS-80s, and other smaller brands like Heath and TI and Atari, the clearest message of

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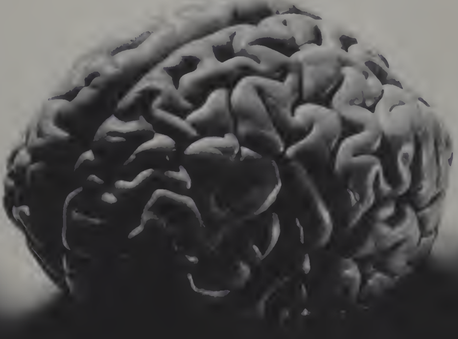

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Ramblings, cont'd...

Held March 14-16, 1980, Jim Warren's Fifth West Coast Faire had the best attendance of any of the series of Faires—over 19,000.

After megahours of visiting exhibits, the area between the two exhibit halls turned into a makeshift lounge/commune.

Practically wall to wall people for three days!

Could we really give out 16,000 catalogs in three days? Yes we could.

the show was that Apple has consolidated its position as the leading serious personal computer. And its margin appears to be increasing. (This is not a statement of preference, but a statement of fact as I see it; however, it did persuade me to buy one.) There were Apples upstairs and down, often associated with important other stuff.

For instance, here was a fairly complete piano keyboard for the Apple: the Alpha Syntauri. It reads up to six keystrokes in parallel, time-slicing at 200 hertz. Okay, you can't do four-hands compositions, but we're getting there. A thousand dollars. (Uses two ALF synthesizer boards, which cost extra.)

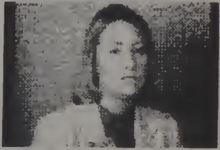
Important new products appeared for that neglected but nice machine, the Sorcerer. Exidy offered a mini-floppy drive for $1100 that connected directly to the Sorcerer without needing the S-100 adapter—a box whose bigness and cost have made it the stumbling block for Sorcerer owners. (Another maker brought out a similar unit.)

Two remarkable S-100 accessories were downstairs, each in the

Our minibooth downstairs did a fair business in T-shirts, records and games.

Howard Harawitz playing an Alpha Syntauri keyboard. It is interfaced to an Apple through a special interface board and uses two ALF synthesizers to play the music. The bars represent each keystroke with the height proportional to volume. The system was designed by Charlie Kellner and is available for $1000 from Vaille Associates, 3506 Waverley St., Palo Alto, CA 94306.

The International Apple Corps (a collection of Apple newsletters) booth was showing the new Apple thermal printer coupled with a Sony camera, an interface board from MicroComputer Technology Unlimited and software by Bob Bishop to make computer images.



Computer image of Julie A. Bengston.

thousand-dollar range. One is the CAT, a real-time frame-grabber that will snatch digital pictures from an incoming video signal, and do contour recognition, on the way to delivering a digital picture into memory. Among its lovingly-designed features are a movie-camera synchronizer and, of all things, a smooth-scrolling text display.

Then there was the Casheab music synthesizer: *thirty-two* separate channels, each humming its own *programmable waveform*. Mr. Casheab, of San Diego, offered matching software to keep all the channels humming along, shivering their timbres to your desire. Don't expect the machine to get anything else done in the meantime; it won't have any.

Quasar and Ithaca Audio, among others, advertised their Z-8000 boards for the S-100, but nowhere were Z-8000s running. ONYX, which has announced UNIX with a Z-8000, showed a box with a Z-80 in it, but that was all. Other unusual machines included Multibus computers and a native-Pascal box called the Pensée (after Pascal's book) but pronounced by some Pennsy (after the railroad?—not a good sign).

There were the usual game paddles, light pens, wooden computer

Ramblings, cont'd...

Jade had a cute "Lucy style" stand set up at one side of their booth.

stands, floppy disk racks.

Much, much software was there, but what can you tell about it walking past? Many people, including Scott Adams—the originator of it all—were offering Adventure-type games. (Personally, I find programs that pretend to converse with you offensive, but that's a matter of taste.)

The most original new software appeared to be Bob Lafore's "interactive Literature" for the TRS-80; one item was a mystery story that you're in, called *Local Call for Death*. Watch for a review in this magazine.

There were two extraordinary hardware announcements.

Hardware From Microsoft

One of the hardware announcements, curiously, came from Microsoft, a programming house. This was a Z-80 [board for the Apple—allowing you to run all that nifty 8080 and Z-80] software on the Apple directly. Yes, a renowned software firm, whose Applesoft is widely loved, is selling a *physical object*. (No plan to become "Microhard" was mentioned.) It goes at about two megahertz.

They were very eager to explain their product. Part of the reason for making the board was that they didn't feel like rewriting all their precious 80-family software, at this point in time, for the Apple. (Such a rewrite would of course be a rather odd thing to do in the present time-frame, with 16-bit processor chips right around the corner.)

Now, there's good news and bad news about this Z-80 card. The good news is that you'll be able to jump from the Z-80 to subroutines on the 6502. The bad news is that you won't be able to subroutine from the 6502 to the Z-80. (But maybe if you can monkey with the stack and make the Z-80 just *think* it's in control...)

Another reason for the Z-80 board, they told me, is that they thought all those Apple users should have the benefit of CP/M. *What?* Hey, I asked, what about those of us who love AppleDOS? Well, they hadn't thought of that, they just assumed that anyone who had an Apple would be only too glad to hack all his filenames down to eight characters and switch over to CP/M. My strong reaction, and perhaps those from readers, might help persuade them to make the Z-80 card accessible from AppleDOS. But, like everything else that makes sense, don't assume it'll just happen.

(One especially desirable use of the Z-80 Apple will be to support the new Z-80 Smalltalk from Rosetta! For those of you who don't know about it, Smalltalk is a language that's been locked up in Xerox's Palo Alto Research Center ("Xerox PARC") for twelve years—while language heavies, graphic nuts, simulation fans and others jumped up and down with envy. Smalltalk is a language that allows multiple independent processes, super graphics and incredibly powerful compact programs. Watch this magazine for developments.)

Publisher David Ahl was taped for cable TV at the CoEvolution Quarterly booth. We're glad that Stewart Brand (Whole Earth Catalog) had the foresight to send people like Lorrie Gallagher to the Faire.

Monster Memory

The other very special hardware announcement at the Faire was Corvus' announcement of a networking system (the "Constellation") and a videotape backup for its Winchester disks (the "Mirror").

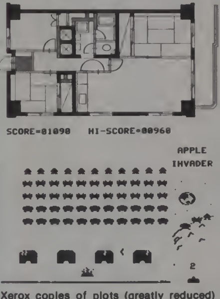
Corvus already has a good reputation for its big little disks—the shoebox-sized ten-megabyte Winchester for $5000 and change—so they're off and running with a certain amount of credibility. The new offerings are elegant and incredibly cheap, so if they work they will be extremely important.

For openers, both the Constellation and the Mirror require the Corvus ten-megabyte disk, so if you've already spent the $5500 for that these are simply minor accessories. The Constellation, which stands in the place of the original computer you hooked the disk to, is essentially a switch between machines. It now stands as a hub, allowing you to hook up the disk to *eight separate computers*—and use their own respective operating systems! Now, if eight computers aren't enough, and of course that's how most of us feel, you can replace these eight computers with eight more Constellations, and hook eight computers to each of these. This gives you a network of sixty-four different personal-type computers. Now consider the price: $750 per hub. That means that the full set of nine costs only $6750—a low price indeed for a network hookup.

Ramblings, cont'd...

Now let's talk about the software. Corvus offers drivers for the Apple, the TRS-80, the S-100 machines and others, all interfacing to the Corvus disk. Surprise! The space in the Winchester disk drive is managed by the Z-80 computer already built into the drive itself! Supposedly the system can be set up for use of those megabytes in various different ways—some of it can be set aside for private use by individual users, some of it can be allocated as shared read-write space for multiple users, some of it can be read-only program storage, and—wonder of wonders—some of it can be used as *pipes* between programs, as on the legendary (and much more expensive) UNIX system. Output can be buffered asynchronously from one computer to another via the disk, and used automatically on demand. (In the IBM world this sort of thing is called "spooling"—but these guys offer it for use on one *or more* machines. They also claim to offer password security.

The Watanabe MIPlot was an impressive plotter from Japan being shown by Astar International. It is termed an intelligent plotter" because of its built-in character generator, printing mode and 8 plotting commands. It is easily driven by an Apple or other small computer with parallel ASCII output. For information, write Astar, 5676 Francis Ave., Chino, CA 91710. Price is around $1200.



Xerox copies of plots (greatly reduced) from the MIPlot plotter.

If this package works, it will be the poor man's ETHERNET—especially useful for schools, colleges, publishing and small businesses. Good luck, fellas. Anyone who can write specs that terrific ought to be able to make the hardware work too. *(For discussion of the Ethernet, see review of the "Office of the Future" Conference, this issue.)*

Oh, I forgot to explain the Mirror. Have you wondered how you're going to back up ten megabytes in case of a crash? On floppy disks, you say. Add it up—that's about a hundred floppy disks, very roughly. Surely you jest. That, indeed, has been one of the questions about these Winchesters.

Well, the Mirror is Corvus' answer. Another $750 wonder, it attaches to their disk drive and to a video recorder. Which one, you ask? Well, they claim to have engineered the Mirror to work with NTSC (the TV system used by the United States, Canada and Japan), PAL (the system used by most of Western Europe) and SECAM (France and Russia). It stores five bytes per horizontal line, which is very conservative use of the technology, and stores a megabyte in one minute of tape, using quadruple redundancy. Oh yes—if you want fully automatic operation, they recommend the Panasonic NV8200, a VHS-format device, at $1300. So there you are: 100 megabytes on line and automatically retrievable for two thousand bucks. (Assuming, as always, that you have the Corvus disk already.) Gee, I remember when DEC offered a 32K disk for the PDP-8...

The last product I'm going to mention is a real Stinger. As we were packing up the *Creative Computing* booth, Dennis Allison (of Dr. Dobbs) showed me a little object from Sharp. It was in one of the "language translator" packages—a shiny palm-sized object, it had one row of liquid-crystal readouts.

A Basic machine, it holds a thousand lines of Basic. It costs a hundred and seventy bucks. It's now available in Japan; look for it here after Christmas.

Maybe you newcomers aren't impressed. But it makes us oldtimers *really* feel old. Shucks, the first Altair was...lessee...well, the first one *worked* only about five years ago... □

On Buying Printers and Other Fun

Part II

David Ahl and Steve North

> **Instant Update**
>
> *Last minute update on Escon. The typewriter broke when an adjusting screw in the spacing mechanism sheared off—Obviously Selectrics were not born to be computer printers and can't take the steady pounding of their innards. Possibly ours was not adjusted to specs which caused the failure but we have no way of verifying this.*

In our first installment (December 1979, pages 28-31) we related some of the Real Life trials and tribulations of buying and getting operational six different printers. As long as one regards one's computer operations as a Real Life Game, this might be considered fun. Otherwise, one more cynical than we might describe it as Frustrating (with a capital F).

The lead-in to the original article playfully suggested that we might lose several printer advertisers. This indeed happened; it doesn't take much imagination to figure out who they were. We received many letters from subscribers thanking us for "an objective job," "a courageous, hard-hitting review" and so on. Unfortunately the competition for advertising is so cutthroat that none of the advertisers that left us have returned and, although we are first and foremost committed to an objective review policy which serves the interests of our readers, obviously it does not serve reader interest to have us go bankrupt. All this is by way of saying, that if you like *Creative Computing* and our review policy, drop us a line, but more important, send a copy or a note to companies that are or should be advertising in *Creative*.

In this second in a series of N articles, we present first some follow up from the previous piece and then a discussion of some new printers. In our next installment Peter Brennan describes his experience with the Anderson-Jacobson 841 Selectric-type printer.

Teletype Model 43

This remains the workhorse of the stable. Its home now is with an original Altair 8800 (not A) computer running Electric Pencil and living in our marketing department. The '43 keyboard is the system input device while its printer is the output device for rough drafts and internal materials. An Escon-modified Selectric is used for letter quality output. (More about that later.) The '43 is also used occasionally to dump Pascal programs from our Apples or when we need more than 40 columns. Its reliability is astonishing—the only thing we ever do is change ribbons and boxes of paper.

Qume Sprint 5

Talk about striking a raw nervel We got so many letters saying something to the effect, "I thought it was only mine" or "well at least you had a Qume service depot an hour away; our closest one is 800 miles." On the other hand we got letters and phone calls from Computer Textile (who sold us the Qume and of whom believe it or not, we think very highly) and Qume themselves (about which, more later).

One gloomy Friday afternoon we got a 4-liter bottle of not-very-good wine (which seemed appropriate) and sat around reading all the pathetic letters from Qume owners. It reminded me of an afternoon at one of the wineries at Hammondsport, NY in my youth when we had a half dozen owners of Triumph TR-2's (Yes, 2's) gathered 'round telling about how their dashboard burst into flames at 10:57 p.m. on a snowy Saturday night whilst calmly motoring back to campus with a date who had to be signed in by 11:00. Clearly most owners had a love/hate relationship—their Triumph had totally done them in (generally several times) at the worst possible moments, yet nobody could imagine owning anything else.

The relationship between man and his Qume seems to be much the same. Except for one poor fellow in New Orleans, no one sent his back in utter disgust, yet everyone had his tale of woe. I wish we had room for all the letters, particularly the one of Keith Antcliff who describes himself as "Qume Lover...sometimes." Keith

Our Qume Sprint 5 (with IMSAI,Thinker Toys Disk and Monitor) is the workhorse of the editorial department. We find roll-around AV carts or microwave oven carts good housing for our systems.

has had ribbon problems: "...be prepared for the ribbon to catch on the daisy wheel and jump to the wrong side. It would appear this may be an adjustment problem. Don't expect any factory help. You can buy a tool from them for $25.00. It consists of a six-inch piece of ¼ inch key stock with a poorly-milled slot to fit the metal pieces that go on the ribbon guides. You deform these

Buying, cont'd...

for proper clearance. That doesn't seem to cure the problem, however."

Keith also found out, the hard way, that the Qume factory warranty starts when they ship a unit to the Dealer and lasts 90 days. Too bad if it sits on Mr. Dealer's shelf for 90 days or more. On the other hand, it seems that Qume was sensitive to this problem and, according to a letter from David Witkowski, Data Terminal Marketing Manager for Qume, a 90-day on-site warranty program is now being offered in conjunction with Sorbus, Inc. and is available in 29 cities. Hurrah! He also claims that many sales dealers now service the Qume as well and that Qume gives them an extra discount for doing so. Again, our applause!

Keith subtitled one of his longer sections "Carriage Slams to Stop." He notes, "If you haven't had this happen yet, you are in for a real treat. It is a real shock to see your pride and joy hammer itself against the stops...I suspect the force is sufficient to trigger fission in a poor uranium sample!" Factory response: "Gee, we haven't experienced that before."

By now, all of you are getting the wrong idea about the Qume. Let me say categorically: I love it! Since ours got its (expensive) tune-up it has been well-mannered and has not had a single nanosecond downtime. The print quality is flawless. Although it goes through ribbons and typewheels like crazy, we have found several economical sources of both. These aren't the only places, but for typewheels, we got good wheels and service from AGT Computer Products, 10906 Rochester Ave., Los Angeles, CA 90024. For ribbons, we got Qume originals at a good price from Supreme Magnetics, 1545 Pontius Ave., Los Angeles, CA 90025. Be prepared to buy at least 36.

On the other hand, if you are forced to use Qume service as we were, have a cashier's check ready because, as Mr. Witkowski explains, "we have received so many bad personal and small business checks that we cannot accept them." Welcome to the club. Also, expect the same service as we got since, "Qume cannot and will not discriminate in favor of large or well publicized customers regardless of the threats they may make." Did we make a threat?

To give Computer Textile its due, we purchased our Qume Sprint 5 from them. As we noted in the first article, we got good delivery and had no complaints. As far as we're concerned, Ken Widelitz of Computer Textile is doing an excellent job and went way out of his way to help us get service here on the east coast. So if you want a fast, high-print-quality, reliable-once-it's working printer, get a Qume Sprint 5 from Computer Textile, 10960 Wilshire Blvd., Los Angeles, CA 90024.

Selectraterm

We were duly chastised by both Shelly Howard and the present owners of Micro Computer Devices (the manufacturer of Selectraterm) for mentioning one in connection with the other since, apparently Shelly Howard sold the company shortly before the article appeared. Sorry, folks.

Micro Computer Devices (MCD) is currently trying to arrange for local dealers to service that product after they sell it—an excellent idea. A sharp improvement over a year ago is the fact that there are three servicing dealers on the Atlantic seaboard. Yep, it could be better, but it's better than air express back and forth to California.

In six months, our Selectraterm has not broken down once and it has been in very heavy service. Print quality is excellent and, for letter quality printing at a modest price, it seems an excellent value.

(As fate would have it, just last week it broke down and we are now trying out the much-touted new service arrangements of MCD. It seems that a microswitch that tells the computer when the typewriter has shifted just died for no reason.)

Escon E-A Interface

The Escon E-A Selectric interface is a modification that converts an ordinary office Selectric into a computer printer. When you manually depress a key on the Selectric, this sets in motion the mechanisms which position the typeball, push it against the paper, and move the carriage to the next position. The Escon conversion installs inside the typewriter and manipulates the levers and trips from within to make it print.

The conversion consists of three sets of solenoids and the associated electronics. One set of five solenoids controls the selector bars which position the typeball to print a particular character. A second relay manipulates the shift lever. A third set of relays controls the basic functions of the typewriter: print, space, and return. This set of solenoids can make the typewriter do most of the same things you would by typing on it. An additional option (which we purchased) handles tab and backspace. Tab is pretty much useless for computer applications, but backspace is handy for underlining with a text editor.

You can buy the conversion as a kit and install it yourself, or have it done at the factory. Since the operation seemed simple enough and we did not like the idea of shipping our Selectric cross-country

Disassembling a Selectric is not for the faint of heart.

and back, we installed the kit. It took about two weeks of working on and off, or a total of roughly 20 hours. The manual has 15 diagrams and illustrations to help you figure out how part A fits into part B, but despite this praiseworthy effort it is not always successful. The installation involves more than just bolting on a couple of solenoids since several of the original typewriter parts must be temporarily moved to accommodate the conversion. A few times the job seemed more like microsurgery than anything else (at

Some of the Escon solenoids and other parts that will soon make their home in the base of our modified Selectric.

least to someone not previously familiar with the Selectric). Once installed the solenoids must be adjusted to within a sixteenth or thirty-second of an inch, so one needs a certain amount of mechanical skill and patience to install the kit. If you would not be likely to remove the cover of your Selectric for any other reason than to change a ribbon or typeball, this would not be a good place to start.

Buying, cont'd...

Overall, we like converted Selectrics for word processing since they are relatively inexpensive and produce professional-looking output. The Escon is the least expensive Selectric modification that has the "approval" of IBM. The repair record on our two units (Escon and Selectraterm) has not been impressive, primarily because any conversion is a mechanical kluge and the typewriter simply isn't designed for high-speed computer printing. Subsequent to the installation we were informed that the Escon is not designed for rebuilt Selectrics which probably explains why ours has needed several readjustments. However, dot matrix printers do not produce output of sufficient quality to use for any documents we send outside, and daisy-wheel printers are much higher priced and expensive to maintain.

Just about finished. Next step: adjustment and checkout.

Malibu 165 and TI 810 Printers

In our last installment, we said that the Malibu printer had never let us down. Well, computer fans, (read this aloud in your best Twilight Zone voice) "Too Bad." One day the Malibu printer suddenly stopped printing although the printer-ready status signal seemed to work OK. After checking the manual we called Malibu, hoping to get an easy answer to our problem, so we could avoid sending the printer on a vacation to California. They suggested the problem might be the I/O card inside the printer so we unplugged it and sent it back. Sure enough, a few weeks later, we got a call from Malibu asking why they had our printer card lying around. Hope we get it fixed someday. Naturally, there is no Malibu repair center anywhere in a 1000-mile radius.

Meanwhile, the TI 810 broke a tractor when the paper jammed. Is that really such a big deal that the printer should break? However, the tractor was repaired in 10 minutes with Crazy Glue and the printer has been up and running since. Despite the minor problem we still very much like the TI 810 as a high-speed dot-matrix printer and it remains one of the best printer buys on the market.

Trendcom 100

This is a 40-column upper and lower case thermal printer which we bought for our Apple. We considered getting an RS-232 interface card to connect to one of our other printers, but this one was available for $400 from Advanced Microcomputer Products (nice people) so we decided this was the best value. The printer is exceptionally quiet and compact, which seem to be underrated considerations in printer design for personal computers. After all, doesn't it seem a little ridiculous to have an 80 lb.printer puttingout 70 dB connected to personal computer that's only half as big, weighs 20 lbs., and is completely silent? The Trendcom comes with a parallel I/O card with on-board firmware so the printer can be activated from Basic with PR#x, so interfacing couldn't be simpler.

Of course, the main limitation of this printer is that it is only 40 columns wide, which is probably OK for Basic but a pain with Pascal or for printing reports. Trendcom also has wider carriage printers which you should check out if you're buying one for your Apple. We also hear the the Trendcom 200 has the ability to print hi-resolution graphics screens, a very nice extra. With a resolution of 60 dots per inch (horizontal and vertical and a price of $575, the Trendcom 200 is virtually in a class by itself. (See sample output.)

Radio Shack Model 779

This printer is really a Centronics printer underneath the cheap plastic. (Why does all Radio Shack computer equipment have to be cheap plastic?) The printer has adjustable tractors and adjustable print width, but is upper-case only. The printer mechanism was apparently designed for bi-directional printing, because the carriage returns at the same speed as its forward print speed but this feature is not used, so it is unnecessarily slow in carriage returns. It's also the noisiest printer we have and the print quality is nothing to brag about. Nevertheless we have used it for the listings in both of our TRS-80 games books and miscellaneous articles, and it has never required repairs. Radio Shack has other printers which are better for text editing, and we feel that there are better dot-matrix printers. On the other hand, the 779 offers adequate performance, Radio Shack nationwide service, and good reliability at a modest price so it should definitely be seriously considered.

Printronix P-300

For the most discriminating of users we present the Printronix P-300. This is a 300 lpm (that's lines-per-minute in computalk) little number we have lying around for printing subscription labels, invoices, reports, etc. It is connected to our PDP-11 of which we have already made more of a fuss than it

Buying, cont'd...

could possibly deserve. You might expect an expensive high-tech printer like this to be immune to the usual problems and, in general, it has. Nevertheless, we were forced to install static protection mats because the entire system would crash if the Printronix printer was given a tiny blast of static from one's pinky. The printer has several nice features: the ribbon is mounted diagonally so that its entire width is printed on; the printer does 4 or 6 lines per inch; and it has an anti-static device for the paper which passes through it (alas, not for the printer itself).

A "reliable rumor" has it that DEC is buying these printers, sticking their own label on them, and marking them up 100%. Something to consider if you're buying a printer.

Heath H-14

Our H-14 is attached to a word processing system and is used primarily for printing documents for internal consumption. It is a low-cost, low-speed, dot-matrix printer. We purchased it in kit form and it was painlessly assembled by a student working for us last summer.

Yes, that's the kitchen which is the (temporary?) home of our editorial WP machine.

The printer can only run at 30 characters per second without handshaking, but we find this speed acceptable since one can usually edit a document, begin the printout, and walk away for five or ten minutes while the printer is working. The text editor we're using with it, MicroPro's Word Star, also does print spooling internally so one may print one document and edit another simultaneously.

The only thing we don't like about the H-14 are the weak hold-down springs on the clips which hold the paper against the tractors. A very minor point, certainly, since we haven't had problems with paper jams. At $625 (kit) this printer is an excellent value. □

Percom's Microdos

Thomas Andrews

Let me go on record right away. I really like Microdos. True, as we shall see, it lacks some of the "sophisticated" features of systems like CPM or even the new TRSDOS 2.2. But it has another feature I have come to appreciate more than any other — rock solid reliability. Microdos is a complete disk operating system written expressly for the TRS-80 by Jim Stutsman, and distributed exclusively by Percom, Inc. of Garland, Texas. In my case, it has made the difference between a computer I can use in my business, and a computer that was so unreliable it was useless. Microdos is very different from TRSDOS. It is designed strictly for the Basic programmer. It has no assembler, debugger, program language dump, etc. In fact, Microdos totally lacks the much-touted automatic features of TRSDOS, such as dynamic file allocation, named files and built-in directory. But there are useful trade-offs. To begin with, Microdos requires only 7K bytes of memory while TRSDOS needs 10K. In addition, with Microdos, once the system is loaded, the DOS disk can be removed and a full data disk substituted because the entire system is continuously resident. With TRSDOS, the system disk must always be available to the computer because parts of the system are moved in and out of memory to perform various functions. Since Microdos was written with the Basic programmer in mind, it automatically brings up full disk Basic whenever the system is booted in. With Microdos, there are no named files. All files, both program and data, are accessed by a simple reference to a particular sector number on the disk (as many as 4 drives are supported).

This means that you, the programmer, are responsible for knowing where files are located on the disk. However, in exchange for this relatively minor inconvenience, you always know where data is stored, and you can "map" the location of your files in advance. And since you set up the allocations scheme yourself, you never get a "DISK FULL" error message. This is particularly important in dedicated business applications, since strange error messages are the last thing your secretary needs to worry about while operating the computer. From the viewpoint of the programmer, Microdos files are accessed very simply as D0SSS, where D is the drive number from 0 through 3, and SSS represents the sector number (the zero always separates the drive number from the sector number). In the case of a program file, reference to the first sector of the program will cause the entire program to be saved or loaded in its entirety starting at the stated sector and ending automatically at the last sector used for that program. When saving a program, Microdos will display on the screen the last sector used to store the program so you can maintain your own directory. Microdos also supports a nice MERGE feature which enables you to bring two programs together. This works exactly the same as TRSDOS, except that it is not necessary to specify an ASCII format for program files. Microdos also provides a means of determining the last sector accessed, the last drive accessed, and the total number of bytes entered or retrieved in the most recent disk I/O operation. Random access files are supported in a manner entirely similar to TRSDOS. In fact, I have taken all my business programs, and rewritten them from TRSDOS to Microdos in just a few evenings. This is made easy by the buffer structure which closely parallels that of TRSDOS.

Microdos was written with the Basic programmer in mind—it automatically brings up full disk Basic whenever the system is booted in.

One of the secrets of Microdos reliability is that all files, both program and data, are contiguous. Thus a file begins at a stated sector and progresses through successive sectors until the end. Files are not scattered at random points on the disk as may happen with TRSDOS. This eliminates the need for an "on disk" directory, and the processing time necessary to refer to it. In using Microdos, you will be pleased to find that it is not necessary to OPEN or CLOSE data files. In the same vein, there is no KILL utility, because there is no directory to worry about. To use disk space for a different purpose, it is only necessary to overwrite the old information with the new, and this is true of both program and data files. If you have ever had a dedicated application in which TRSDOS spent endless time thrashing around looking for a named file, you will really appreciate the simple Microdos approach.

Microdos includes many of the Radio Shack Disk Basic features you may have found convenient, including instr and Mid$(A$,B$). The "clock" feature has not been implemented, but the keyboard has been very effectively debounced.

Although it lacks some of the fancy utilities of TRSDOS, most of

Thomas R. Andrews, WLKI Radio, Angola, IN 46703.

Microdos, cont'd...

which are of interest to machine language programmers, Microdos does include the essentials, including a copy and backup feature as well as other utilities which are, incredible but true, written in Basic, so you can modify them or include all or part of them directly in your own programs. For example, in my payroll program, I have an automatic backup feature which requires no extra effort from the operator, and makes sure that a proper backup is created. For dedicated applications, Microdos can be self-booting, automatically answering the MEMORY SIZE? question, and loading and running a program. This way you simply insert the main program disk, press reset and go!

What about bugs? Well, I received one of the first copies of Microdos, and only two bugs showed up. But not to worry! Within a week after I called Author Stutsman concerning a program save problem I was having, I received an update! This was the only fix needed, and the system has worked flawlessly since then. With Microdos, fixes or updates are easy to make. Each

I have taken all my business programs, and rewritten them from TRSDOS to Microdos in just a few evenings.

copy comes equipped with a special "Fixit" utility which makes it possible to alter Microdos by simply adding data lines to the "Fixit" program which is written entirely in Basic. Neat! And, the updated version of Microdos can be applied to all existing disks without disturbing any program or data files on them. The only thing that changes is *Microdos itself.*

In conjunction with Microdos, I have been using Siemens disk drives also purchased from Percom. Although Microdos will work fine with any minifloppy drive of 35, 40 or even 77 sectors, I have found the 40 track drives from Percom to be uncommonly tough and reliable. In the better than six months since I converted all of my previously TRSDOS based business programs to Microdos, I have had no disk I/O errors. After using Microdos in extremly demanding business applications, I have come to believe that it is the biggest bargain in computing. It saved my '80 from oblivion just as I was about to give up. Microdos has got to be the best $30 you will ever spend.□

Ed. Note — Microdos is available from Percom Data Company, Inc., 211 N. Kirby, Garland, TX 75042.

For TRS-80 & Apple Systems

Mind-Memory Improvement Course

James W. Garson

After stumbling through a good part of my life as an absent minded professor, the thought of taking Teach Yourself by Computer (TYC) Mind-Memory Improvement Course was quite intriguing. I won't say that it changed my life, but in one sense, these programs clearly worked.

I have devoted something between 3 and 4 hours to the course and I am already able to study a list of 25 shopping items for about five minutes and recall it perfectly. Not only that, I can instantly answer questions like "What is the fifth item on the list?" or "How many things on the list appeared before potatoes?"

The course consists of 10 programs on two TRS-80 (or Apple) cassettes, and an 18-page booklet of instructions, all neatly packaged in a cassette holder. The course introduces you to a simple, but apparently effective, trick. You begin by learning to associate objects with the first four numbers: 1 - ice cream cone, 2 - twins, 3 - triangle, 4 - square. When you want to remember the list red, blue, green orange, you imagine first a red ice cream cone, a blue set of twins, a green triangle, and an orange square. This may seem to be an awfully roundabout way of memorizing, and it is probably not the best way to remember a short list, but once you apply it to lists of 12 or 25 items, the power of the method becomes clear.

The course starts very slowly by introducing you to the objects for the first four numbers. The program presents simple pictures of the objects, and runs you through the objects a number of times. You are then quizzed on what you have learned, and repeat the process if you fail to get all the questions right. The second program lets you practice memorizing lists of four items using the objects learned in the first program. The picture for the first object is presented along with the word for the first item on the list. After a short while, you move to the second object, and the second item on your list, and so on. The whole process is repeated three times, by which time you are bound to have the list down cold.

James W Garson, Dept. of Philosophy, University of Notre Dame, South Bend, IN 46556.

Subsequent programs introduce you to the objects for the numbers 5-12, and then lets you practice memorizing lists of 12 items. I was quite worried at being confronted with a list of 12 names to memorize during my second practice session. But after going through the list three times, and associating with the 12 objects, I had no problem. Don't try to write me off as a genius. My 6 year-old seems to be able to handle 12 item lists as easily as I do, and he didn't go through as much training as I did. The last set of programs present the objects for the numbers 13-25, and give practice on 25 item lists.

Imagine first a red Ice cream cone, a blue set of twins, a green triangle, and an orange square.

I'm not sure that this training will keep me from forgetting to put out the garbage on Sunday night, but it has helped me remember a long list of things I have to do on Sunday night. Taking out the garbage is associated with cat, the object for 9 (cats have 9 lives). Now all I have to do is remember to recite this list to myself on Sunday night!

By the way, the two cassettes I worked with only represent the first part (Step 1) of TYC's Mind Improvement Course. Step 2 includes two more cassettes, and concentrates on improving your listening abilities and abilities to organize as you memorize (people's names, faces, etc.). It consists of 9 programs with an audio tape and 22 page manual.

Though my overall impression of the course is positive, there were a number of oversights that bothered me. The course developers missed an important opportunity. Running the practice programs is a very effective way of learning lists, so why didn't the authors write a practice program that lets *you* type in the items you want to memorize? Instead, the practice programs all force you to learn the lists supplied by the programmers.

This is especially annoying when you realize that the second of the two cassettes contains nothing but 5 practice programs that are identical except for the data on the lists to be memorized. The authors could easily have gotten the whole course on one tape by writing a short practice program that lets you supply the list of however many items you want to learn. Alternately, they could have avoided the second tape by putting the data for the lists on files, which could be read by one practice program.

Before we accuse them of forcing us to buy a second tape, I should point out that their course was obviously designed with the Level I (4K) Basic in mind. (For example, the recorder volume setting listed in the booklet on p. 8 is 7-8, which is correct for Level I and wrong for Level II.) In Level I you can't read data from files, and the limitation of 4K per program may explain why they couldn't write just one practice program which contained data for all the lists to be memorized.

There is a second oversight limiting the effectiveness of their practice programs. It is useful to practice memorizing the same list of items in a different order, so you want the programs to shuffle the lists (thor-

Memory, Cont'd...

oughly) at the beginning of each session. Unfortunately, the practice programs don't do this. Though the first item on a list is picked randomly, the order of the items never changes from one running to another. (So, though milk may be the first item one time and the fifth the next, bananas will always be the item that follows milk.) If you run the same practice program a few times, you will have memorized the order of the items on the list, and the program no longer offers a new challenge. I was surprised at this, since it is a simple matter to give a list a thorough suffle. Once and for all folks, here's how to shuffle N items (stored in array A$):

```
        FOR J=N TO 2     STEP -1
        R=a random number between
              1 and J

    REM
        Now swap item A$(R) with
            item A$(J)

        T$=A$(R)
        A$(R)=A$(J)
        A$(J)=T$

        NEXT J
```

A third criticism I have concerns the quality of the graphics. It was an excellent idea to "draw" the objects on the screen to help you make associations. But many of the drawings don't look enough like the object they are drawings of. The "egg," for example, looks more like a fir tree, and their "cat" is a strange arrangement of lines, and doesn't even have a head. Just a bit more care could have resulted in much more pleasing drawings.

While I am discussing graphics, I should mention that some programs do not take full advantage of the TV screen. For example, during quizzes, you enter a number to indicate your choice, and the list of numbers and items is put on one line like this:

1.RED 2.GREEN 3.YELLOW 4.BLUE

This is a bit awkward on the eyes. In later programs, the choices are nicely spread out in a list, but here I would have liked it better if the choices were alphabetized, so it would be easier to locate the item you want to select.

Finally, I want to mention a chronic problem that appears in most software I have worked with. The programmers have done a poor job of dealing with inappropriate responses from the user. For example, if the possible answers on a quiz are 1-12, and you enter 14, the program simply records your answer wrong, instead of printing a message that the response was inappropriate and asking you to try again. There was a particularly annoying "bug" of this kind that can be traced to their programs' heritage in Level I Basic. For some reason, the INPUT A statement in Level II does not affect the value of A if the user simply hits RETURN (or ENTER). Level I has it right: if you type RETURN, you have tried to store the null string in A, so a polite error message is printed, and you get a chance to try again. This quirk wouldn't be so bad if it weren't for the fact that Level II machines quite often suffer from keybounce problems. That means that you may hit the RETURN key once and have the computer think you hit it twice or three times.

All these "features" of Level II conspire to make taking quizzes with these programs quite frustrating. Suppose you type 3 as the answer to question 5 of a quiz, and your RETURN key happens to bounce. Then you have ended up entering 3 as your answer to question 5, and *also* to question 6 (since your response to question 6 is read as a RETURN, which leaves your answer the same as it was before). On a day when your keys bounce, it is almost impossible to get a 12 item quiz right even when you know all the answers.

The programmers could easily have protected us from this frustration by setting their input variable to zero before any INPUT command, and then requesting a new value for the variable in case it remained zero after the execution of the INPUT. If you look at the code, you can see why the programmers did a poor job here. They should have defined a subroutine to handle the user's input and deal with inappropriate responses. This is an important practice to follow in writing programs for the outside world in languages like Basic where the INPUT command is full of booby traps. It makes life easier on the programmer as well as the user.

All I have to do is remember to recite this list to myself on Sunday night!

To reiterate, the shortcomings I've pointed out notwithstanding, the program did improve my memory skills and I'm pleased with the results. □

The Mind-Memory Improvement Courses are available from:
Teach Yourself by Computer (TYC) Software
40 Stuyvesant Manor
Geneseo, NY 14454

Available in Level I, II, TRS-80 and Apple versions:
Mind-Step I $24.95
Mind-Step II $29.95

Response From TYC Software:

We feel the reviewer did a thorough job of examining our product. However, his criticisms are for the most part differences of opinion rather than oversights on our part.

We have tried to build in inappropriate response routines in as many places as possible in our programs. We agree with the reviewer that the inclusion of these are important. However, in the particular case he cites we felt that it was a judgment call whether to treat it as inappropriate or incorrect.

In regard to his suggestions on our randomizing technique and there being no program to allow the user to memorize his own material, we see the program exercises as only for practice and review. Our philosophy is that the user should quickly learn to use the techniques on his own without the computer as a crutch.

We are pleased to read that despite some minor shortcomings, the reviewer felt our MIND-Memory Improvement Course did in fact help improve his memory skills. We also recently received a letter from a doctor stating that he was using our MIND program with his patients and they were meeting with great success.

Lois B. Bennett
Director of Marketing

I'm all in favor of the democratic principle that one idiot is as good as one genius, but I draw the line when someone takes the next step and concludes that two idiots are better than one genius.

—Leo Szilard

"It's the electronic age all right, Helen... I sometimes think I spend more for batteries than for food!"

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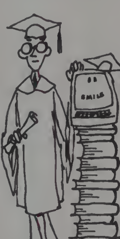

Software for People. The problem with BASIC as a language is that it was developed on timeshare and other large capacity computers. But Microsoft BASIC was specifically designed to run on micros; it's fast, it's simple, and memory requirements are minimal.

All the programs in the *University Software* set were written on micros, for micros. If you own a TRS-80, Apple, Texas Instruments, Atari, Commodore PET, Sorcerer, or Ohio Scientific micro,

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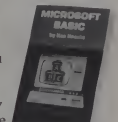

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CIRCLE 146 ON READER SERVICE CARD

"Lindy Squared"

David Ahl

For almost a week in mid-April 1977, passersby were mystified by the gray blocks being painted on the west wall of a garage in downtown St. Louis, Missouri. By the end of April, however, the puzzle began to form a computerized image of the famous aviator Charles A. Lindbergh.

The mural was designed and painted by On The Wall Productions in St. Louis. Up close the 40 x 60-foot mural appears to be a blur of 1160 square blocks in more than 70 shades of gray. But when viewed from a distance the squares coalesce into the face of St. Louis' famous son.

Actually the term "computerized" is not correct. The image was originally produced by Ed Manning of Blocpix, Inc., Stratford, Conn. using an optical system about which Ed is quite secretive. There are computerized systems that can produce the same kind of image of "blocks" which are used in space "photography" or imaging. They are valuable in this kind of work because the image must be converted to digital form for transmission. On the other hand if there are no transmission requirements, using a computer requires unnecessary overhead and time compared to Manning's pure optical approach.

"Lindy Squared" located at 10th and Chestnut Streets in downtown St. Louis.

"Lindy Squared" was one of a series of giant outdoor murals done in St. Louis by On The Wall Productions. Although New York supposedly has over 50 outdoor murals, they tend to be hidden compared to the spectacular settings of the murals in St. Louis. Today the 30 some odd giant murals in St. Louis' "City Scenes" program clearly make it the world leader in this form of art.

If your city would like a giant mural, write Bob Fishbone, On The Wall, 2023 Arsenal, St. Louis, MO 63118. □

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CIRCLE 120 ON READER SERVICE CARD

The Atari Machine

Ted Nelson

The Atari Machine

I first saw Atari's Mean Machine at an education-and-computers conference last September. A lot of pompous Educators had come to receive the word from some Foundation People about the blessings that small computers and videodisk were about to bring to them. I was there with Stuart Greene, an associate and filmmaker who also has a sense of what computer graphics ought to do.

Well, there was a keynote address from the highest Foundation Person, and good things were said; and then a wonderful thing happened.

Up got Ludwig Braun with his fierce mustache and apologetic manner, Lud Braun who has tried indefatigably for so long to arouse the educational establishment to the educational potential of simulation and little computers; up got he, at an Advent screen, and said he had a new machine to show us.

He turned on the Atari.

Here is what we experienced.

We are on a spaceship, cruising at near-light speeds. Stars are on the screen, but they part before us, moving smoothly *out from a common center* as we cleave the void. A low rumble—ship's noise or remanant Big Bang—accompanies our movement.

The pilot turns. The stars still move apart for us, but now the center of diverging motion has moved to another part of the screen. Stars pass each other—they must be the near ones—and we see that the display really shows us moving through stars in *three dimensions*.

PLANETS shoot by.

Enough of the slow stuff. Let's take this baby out for a spin.

Acceleration! The rumble rises in pitch and volume. The stars really start to fly apart. HYPERWARP ENGAGED, flashes a warning on the screen. Faster and faster shoot the stars, as from a Fourth-of-July sparkler, AND NOW THE SCREEN IS RED IN SUDDEN SILENCE, AND IT FLASHES "HYPERWARP"!

And out again! There is roaring anew, and new stars split to let us pass, but we are slowing down now.

The rumble lowers. We have gone halfway across the universe.

Stuart and I were shouting and cheering and clapping. I think I may have been on my feet with excitement. The Educators turned to stare at us. "What does this have to do with Education?" asked their faces. Guys, if you don't know, we can't tell you.

I've been in computer graphics for twenty years, and I lay awake night after night trying to understand how that Atari machine did what it did.

We are on a spaceship, cruising at near-light speeds. Stars are on the screen, but they part before us, moving smoothly out from a common center as we cleave the void.

As I have always known the field, there are basically two kinds of computer graphics machines. The bit-map machines, the video type, have a fixed number of dot positions, and if you want to "move" a shape, you have to keep erasing it at one spot and re-writing it at the next. (The Apple computer's hi-res is of this type.) Either the movement is cyclically jerky, as your movement subroutine reaches different picture elements, or you have to prepare a "next frame" in a different area of core, which may be slow, and flip the new image to the screen when it's all ready. (The Apple allows this.)

Problems arise when a moving figure crosses a still figure; restoring the background after a moving shape has passed is a real problem. Preparing an unseen Next Frame that restores the background is again the solution, but that takes still more time.

Then there's the other kind of graphics machine, the Super kind—the "calligraphic" display—where points and lines are individually placed on a rasterless screen. Special hardware steps through a display list in core, putting each part of the picture where the program says. Each time the screen is refreshed, the points and lines can be moved individually as your program changes the screen positions specified by the display list. (Examples are the Picture System from Evans and Sutherland for \$100K, or in the \$15K ballpark, Imlac's PDS-4 and DEC's VT-11.)

But this, *this* new machine, was something else.

In a package under one thousand dollars, and using a conventional raster screen—a TV—the Atari computer was doing smooth motion in all directions at once, seemingly in 3D.

This had to mean, I reasoned, that there was some sort of a DMA readout from core (as in the calligraphic machines), in order to match the raster-timing demands of the TV screen. But then there would have to be some sort of address translator, allowing the element itself to remain on a display list in core, where its screen address could be changed between frames.

But then there would also have to be some list, corresponding to the picture arrangement on the screen, of where everything was in core.

It just didn't make sense.

Machine, cont'd...

Well, I know how it works now, dear reader, and I wish I could tell you. But, unfortunately, *Creative Computing* as a software producer, has signed a non-disclosure agreement with Atari, so that anything I've learned through these channels I can't publish. But aha, if I can find it out through *other* channels, says Dave Ahl in his Solomonic wisdom, then I can publish it. So I will be spying assiduously, dear reader, to find out what I already know so I can tell you about it. Ah, modern life.

The Atari machine is the most extraordinary computer graphics box ever made, and *Star Raiders* is its virtuoso demonstration game. Be not misled by the solidity of the *Star Raiders* capsule you must push into place; it is not hardware. It is a program.

Yes, friends, all the effects I have described—and many more indeed—can be programmed on the Atari.

There is just one problem.

They won't tell you how.

That's right. You can buy an Atari computer and they won't give you instructions on how to work it.

Everything is under wraps. Oh, of course you can program the 6502 chip, that's in there, same as in the Apple. But that *other stuff*, those mysterious peek-and-poke locations that move the stars, and whatever else they do do, are a deep dark secret.

Now, I'm pretty sure that if you wanted to bring a case before the Federal Trade Commission, there's some statute saying you're entitled to get operating instructions for whatever you buy. So if you want to make a federal case out of it, you can probably get the inside data in about three years for a quarter of a million dollars in legal costs. However, there's a faster way.

Wait.

The hacker's race is on. Who can figure it out first?

Even if nobody violates Atari's elaborate security, I'll wager that most or all of the secrets of the Atari machine will be out by the end of 1980—probably including secrets that the Atari people didn't know existed. Because there is nothing like a real challenge to delight a computer hacker, and this is a real challenge.

Now, there are all kinds of signs in the wind. For instance, one California company, advertising in these very pages, says they have a book on the Secrets of the Atari. Not to mention a disassembler that will ferret out even the deepest secrets of *Star Raiders*.

I called them about the book and they said well, it wasn't quite ready yet, and when I asked for galleys they allowed as how it wasn't quite *written* yet, but I'm sure it will be a very good book when it comes out, and that they won't be the only sources for the information. Because if there's one thing that makes the world go round it's gossip, especially juicy true gossip, like how to control horizontal scroll or interrupt on raster-line count (just to take fictitious examples).

An interesting question is why Atari is bothering to hide the information at all, and from whom. Is the information being hidden from the purchaser of the Atari computer? That would hardly seem proper, let alone sane. From rival hardware manufacturers? Fiddle de dee. The last thing any hardware rival would do would be to sink hundreds of grand in copying the Atari special chips. Anyone who has the temerity to design a computer always thinks he can do it better anyway. (One conceivable possibility is that Third-World Manufacturers might try to build imitation Ataris—as has been done for the TRS-80, but not the Apple. It seems a lot of effort for a far-fetched threat—especially considering the system price, which is an extraordinary value; it's hard to see how Taiwan or the Philippines could compete with it in price for several years. Perhaps the Atari folks are just that sure of their own infallibility that they worry about others horning in on a multi-million-unit market.)

Another interpretation is that the Atari people are trying to hobble potential software rivals. If nobody else knows how to get the hotshot effects, then the Atari guys have an advantage with their software, right? Again a strange notion. Since Atari makes the machines, why do they mind? (Anyway, Atari is being co-operative with independent software vendors, *provided* they don't tell how it works. So the whole thing is very mysterious.)

There is nothing like a real challenge to delight a computer hacker and this is a real challenge.

What It Can Do

The only way to explain fully what the Atari will do is to reveal its internal hardware structure. As explained above, that cannot happen here now yet. However, there is a very simple way for you to study the capabilities of the Atari machine: that is to go to your local video-game arcade and play the Atari arcade games. Because everything they do, the Atari computer will do. (I know of only one exception: the "Lunar Lander" Atari game, which uses vector graphics and is therefore incompatible.) Two very good examples for study, if you can find them, are "Basketball" and "*Sky Raiders*."

(I regret that Sky Raiders is a shoot-em-up game, or, indeed, that our society has such a high regard for games where you get high scores for murdering lots of imaginary adversaries. It could be argued that Vietnam, the Body-Count War, was born in the arcades of yesterday, and that Star Trek games are setting us up for World War Three—but that's a different article. Anyway, consider that the effects you are seeing can be put to peaceful uses, like the teaching of physics and watching the flowers grow.)

Here are some things you should look at.

The way that the whole screen can be filled with shaded graphics, that is, pictures made out of colors or grey levels. (Colors are not much used in Atari arcade games, with some exceptions like the multi-car Speedway game. But the colors are just fine on the Atari computer.)

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Machine, cont'd...

The way that pictures of small objects can move across this overall picture without disturbing it. (Examples: basketball players in the Basketball game; automobiles in the speedway game; the hook and ladder truck in the Fire Truck game, which can actually be driven across people's lawns and driveways, and through their houses, with very satisfying sound effects.)

Of all the Atari arcade games, the most portentous, in my opinion, is *Sky Raiders*. This is a bombardier game in which you get points for destroying cities, factories and power lines. (Again, ignore the shoot-em-up aspect.) What you see is a continuing panorama unrolling below your bombsight: the aerial view of the countryside. The video monitor is mounted vertically, and the aerial view descends down the screen—sideways on the video.

In other words, what you are seeing is *horizontal scroll* of detailed graphics relative to the monitor.

Another feature that merits your close attention is the interaction

Consider that the effects you are seeing can be put to peaceful uses, like the teaching of physics and watching the flowers grow.

between moving objects and the background. In the basketball game, for instance, not only do the two players move around in front of a full background picture; they also *block one another*: either the black player is in front of the white player, or vice versa. You may have an interesting time thinking about what hardware this implies.

Moving objects may also interact with the background picture. For instance, in the "Sky Raiders" game, a bomb which is on target creates an explosion on the ground. This implies interesting interaction between the data about moving objects and the data about the background.

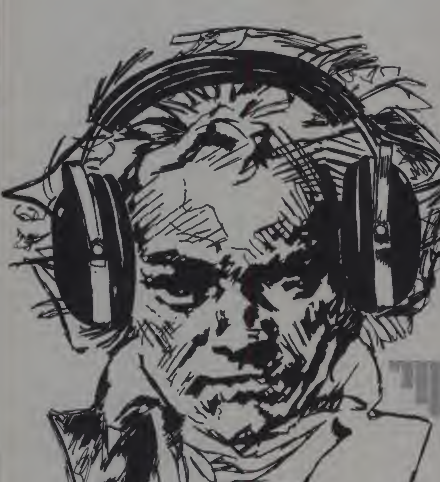
Well, Space Troopers, that's it for now. The Atari is like the human body—a terrific machine, but (a) they won't give you access to the documentation, and (b) I'd sure like to meet the guy that designed it. □

Those who cannot remember the past are condemned to repeat it.

Statistics are no substitute for judgement.

DIGITAL AUDIO

David H. Ahl



Audio sound reproduction in the 1980's is on the threshold of some major changes which will make even the most jaded listener sit up and take notice. Most of these changes are a result of applying digital or computer technology to audio recording, transmission and reproduction.

The range of the changes taking place is staggering. LP records are being made which employ digital recording techniques. Although today the disk is still "analog" and playable with standard cartridges, before long there will be all-digital disks using a laser playback mechanism such as the one in the Philips/MCA videodisk player. Microprocessors are being used in turntables to control the speed, in FM receivers to tune the station, and in cassette tape recorders to "remember" the sequence of commands. Computer-controlled speakers are available which prevent bass overload. And devices are available which simulate a concert hall, in real time, in your own home.

Couple all this with computer music synthesis systems and one can't help but be excited about the coming new era in high fidelity.

Digital LP Records

Typically, a record goes through the following steps: microphone, tape, editing to second tape, lacquer master, metal pressing master and, finally, vinyl record (or another tape). All of these steps introduce distortion of one kind or another. While rock music has come to rely upon editing and the introduction of additional sounds which were not originally part of the music (reverb, echo, fuzz, etc.), classical and folk music seldom benefit from these enhancements.

Digital, cont'd...

A recent advance which cuts out the first taping step is the direct-to-disk recording technique. In this process, the recording is made directly onto one or more lacquer masters. Editing is not possible, which puts quite a strain on the musicians to achieve a perfect take. Nevertheless, the three dozen or so direct disks on the market today are spectacular in their sound quality. Good examples are those from Crystal Clear, Telarc and Sound 80.

A serious problem with direct-to-disk recordings is that only a limited number of disks can be pressed since there is no original tape master from which to make new lacquers. Consequently, the cost of each disk must be amortized over fewer total sales, and the price of each record is fairly high ($12 to $18).

A digital recording, on the other hand, uses tape — but with a big difference. Instead of an analog signal, the sound is coded into pulses (using Pulse Code Modulation, or PCM recording), and it is these pulses that are recorded. Why is the result better than an analog signal? Because the loudest sound of a full symphony orchestra is over 30,000 times as loud as its softest sound. This represents a dynamic range of over 90 dB, whereas most studio tape recorders rarely have a better than 60 dB signal-to-noise ratio. This means that with conventional high quality recording the sound must be compressed into a range of 1000-to-1 at best, and usually a good bit less.

Using PCM, the analog electrical representation of the audio signal from the microphone is sampled at fixed intervals at a frequency at least twice the highest frequency to be recorded. For the most part, the audio industry has settled on an upper recorded limit of 20,000 Hz (cycles per second), which is above the upper limit of audibility for most humans. Thus the sampling rate must be at least 40 kHz. The Soundstream equipment used by many companies making digital recordings today uses a sampling frequency of 50 kHz.

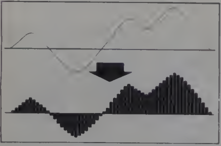


Figure 1. The electrical analog of the sound pressure (top) is sampled every 20 millionths of a second, and discrete amplitude values are obtained.

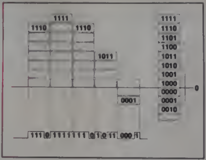


Figure 2. For each amplitude value, a corresponding binary number is generated. The lower trace shows the binary coded signal.

This sampling operation converts each smoothly varying waveform into a series of amplitude values that remain constant for an instant — if one could call 20 millionths of a second an instant. (See Figure 1).

A number is then assigned to each of the amplitude values between 0 and 65,535, using a 16-bit binary code. (Figure 2 illustrates this for a 4-bit code.) One might argue that since the analog waveform is continuously variable, forcing it into 65,536 discrete amplitude values introduces distortion, and indeed it does. However, considering that a sample is taken every 20 millionths of a second, the distortion is virtually undetectable by human or machine. Needless to say, the master tape is not made on standard home or even studio equipment. Rather, computer instrumentation tape or videotape machines are necessary to provide the needed bandwidth.

To eliminate speed variations completely as a source of possible distortion, the playback numbers are recorded in a computer memory and retrieved on a precision half-time basis to cut the master. The results are absolutely superb and can be sampled on records from RCA, Delos and others.

However, you might ask, and rightly so, whether using a lacquer master — and indeed, with the same lacquer used by Edison in Menlo Park over 50 years ago — isn't a bit anachronistic? Yes it is. But within a year or two, that will be gone also. Read on.

First, a side note. The best, low-noise material for making the final record is virgin vinyl. However, the U.S. Gummint, OSHA in particular, has virtually closed down the PVC vinyl industry in the U.S. due to health hazards. That's why many recent records have more surface noise and imperfections than those of ten years ago. The few high-quality vinyl records that are available cost more today because they have to be made in Japan or Europe where PVC vinyl is still being made.

True Digital Records

Whereas the end product of today's digital recording technique is an analog record, a true digital record (or tape) consists of nóthing but coded numbers. While several different systems are under development for the consumer, the Philips "Compact Disc" is perhaps furthest along, so the rest of this description will be about that system even though there are various competing approaches.

The disk plays for one hour per side and contains 6 million bits on a 4-km helical track.

Systems using 16-bit resolution and 50 kHz sampling are about the current limit of the state of the art. They are wonderful for mastering, but less than wonderful for the typical, or even well-heeled consumer's budget. Less memory means less money so Philips opted to reduce the number of bits from 16 to 14 and accept as adequate the resulting 84 dB signal-to-noise ratio. (Sony has opted for a non-linear 12-bit encoding system using videotape, which results in a dynamic range of 84 dB although the instantaneous S/N ratio is 71 dB. Called the PCM-1, the price is pegged at a healthy $4000.)

Philips sampling rate is 44,330 Hz and uses a linear 14-bit PCM coding scheme. The disk plays for one hour per side and contains 6 million bits on a 4-km (yes, kilometers) helical track. The left and right stereo information is carried in alternate words along the track and cannot be mixed, thus intensifying the stereo image.

The master disk is a glass plate (no lacquer) with a photosensitive surface layer. The digitized audio modulates a laser beam that deposits pits and flats on the photosensitive layer. A developing process leaves a pattern of pits in the glass plate. Copies are pressed by methods similar to those for producing standard phono records. After it is pressed, the disk surface is coated with a reflective aluminum layer, and further sealed with a clear plastic layer.

The playback element is also a laser mounted in a "lightpen," with a lens-and-prism arrangement that both focuses the laser beam and conducts the reflected beam back to a photodiode detector. The pits in the disk act

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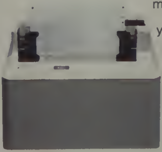

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Digital, cont'd...

as light diffractors, modulating the intensity of the reflected laser beam.

All very "gee whiz," but the proof is in the performance. Philips claims an 85 dB range and total harmonic distortion of 0.05 percent. The second harmonic distortion in a top-of-the-line cartridge such as the Ortofon M-20FL Super or Shure V15 Type IV is around 1 percent, so true digital disks represent a substantial improvement, even allowing for some slippage in manufacturers' claims. However, the biggest performance difference is in the record itself. The best analog disk recordings have a dynamic range of 80 dB *but* a single-to-noise ratio of 40 dB at best. The direct-to-disk and digitals extend that range somewhat. But the pure digital disk goes even further with an 84 dB range coupled with an S/N ratio of 95 dB!

Philips predicts that its Compact Disc player will sell for about $500 and that one will be able to hear its unusual sonic quality with a reasonably good $500 stereo system. Philips plans to market the audio disk player separately from its video disk system. Two competitors, RCA and JVC, are developing outboard adaptors to rig to their video disk players to play digital audio disks. In addition to the PCM-1 system mentioned above, Sony also has a DAD-1X system with a 16-bit linear coded signal which is burned into a metallic layer on a master disk with a powerful argon laser. The audio is retrieved by a low-power, helium-neon laser and is said to have a dynamic range of 95 dB and less than 0.03 percent distortion. No leaks on the price though.

You've never heard the themes from Star Wars, Close Encounters, Battlestar Galactica and Superman played like this before!

At this point standards are nonexistent. In the past this has led to some very undesirable situations. How many of you remember the 45 vs. 33⅓ vs. 16⅔ rpm fight for LP records in the early 50's? Fortunately, the Philips/Norelco compact cassette standard and Dolby noise reduction standard prevailed in the tape recording field. No such luck in videotape, with Beta and VHS currently slugging it out. Or in videodisks with Philips, RCA and Pioneer set for a no-holds-barred three-way slugfest. It would be nice to see one digital disk system adopted as standard, but at this point it would seem that it won't happen for several years. Too bad.

Turntables and Changers

Changes in turntable and changer design over the past 20 years have been largely of an evolutionary nature, while the same 20 years have seen absolutely revolutionary changes in electronics. Four-pole synchronous

Figure 3. BIC Model 80Z with microprocessor speed control.

motors and DC servo motors were both around in the 50's. Speed controls got better, and drive idlers gave way to belt drive and direct drive, but fundamentally turntables haven't changed a great deal.

Most top-of-the-line turntables offer rumble of -70 dB or less, wow and flutter of 0.03% or less, and speed variation of 0.5% or less. Examples are the Pioneer PL-630, Fisher MY6250, Yamaha YP-D71, Onkyo CP-1280F, Garrard DDQ550, and Technics SL-1401, all of which use a linear quartz phase-locked loop for speed control and direct drive. Unfortunately, turntables in this class are a bit pricey ($290 and up).

However, if electronics could be used to replace some of the costly electro-mechanical components, it ought to be possible to lower the overall price with little or no sacrifice in performance. BIC seems to have done

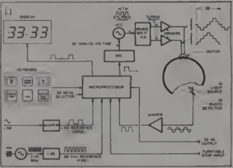

Figure 4 Block diagram showing the speed control circuit used in the 80Z

just that with their 80Z changer-turntable (Figure 3) and SP 85 single play turntable. A 24-pole, 300 rpm (relatively low speed) motor is used with a belt drive. A quartz crystal is used to transmit an 89 kHz reference frequency to a microprocessor. A photo detector reads platter speed, not motor speed, feeding it also into the mpu. (See Figure 4.) The mpu then corrects actual turntable speed and holds it to 0.01%. The speed is user programmable in increments of 0.01 rpm to + or - 100 steps of 33⅓ and 45 rpm. This lets you match the frequency of a flute or piano in the event you would like to play along with a record. Best of all, the 80Z is modestly priced at $240.

Another use for digital electronics is to keep track of playing time logged by the stylus — this feature is found on the Sanyo Plus Q60.

Computer Controlled Speakers

Until recently it has been largely true that good bass response went hand in hand with the size of the loudspeaker. Over the past three or four years several smaller speakers have been introduced which permit extremely long cone movements (one inch and more) and thus give much improved bass response. Nevertheless, the typical high quality, small bookshelf speaker (0.5 cu. ft. or less)

A Sampling of High-Quality Records

Here is a sampling of direct-to-disk and digital disk recordings which we particularly like. Some have been previously reviewed on these pages, while others have not. All of them are guaranteed to show off, if not be a genuine challenge of your hi fi system.

Classical

"Sonic Fireworks I and II," Richard Morris and the Atlanta Brass Ensemble. Crystal Clear CCS-7010 and 7011. These records feature a spectacular organ along with 10 brass players and 2 percussionists. We particularly like the Mouret "Rondeau" which is the theme music to Masterpiece Theater, and Copland's "Fanfare for the Common Man."

"Gould conducts Gould." Morton Gould conducts "Spirituals for Orchestra" and "Foster Gallery." Crystal Clear CCS-7005. The only recording of "Foster Gallery" on LP, this is a delightful Americana addition to any collection.

"The Classical Trumpet Concerti of Haydn/Hummel" and "The Sound of Trumpets." Gerard Schwartz, Conductor and Trumpet Soloist. Delos D/DMS 3001 and 3002. We have had people listen to these (with our Advent SoundSpace control) and say that they could not believe they were not listening to a live performance. Maurice Andre, make way.

"American Brass Quintet." Renaissance, Elizabethan and Baroque Music. Delos D/DMS 3003. Accurate, stunning performances of a wide variety of pieces will turn you into a brass lover even if Paganini used to be your only hero.

"The World of the Harp." Susann McDonald. Delos D/DMS 3005. Shure's test record claims the harp is one of the most difficult to reproduce instruments. We don't doubt that claim. But if your system is up to it, this is perhaps the most beautiful solo harp album ever recorded.

"Digital Hits of 1740." Cambridge Chamber Orchestra and Empire Brass Quintet. Digitech 101 (Distributed by Sine Qua Non Productions, Providence, RI 02904.) The clarity of the harpsichord was particularly impressive on this disk. The arrangements are not "authentic" but are stirring and dynamic. We especially liked the Mouret Rondeau and Handel Largo from Xerxes. On the curious side was Bach's Badinerie (from Suite #2) played with a trumpet instead of the usual flute.

"Renaissance Brass." Empire Brass Quintet. Digitech 102. A nice counterpart to the Delos record above. Beautiful, majestic sound on the Gabrieli Canzona while the earlier Isaac pieces are rarely heard in performance or on disk. A lively and interesting record.

Handel: Water Music and Royal Fireworks Suite. Anthony Newman on the Hilborne Roosevelt Organ. Digitech 103. The jacket notes say that "Handel would have liked this record" and we agree. Although we have gotten accustomed to the orchestral arrangements of these pieces, the organ has incredibly rich sonorities and exacting clarity accurately recorded by the digital process.

(We are impressed with Delos' and Digitech's warranty. They guarantee that any (genuinely) defective disk will be replaced at no charge to you direct from the manufacturer. I have about a dozen Turnabout, Nonesuch and Angel disks right now purchased from stores in distant cities that I'm stuck with due to warpage or major surface imperfections. All of these manufacturers require that defectives be returned to the store from which it was purchased. Bah.)

Schubert: Symphony #5 in B. Dennis Russell Davies with the St. Paul Chamber Orchestra. Sound 80 S80-DTD-102. A delightful recording of Schubert's 5th which, while not as popular as his 8th ("Unfinished") is equally delightful. I think of this symphony as the dividing line between "classical" and "romantic," and this is by far and away the most sonically perfect recording.

Copland: Appalachian Spring and Ives: Three Places in New England. Dennis Russell Davies and the St. Paul Chamber Orchestra. Sound 80 S80-DLR-101F. If you're into Copland or Ives, don't miss this one. And if you're not, maybe you should become acquainted.

Holst Suites Nos. 1 and 2, Handel: Royal Fireworks Music, Bach: Fantasia in G. Frederick Fennell and the Cleveland Symphonic Strings. Telarc 5038. This was one of the first digitals and is perhaps still the most breathtaking, particularly the kettle drums in the Holst Suites.

Chopin: Various polonaises, mazurkas, dances and variations. Played by Malcolm Frager. Telarc 10040. Overall evenness and crisp treble set this record apart from other solo piano recordings.

Popular, Folk and Misc.

"Space Organ." Jonas Nordwall plays the theater organ in Portland, Oregon. Crystal Clear CCS-6003. You've never heard the themes from Star Wars, Close Encounters, Battlestar Gallactica and Superman played like this before!

"First in Line." Randy Sharp and group. Nautilus NR1. Randy plays a 6- and 12-string acoustic guitar in this folk/rock recording. Amazing range of sound.

"In My Pocket." Victor Feldman. Cohearent Sound CSR-1001. Feldman is widely considered to be Britain's finest jazz musician. After hearing this record, we'd have to agree.

Digital, cont'd...

rarely has bass response much below 55 Hz. Furthermore, if one was determined to turn up the power to drive deep bass through such a small speaker, one was usually left with a distorted cone or some other nastiness.

KLH, in working on this problem, came up with some theoretical calculations which indicated that a woofer in a 6-liter vented enclosure should be capable of producing a 92 dB sound level at 45 Hz if (and this is a big if) there were no low frequency transient distortion. This transient overload causes excessive cone displacement and, of course, sound distortion and possible speaker damage.

The first improvement was to incorporate a steep-cut high-pass filter to eliminate all frequencies below the lowest rated operating frequency. In other words, eliminate any 32 or 35 Hz signals which cannot be reproduced but that do use up cone excursion capacity thereby increasing distortion and the likelihood of overload.

The second improvement was to construct an electronic "processor" in a feedback circuit to detect when maximum cone displacement is about to be exceeded, and then lower the amplifier input level to just under the distortion level. (See Figure 5). The "attack-time" of the processor is so fast that mechanical overload is just about impossible, even with extremely loud sharp percussion sounds. In listening to many varied kinds of music, the operation of the control could not be detected except by trained ears.

KLH calls this device the Analog Bass Computer. It is separate from the loudspeakers and must be used with speakers matched to its pre-programmed characteristics. In addition to filtering and compensating for possible overload, the unit also provides midband compensation for speaker placement (close to or away from a wall).

Each KLH-3, the smallest speaker to use the computer, measures only 8½" x 12½" x 6" (volume 0.25 cu. ft.). Response is -3 dB at 40 Hz. (See Figure

Figure 6. KLH-3 speakers are much smaller than other speakers with comparable performance.

6.) The larger KLH-1 has response of -3 dB at 32 Hz and measures a compact 11" x 30" x 10" (volume 1.25 cu. ft.).

It is obvious to anyone who has attended a concert and later listened to a recording of the same concert at home, that it is just not the same.

Simulating the Acoustic Environment

It is obvious to anyone who has attended a concert and later listened to a recording of the same concert at home, that it is just not the same. Even over the very finest high fidelity equipment it is not the same. Why not? Obviously because your living room is not Lincoln Center or the Hollywood Bowl. Your room differs from others in two important ways.

Some years ago, as part of my senior project in EE at Cornell, I set about measuring the acoustic properties of various concert halls, lecture halls and other buildings in Ithaca. Two characteristics can roughly define most rooms — size (heard acoustically as echo) and absorption/reverberation (heard as the damping of some frequencies due to draperies, seats, people, etc. and the reflection of others from ceilings, pillars, walls, etc. It is this characteristic that gives a room its acoustic character.). Feeding these data into a computer and analyzing the results, I concluded that it would be theoretically possible to derive a rear channel from each front channel and that this rear channel could be programmed to simulate the sound that would come from the back of any concert hall you wished to program. However, with then-current technology (1960), it would have taken approximately one hour of computer time to reconstruct the back channel for each one minute of listening time. Not a very economic proposition! My conclusion was that one's best bet was to pay careful attention to speaker arrangement, draperies, carpeting, etc. in order to achieve to best high fidelity reproduction.

Now, 20 years later, Advent has introduced a device called the SoundSpace control which models an acoustic environment in real time and derives two rear channels to simulate any desired characteristics. (Figure 7). The SoundSpace control digitally processes a mono or stereo signal, adds multiple time delays which are mixed and recirculated according to the size and absorption (they call it reverberation) programmed in by the listener. SoundSpace control has a 32K bit RAM and crystal clock circuitry which keeps distortion below 0.1%. The control requires a second power amplifier and pair of speakers placed to the rear of the listening room.

The listener is provided with two continuously variable controls, Size and Reverberation. Size sets the basic delay time from 1 to 100 milliseconds. Values between 20 and 35 would be typical of small clubs while 70 to 99 milliseconds would be typical of cathedrals and sports arenas. The reverberation control determines the "liveness" of the acoustic space from dry (few reflections) to live (reflections of many frequencies in many directions).

I first heard this device at the 1978 Summer CES and was astounded. In the computer industry we have come to expect many problems in the production of a new semiconductor device. Advent, without this history behind them, confidently predicted delivery in the fall of 1978. We finally got our unit in February 1980. Upon its arrival, we eagerly hooked it up and turned it on and, yes, there was the same uncanny realism that I remembered a year and a half earlier. It was worth the wait.

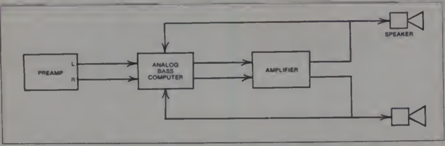

Figure 5 Block diagram of KLH analog bass computer showing feedback loop.

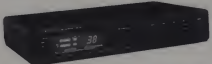

Figure 7. Advent SoundSpace Control adjusts for different rooms with size and reverberation controls

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CIRCLE 123 ON READER SERVICE CARD

Digital, cont'd...

Other Uses of Digital Electronics

For the most part, other uses of digital electronics in audio are in tuners and tape decks which "remember" a programming sequence, the location of stations on the FM band, etc.

For example, the Fisher CR5150 cassette deck has a built-in digital timer which can turn the deck and a receiver on and off at a preset time for unattended recording. It uses the same digital timing circuit as a tape counter,

Another use for digital electronics is to keep track of playing time logged by the stylus.

thus overcoming the problem of most counters which don't indicate actual time elapsed. (Most tape counters are geared to the tape motor so as not to put any extra load on the tape drive capstan. At the beginning of a cassette, the empty reel holds approximately 1 second worth of tape per revolution while at the end, the full reel holds about 2½ seconds. Thus the tape counter, which is geared to the number of turns made by the reel, bears little relation to the actual time of recording.)

The Marantz SD9000 two-speed "CompuDeck" is even more elaborate. It allows the user to seek out up to 19 selections to be played in any order that you select. At the end of a selection, you can stop, rewind to any other point, or replay continuously. Coupled with the 24-hour clock, the SD9000 can record FM programs by turning on and off a tuner. On the other hand, expect to pay for these computer features — $800 for the SD9000.

In tuners, the Sherwood Micro/CPU 100 is a good example of the use of digital electronics. (Figure 8). In this

Figure 8. Sherwood Micro/CPU 1000 has exceptional tuning accuracy.

tuner, the CPU controls all the tuning functions and operates the three tuning displays: digital station frequency, an LED showing approximate position on a linear dial, and a station call letter display. Four stations can be stored in memory. Complementing the CPU, the tuning is also done electronically — turning the tuning knob operates a photoelectric system which translates speed and direction of knob movements into frequency information. A phase-locked loop tuning system eliminates the need for either center tune meter or oscilloscope; the synthesizing process makes station drift impossible.

Computer Store of the Month

Computerworld, Lawndale, California

Avi Ronen and his determined staff of six have earned the title of June Computer Store of the Month for their store, Computerworld of Lawndale, California. Since the store's modest beginnings in November of 1978 as the QI Corporation, it has grown to encompass two thriving computer stores in Southern California, a new mail order division known as Micro Business World as well as a wholesale program for small computer dealers. Their success formula is the age-old story of considerate service and hard work which always deserves to be re-told.

Computerworld has endeavored to be a full-service—one stop—center for personal and small business systems, modules and components, software, books, accessories and supplies. Sales staff are on hand to advise new computer owners and a full-time programmer is always available to assist small-businessmen with customized packages. The mail order and wholesale divisions acknowledge all orders immediately and usually ship within two weeks. The main objective is SERVICE. This attitude has made Computerworld a well-established landmark in the Southern California scenery. QI president, Avi Ronen, comments:

"The future of our industry is bright, and the future of QI Corporation is brighter. We plan to open more stores in California and other states as well and we expect that our experience will help our future customers."

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CIRCLE 121 ON READER SERVICE CARD

Editor's Choice Sound System

We started this project back in the summer of 1978. That spring we had evaluated several S-100 music synthesis boards. Some of them required external amplification while others did not, although all could use it. When we cranked up the volume of our hi-fi we noticed more and more distortion. With normal signals sources (tuner, phono, tape) this distortion was not present. We then took a look at the input signal with an oscilloscope and, as espected, found that most synthesized music was constructed of square waves. Putting the same oscilloscope on a microphone in front of the speakers revealed anything but square waves. Even on the speaker output terminals, the square waves had all but disappeared.

Not that we wanted a hi-fi system solely for the reproduction of computer-synthesized music, but we reasoned that a system that could do a good job with computer music, could do an outstanding job with standard input sources. Furthermore, we wanted a system that could record computer music and play it back with some resemblance to the original. A further goal in building a system was to use modestly-priced components wherever possible. Exotic components and bells and whistles for their own sake were to be avoided.

Audio sound reproduction in the 1980's is on the threshold of some major changes which will make even the most jaded listener sit up and take notice.

Amplifier

We started listening to state-of-the-art components and looking at manufacturer specifications at the 1978 summer CES. It seemed that a DC/DC (Direct coupled) amplifier with reasonable power (50 w per channel or more) would make the most significant improvement over our existing system. We looked at JVC, Nikko, Rotel, Marantz, Sony, Kenwood and others too numerous to mention. Both listening and on paper, all were impressive. We finally settled on the Sansui AU-719 90 watt integrated amplifier. Sansui has been one of the leaders in DC amplifier design and seemed to have honed their design to very high performance levels at a relatively modest price. (Figure 9).

We, are not, of course, a hi-fi testing laboratory, and have to go by the figures of others. Given the goal of accurate reproduction of computer-synthesized music, we were particularly impressed by the rapid slew rate and rise time of the Sansui. That, coupled with exceptionally low TIM (Transient Intermodulation distortion), contribute to helping the amplifier respond more quickly and accurately to the pulsive musical waveforms fed to it.

Adequate power (90 watts per channel) and acceptably low THD (total harmonic distortion) of 0.15% translates into remarkably clean sound at all listening levels. An unexpected benefit is that the Sansui seems to work somewhat better with the Advent computer-controlled speakers and not get locked into feedback loops as do our non-DC coupled Marantz and Scott amplifiers.

Figure 9. Sansui AU-719 is a DC/DC amplifier with exceptional performance reproducing transients

Tuner or Receiver

Given our druthers, we'd probably opt for the Sherwood Micro/CPU 100 described above. However, we also need a second amplifier for the rear two channels of derived sound. We couldn't quite justify a second Sansui AU-719, particularly since the rear channel needed only a power amplifier (the controls are on the Advent SoundSpace control) and the power requirements are about 10 percent of that of the front channel. Hence, we set out to look for a receiver with a power-amplifier section with separate connections, i.e., the output from the tuner section would be fed into the Sansui and the amplifier section used for the rear channels. (Yes, it probably would have been easier to get a Sansui G-7700 receiver in the first place. Ah, well.)

Figure 10. Marantz 2265B is an excellent receiver with separate preamp and amplifier sections, helpful for computer-controlled devices

In any event, we decided upon the Marantz 2238B, but then got a good deal on a 2265B. Having 65 watts for the back channel which seldom needs more than 10 watts is obviously overkill. Justifying this choice is the fact that if we ever split up this system, the 2265B is an outstanding receiver and would be a beautiful component around which to build a stereo system. (Figure 10.)

Having separate user-accessible preamp and amplifier sections is something found on surprisingly few receivers and integrated amplifiers today. With the advent of devices such as the SoundSpace control and computer controlled speakers, it is becoming more and more vital.

Turntable or Changer

We selected a BIC 80Z changer (described above) for our sound system. Purists, or course, will find fault with our choice of a changer instead of a turntable; however, the BIC can easily be used as a turntable for those expensive digital discs, but for hours of listening it is very nice not to have to jump up at the conclusion of every record.

For a shade over $2000 for everything but the reel-to-reel deck (list prices — discounts widely available), we definitely have the best sound system on the block.

Cartridge

Over the years, I have been rotating between Empire, Shure and Audio Technica in cartridges. Accordingly, I looked to all three for their latest and best as well as Ortofon, Adcom, ADC, Denon, Pickering and several others. I must confess, I was not prepared for prices that went as high as $1500 (Koetsu), nor am I convinced that kind of price is justified by the performance. The big trend

Digital, cont'd...

seems to be to moving coil designs. The Adcom Crosscoil and Audio Technica AT30E looked like excellent choices. Or JVC's MC-2E with an ultra-low-mass printed-circuit coil.

While I am not adverse to leaping onto the latest technology bandwagon, I was not convinced that the crosscoil, with all its crossed arguments as to whose design is best, was significantly better than the best "conventional" design cartridge. Hence, I chose the proven Shure V15 Type IV. The trackability — the ability of the stylus to stay in contact with both groove walls — is exceptional. I tried four other cartridges with the RCA digital disk of Bartok's Concerto for Orchestra and none of them could track it. With the Shure, there was no hesitation whatsoever. Furthermore, the Type IV tracked some warped records that I had long written off as unplayable. Part of this is due to finely honing a proven design and part is due to the new hyperellipitical stylus tip.

Tape Recorder

Cassette tape or reel-to-reel, that is the question. First of all, there is no question about the performance superiority of reel-to-reel, with its much higher speed (either four or eight times that of the 1⅞ ips speed of standard cassettes). On the other hand, reel-to-reel is bulky and cumbersome.

For 90% of our applications, cassette quality is adequate, so we decided to put a cassette recorder into our sound system. However, for high-quality mastering, we needed reel-to-reel. Since we needed both, we opted for a less than outstanding cassette recorder, namely the Realistic SCT-18. In retrospect, this was much too great a compromise and we should have minimally chosen a cassette recorder with a 3-head design (separate playback, record and erase), DC Servo motors, and response down to 30 Hz.

On the other hand, we made no compromises with our reel-to-reel recorder, particularly since it is the same one on which the masters for all the Creative Computing Software tapes are made. For this mastering function, we got a Pioneer RT-2022, 2-track, 2-channel professional tape deck system. It handles 10½" reels and has three motors, one for each reel and one for the capstan. THD (total harmonic distortion) is 0.8% — about half that of the very best cassette recorders. This is a rugged and precision machine which has performed extremely well for us in a wide variety of circumstances over the past year and a half. (Figure 11.)

Figure 11. Pioneer RT-2022 open reel tape deck system is high enough quality to cut digital or audio masters.

Speakers, Etc.

Since space was at a premium in our offices where this audio system is located, we immediately ruled out the 9 x 3 x 3 foot Fosdick speakers and others of their ilk. Even the lovely sounding AR-9's were a bit large for our space. Naturally, with smaller size we did not want to sacrifice sound quality. Consequently, we chose the KLH computer controlled speakers discussed earlier. There is absolutely no question in my mind that these speakers are better than considerably larger conventional-design speakers. That is not to say that these are absolutely the best speakers ever built, but rather that, for their size, they are oustanding.

Since space was a major consideration, especially when we transport our system to various conventions and trade shows, we chose the KLH-3. For a fixed environment (office or home), I would recommend the somewhat better performing KLH-2 or top-of-the-line KLH-1.

Performance or power handling is not nearly as critical for the rear channel speakers, although good bass is desirable. It is my feeling that the KLH-4 (same as the KLH-3 but without the computer) would be a good choice. Since I already had a pair of AR-2's available, they were put to use in the back channel.

The Advent SoundSpace control described earlier rounds out our system. It was no small challenge getting all this wired up correctly, since both the KLH speakers and the SoundSpace control wanted output from the preamp and input to a separate power amplifier. This the Sansui does not have, so we had to use the backup technique of cutting in at the tape monitor point. This unfortunately means that the front and rear channels are on separate volume controls. Advent recommends the use of Advent speakers (of course) and "couldn't say if the SoundSpace control could be used with the KLH speakers." They recommended against it.

We ended up "simply" connecting the tape output from the Sansui to the Advent input, the Advent output to the KLH computer input and Marantz amplifier input, and the KLH computer output to the Sansui amplifier input. It didn't seem to make any difference which came first, the Advent or the KLH computer. Tape signals are gotten from the KLH computer control. (See Figure 12).

For a shade over $2000 for everything but the reel-to-reel deck (list prices — discounts widely available), we definitely have the best sound system on the block. It is highly compact and can be trotted off to shows with relative ease if you don't mind reconnecting 22 cables (yes, twenty-two) each time. Also, the Sansui is no lightweight at 39 pounds. Nevertheless, the performance is spectacular, whether playing a digital disk, the ALF/Apple synthesizer or a tape. □

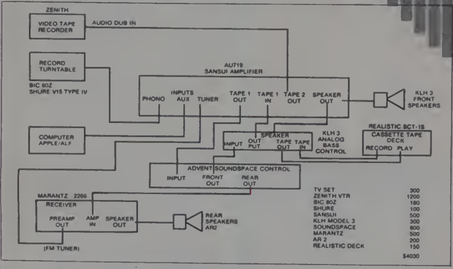

Figure 12 Block diagram of Creative Computing editor's choice sound system.

A New Type of Game

Welcome to an astonishing new experience! ADVENTURE is one of the most challenging and innovative games available for your personal computer. This is not the average computer game in which you shoot at, chase, or get chased by something, master the game within an hour, and then lose interest. In fact, it may take you more than an hour to score at all, and will probably take days or weeks of playing to get a good score. (There is a provision for saving a game in progress).

The original computer version of Adventure was written by Willie Crowther and Don Woods in Fortran on a PDP-10 at MIT. In this version the player starts near a small wellhouse. Upon entering the house, he finds food, water, a set of keys and a lamp. Armed with only these items, he must set out to explore the countryside in search of treasure and other objects of play. He must also confront dwarfs, snakes, trolls, bears, dragons, birds, and other creatures during his quest. The game accepts one-or two-word commands such as GET LAMP" SOUTH" or KILL DWARF. Of course, if you don't have the proper tool to carry out an action, or if you do something foolish, you may find yourself in big trouble.

In playing the game you wander thru various 'rooms' (locations), manipulating the objects there to try to find 'treasures'. You may have to defeat an exotic wild animal to get one treasure, or figure out how to get another treasure out of a quicksand bog. You communicate thru two-word commands such as 'go west', 'climb tree', 'throw axe', 'look around'.

Adventure

For Apple, TRS-80, Sorcerer, PET, CP/M

MISSION IMPOSSIBLE ADVENTURE (by Scott Adams) - Good Morning, Your mission is to... and so it starts. Will you be able to complete your mission in time? Or is the world's first automated nuclear reactor doomed? This one's well named, its hard, there is no magic but plenty of suspense. Good luck.....

THE COUNT (by Scott Adams) - You wake up in a large brass bed in a castle somewhere in Transylvania. Who are you, what are you doing here, and WHY did the postman deliver a bottle of blood? You'll love this Adventure, in fact, you might say it's LOVE AT FIRST BITE.....

ADVENTURELAND (by Scott Adams) - You wander through an enchanted world trying to recover the 13 lost treasures. You'll encounter WILD ANIMALS, MAGICAL BEINGS, and many other perils and puzzles. Can you rescue the BLUE OX from the quicksand? Or find your way out of the maze of pits? Happy Adventuring.....

VOODOO CASTLE (by Scott Adams) - Count Cristo has had a fiendish curse put on him by his enemies. There he lies, with you his only hope. Will you be able to rescue him or is he forever doomed? Beware the Voodoo Man.....

ORIGINAL ADVENTURE (by Crowther, Woods, Manning and Roichel) - Somewhere nearby is a collosal cave where others have found fortunes in treasures and gold, but some who have entered have never been seen again. You start at a small brick building which is the wellhouse for a large spring. You must try to find your way into the underground caverns where you'll meet a giant clam, nasty little dwarves, and much more. This Adventure is Bi-Lingual—you may play in either English or French—a language learning tool beyond comparison. Runs in 32K CP/M system (48K required for SAVE GAME feature). Even includes SAM76 language in which to run the game. The troll says "Good Luck."

PIRATE ADVENTURE (by Scott Adams) - "Yo Ho Ho and a bottle of rum..." You'll meet up with the pirate and his daffy bird along with many strange sights as you attempt to go from your London flat to Treasure Island. Can you recover LONG JOHN SILVER's lost treasures? Happy sailing matey.....

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Neelco's Music Box for PET

Jack Hobson

Like most small computer hobbyists, when I got a PET my peer group sneered: "That's a nice toy, but can it do anything useful?" They weren't satisfied by promises of computer-controlled home security and automated menu planning. Come to think of it, neither was I. So my PET was regarded as a very expensive arcade game — until I got a "Music Box" for it.

When the pages are filled, they can be played back in any order: the screen prints the music staves and as each note sounds, it appears on the screen, giving the impression that the tune is playing itself.

The Music Box comes from New England Electronics Co., and costs $49.95. It comes with minimal hardware: a speaker/amplifier which mounts inside the PET and is powered by the PET's power capacitor, and an edge connector for the parallel user port. The edge connector's pins K9 and L10 are presoldered to drive the speaker/amplifier. The more substantial part of the package is the software; a cassette which holds the program, and a manual to tell how to operate it. (A modification exists for PETs having the new ROM set.)

The program was written by Ted Scott, who reportedly spent over 200 man-hours constructing it and has taken remarkable steps to protect his ideas — if you try to enter Basic commands such as RUN etc., a SYNTAX ERROR? is returned. If you try to LIST the program you get a system crash, and a lot of garbage is output to the screen; the PET has to be turned off and the Music Box reloaded. (It loads only in the RUN mode so you can't LIST it before running it!)

Jack Hobson, 64 Upper Mountain Ave., Montclair, NJ 07042

There are two modes of the Music Box. Mode "A" has an auto compose feature in which the PET can compose its own music, much more melodic than standard sci-fi random music. The "E" mode has "Exit" capabilities, meaning that the program can be used to compose a tune then a new program can be entered which uses the tune, without the Music Box. In either mode, a blank "page" for music is printed on the screen, consisting of a treble staff and a bass staff. Notes are entered by typing their letter name, "E," "G," etc. Sharps are created by hitting "#"

before the note. Flats are made by "sharping" the next lower note. The time value of the notes is adjusted by hitting "T," then a number from 1 to 9. This gives a value of from a sixteenth note (♪) to a whole note (o). If an "R" is keyed, a "rest" of that time value will occur. Particular codes before a note cause the note to be an octave higher or lower.

A melody can be transcribed from sheet music or by ear into the Music Box. As each note is keyed, it is also played so that any mistakes are audible and can be corrected on the spot. When the pages are filled, they can be played back in any order: the screen prints the music staves and as each note sounds, it appears on the screen, giving the impression that the tune is playing itself. One rather amazing and handy feature is the transposition function — by typing the letter 'K' and

Each page of music can be transposed up or down. For arrangers and song-writers this is like having a robot copyist, saving hours of tedious work.

the number of half steps up or down (+ or -), each page of music can be transposed up or down. For arrangers and song-writers this is like having a robot copyist, saving hours of tedious work.

The Music Box makes a remarkable teaching aid because it combines written music with audible music, increasing the association of one with the other. It also makes an impressive display of the PET's capabilities. And when my friends complain, "Sure, it plays beautifully. But can it do anything practical?" I just remind them that since I'm a professional musician, my PET *is* doing something practical!

SUMMARY OF COMMANDS

↓ — (cursor down) — shifts octave down.

↑ — (exponentiation key) — shifts octave up.

T — Sets note or rest duration (followed by 1 digit #1-9).

R — Produces rest.
A-G — Plays the musical note.
— Causes the next note to be sharp.
← — (backspace) deletes last note entered.
? — (followed by 2 digit #) sets tempo.
RETURN — Ends page and displays next page.
P — (followed by up to 40 two digit numbers) plays a sequence of pages.
S — Causes current play list to be saved on tape.
L — Causes file to be Inputted sequentially by file name.
K — Transposes by # half tones up or down.
X — (In 'E' version) — Exits MUSIC BOX software saving 8 pages of music for use in another program.
X — (In 'A' version) — Autocomposes a 4 page random tune.
M — Moves display to a specific page number.
P99 — Automatically plays existing play list.
Shift C — (In 'E' version) copies displayed page onto another page.

Available from New England Electronics, 679 Highland Ave., Needham, MA 02195

Heathkit/Thomas Electronic Organ Kit

Stephen B. Gray

There's a much easier way to make electronic music with a computer than by programming the pitch, duration and whatever else of each note, one by one, taking hours to program a simple little tune.

What's the easier way? Playing the computerized Heathkit/Thomas electronic organ. The organ with two keyboards? With pedals? With 55 controls? Yes, and it isn't all that difficult to play, because the organ uses a microprocessor to make playing as easy as possible, along with color-coordinated keys.

Kit Version of Thomas Organ

This kit version of the Thomas Organ Company's Troubadour model contains a microprocessor that controls the inputs from the keyboards, pedals and pushbutton switches. Two ROM chips store the percussion rhythms and some fancy accompaniment patterns.

Among the functions of the microprocessor are: making the organ sound only one pedal note at a time by programming for low-note preference; generating the lower octaves from the twelve top-octave frequencies provided by the master oscillator; controlling the rhythm ROMs; and controlling the various accompaniment features by enabling them on multiplexed lines, which combine keyboard notes, pedal notes, feature information and feature-enable codes, and use a 1-MHz clock to pick out the right signals at the right times.

As for building the organ from a kit, the nine major circuit boards are already assembled and tested for you, so that most of the electronics are already taken care of.

Can't Read Music?

If you can't read music at all, you press the POWER key and then the COLOR GLO key. Fluorescent lights under both keyboards turn on, illuminating the letters C,D,E, etc., that are molded into the underside of all the white keys in the top manual. Also lit up are the letters under seven white keys of the lower manual, along with nine plastic color chips you've inserted up into the hollow inside of these seven keys.

The Heathkit/Thomas TO-1860 organ kit comes with a glass music rack, and a bench that has storage space inside for music.

Three of these color chips are black, three red, three green, and when all of one color are held down, they play a chord to accompany the melody you play, with one finger, on the upper keyboard. Which melody keys do you play? The color-coded music is written so that if you can already read notes, you do it that way; if you can't, you look at the letter printed inside each note in the melody, and play that on the matching key of the top keyboard.

The music staff behind the notes is colored to indicate which chord you play on the lower keyboard: grey for the black G-C-E chord-keys, red for the G-B-D chord-keys, and green for the A-C-F chord-keys. So all you do is follow the letters to play the melody, and follow the colors to play the accompaniment. The set of music books you get with the organ contains several dozen familiar tunes.

Pedalling Along

Once you get the hang of the letters and colors, you can try the pedals. Although there are a dozen pedals, you need only four to start with, and they're color-coded in black (the two C pedals at each end of the pedal octave), red (the G pedal), and green (the F pedal). Which pedal do you play, and when? Simple: just put your left foot on the pedal that matches the color of the music staff behind the notes, the same color as the three chord-keys you're holding down with your left hand. With the pedal held down, you get a bass note that "fills out" the music you're playing on the keyboards, giving it a full-bodied sound.

A microprocessor controls most of the complicated features, so you can concentrate on making music.

That's all there is to the basics of playing the Heathkit/Thomas Troubadour organ. To do anything fancier than that would be rather complicated on a pipe organ, and thus difficult or impossible for a beginner, and even, in some cases, not so easy for an advanced player.

Let The MPU Do The Work

But this organ contains a microprocessor that automates most of the

Organ, cont'd...

difficult keyboard fingers and pedal-playing, such as walking bass, strum, arpeggios, etc. All you do is first press one of the features buttons above the keyboard, and the microprocessor takes over all the hard work, letting you play some very fancy music with only two fingers and a toe. Some of the features even play the pedal note for you, so you can concentrate on the two fingers.

The Chord Memory feature, controlled by one of the 11 switches above the left end of the top keyboard, converts the lower-keyboard octave of Color-Glo keys into 12 major and 12 minor one-finger chords. To play a C chord, just press the C key. At the same time, automatic circuits select and play the corresponding bass note for that chord, and will make the organ continue playing the chord and bass note, even if you stop holding the key down, until you play a different Color-Glo key.

Any major chord is changed to a minor chord if you press any pedal with your foot.

Once you get the hang of the letters and colors, you can try the pedals.

I've Got Rhythm

Above the right end of the upper manual are switches for nine pre-programmed drum-rhythm patterns, which can be controlled as to tempo and volume. The rhythm patterns include Waltz, Rhythm & Blues, Rock, Samba, Foxtrot and Rhumba. A Cymbal switch lets you add a cymbal sound to any drum rhythm, and a down-beat LED lets you know, with a pulsing red light, where the beginning of each measure is.

Now comes one of the trickier features. Push the Fancy Fingers switch, and you hear a counter-melody of pre-programmed notes, a different pattern for each of the nine drum rhythms. You can use this as a "light-touch" accompaniment to your one-finger melody, instead of the chord memory, which produces continuously-playing chords.

Four Accompaniment Preset switches provide four unique voices (piano, guitar, banjo, harp), and play in rhythm along with whatever drum-rhythm switch has been pressed.

The automatic Strum feature will "strum" whatever notes you hold down with your left hand within the lower-manual Color-Glo octave. The speed of the strumming is controlled by a slider beneath the switches.

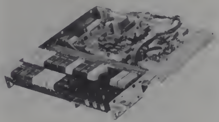
Two more features add life to the bass pedals. After the Fancy Foot switch is pressed, any rhythm-pattern switch has been pressed, then holding down any pedal will generate two pedal notes, alternating back and forth. Going that one better is the Walking Bass switch, which creates, instead of the back-and-forth notes in Fancy Foot, a "walking" effect up and down the pedals.

Hand Me My Harp

Once you've gotten your feet used to playing the pedals, you can use the Arpeggio accompaniment feature. The arpeggio is something like a strum, but is harp-like, playing the notes of a chord one at a time, from low to high and/or high to low.

If you had to play a fast arpeggio without help from the organ's automatic features, you might find it difficult, unless you'd had quite a few lessons. But with the Heathkit/Thomas organ, you shift your right foot, which is on the volume or "expression" pedal, so that your toe activates the kick-switch over at the left edge of the pedal. When you do that, then any one-finger Color-Glo or ordinary chord is automatically transformed into a harp-like arpeggio, which has its own voice.

Various forms of the arpeggio can be played by activating and releasing the kick-switch at different times. So, with a little practice, you can create a variety of arpeggios: up only, up and down, continuous up and down, short ups only, or a cascading sound. You wouldn't want to use an arpeggio with everything you play, but with some music it is very effective.



The pre-assembled "upper left cheekblock" contains all the switches and circuits for the 13 manual voices, pedal voice, balance controls and several other controls.

If all of this sounds terribly complicated, think of the fun you could have, trying out each of these features, one at a time, learning to use them in increasingly complicated combinations. After all, if you can drive a car, listen to the radio, smoke a cigarette, and talk to somebody else, all at the same time, why should an organ be so hard to play?

Inside The Organ

Although the entire organ is electronic, there's no point going into all of it, since most of the music circuits are fairly standard. A master oscillator drives an integrated circuit called the Top-Octave Synthesizer, which divides the top frequency to generate the notes of the top octave.

You play some very fancy music with only two fingers and a toe.

The LSI Rhythm Chip-1 is a ROM that provides short pulses at the proper moments to drive the various percussion oscillators, such as the Bass Drum, Snare Drum, Clave, etc. This ROM also supplies the pulses for the Fancy Foot pedal patterns.

LSI Rhythm Chip-2 is another ROM, which contains the bit patterns for the Walking Bass coding and the Fancy Fingers coding.

Where is the computer in this "computerized" organ, and what does it do? The service manual doesn't identify the circuit as a microprocessor. It's called the Features Chip, and it provides the major controls that turn the manual and pedal notes and the various features on and off at the right times.

The organization of the microprocessor chip, designed by Thomas Organ Co., and custom-made by AMI, is proprietary, but is probably something like the F8 processor.

The Features Chip is a microprocessor whose computing capability is designed around the requirements of an electronic organ; it can't be used as a standard microprocessor if taken out of the organ.

Here's an example of what the Features Chip does in Auto Pedal: the processor looks at the keyboard information by examining which notes you've depressed with your left hand. If you've played G-C-E, the processor determines that this is a C-chord, plays C as a pedal note, rather than G, and then plays the rest of a walking bass in the key of C, not the key of G.

Building The Organ

A great deal of the work in building the TO-1860 Heathkit/Thomas Troubadour organ has already been done for you, because nine of the circuit boards are already assembled and tested. The reason for this is that Heath found that if a kit takes more than 30 hours to build, the kit-builder often gets impatient, and tries to finish in a hurry. He makes mistakes, and ends up with something that won't work, and which can be a little monster to debug.

Organ, cont'd...

By providing nine boards already built, Heath makes your building time shorter, makes the construction manual shorter and thus less expensive for Heath to write, and also eliminates a great many telephone calls to the Technical Consultants in Benton Harbor, Michigan.

The fully-assembled cabinet also simplifies the organ-building (you don't have to do any woodworking). Precut and color-coded wiring harnesses, and several preassembled mechanical units such as the "upper left cheekblock," which contains 24 switches for the different voices and balance controls are fully assembled as are the tremulant assembly of three switches.

So what's left for you to build? You assemble the pedals and the switches they activate, the transformer-and-ballast unit that operates the Color-Glo fluorescent lights, the stereo amplifier and the expression pedal atop it, and the two keyboards. You install all these in the cabinet, along with the preassembled circuit boards and switch units, the two speakers, the reverberation unit, and you're ready for the chapter on Organ Checkout.

Heath found that if a kit takes more than 30 hours to build, the kit-builder often gets impatient.

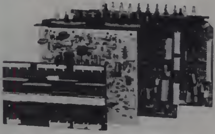
The hardest part for me was the keyboard assembly, which is almost entirely mechanical work. You start with a complex metal keyboard chassis, at the rear of which you mount a circuit board into which you insert spring contacts (68 for the lower keyboard, 44 in the upper keyboard). The keys do not activate switches, but instead move the wire spring contact until it touches a bus bar. This means adjusting the spring contact so it just touches that bus bar, and also adjusting the keys so they're in a straight line horizontally, which isn't all that easy.

But if you've got a little mechanical ability, the manual gives complete instructions on exactly what to do, so that if you follow the steps precisely, you'll have a minimum of difficulty.

The Shrink

One of the hard parts for me was trying to shrink several dozen half-inch lengths of plastic tubing onto the "key rack." A match or a lighter can be used, but that's so uneven that I borrowed a hair-dryer instead and did the whole job, on both key racks, in 18 minutes.

Soldering the spring contacts isn't easy either because they have to be perpendicular to the circuit board. A couple of the plastic keystop bumpers, which the keys touch when they bottom, didn't have holes in them, but a call to Heath brought holed bumpers in the mail. Adjusting these bumpers to make the keys line up evenly in a row was just about the hardest part of the mechanical assembly.



Here are four of the nine circuit boards that are already assembled and tested by Heath, needing only to be installed in the organ cabinet and connected to the wiring harnesses.

The wiring harnesses make the hookups easy, but there's so much harness that you have to pack it down around the circuit boards and out of the way, carefully and very neatly, so you can swing down the top keyboard and the top lid, which are on hinges, so that no wires get between circuit boards and the top keyboard or the lid. Otherwise things may not work just right.

And when I finished, the organ didn't work right. Nearly all the problems were caused by wiring pressing against something it wasn't supposed to be pressing against. Once that was taken care of, and a couple of contact springs resoldered, I was ready to play.

For My Next Number . . .

For the first couple of weeks, I played the organ using headphones, so as not to annoy the neighbors with unmusical sounds. After a couple of weeks, I stopped using the headphones, turned the speaker switch on, and found that the sound is much better through the speakers, because not all the effects are channeled to the headphone jack.

By the way, there are also stereo input/output jacks, for recording your music, or for playing a duet with previously recorded tapes.

After playing some of the tunes in the three books that come with the organ, I looked for something that would help me more with playing the pedals. A church hymnal turned out to be just the right thing. I started with simple, familiar hymns, playing the four parts on the keyboard, and also playing the bottom or bass part on the pedals.

Then I worked slowly up to the more complicated hymns. There's only an octave of pedal notes, so you can't play complicated pedal solos, but it's adequate for nearly anybody who would be buying this organ.

I Hear Voices

If you're used to the sound of a pipe organ, some of the ten solo and five accompaniment voices may not please you. But they provide a variety that enables you to play any tune in dozens of pleasant ways. Many of the 36 voice combinations or "registrations" given in the manuals provide quite striking music, such as Huge Theater Organ, Hollow Liquid Tibia, Calliope and Honky Tonk Piano.

These registrations are all combinations of six flute voices (flute, diapason), seven reed voices (trombone, trumpet, bassoon, clarinet, oboe, tuba horn, English horn), and two string voices (violin, cello).

Each of these three groups of voices has its own tremulant control, to give the music a "quivering" sound. Mandolin and banjo controls give two different "picked" sounds to upper-manual music.

Three balance controls are provided. Reverb adds a concert-hall sound, Pedal Volume controls how loudly the pedals sound, and Manual Balance lets you use either the upper or lower keyboard for solos.

You can play the Heathkit/Thomas Troubadour organ with just the two keyboards, the pedals and the 15 voice stops. But the fun really begins when you let the microprocessor and ROM circuits help with making fancier music, by adding a rhythm accompaniment and a walking bass, or play single-finger chords, or use the Fancy Fingers rhythm, or the strum or the arpeggio or . . . You'll need several months to find all the various combinations of voices and features that are possible with this organ.

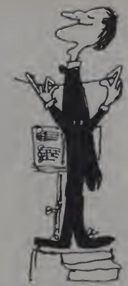
The 36 voice combinations or "registrations" given in the manuals provide quite striking music.

To paraphrase an old ad, "They laughed when I sat down at the organ, but their laughter turned to amazement when I began to play the Heathkit/Thomas Troubadour."

For $1495, you too can amaze your friends and neighbors. And the organ is even more of a bargain now, because the kit was originally $1749.94. .... □

Computer Music— With the Accent on Music

Jaxitron



Here's a one-of-a-kind article. First, a little music theory to fill in the technically clever but musically ignorant. And then on to Hyperwarp!

Jaxitron suggests experiments in music composition that will please a lot of you. What he ought to do is sell the package on disk...

Computer music has to sound awful! Right? Well, in the words of a song whose composer would strongly disagree and dynamically prove his point were he still with us, "It Ain't Necessarily So!" There is no law that confines the use of computers in music to experiments in sound in which all previous musical thought must be avoided. And home-computer manufacturers who advertise, "Compose your own music," are not addressing the general, music-loving public, but only one-finger pianists. Here I hope to demonstrate the computer's power to capture and convey musical concepts that can help you, as well as professional arrangers and composers, find material that would otherwise be overlooked.

From Numbers to Notes

Before going on to more interesting and creative matters, let me show the basic correspondence between musical pitch and our number system.

It seems to be common knowledge that the standard piano has 88 keys. Yet anyone who thinks numbers are pitted against the human spirit is disturbed to learn that, because the order of these keys is absolutely fixed, we can label them zero to 87 or one to 88 or in fact use any sequence of integers at all. For example, we can place zero somewhere around the center of the keyboard — say at middle C — and use negative numbers for lower pitches and positive numbers for higher ones.

In looking at a keyboard, you are immediately struck by the repetitive pattern highlighted by the black keys placed in alternating groups of two's and three's.

Jack Citron, 18136 Saticoy St., Reseda, CA 91335.

Let's extract one complete cycle of this pattern and number the keys from zero to eleven. Letting the first note be the white one just to the left of the two black keys, we force zero to correspond to the note C. The other white notes follow most unimaginatively in alphabetic order up to G but then revert to A and B as though mocking our choice of a starting point. Of course the initial note need not be C, but if it is, then the complete correspondence between numbers and notes for one "octave" becomes:

And home-computer manufacturers who advertise, "Compose your own music," are not addressing the general, music-loving public, but only one-finger pianists.

0	C	white	
1	C#		black
2	D	white	
3	D#		black
4	E	white	
5	F	white	
6	F#		black
7	G	white	
8	G#		black
9	A	white	
10	A#		black
11	B	white	

Now to cover the entire range of conventional musical pitch, the first column can be extended as required with negative and positive numbers above and below while the pitch pattern is simply repeated over and over. To change the reference pitch, you need only shift the columns with respect to each other so that zero is opposite whatever note you like.

Intervals and Scales

The word "interval" is commonly used to express the distance between two notes. Without worrying about arcane adjectives such as major, minor, augmented, diminished and perfect, we will here simply label intervals by the numeric differences involved. Thus the interval from E up to G (in the same octave) will be the difference between their assigned values — here, from 4 to 7, or +3. Similarly, the interval from G down to E will always be -3 (negative three). If you feel uncomfortable about the lack of units here, you can call them tones, half-tones or semitones (but not whole tones).

Now notice that the seven "white" notes in our setting that starts with C are numbered 0 2 4 5 7 9 11. The next white note would be 12 for the next C. It is no accident that this turns out to be the well-known major scale. But now notice that the successive intervals in this scale are 2 2 1 2 2 2, and 1 to the next C. So if you wish to express a major scale starting on D#, you can perform successive additions of the intervals beginning with the pitch 3 — that is 3, 3+2, 3+2+2, 3+2+2+1, ..., 3+2+2+1+2+2+2. The resulting numbers, 3 5 7 8 10 12 14 (and 15 to start the next octave) correspond to D#, F, G, G#, A#, C, D (and the next D#). Incidentally, throughout this article a minor technical limitation encourages my commission of a major musical sin — my typewriter as well as my computer terminal have no "flat" symbols.

Through the use of numbers, then, transposition to any key becomes a trivial matter. But more important benefits are to be gained through such calculations. Notice, for one thing, that the intervals in the scale add up to eleven (or twelve if you include the repeated "key-note" or "tonic"). By permuting these intervals in every possible way, you can use any of the 21 "modal derivatives" of a major scale. By collecting all sequences of seven positive integers that add to twelve, you make available all 462 seven-note scales in the conventional twelve-tone system of pitch. And my hand calculator tells me that amounts to 5544 scales considering transpositions to all twelve keys.

But a scale need not have exactly seven notes and the intervals need not total eleven or twelve as long as we remember that our hearing apparatus responds to the doubling of pitch as the same note.

We can form a short scale spanning any total interval. We might choose the intervals 2 1 2 or, beginning on zero, the notes 0 2 3 5. We can now treat this as a subset of a "complete" scale by repeating the *interval* sequence using one other fixed interval. That is to say, if I write 2 1 2 (2), I mean

2 1 2 (2) 2 1 2 (2) 2 1 2 (2) 2 1 2 (2) 2 1 2 . .
C DD#F- G AA#C- D E F G- A B C D- EF#GA .

Notice that 2 1 2 plus the separator 2 adds to 7. If the separator interval were 1, the sequence would add to 6 so that a single repeat of the subscale would bring the whole to completion:

2 1 2 (1) 2 1 2 (1)
C DD# F — F# G# A B — C

Whenever a completed cycle brings the total spanned interval to a multiple of twelve, the total pattern will repeat (because the name of the pitch is the same for 0, 12, 24 ... and for 1, 13, 25, ... and so on).

Even if it implies some internal clash (tension!) between theory and practice, we'll stick to the statement that a melody note already present in the chord adds no tension.

Having gone this far into heresy, we might as well question whether the separator interval needs to be positive. Consider 2 1 2 (-1):

C D D# F – E F# G A – G# A# B C# – C
2 1 2 (-1) 2 1 2 (-1) 2 1 2 (-1)

Here the pattern repeats twice before adding to twelve. And this raises the obvious question about the use of negative integers in the fundamental pattern itself (not just the separator interval). Well, one could certainly object that the introduction of negative values produces a melody rather than a scale. Indeed this is true if the result is treated as a melody. But if it is used only to select notes for the actual melody, it is a scale — even though it may contain repeated pitches and retrograde motion.

Programming Fundamentals

You might now want to write some programs based on this simple arithmetic approach. Your first input as data to one program would be the subset interval sequence with the separator interval either included or given as a separate parameter. The program can then calculate the pitch numbers up to the point where the separator interval causes the next pitch to be any multiple of twelve. And, of course, if you prefer to see the output in terms of alphabetic names, you will need a conversion routine using whatever special symbols you find convenient for flats or sharps. (Because the white notes run from A to G, I call the black notes sharps so that all pitch names are two characters long with the second character being either a blank or the letter S.)

Another program can now operate on the scale making use of another input sequence to create a melody or just a suggestion for one — depending on how far your ear will allow you to go. As an example, suppose we use the previous scale developed from 2 1 2 (-1), and for the melodic input sequence we arbitrarily pick the numbers 1 3 2. The logic of the program might use these as pitch indices directly (giving the first, third and second notes — C D# D) or as *scale* intervals (that is beginning on C, an interval of one gives D, three from there in the scale gives E and two more brings us to G). Either way, there are all sorts of creative schemes you can devise to convert a short input sequence into an extended one so as to produce a long melody with a recognizable stylistic pattern based on the way your logic manipulates the numbers. Those with little musical experience will find this educational, those with more will be fascinated.

But sooner or later you will miss the all-important part of Western music that isn't there — namely harmony. (I suspect that many of you thought I would say rhythm. While ordinary rhythms are simple to the point of being trivial, more complex rhythms are indeed interesting, but they will not bring you as close to real composition as will some understanding of harmony.)

Harmony

Although no one needs to be told that melody consists of single notes ordered in time, few laymen could state clearly what harmony is. This may be because of something it shares with such deeply technical areas as high-energy physics and time-sharing computer systems — namely, it has a virtual as well as a real existence.

Harmony is made up of simultaneous groups of pitches called chords which are ordered in time, but the pitches in a chord need not be played in simultaneity. During the time a particular chord is in effect, any background containing its notes is possible. The trick behind ordinary composition in our culture is to create harmony and melody that fit together like a stage setting and story line. The harmony not only shows "where" the melody is, it also suggests where it may go next. But enough of such generalities.

Aesthetically, the diagrams of the most symmetric states appear too simple to be pleasing, while those with less order become increasingly interesting until a point is reached where randomness becomes overpoweringly confusing and so distasteful.

Chords

Again we will use intervals, but now they are to be taken at the same point in time. For example, the interval structure 4 3 "built on" the pitch zero produces the three note chord:

0, 0+4, 0+4+3 = 0 4 7 or C E G

which is a major triad. By reversing these two intervals, we have a minor triad — i.e., 3 4 implies

0, 0+3, 0+3+4 = 0 3 7 or C D# G

Again notice that these combinations of two numbers will let you build major or minor three-note chords on any pitch through simple addition

D# major = 3 + (4 3) = 3 7 10 or D# G A#
A# minor = 10 + (3 4) = 10 13 17 or A# C# F.

Note that the remainder modulo twelve gives the pitch name in our reference octave

10 13 17 becomes 10 1 5 or A# C# F

Of course triads or three-note chords can be constructed from any pair of intervals — but you will find something "strange" about the musical flavor of most such structures. An interesting explanation can be given in terms of order, symmetry or what scientists might call "psychological entropy" — but we can't go into that here. For the moment just accept the fact that 3's and 4's will produce conventional results while other intervals *will* introduce possibilities that you may or may not be ready to appreciate.

Music, cont'd...

Now you may want to write a program that will construct all possible n-note chords containing only intervals restricted to some given set. For example, if n equals four and we limit ourselves to the intervals 3 and 4, the program should find these interval sequences:

3 3 3	3 3 4	3 4 3	3 4 4
4 3 3	4 3 4	4 4 3	4 4 4

Next, each of these sequences must be tested for the presence of a subtotal within the structure that equals twelve or any multiple of twelve. If such intervals are present in a structure, there will be fewer than four unique notes. On this basis, only seven possible chords will remain here because 4 4 4 is an obvious reject. Now any of these seven chords can be built on any of the twelve different pitches through the usual summation technique.

By changing the value of n from 4 to 7 or 12, you can now find all 36 seven-note chords consisting of only threes and fours, or all four twelve-note structures containing these same intervals. And, of course, with a sense of adventure you need not be limited to just these two interval values. Further, you might introduce separator intervals to increase the already endless supply of possibilities and at the same time create new kinds of harmonic flavors. As an example,

m n (p q) r s t

would specify structures containing first three pitches using only the intervals m and/or n, separated by the interval p or q from a four-note structure limited to the intervals r, s and/or t.

The mind-boggling assortment of possibilities that you create here cries out for some sort of selection apparatus to let you pick out only the agreeable chords without actually sampling every structure found. To accomplish this, you can use the following method for measuring the "tension" in a chord structure. Structures outside any tension range of your choice can be discarded by your program.

Tension (Order In Simultaneity)

Each interval in a structure contributes to the net tension in the structure. The following table shows the value to be added for each interval, and the intervals shown are really remainders modulo twelve.

Interval	Tension Contribution
10	1
2	10
11	100
1	1000
other	0

TNSN		S T R U C T U R E								CLASS
232	|	3 3 4 4 3 3 :	C	DS	FS	AS	D	r	GS	-MI7
321	|	3 3 4 4 3 4 :	C	DS	FS	AS	D	F	A	-MI7
421	|	3 3 5 3 3 5 :	C	DS	FS	B	D	F	AS	-MA7
232	|	3 4 3 4 3 4 :	C	DS	G	AS	D	F	A	MI7
321	|	3 4 3 4 4 3 :	C	DS	G	AS	D	FS	A	MI7
232	|	3 4 4 3 3 4 :	C	DS	G	B	D	F	A	MI
322	|	3 4 4 3 3 5 :	C	DS	G	B	D	F	AS	MI
321	|	3 4 4 3 4 3 :	C	DS	G	B	D	FS	A	MI
411	|	3 4 4 3 4 4 :	C	DS	G	B	D	FS	AS	MI
331	|	3 5 3 3 3 5 :	C	DS	GS	B	D	F	AS	+MI
322	|	3 5 3 3 4 4 :	C	DS	GS	B	D	FS	AS	+MI
421	|	3 5 3 3 5 3 :	C	DS	GS	B	D	G	AS	+MI
1221	|	4 3 3 3 5 3 :	C	E	G	AS	CS	FS	A	LG7
232	|	4 3 3 4 4 3 :	C	E	G	AS	D	FS	A	LG7
321	|	4 3 3 5 3 3 :	C	E	G	AS	DS	FS	A	LG7
232	|	4 3 4 3 4 3 :	C	E	G	B	D	FS	A	MA7
322	|	4 3 4 3 4 4 :	C	E	G	B	D	FS	AS	MA7
1320	|	4 3 4 4 3 2 :	C	E	G	B	DS	FS	GS	MA7
321	|	4 3 4 4 3 3 :	C	E	G	B	DS	FS	A	MA7
411	|	4 3 4 4 3 4 :	C	E	G	B	DS	FS	AS	MA7
2122	|	4 4 2 3 5 1 :	C	E	GS	AS	CS	FS	G	+7
1133	|	4 4 2 4 4 1 :	C	E	GS	AS	D	FS	G	+7
1222	|	4 4 2 5 3 1 :	C	E	GS	AS	DS	FS	G	+7
233	|	4 4 3 3 4 4 :	C	E	GS	B	D	FS	AS	+MA7
322	|	4 4 3 3 5 3 :	C	E	GS	B	D	G	AS	+MA7
322	|	4 4 3 4 3 4 :	C	E	GS	B	DS	FS	AS	+MA7
411	|	4 4 3 4 4 3 :	C	E	GS	B	DS	G	AS	+MA7
1221	|	5 2 3 3 3 5 :	C	F	G	AS	CS	E	A	7+3
241	|	5 2 3 4 2 5 :	C	F	G	AS	D	E	A	7+3
1222	|	5 2 3 5 1 5 :	C	F	G	AS	DS	E	A	7+3
241	|	5 2 4 3 2 5 :	C	F	G	B	D	E	A	MA7+3
331	|	5 3 3 3 5 3 :	C	F	GS	B	D	G	AS	+MA7+3
322	|	5 3 3 4 4 3 :	C	F	GS	B	DS	G	AS	+MA7+3
421	|	5 3 3 5 3 3 :	C	F	GS	B	E	G	AS	+MA7+3

Table 1.

This is not meant to establish a linear scale, allowing us to say that this chord is twice as tense as that one. Instead it gives a logarithmic relation, and so should have psychological value! Consider as an example the seven-note structure with the interval sequence

4 3 4 3 4 3.

The intervals between the first note in the chord (root tone) and each of the other pitches can be tabulated

Interval from root	Remainder mod 12	Tension
4	4	0
7	7	0
11	11	100
14	2	10
18	6	0
21	9	0

Notice that if the root tone were zero, the second column (remainder mod twelve) could be interpreted as the other pitch names in the chord. From this it is clear that we do have seven unique notes.

To tabulate this information for the second chordal tone, we drop the first interval leaving 3 4 3 4 3 to form the partial sums:

Interval from 2nd note	Remainder mod 12	Tension
3	3	0
7	7	0
10	10	1
14	2	10
17	5	0

And similarly for the remaining notes:

Interval from 3rd note	Remainder mod 12	Tension
4	4	0
7	7	0
11	11	100
14	2	10

Interval from 4th note	Remainder mod 12	Tension
3	3	0
7	7	0
10	10	1

From 5th note	Remainder mod 12	Tension
4	4	0
7	7	0

From 6th note	Remainder mod 12	Tension
3	3	0

Net: 232

The tension of this chord is the sum of all the tension contributions imparted by the various intervals shown — namely, 232.

As the term tension implies, chords with lower tension values will exhibit less interval clash between pitches in the chord. Your own musical experience and taste will determine the tension range within which you will feel comfortable. You can see that the fewer notes a chord has, the better its chances of having a lower tension. But you can also see that a change in the order of the notes in a chord can alter its tension drastically.

Melody Plus Harmony

Before considering chord continuity, we can now easily link the concepts of melody and harmony using the notion of tension.

Consider as a first example a C-major triad (C E G). By measuring the intervals from each of these notes to every other note, we can assign a tension value that describes how well any note "fits" or is harmonized by this chord. Any pitch already in the chord will be given a tension of zero because it doesn't add anything (usually!). As a result, every note in the octave can be evaluated for use with this (or any other) chord. "Wrong" notes become those whose tension values exceed your personal limits. For the C-major triad:

Note	Tension
C	0
C#	1000
D	11
D#	100
E	0
F	1001
F#	110
G	0
G#	1000
A	10
A#	1
B	100

Here the tension of the pitch F, for example, was found as follows:

F-G = 5-7 = -2 implies	10 or a tension of	1
F-E = 5-4 = 1	1	1000
F-C = 5-0 = 5	5	0
		Total: 1001

For a more unusual example, consider the triad with intervals of five and six built on C (C F B) or (0 5 11).

Note	Tension
C	0
C#	1010
D	10
D#	1
E	100
F	0
F#	1000
G	10
G#	0
A	1
A#	110
B	0

The most "professional" approach would intermix both procedures letting the inherent strength of the melody or harmony alternately suggest what should come next.

Here, the chord itself has tension — a value of 100 if the C is below the B. Yet a C in the melody might seem to add considerable tension because it lies above the B in the chord. This leads to a number of additional considerations that cannot be taken up here. Even if it implies some interval clash (tension!) between theory and practice, we'll stick to the statement that a melody note already present in the chord adds no tension.

Seven-part Harmony

If you can accept the above declaration, you can see that a chord with N notes could have N melody notes that add no tension. This makes seven-note structures most attractive for connecting harmony and melody because each such structure carries its own "complete" (seven-note) scale. Using such a structure, you can take the first three or four tones as the chord to be played while the melody ranges over any part of the seven-note scale.

As a result the melody can have considerable variation in tension, and yet be controlled to the extent that its net tension cannot exceed that of the original seven-part structure. A computer listing of 34 such structures showing for each the tension, interval sequence and the corresponding pitch names if C is taken as the root tone is shown in Table 1. The list is ordered and grouped by the last column, which is labelled "class." The entries under this heading represent terminology that is too specialized for this article, but you will notice that all structures in the same class have in common at least their first four notes.

You might also notice the structures are not completely unique. For example, the first structure built on C has exactly the same set of pitches as the sixth structure built on D# and also structure number 14 built on G#. This means that rearrangement of the same set of notes can alter the net harmonic effect. It also implies that more than one chord can harmonize the same fragment of a melody. But for that matter, if a single melodic pitch is to be harmonized, there are seven settings for each of these 34 structures, or 238 possibilities that will work. By this I mean that the melody note can be the first, second ..., sixth or seventh note in any of the 34 structures and seven times 34 is 238.

Before going further, you should validate each of these structures with your own harmonic sense. To do this, play the first three or four notes of a structure with your left hand (either simultaneously or in a fixed pattern) while picking out the entire seven-note scale (one note at a time) with your right. The scale is usually found by reordering the pitches ordinally: 1 5 2 6 3 7 4. In a few cases, this is not quite correct, but it will still give the taste of each structure. Test just one chord at a time and give your ear a good rest before changing structures. Cross off any that strike you as too unpleasant and don't be surprised if this removes quite a few — perhaps even a majority — from the list. You may be able to describe the throw-aways as having too much tension or no feeling of being in a "key." If you find you can keep only three or four out of the entire list of structures, don't worry about it. It simply shows you've led a sheltered musical life and your musical morality has persuaded you to draw the line between artistic license and unrestrained licentiousness in a conservative way.

Continuity

There are any number of programmable schemes for selecting structures and root tones for the initial composition of a harmonic continuity. Having begun this way, you must next select melody notes to fit the harmony. Conversely, a melody could be given or composed first and harmonization made to follow. The most "professional" approach would intermix both procedures letting the inherent strength of the melody or harmony alternately suggest what should come next. But in the space remaining, we will concentrate on the hardest of the basic tasks to computerize — harmonization of melody.

Music, cont'd...

Given a melody, the first chore is to decide where the harmonic changes should occur. This amounts to being able to say that the first n notes will go with one chord, the next m notes with another, and so on. If your musical experience is minimal, it will be easiest to force chord changes wherever you feel a "strong" beat in keeping the rhythm — essentially the first beat of each bar of music. For the first group of melody notes, any of your allowed structures built on any possible root tone can be tested against the melody. The test must be designed to keep only those chords that satisfy certain conditions regarding the fit between harmony and melody. The creativity lies in specifying the conditions to be met. Here are just a few suggestions for tests that a chord must pass in order to harmonize a given melodic segment.

1. Entries, a, b, ... of the melody must (not) be in positions n, m, ... of the chord structure
2. More (fewer) than N melody notes must (not) have tension higher (lower) than T with respect to the first M notes of the structure
3. The root tone must be r (or s (or tones).
4. The structure number (class) must be c (or d (or ...))

You may even want to apply conditions to choose which tests to use. For example:

> If there are more (fewer) than M melody notes, use test a, otherwise use test b.

In any case, conditions of this sort can be so restrictive that your program finds no structures can satisfy them. When more lenient specifications are made, chances are that more than one structure will be found to work. Your choice from this set of potential structures can be free or based on some additional tests.

Only after you have settled on the first chord are you really into the problem of continuity. All the features just discussed for finding a suitable harmony for the first fragment of the melody are now combined with considerations that take the previous chord into account, although, of course, we are now trying to fit the next group of tones in the melody. A direct approach might be to add conditions to the above set using a logical "and" to force interchordal relationships. Such conditions could include:

1. The Nth entry in the new chord should be less than (more than, exactly) P pitches above (below, in either direction) from the Mth entry in the previous one.
2. Entries x, y, ... of the previous structure should (not) be in the next one.

Another approach would be to construct a table of allowed structure changes — that is, structure type A can go to types B, C, ... A table might also contain explicit restrictions — structure type A can go to type B if the root tone moves through an interval, I. A well-thought-out table will establish a definite style in any given piece.

Order in Continuity

Another technique for controlling the style of harmonization makes use of psychological entropy (order). Suppose we are using all 34 of the seven-note structures shown above and the next section of the melody to be harmonized has only a single pitch. Without any continuity restrictions, there are 238 possible harmonizations. With relative ease, a computer can compare each of these with the previous chord and establish a distribution table of the following type.

# of changes	0	1	2	3	4	5
# of chords	4	17	43	83	79	12

A friend, having invited me over to see his new home computer, insisted on displaying its virtuosity with no less than six identically unrousing choruses of "Mary Had A Little Lamb"! Need I say more?

Here the computer found that four of the potential chords contained all seven of the pitches in the previous chord. Seventeen of the new ones had a single pitch that was not in the old one, 43 had two pitch changes, and so on. Because seven pitches out of twelve are always being used, the number of pitch changes cannot be greater than five. While 238 is not statistically large, the distribution does show typical statistical properties in that more samples fall in the inner categories than in the outer ones.

But, to get across the most fascinating property here, I must digress just a bit. There are many physical systems that display such statistical behavior. These systems can generally be described in terms of geometrical diagrams that represent some vital aspect of the property being counted — for example a cluster of arrows pointing in various directions. Generally the states more unlikely to occur — those falling in the outer columns (smaller numbers of occurrences) — exhibit high if not total symmetry (order) while the more populated distributions appear more chaotic. And *aesthetically, the diagrams of the most symmetric states appear too simple to be pleasing, while those with less order become increasingly interesting until a point is reached where randomness becomes overpoweringly confusing and, so, distasteful.* The rightmost column usually shows a peculiar sort of order which may or may not have aesthetic value depending on its apparent simplicity. Of course there is subjectivity involved here, but the determinant of aesthetic appeal in any case is a function of the number of ways each possible state of the system can be achieved.

In the case at hand, there seems to be no convincing geometrical representation with these properties, but — and this is the source of my fascination — the ear somehow categorizes the entries just as described above with the same aesthetic result! When more than a single note is to be harmonized by one structure, the number of possibilities decreases so that you might well expect the distribution to become even less statistically valid. Yet I have found that, even with only a dozen or so possible structures, the distribution — though containing fewer than six categories — still exhibits the same aesthetic patterns.

From here, you can choose chords freely from those the computer places in the more or less ordered categories. Or you may devise some automated methodology using decision-making techniques or directed graphs taking all sorts of things into account. Arrangers will be delighted by the chord changes suggested through the statistical approach.

You might well wonder what could have caused me to try to encapsulate so much material in so short a space. The impetus came from a most unexceptional, even homespun occurrence. A friend, having invited me over to see his new home computer, insisted on displaying its virtuosity with no less than six identically unrousing choruses of "Mary Had A Little Lamb"! Need I say more? □

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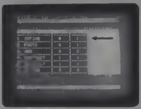

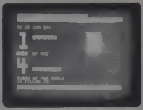

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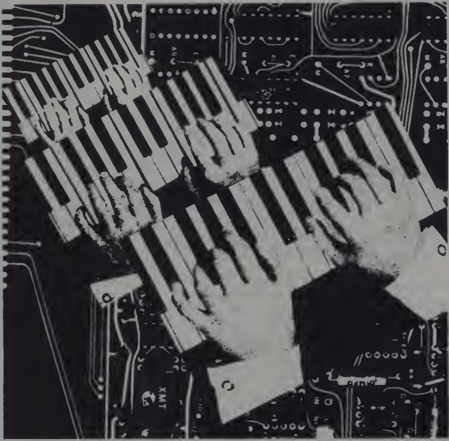
A Third Medium for the Music Composer: Computers



Judith Richland

A painter doesn't take on the whole world. The artist works within limitations — it will be this big, in these colors, with this amount of motion. In the case of a music composer working on a piece, he or she is typically restricted to a limited set of timbres or instruments.

This is especially important when composing computer music, says Barry L. Vercoe, associate professor of music, who founded M.I.T.'s Experimental Music Studio and directs a summer composition workshop. The computer affords the composer a literally limitless choice of sounds, even beyond those of the conventional instruments. Some can be simulated immediately, some only after painstaking research. So time is spent on not just creating musical compositions, but on the construction of specifically desired "instruments."

How is it done? At M.I.T.'s experimental music studio, the composer can use two computers, a PDP–11/50 (a gift to the studio from Digital Equipment Corp. in 1973), and an IMLAC PDS–4.

To make the computer accessible to the composer, Professor Vercoe developed a computer language that gives the composer the luxury of working in his own medium, the musical note. "To the majority of composers, a standard computer-based system is artistically inhibiting," he explains. "Card punches, teletypes, and printers are ill-suited to conveying musical information."

Using Professor Vercoe's system, the composer can type melodies onto a keyboard and see the result on a screen in front of him, displayed in standard music notation. He can create a large, complex score and can make modifications as he goes. Upon request, the computer system will synthesize and play back any segment of that score. And it will print copies of the score and parts for individual players. "The screen is quite intelligent," says Professor Vercoe. "It has the intelligence of about a second-year music student."

Like an Experienced Performer

Professor Vercoe also has additional methods of approaching the computer — "much as a composer would approach an experienced performer, communicating about the control of the performance at a higher level than the details of individual notes, talking about phrase structures and the manner the notes should be communicated and distributed over various octaves. I would then have the computer play it back to me, and I would say 'yes, that's right," or 'no, try again or make a change,' " he explained to David MacNeill in an interview on WCRB radio.

"I went to the console with a sketch of the piece in mind, an indication to the computer of what my technique of putting the piece together should be for this very small segment, and then left the details to the computer. It simply took care of the details and reported back. The thing that I was really honing in this case was not the computer performance, but rather my communication of the control to the machine. If I was incomplete in my communication, the computer performance reflected that, and I had to restate it until it got it straight," he added.

One Instrument at a Time

The computer doesn't compose, it performs the music by drawing sound waves with numbers. The more numbers per second, the better the sound, and some 40,000 numbers per second are typically required for high-fidelity sound for each of four channels if it's quadraphonic. These are then converted to electrical voltages to produce a signal that can be tape-recorded or used to activate a speaker system.

This does not happen quickly. The computer must simulate one instrument at a time and then add them all together. When it does this, a single machine can "play" all of the instruments of an orchestra at the same time.

Standard computers can synthesize only simple sound waves at the speed to be presented to the listener, or in "real time" (sound generated as fast as you hear it). For more interesting, complex sounds, the computer needs to take its time. The synthesis of a complex ensemble using high quality sounds can take the computer 10 or 20 times longer to develop than the sound will actually play in performance.

It builds the sound up slowly, on a digital storage medium such as a disc. (A disc may hold 20 minutes of music in mono,

Composer Barry L. Vercoe, associate professor of music (*right*) works with violist Marcus A. Thompson, associate professor of music, on a piece for viola and computer. For the past two summers, Professor Vercoe has shared his insights with students in a workshop for composers. It is in two parts: a two-week program on the techniques of digital sound synthesis (taken by composers, engineers, and people in the audio industry), and then a three- or four-week workshop for composers of considerable experience.

10 minutes in stereo, 5 minutes in quad.) Digitized sound on the disc can be burst back at the correct frequency and converted from digital to analog to permit the hearing of the piece at its correct speed.

Live Performer Input: Vital, and Absent

Music synthesized this way, stored on analog magnetic tape in a standard tape recorder, can be transported to a concert hall and played back for an audience. Herein lies a problem.

"Most composers in our summer workshops have usually had considerable experience in writing for traditional ensembles and traditional instruments. They have come to rely, to a very large extent, on the contribution made by a live performer," Professor Vercoe told David MacNeill. "A musical score written by a composer is basically a framework upon which performers drape an entire communication to the listener," he continued.

So when a composer chooses to express his work through a digital computer, his is a "canned" performance. However painstakingly it was constructed, the music lacks the element of live performance. The composer must take on the responsibility of "adding to his original concept all of those subtle nuances that live performers have traditionally contributed to scores in order to bring the music to life," explains Professor Vercoe. These vital additions to the score are seldom represented in traditional music notation, which affords only a skeleton guide.

A live performer may be used in conjunction with the computer, as a violinist in a violin concerto; the performer plays with the computer as a background and accompaniment. But here, too, the problem is acute. A live performer must synchronize his own performance with a prerecorded performance on electronic tape, which is played at a fixed speed. Thus he or she relinquishes the traditional freedom of tempo in the performance.

There will eventually be a solution, says Professor Vercoe. It will come with the development of very-high-fidelity digital synthesizers that can perform complex compositions in real time. Then there could be an interaction between computer and live performers — "the final emancipation of the medium," he says.

Survival of the Fittest: A Third Medium is Tested

In the 1600s, what had been largely a choral tradition of music changed to instrumental: violins were at the height of their development; chamber orchestra and symphony instruments could produce sounds as interesting as the human voice. The instrument had previously been only an accompaniment to voice. Now it rose to a parallel position, allowing composers two major resources.

Each time an instrument like the violin was invented, it was subjected to years of experiments and tests regarding its ability to produce interesting sounds. "Those instruments that failed the test, or interested only a few people, were those that did not titillate the hearing mechanism at all its various levels of information decoding. Such instruments failed to have a literature written for them and simply fell into disuse.

"This process of 'natural selection' has always gone on in musical instrument making," says Professor Vercoe, and "the development of computer music will be little different from the development of instruments in the past. Natural selection will be rigorously applied to the computer."

What we're seeing now is the active development of a third medium — not of mechanically produced sound (like a violin) but of electronically produced sounds. But these changes don't come about overnight, or in one year, or in one decade. As in the 17th century, they take 50 or so years.

"The thing that has fascinated me," says Professor Vercoe, "is that electronically produced sounds are now achieving an equal ability to be interesting. Not to replace other music but to join it, either as sounds to be heard in the concert hall alone or sounds joined with either or both of the other forces, affording the composer an enriched palette.

"We see an ever-increasing array of synthetic instruments using electronic and digital technology. Those techniques that last will be those that can be refined to the point where they can respond to the composer's need for control of detailed information. The listener will insist on this interest in the sound if he is going to stay at the concert."

"A Labful of Sci-Fi Tinglers"

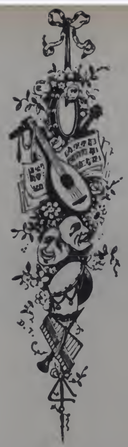
Where is computer music headed? "To the concert hall," says Professor Vercoe emphatically. He can now manipulate the sound enveloping an audience so that he has control of space as another dimension in music. With speakers located throughout the room, "we can move sounds around the auditorium at high speeds," he explains.

The computer music studio at M.I.T. has put on seven major concerts under Professor Vercoe's direction. "Three years ago concerts were not always accepted as legitimate music. There would likely be walkouts from the first row near the beginning of the concert," he says. It was unrecognizable as music, sniffed a *Boston Globe* reviewer at that time.

This summer, Professor Vercoe's concert in Kresge received quite a different response. "From what one can tell, everyone was extremely interested," he says. The *Globe*'s Richard Buell wrote of one piece by Richard Boulanger: "This had the makings of a sonic spectacular. It trafficked knowingly in extremities of volume and pitch, worked with a colorful palette, and sucessfully evoked a labful of sci-fi tinglers and their ilk."

And a large audience stayed to the finale.

Resynthesis of old recordings—where's the line now between "live" and "artificial"?



Rise Up, Rachmaninoff

Steven R. Newcomb
Sherwin Gooch

Mr. Newcomb is Associate Director of the Center for Music Research at the Florida State University in Tallahassee.

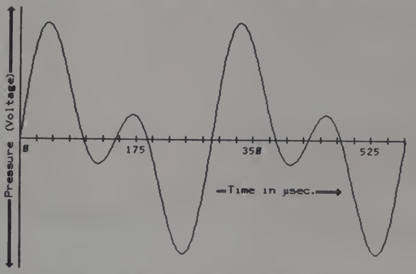
Mr. Gooch is a computer engineer involved in music research at the Computer-based Education Research Laboratory of the University of Illinois at Urbana.

PLATO™ Graphics by Steven R. Newcomb, Sherwin Gooch and Bradley K. Weage.

The art of recording and reproducing sound has only recently come of age. However, great musicians were making sound recordings almost from the moment of Edison's first patents. Unfortunately, many of the musicians who lived long enough to leave behind a legacy of recorded music did not live to take advantage of important technical advances in the art of sound recording, technical advances which have made it possible to create the illusion of attending a live performance. Can old recordings be electronically enhanced, so as to render them as lifelike as recent recordings? This article proposes that it should be possible to replace the sound of certain old recordings, and thereby enhance them, by means of a digital computer system.

Let us confine ourselves to the question of enhancing recordings of piano solos. For purposes of illustration, we shall concern ourselves with recordings made by Sergei Rachmaninoff during the years 1919-1941, which are now available in a collection, *The Complete Rachmaninoff* (5 vols., 15 discs; RCA ARM 3-0260, 0261, 0294, 0295, 0296). This reissue collection has been painstakingly remastered by the production staff at RCA. Under the direction of Jack Pfeiffer, vaults and collections were searched for the best-preserved copies (often metal stampers) of the various old recordings. By carefully fitting a stylus and tracking force to each, they tried to re-record as exactly as possible the

Fig. 1a: Input Signal to be Recorded



A 3472 Hz signal, shown here over a time interval of 576 microseconds. The waveform is a sine wave combined with its second harmonic.

Rise Up, cont'd...

wiggles originally inscribed by the old cutting heads. No analog or digital sound-processing techniques were used in the remastering. However, it is a common (and often misguided) practice to employ such techniques as filtration, "equalization," "phasing," the addition of reverberation, and dynamic expansion when remastering old recordings.

Analog Recording

The earliest recordings were made by acoustic power alone (i.e., without electronics), because until the mid-1920's, acoustic machines were all that were available. Acoustic recordings tend to have low signal-to-noise ratios. Early electronic recordings have much improved signal-to-noise ratios, but are still lacking in dynamic range and frequency range, and tend to be distorted. With the advent of magnetic recording (mid-1940's) it became possible to record uninterrupted pieces longer than six minutes. Microgroove recordings (1949) made long, uninterrupted pieces available to the public, and were made using standardized treble pre-emphasis and bass rolloff curves; this was the beginning of high fidelity for the consumer. Stereophony (1958) brought heretofore unimagined realism to the consumer recording medium.

Until recently, all commercial recording has been done by means of analogous representations of sound pressure waves, either as wavy grooves inscribed on discs or cylinders, or as rows of magnetized areas on magnetic tape or wire. Since the machines which do the writing of sound-wave analogs are complex mechanical devices which are necessarily somewhat finicky and subject to changes due to wear, there are obvious problems with analog recording techniques — the sounds which are put in are not necessarily those which will come out on playback. Moreover, any two playings of the same recording can never be exactly identical.

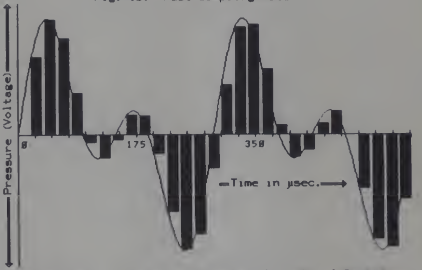
Perhaps less familiar are the problems involved with long-term storage of analog recordings. Modern discs are subject to slow deformation which, over the long term, causes some loss in fidelity. The metal stampers used in record manufacturing survive much longer, provided their storage environment is kept dry. Magnetic tape is also subject to gradual deformation and degradation of the base material, but it has another serious problem in that the magnetized areas slowly interact and weaken each other over time. This degradation is especially noticeable in the high frequencies.

The recording-vault librarian is faced then with two unpleasant alternatives: either he must rely on decaying masters for the enjoyment of his recordings by future generations of music-lovers, or he must transfer the old recordings onto new tapes, which will hopefully last longer before the gradual decay of the new tapes makes yet another transfer necessary. Because the addition of noise and distortion are inherent in the analog recording process, the disadvantage of re-recording an analog recording is that each "generation" adds a measure of distortion to the already somewhat distorted previous generation, as well as adding further unwanted noise.

Digital Recording

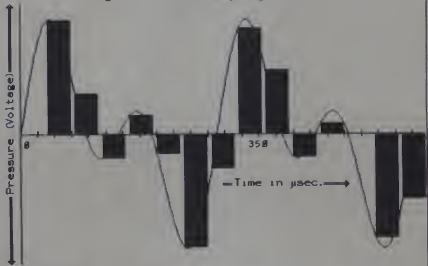
The answer to the librarian's dilemma is digital storage and retrieval (digital recording). High-fidelity digital recording involves "sampling" the amplitude of the signal some 50,000 times per second, and assigning a numerical value to the amplitude of the signal at the time of each sample (see Figures 1a, 1b and 1c).

Fig. 1b: Fast Sampling Rate



Samples (vertical bars) recorded at the rate of 50,000/sec. The height of each bar corresponds to a specific numeric value which the analog-to-digital converter has chosen as being the closest approximation proportional to the voltage of the input at the moment each sample was recorded.

Fig. 1c: Slower Sampling Rate



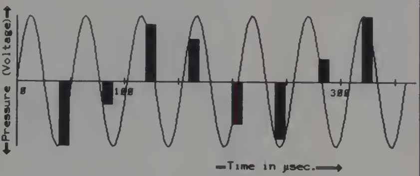
Same 3742 Hz signal, with samples recorded at the rate of 25,000/sec.

Rise Up, cont'd...

The Nyquist sampling theorem dictates that the sampling rate must be at least twice the highest frequency to be recovered. In the case of high-fidelity sound recording, 20,000 Hz is the rule-of-thumb upper limit of human hearing, and therefore this frequency is selected as the cutoff point. Our sampling rate, then, must be at least 40,000 samples per second. Certain practical problems, such as the impossibility of making samples coincide with the maximum excursion of the highest-frequency components of the signal, make 50,000 samples per second a better choice.

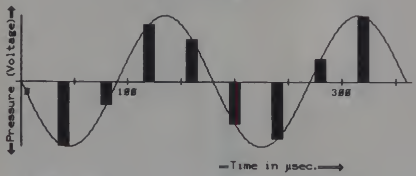
We must apply a low-pass filter with a cutoff point in the neighborhood of 20,000 to 25,000 Hz to the incoming signal prior to sampling, because if a sound of higher frequency than 25,000 Hz is sampled at a rate of 50,000 samples per second, a phenomenon called "foldover" occurs: the effect of foldover is that the wrong frequency is recorded (see Figures 2a and 2b).

Fig. 2a: Input Signal Sampled Too Slowly



Sine tone at 19,444 Hz, seen here over a time interval of 360 microseconds. The samples (vertical bars) are recorded at the rate of 25,000 samples/sec., which is less than the required minimum of at least two times the frequency of the signal we are attempting to record [25,000 samples < (2 × 19,444 Hz)].

Fig. 2b: Recovered Signal Quite Different Due to Foldover



The samples as recorded (Fig. 2a) are shown with the fundamental sine wave of the signal which can be recovered from them. The frequency of the recovered signal is 5556 Hz. Subtracting the original signal frequency (19,444 Hz) from the sampling rate (25,000/sec.), gives the 'foldover' frequency (5556 Hz). Foldover is perhaps best visualized as a stroboscopic or moiré-pattern effect.

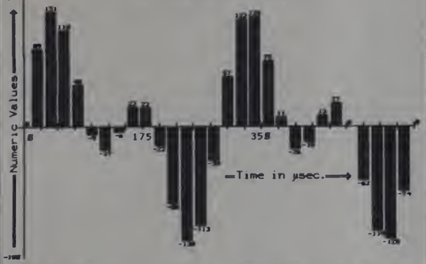
A similar filter must be applied to the playback of a digital recording, because the desampling process produces many spurious sounds at higher frequencies than one-half the sampling rate. This is most simply explained by means of a hypothetical example: suppose we wish to record a sine wave at 25,000 Hz, using a sampling rate of 50,000 samples per second; the computer can only use two numerical samples for each cycle, and therefore the signal recovered from the samples will consist of two voltages alternating at 25,000 Hz. A signal consisting of two fixed alternating voltages is a square wave, which is a waveform composed not only of the fundamental frequency contributed by the original sine wave (the input), but also of many strongly represented overtones, all of which are spurious in comparison to the original input.

Digital recording is inherently less noisy than analog recording; in fact, it can be essentially noiseless.

These overtones can be seen in the 90° angles found in the recovered waveform. Although these overtones are outside the range of human hearing, such large amounts of high frequency energy can wreak havoc on ordinary listening equipment — amplifiers have a shorter life, speakers overheat and phonograph records become untrackable. Moreover, these high frequencies have an unpleasant tendency to mix with the high frequency bias signal which is used in analog magnetic tape recorders, causing strange, spurious difference tones to be recorded on the tape. Fortunately, these inaudible frequencies are easily filtered out with a good low-pass filter (see Figures 3a and 3b).

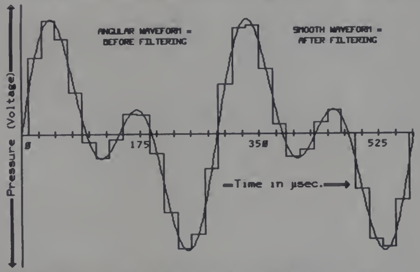
With today's high-speed digital circuitry, a sampling rate of 50,000 samples per second can be readily accommodated. The samples (each sample is a number and there are 50,000 numbers for each second of recorded sound) can be stored in any computer-memory device which has sufficient capacity. An analog-to-digital converter is needed for digital recording, and a digital-to-analog converter is needed for playback. Both of these items are made by several manufacturers and are available in single integrated circuit chips. In analog-to-digital conversion, the converter assigns a numeric value to each sample which is proportional to the voltage of the signal at the moment that the sample is recorded. In order to convert in real-time, the converter and its associated control logic must be

Fig. 3a: Samples (from Fig. 1b)



Samples (see Fig. 1) shown with their numeric values. For illustration, there is an arbitrary number (301) of values (-150 to +150) which a sample can have. The digital-to-analog converter works from a list of numbers (samples), which is in this case {0, 89, 131, 110,...}.

Fig. 3b: Recovered Waveform Before and After Filtering



The digital-to-analog converter's voltage output jumps to each new voltage (as prescribed by each sample), and holds each voltage for a length of time equivalent to $\frac{1}{\text{SAMPLING RATE}}$, in this case, $\frac{1}{50,000}$ sec. This distortion of the waveform can be removed with a low-pass filter.

able to make at least 50,000 times $\log_2$ of n decisions per second, where n is the number of amplitude values in the converter's repertoire. Many amplitude values are required for high fidelity in order that the dynamic range be wide enough for music, and yet be well-enough defined within its limits to avoid unacceptable distortion. (Sixteen-bit converters, for example, have 2^{16} [65,536] possible numeric values.) In digital-to-analog conversion, the converter must generate a voltage proportional to the numeric magnitude of the sample over a length of time equal to

$$\frac{1}{\text{number of samples per second}}$$

of a second.

Why is digital recording the answer to the librarian's dilemma? Although the actual digital recording process does have an inherent minimum distortion, due to rounding off each sample to the nearest available numeric value ("quantizing error"), the distortion is added only once. It never increases from generation to generation, because the numbers themselves are unaffected by copying, regardless of the number of generations removed from the original a particular copy happens to be. (It has been suggested that another verb be used instead of the word *copy* in the phrase "to *copy* a [digital] file or record." *Copying* implies that there is in fact an "original" which is somehow different. "To *clone* a file" would be better because the word *clone* implies no difference between the original and the copy; the clone file and the cloned file are identical in every respect. The only errors which can creep into the cloning process are due to hardware failures, which are generally quite detectable, or quantum mechanical effects, which are statistically very unlikely.)

Digital recording is inherently less noisy than analog recording; in fact, it can be essentially noiseless. The sound recoverable from an analog recording is irretrievably affected by the nature of the medium. For example, the unwanted hiss in the background of analog tape recordings is contributed by the tape itself. Computers, by contrast, read only the numbers; they ignore the hiss. The only noise inherent in the digital recording process is the noise introduced by microphones and amplification circuits.

Manipulation of Digital Representations of Sounds

When one waveform is added to another waveform, a single complex waveform is the result. This is why only one eardrum is needed to hear many sounds at once. A computer can be programmed to calculate new waveforms by simply adding corresponding samples together. Similarly, it is possible for a computer to reduce a given complex sound to its component parts, particularly if it is programmed to look for certain patterns.

Remastering Old Piano Recordings

Let us say that we have decided to employ the enormous power of a large digital computer to enhance an old Rachmaninoff piano recording, and we are well funded by a generous, music-loving foundation. We have available to us a recording studio which happens to be within cable distance of an

Rise Up, cont'd...

analog-to-digital converter, and we have a team of brilliant computer programmers who also happen to be musicians. We take the old rehearsal-conductor's view that musical expression can be specified in the six directions, "faster, slower, louder, softer, longer, shorter."

Since it is possible to divide a given old recording into a number of discrete parts equal to 50,000 times the number of seconds of duration, every note which is played in the recording will begin in a specific sample, and end in a specific sample. With an appropriate pattern analysis program, it should be possible for the computer to decide when each note was played, and when it was released. Thus, how fast or slow a passage of music was played, and how long or short a note was, are facts which are known to an accuracy of 1/50,000 of a second.

All these considerations are but aspects of the single parameter of time. (As we shall see later, however, accurate determination of the *loudness* of a note involves several problems).

When the agogic* and dynamic dimensions of each note are known, a second computer program, which we shall call a realization program, can be used to recreate the musical performance. It will draw on a database containing the digital equivalent of the eighty-eight keys of the piano keyboard, struck at various loudness levels. The output of the realization program is a digital recording which can be run through a digital-to-analog converter, whose output in turn will be a flawless recording of Rachmaninoff playing a piano he probably never touched, in a studio which probably did not exist during his lifetime.

Enhancement Preliminaries and Procedures

Our first steps involve giving the computer the data with which it needs to work. We must have a digital library (database) of the sounds which a piano can make. (The algorithm for creating such a library given below should be considered a thought experiment for purposes of illustration. The development of better algorithms is an ongoing field of research which is outside the scope of this article.)

We must feed into the database a digitally recorded example of each note on a piano at each practical dynamic level. Blake Patterson ("Musical Dynamics" in *Scientific American*, Nov 1974) has presented evidence that comparatively few dynamic levels may be necessary, because each just-noticeable difference in the perceived loudness of notes played on musical instruments requires a change in the acoustic power equal to a substantial portion of the total range of its acoustic power. Therefore, as few as eight dynamic levels may be adequate (Patterson's work actually suggests that only six may be needed). The eight dynamic levels can be achieved easily enough by means of dropping a padded weight on each key, aiming it by some mechanical means. The weight could be dropped from eight different heights, as determined by experiment.

The output will be a flawless recording of Rachmaninoff playing a piano he probably never touched, in a studio which probably did not exist during his lifetime.

Since gravitational acceleration is a constant 32 feet/second/second, and since the loudness of the sound of the piano is determined by the speed at which the key falls, dropping the weight should be a way of standardizing the dynamic output of the piano. However, pianos differ from each other, e.g., some have a "hot" treble range, and some do not. Any good pianist automatically corrects somewhat for the peculiarities of the instrument he happens to be playing, but a computer will not do anything without specific instruction. We can protect ourselves from distortion due to the peculiarities of the "model" piano first by using the finest available instrument (after all, the legendary Rachmaninoff is going to "play" it) and second by referencing the *perceived* loudness of each note at each dynamic level. This referencing is done by placing in a listening room a number of hapless volunteers who will listen to each key as played by dropping the weight from several heights. They will choose the height which yields a loudness which most closely matches the loudness of each dynamic level of a single reference key (e.g. middle C). In these experiments, the computer will be of enormous help in randomizing the examples and statistically analyzing the responses so as to make final judgments on the height from which the weight must be dropped on each key in order to achieve the most uniform perceived loudness across the keyboard at each dynamic level.

"Now it's trying to psych me out with readouts before each game like "I'll play but I'm not up to my game" and "surely you will win as my circuits are overworked." ©Creative Computing

We shall have to do all of these library-building procedures four times, because we must account for the greatly altered sound of a given note when the damper pedal is depressed, and when the *una corda* is depressed. Our database is complete when we have a fully referenced library of 2816 played-note models (88 keys x 8 dynamic levels x 2 modes of the damper pedal x 2 modes of the *una corda* pedal). Incidentally, the recording of our "model" piano should be made in an acoustically dead environment, because reverberation is easy to add and impossible to take away later. Another reason to make "dead" recordings is that the computer will turn off the sound of the hall reverberation simultaneously with its execution of the release of the note; this would be a most unnatural effect.

Can we rely on the original recording for accurate data concerning the relative loudness of any given note? The answer is no and maybe. The answer is *no* because many old recordings do not have anything like a smooth frequency-response curve. In some recordings, the transfer characteristics of the original equipment were so poor that some notes on Rachmaninoff's piano caused a shattering sound by coinciding with a drastic peak in the response curve, and some almost failed to be recorded at all by coinciding with a valley. Moreover, many of the lower notes of the piano are only represented by their upper partials, which are usually enough to give our ears the impression that the fundamentals are reproduced even when they are not; there must be some accounting for the missing fundamentals and lower partials of low notes. Similarly, we must account for

*intentionally askew relative to the meter the missing higher partials of high notes. On many old recordings, the percussive quality of the piano is all but lost, and this quality gives our perceptions important information about the musical dynamics. Another reason why accurate data may be unobtainable from the old recordings is that they have very little dynamic range. However, it may be possible, through various avenues of research, to generate the necessary data from the recordings themselves. One avenue might be to obtain some old recording equipment like that which was used to make the old recording in question, and run a response curve test on it at various dynamic levels. The resulting curves can be used to create a filtration program to compensate for the inaccuracies of the old recording. Another strategy would be to analyze each note as played in the context of the recording to extract information about the transfer characteristics of the piano, hall and recording equipment employed in the original recording. This information would allow us to compensate for any recurring anomalies caused by poor transfer characteristics. A third strategy would be to study the energy spectra of notes played on the piano, with the intention of "tagging" the decay rates of various portions of the spectra to various dynamic levels. If enough spectral information remains on the old recordings to establish a recognizable energy decay pattern for a given note, it should be possible to establish that note's dynamic level as it was originally played. To implement this strategy, it may be necessary to study the very pianos used in the original recordings (at least some of the instruments used by Rachmaninoff are known and still exist); however, it will be quite difficult to compensate for the unknown changes which time and normal maintenance have wrought.

Execution

Assuming that the problems outlined above have been solved, the computer now has everything it needs except the program which actually accomplishes the synthesis of the enhanced recording. This program should be divided into a number of phases. In the first phase the computer will analyze what it "hears" in the old recording. For each note, the computer will answer the questions, "When was it struck? how loud was it? when was it released?" Answering the third question may be difficult. Particularly in the noisy old acoustic recordings, one cannot tell when the note was released because as the note decays it is lost in the background noise. There are two ways of handling this problem. One is for the computer to signal the operator (necessarily a good musician) that a case of this kind has occurred, and have the operator make a decision about when the note is to be released. The other way of handling the problem is to have a third set of input data: the score of the piece, translated into a computer language such as GCSMCL. (The Gooch Cybernetic Synthesizer Music Compiler Language [GCSMCL] is a sophisticated five-pass score input language which was originally developed at the University of Illinois Computer-based Education Research Laboratory [Urbana] as part of the operating system for the Gooch Cybernetic Synthesizer [GCS]. The GCS is a music peripheral for the PLATO interactive graphics computer system. GCSMCL has been under development since 1976, and is now in the final stages of refinement.) The computer can then identify the troublesome note in the score, and simply make the assumption that Rachmaninoff released the note at the time indicated, taking into account, of course, the current agogic context. Since computers are completely lacking in good taste, however, it would be wise to have the computer flag that note for future reference in case the output (the enhanced recording) sounds unlikely.

Any good pianist automatically corrects somewhat for the peculiarities of the instrument he happens to be playing, but a computer will not do anything without specific instruction.

Now employing its realization program, the computer simply adds up all the sound, drawing from its library of 704 unpedalled played-note models. The result should be a convincing but dry recording of a Rachmaninoff who inexplicably refused to use the damper pedal, recorded in a bone-dry hall, and had at least twenty-nine fingers, judging from the number of notes he was able to sustain at one time without using the pedal. At this time, the operator adds the pedalling, simply by telling the computer when to do what. Obviously, this last part of the enhancement process involves the artistic judgment of the operator, but it is the only part of the operation of this electronic player piano system which is completely dependent on the operator for information. It is even possible that by analysis of background energy levels, we may learn when the performer pressed and released the pedal.

The computer now runs its realization program again, this time drawing from its complete library of 2816 played-note models. The completed tape can now be brought to the recording studio for the addition of a tasteful amount of hall reverberation, using standard devices such as a stressed-plate reverberator coupled with a digital delay line. The finished product should sound as good as any modern recording, and quite possibly better. It is not only more pleasurable to listen to than the old recording, but it is also more valuable to the student and to the musician, because Rachmaninoff's true intentions with regard to dynamics are better represented, while his agogic nuances have survived the whole process virtually unscathed.

Commercial Potential

The market for these recordings is ready-made. Many who have the old recordings on the reissue albums will want the new, improved versions. Sales to libraries are assured.

Would it be feasible to undertake the project outlined in this article as a commercial venture? It depends on the cost of production. It is probably safe to say that if research and development costs are not a consideration, then there is no reason not to run virtually all valuable old piano solo recordings through the system. It might require about ten hours of computer time to analyze and reassemble a five-minute performance. This gives a production cost in the neighborhood of $12,000 per record album, a figure roughly comparable to the cost of producing new recordings. The cost of developing the necessary programs and associated databases is very considerable, and very difficult to estimate; this might be in the neighborhood of $1 million with currently available technology.

Other Applications

It is very difficult to imagine how the technique outlined above can be applied to old recordings of instruments other than the piano, or to old vocal recordings. However, even these problems may someday be surmounted. After all, the digital synthesis of human speech has already reached the point where talking toys are commercially available for under $50. One may even wonder whether it will be necessary to exhume and measure Caruso's sinuses in order to enhance his old recordings. □

Caruso Lives Again

A half century after his death, Enrico Caruso's vocal recordings are among the top ten on the classical charts.

"Caruso, a Legendary Performer," an RCA album of 16 operatic selections, is the first long-playing record produced by a Utah firm using a computer-processing technique. The operation compensates for technical defects to reveal the power, opulence and expression of the great Italian tenor.

The first Caruso record was released in August 1976 by RCA and was the No. 1 selling classical record in America during November and December 1976, according to *Billboard*.

Using a DEC PDP-11/45 minicomputer and a technique called deconvolution, Soundstream, Inc. of Salt Lake City rid the music of distortions and colorations intrinsic to the "acoustic" method of recording. In the acoustic method, developed in the 19th century by such notables as Thomas Edison and Emile Berliner, and used from 1890 to 1925, sound waves were gathered into a megaphone, amplified through a simple resonant cavity and transferred to a wax disc by the recording stylus.

According to Dr. Thomas G. Stockham, Jr., president of Soundstream, the purely mechanical process put serious limitations on the artist.

The full power of Caruso's extraordinary voice could set the stylus vibrating violently producing a distortion called "blasting" while soft passages were obscured by surface noise. Then, because 78 rpm discs had a maximum recording time of four and a half minutes, Caruso often had to sing much faster than his normal tempo.

In addition, to achieve necessary volume, violins were fitted with mechanical resonators and the string bass was replaced by the tuba as a low-register instrument. These changes gave the recordings a mechanical "rinky-tink" flavor.

The deconvolution technique developed by Stockham and his staff strips away, as he puts it, a "curtain of sorts" that hides the musical value of old records.

"It is not intended as a step toward high fidelity in the sense of modern electronics, but was designed to achieve an accurate insight into musical history," Stockham said.

The audio conversion system designed and built by Soundstream is connected to the minicomputer. The unit combines computer interface modules, analog-to-digital and digital-to-analog converters, waveform conditioning circuits, timing mechanism, filters, amplifiers and other components into an integrated hardware package essential to computer interfacing of high quality audio signals.

The computer program designed by Stockham determines the magnitude of tonal abnormalities on the record and corrects them through a resonance inversion procedure.

To correct tonal imbalance, Stockham uses a linear digital filtering method he discovered during his research at MIT in 1965. The process, known as high-speed convolution, has become standard for much digital signal processing work.

Stockham's deconvolution is similar to the technique used by geologists in clarifying seismic signals and begins by converting analog audio signals to digital data.

A needle transversing a record groove sets up an electrical impulse that produces an analog signal electrically equivalent to the recorded sound wave. Using an analog-to-digital converter, Stockham translates these analog signals into digital values the minicomputer can process; these are transferred to an RP04 storage disk.

A three to four and a half minute production is chopped into 300 to 400 lengths each representing a ½-second segment of music. Each segment is treated to precise analysis and examination of over 1,000 frequency components. Frequency imbalances are detected by the computer program and corrected by the computer. Frequencies that fall within a range where noise dominates are discarded in the correction process.

"The result is significantly better and copies can be made digitally with no generation loss whatsoever. The resulting sound retains some of the original flavor, but with improved clarity, voice texture and artistic interest," Stockham said.

Soundstream is continuing its work with old records and has produced a restored version of "Rhapsody in Blue" as part of a recently released RCA album "Gershwin Plays Gershwin."

Dr Thomas Stockham, Jr., Soundstream, Inc., 34 South 600 East, Salt Lake City, UT 84102

The ALF designer discusses his approach

Apple Music Synthesizer

Philip Tubb

Once upon a time only a few people in the world had printed books or other printed material. Eventually, printing technology advanced to the point where many people could afford to have books. Naturally, this had a great impact. Another step forward came in the form of the photocopying machine. With this technology, many people could not only possess written material, they could create their own materials to give to their friends and associates. Now, of course, printed material is quite common. We've even reached the point where the thousands of local computer clubs each feel obligated to produce printed newsletters, whether or not they have anything to write.

Recording technology made it possible for many people to have music, like printing technology had done earlier for text.

There was a time when only a few people in the world could afford to have music. Orchestras (and even individual instruments) were expensive, and there was as yet no way to record their sounds. Recording technology made it possible for many people to have music, as printing technology had done earlier for text. Today, we still struggle to bring music to the stage that photocopiers have taken text. "One-button chords" and "rhythm masters" abound in organs which "anyone can play without lessons." Many feel that what computers have done for word-processing, they can do for music-processing, thus solving the problem of music production by the average person.

Phil Tubb, 1448 Estes, Denver, CO 80215.

When my colleagues at ALF Products and I began work on a new computer-controlled music synthesizer (for the Apple II), we hoped to make new advancements in the area of personal music. First, the hardware had to be fairly versatile, and yet simple enough to be sufficiently low cost. Second, the software had to be easy enough for the average computer user to use. Personal-computerists are pretty good around a computer, but many are lost in the esoteric field of music. Since we made remarkable progress in the software area, I will begin with it.

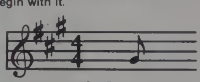


FIGURE 1

The Software

In Figure 1 you will see one of the basic elements of sheet music: a note. This particular note is shown in its natural environment (a treble staff with time and key signatures) and happens to be a G and also an eighth note, plus a few other things which will come up soon. Assuming one will want to take sheet music (which is where you're likely to find notes like this one) and cause it to be performed with a computer-controlled music synthesizer, it is necessary to take lots of these notes and describe them to a music entry program. Once a song has been thus described, music production can begin.

Probably the most obvious way to get these notes into memory is to type them in with a standard ASCII keyboard, because all usable computers seem to have such devices. Obviously, you just type EIGHTH G. It's simple. However, EIGHTH is a little long, and DOTTED THIRTYSECOND will be even worse. So, people usually abbreviate quite a bit. Let's use EG. It's harder to read, but who cares? The time savings in typing will be worth it. The various notes are Whole, Half, Eighth, Sixteenth, Thirty-second, Sixty-fourth and so on. The first letter is enough as long as we quit before we get to Sixty-fourth. Period looks great for "dotted," so the DOTTED THIRTY-SECOND G becomes T.G or maybe .TG.

Now things begin to get complicated. The note in Figure 1 isn't really a G, it's a G sharp. This is because the key signature has indicated that all C's, F's and G's will be sharp unless otherwise noted. This saves a lot of space when writing songs in which these notes are almost always sharp. There are several key signatures, in which one to six of the A through G notes are sharp or flat. In the more advanced music entry programs, one just inputs the key signature and the program figures out that it is really G sharp instead of G. But in simpler systems, and on those occasions where a note is "natural" (meaning not sharp or flat regardless of what the key signature says), or where a note must be sharp or flat even though the key signature doesn't so indicate, one must indicate this exception in some fashion. These exceptions are called accidentals. Usually this is done by adding S, F or N (Sharp, Flat or Natural). This gives us EGS. On simple music entry systems, one must always type the S, F or N; and in more advanced systems you need only type them when absolutely necessary.

Are we running out of complications? Of course not. There are many

Synthesizer, cont'd...

different G's in the piano scale. The scale goes A, A sharp, B, C, C sharp, D, D sharp, E, F, F sharp, G, G sharp; and then starts over at A. (Or you can use flats instead of sharps if you like: A, B flat, B, C, D flat, D, E flat, E, F, G flat, G, A flat.) Each section of the scale, from any given note up to but not including that same note again, is called an octave. Octaves are significant in that the pitch (or frequency) of any given note is always twice that of the same note in the next lower octave. Or, if you prefer, the pitch of any given note is always half that of the same note in the next higher octave. This fact comes in handy in the hardware, as you'll see later. Now, musicians like to start the octave at C. The overly-rational crowd (including myself) like to start it at A. Computer-controlled music companies often like to start their octaves at whatever their lowest note is. In any

It is difficult to remember the octave number for each note, and people often type in the wrong one, thus making the song jump up and down an octave or two on a particular note.

case, generally one winds up with "octave numbers," in which each octave is assigned a number. This is because the "traditional" notation is far too cumbersome to use. The A's in this sytem go like this (from lowest to highest pitch): A,, A, A a a' a" a"' a"" and so forth. Further, they are blessed with names like "subcontraoctave" and "four-line octave" and they switch at C, of course. The infamous Middle C (the only note most people know by name) is written c'. Rather than resort to buying an upper and lower case keyboard, and replacing the comma and apostrophe keys every other week, most people use octave numbers. So now we have EGS3, or some such. Naturally it is difficult to remember the octave number for each note, and people often type in the wrong one, thus making the song jump up and down an octave or two on a particular note.

So, you type in your EGS3's and cheerfully input the song. Of course, you'll eventually come upon a tied note, or a triplet note, or some such. There isn't any representation for these yet, but the more advanced systems come up with something. Usually the music is typed in with line numbers, as one would in Basic or most other languages, so it can be edited later. A listing of one of these songs looks like a test print-out of a defective modem. No mere mortal can read them. This difficulty makes editing quite a task, and the problem is further compounded by the fact that most systems require a "compiling" phase in which the numeric-alphabet soup is taken from the "easy to type" format and turned into an "easy to play" format. Although this is usually necessary because the processor will need all the help it can get in order to play the song at a reasonable speed, the delay involved during the compile makes it hard to go back and forth between typing in corrections and hearing the corrections.

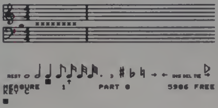


FIGURE 2

At ALF we'd been through this several times. It really is hard to use, and one's most creative impulses often die an early death in sheer frustration. A new system was needed. Fortunately, we picked the computer most likely to succeed. The high-resolution graphics meant we would be able to plot traditional (or near-traditional) music notation on the television screen. Further, the Apple has "game paddles" which are simply rotary knobs, each with a simple pushbutton just like the TV "pong" games. This indicated a possible escape from all that typing. (Really, the Apple was, and still is, the only mass-market home computer with space inside for the synthesizer.)

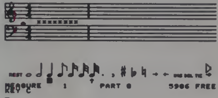


FIGURE 3

It works like this. Figure 2 is the way the screen might look when you first run our Entry program. One of the knobs (Paddle 0) changes the position of the little upward-pointing arrow. If it were turned clockwise a little, the screen would then look like Figure 3. This arrow is used to select the various "menu" items shown right above the arrow. The other knob (Paddle 1) changes the position of something we call the flying saucer cursor. Turning Paddle 1 slightly clockwise makes the

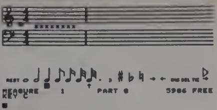


FIGURE 4

screen appear as in Figure 4. These two paddles are used for virtually all note entry. More complicated things, like key signatures, are entered using the ASCII keyboard.

The key signature shown here is the key of C, in which no notes are automatically made either sharp or flat. We want a key with three sharps. Momentarily succumbing to the omnipotent power of abbreviation, one types KEY:3S and presses return. Just

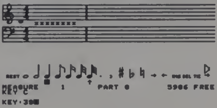


FIGURE 5

to give you the idea, Figure 5 shows the screen just before return is pressed, and Figure 6 just after. The checkerboard filled-in square is meant to

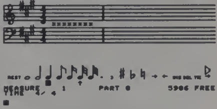


FIGURE 6

represent the text cursor on the Apple which is really filled in solid, but which flashes on and off. (For those of you dying of curiosity, these "screen photos" were printed using periods on a Hytype 1640, and reduced.) You'll notice that the cursor has moved so it is now where the 4/4 is. This cursor is always at the point where a note or special item will appear if entered. If we use Paddle 0 to aim the upward arrow under the leftward arrow, then pressing Paddle 0's button will move the cursor left one item. Figure 7 shows the screen after one such back-up.

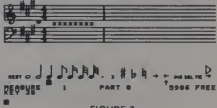


FIGURE 7

Synthesizer, cont'd...

Note that the place on the screen which originally showed KEY:C now shows KEY:3S. This spot always describes the item which the cursor is on. If we typed KEY:C and pressed return now, all would be as it was originally since the item at the cursor (KEY:3S) would be overwritten with a KEY:C. To move the cursor to the right, one positions the upward arrow under the right arrow, and presses the button. The cursor moves right once for each button press. The asterisks (*) shown where a Middle C note would go (that is, between the two staffs) each indicate some bizzare item which is not easily represented in traditional notation. In this case, they are all specifications of envelope and volume settings. After moving right past all these, the first note of the song can be entered.

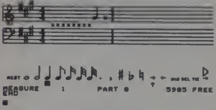


FIGURE 8

By rotating Paddle 1 until the cursor is at the desired position, one selects the pitch of the note to be entered. Pressing Paddle 1's button then causes the note to be entered (see Figure 8). As the cursor moves up and down, a "click" is heard through the Apple's built-in speaker; one click at each possible note position. This allows one to position the cursor without having to look at the screen in some cases. While the Paddle 1 button is held down (and while the new note is plotted on the screen, which occurs in the blink of an eye), the synthesizer plays the appropriate pitch. This allows instant feedback so you're sure you entered the right note. If we're entering the note shown way back in Figure 1, then it will have the right pitch, but the note entered was a quarter note instead of an eighth note. This is so I can show how errors are corrected. When Paddle 1's button was pressed, the note entered was determined in pitch by the location of the flying saucer cursor, and in duration by which note has a

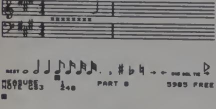


FIGURE 9

Phil Tubb hooking up his Apple/ALF synthesizer.

block under it in the menu. If we aim the arrow under left movement, press the button to back up once, and then position the arrow under the eighth note, we can then press the button to select an eighth note. The block under the quarter note disappears, and one appears under the selected note duration (see Figure 9). Now all notes entered will be eighth notes, until we change the duration again. Pressing Paddle 1's button now causes the correct note to be entered since the duration is right and Paddle 1's knob is still positioning the cursor at the same pitch. The old quarter note is wiped out (see Figure 10).

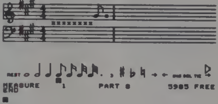


FIGURE 10

Music entry is simplified by an automatic measure bar feature. For example, if we enter a few more notes, a measure bar will appear when the measure is full (see Figure 11). The measure bar appears automatically, and serves as a quick check that you're doing all right. If we like, we can

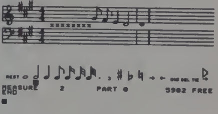


FIGURE 11

change the time signature at any point. For example, if we type TIME:2/4 and press return, a new time signature is plotted. If we then enter a quarter note followed by a half note, the half note must be converted into two quarter notes tied together. This is done automatically by the Entry program (see Figure 12).

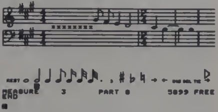


FIGURE 12

These measure bars are more important than you might think. Sure, they let you know you're still together with the sheet music. But in sheet music they also have to do with the accidentals. After typing TIME:2/2 for a more reasonable measure length, we can enter a few notes to explain the situation (see Figure 13). The first note is a regulation A. The next is an A

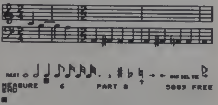


FIGURE 13

sharp. (Sharp notes are entered by using Paddle 0 to light up the block under the sharp sign in the menu before entering the note with Paddle 1's button. The block under the sharp is cleared when the note is entered, since the next note will probably not be sharp, too.) The next two notes are also A sharps, because a sharp sign continues to make other notes (of the same letter) in the measure sharp (and a flat sign makes notes flat in a similar fashion). The next note is in a new measure, so it is not sharp. Now, the next note has been entered as sharp. If we want the next note to not be sharp, we just light up the natural sign before entry. The last note is, of course, not sharp since the effect of the sharp sign is neutralized by the natural sign. This natural sign is also used to counteract the key signature.

Some of you may be wondering what happens if you move the cursor down a little more, so it would be below the staff. Figure 14 is for you.

This entry scheme is fast. You rarely do any typing. Further, you just put one hand on Paddle 0 and the other on Paddle 1, set the sheet music on the Apple, and breeze right along. But

Synthesizer, cont'd...

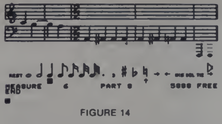


FIGURE 14

more importantly, it looks just about like regular sheet music. Most importantly, it is really easy to edit. If you make a mistake, you must adjust a paddle knob and back up, then reenter the note. The little speaker with a right arrow under it also helps in editing.

When you use Paddle 0 to light up a block under it, the notes already entered will be played back as you move right using the right pointing arrow. When a block is not present, no playback occurs during right movement. If you want to play the song back at normal speed and with envelope and volume control, you just type PLAY. No, the sheet music notation doesn't zip across the screen while it plays. Speed problems with the Apple (or just about any processor) would degrade the quality of the playback, and a display with several notes playing simultaneously would be nearly impossible to read with Apple's graphics capabilities. We use a low-resolution display which is easy to plot and fairly easy to read. A dot for each voice moves left for lower notes and right for higher notes, and its color indicates the volume.

The Apple is the only mass-market home computer with space inside for the synthesizer.

Obviously this entry scheme only allows one note to play at any given moment. How, then, are multiple notes played at once? Has ALF not heard of chords? The answer is really quite simple. Since each voice could well be a separate (but, it is hoped, coordinated) melody line, and since the synthesizer is capable of completely independent operation with each voice, we allow each voice to be entered separately. Not only does this make entry simple and concise, it is easy to learn and effective to use. By typing PART:1, we are magically presented with a screen that looks a lot like the screen of Figure 2, except PART 0 on the screen has changed to PART 1 and there are fewer notes of memory available. (In reality it is necessary to use the EDIT command to create a part 1 unless a part 1 has previously been created.) The second voice (where a "voice" is a melody line or chord fragment in which at most one pitch is played at any given moment) is entered into Part 1. The third voice is entered as Part 2, and so forth. Parts 0 through 8 are available, although the ALF Apple Music Synthesizer has only three voices per card, so two or three such cards are required for six or nine voices/parts. These parts are completely independent, so you can do anything you want in them. They are virtually separate songs, although they are all played back simultaneously when you use the PLAY command.

There are a couple of ways in which the parts are not completely separate. One is an incredibly useful feature called subroutines. Those of you who program in any non-alien computer language are already familiar with subroutines and probably know what's coming up. The subroutines can be called from any part, so they are more or less part-independent. An example is in order. Let's say we want to play Row, Row, Row your Boat. If we are to do this merrily, merrily, merrily we will need subroutines, subroutines, subroutines. (Actually only one subroutine is needed but I got carried away.) Here's how it is done. First, we type SUBROUTINE:0. Really we type SUB:0 since all commands can be abbreviated as much as you like, as long as there is no confusion as to which command is desired. This is like the PART command in that it gives us a new area in which to program music. Unlike the PART command, the screen starts off "empty" (just the staffs, menu, etc.) without a key and time signature and envelope parameters. We enter the notes for row, row, row. Now we go to Part 0 using the PART:0 command, skip past the standard envelope settings, and type CALL:0. When the playback software sees this CALL, it will trundle off to the specified subroutine (number 0, as requested, although 0 through 99 can be used) and play whatever is there. When the end of the subroutine is found, it will zip back to whatever was after the CALL. Since we need to play this section several times, we put in several more CALL:0's in Part 0. Now, in Part 1 we put a rest as long as we need for the round effect. Then several CALL:0's are needed. During playback, Part 0 will start in right away, while Part 1 rests. At the proper moment (or at the programmed moment) Part 1 will come in with the same melody. Additional parts can be added to taste. Further, we can change the envelope parameters on the various parts so they will produce different sounds. We can even change the transpose settings, which will allow one part to be played higher or lower in pitch than another, even though the same notes were entered (using the subroutine) for both. The contents of subroutines are not limited to notes. They can include volume and envelope changes, or other changes, as well. This allows various sound settings to be entered into subroutines which can be called whenever that sound is desired. Subroutines can even call other subroutines. We've entered the Twelve Days of Christmas using subroutines instead of entering each section several times, and you can imagine how complicated that is!

Music entry is simplified by an automatic measure bar feature.

Once a song has been entered, it can, of course, be stored on cassette or on a floppy disk. It can then be read in again at any time and played back, or one could add more or perhaps change what is already there. An interesting aspect of the storage feature is that it is about the only way to record audio which does not degrade with repeated playbacks. When a tape or disk seems to be about ready to wear out (that is, becomes difficult to load) a new tape or disk, which is exactly like the original, can easily be made. Other than the now emerging digital tape recorders, all other recording methods have noise or distortion which increases with each playback (although perhaps only a little at a time), and each new copy is of less quality than the original. With a computer-controlled synthesizer, each performance can sound exactly like the original. Or, it can be different. Another interesting aspect of music data is that it can be subjected to algorithms. Programs can be written to modify the song in various ways. One popular algorithm is to flip the scale over so that all low notes are high and

Synthesizer, cont'd...

vice-versa. If done properly, this changes minor keys to major, and major keys to minor. The results are often interesting, or at least amusing. Another possibility is changing formats. If you have an audio tape recorded with DBX or Dolby, you'd better have similar equipment for playback. However, if you have a disk of songs written for Micro Music's synthesizer, you can still play them on

Say we want to play Row, Row, Row your Boat. If we are to do this merrily, merrily, merrily we will need subroutines, subroutines, subroutines.

our synthesizer. A simple conversion program is used to change MMI's format to the ALF format, which can then be played or edited in the normal fashion. (Note that you must buy a copy of the disk, and you are then free to use it as you like. "Borrowing" a disk from a friend who has an MMI unit is in violation of copyright laws if the disk is copyrighted.) Likewise, MMI users can play ALF songs if they have an appropriate conversion program (but again, you must buy a song disk or tape). The playback will sound different on the two synthesizers, of course, because they have different capabilities. I suspect that most computer music companies will be offering conversion programs so you can use music disks available from other companies.

The various menu items on the screen are used as follows:

REST is used for entering rests. Rest duration is selected in the same fashion as when entering notes.

The seven notes shown are for selecting note duration.

- • is used for entering dotted notes.
- 3 is used for entering triplet notes.
- # is used for entering sharp notes.
- ♭ is used for entering flat notes.
- ♮ is used for entering natural notes.
- → is used to move the cursor right.
- ← is used to move the cursor left.

INS is used to control "insert" mode. When insert mode is on, all entered items are inserted in front of the cursor, rather than over the current item.

DEL is used to delete an item.

TIE is used to add (tie) another note or rest duration to an existing note or rest.

▷ is used to turn on or off playback during right movement and DEL.

The following commands are available:

NEW is used to start fresh.

EDIT is used to change the number of parts, the suggested playback speed, or for the four text lines which are shown during playback.

STEREO is used to specify the left/right/middle playback assignments for each part (when using two or three synthesizers).

PART selects which part will be shown and available for editing.

SUBROUTINE is the same as PART, but a subroutine is selected. If not present, it is created.

GOTO is the same as PART except it puts you at the same measure you're currently at (but in the specified part).

MEASURE is used to move the cursor to any desired measure (within the current part or subroutine).

DELETE is used to delete several items from the song.

INTEGER is used to go back to Basic.

LENGTH is used to specify a note or rest length in "time periods" for unusual note durations.

LOAD is used to read a song from disk or cassette.

SAVE is used to save a song to disk or cassette.

PLAY is used to play the song.

The following commands are stored in the song data:

VOLUME selects a new volume level.

ATTACK used for envelope control.

DECAY used for envelope control.

SUSTAIN used for envelope control.

RELEASE used for envelope control.

GAP used for envelope control.

KEY specifies a new key signature.

TIME specifies a new time signature.

CALL calls a specified subroutine.

QUARTER specifies a new "time period" duration for all following quarter notes (during entry) and thus indicates the length of all menu notes.

TRANSPOSE specifies a new transpose value to be added to all following pitch values. During playback, pitches can be raised by 1 to 127 quarter steps and lowered by 1 to 128 quarter steps.

TEMPO specifies a new tempo (playback speed) when using the optional timing mode input board.

POKE is used to enter any code. This must be used with great caution, and is not recommended for general use (of course).

In addition to song data entry and editing, the software also takes on some tasks which would normally be in the hardware, but have been placed in software since it works out well. The most important of these functions is the creation of envelopes.

The term "envelope" refers to the volume contour of an individual note: the way in which it becomes loud and then dies away. For example, a plucked string becomes loud quickly, then dies away. In contrast, a piano note becomes loud quickly, stays loud (but slowly fading out) while the key is held down, then rapidly dies out when the key is released. By creatively selecting the rates and levels used, a variety of different sounds can be created.

Our software creates Attack-Decay-Sustain-Release (ADSR) envelopes, as do nearly all professional music synthesizers. This envelope has four "stages." The first is the attack stage, during which the "loudness" (or volume, but I use volume to describe the overall sound level rather than the level during individual notes) goes from its current level (which is usually zero, but can be about anything) to the currently selected "volume level" (as set by the most recent VOLUME item in the song data). The most recent ATTACK setting in the song determines the rate. In fact, the ATTACK setting is the number to be added to the volume each "time period" (yes, the same time periods used for specifying note durations). When the loudness gets to the volume level, the next stage begins. This is the decay stage, in which the loudness goes down (at a rate selected by the most recent DECAY setting) to the currently selected SUSTAIN level. The sustain level is usually some (fairly high) percentage of the current volume for piano-like sounds which hold at a high loudness level (the sustain level) after an initial "thump" (created by the attack and decay stages). In plucked-string sounds, the sustain level is selected as zero so the loudness will die out with just the "thump." Assuming that a non-zero sustain level is used, then the sustain stage occurs when the loudness simply sits around and stays at the selected sustain level. A certain amount of time before the next note begins (the time being

The term "envelope" refers to the volume contour of an individual note: the way in which it becomes loud and then dies away.

selected by the most recent GAP setting), the release stage begins. During the release stage, the loudness drops from the sustain level to a zero level at a rate specified by the most recent RELEASE setting. (It may not actually get down to zero before the next note starts, if your release rate is too slow, but it will try.)

The synthesizer software creates up to nine of these envelopes at once, all of them with independent parameter selections. Very complex sounds can be created by having more than one part play the same notes (using subroutines, of course) but with different envelope and/or transpose settings on each part. Further, parts can be delayed (using a very small rest at the beginning) for particularly devious sounds or for echo/reverb effects.

Although all this time I have been discussing the Entry program, there are five other programs supplied with the synthesizer. The programs are designed for use with Apple's Integer Basic, but versions compatible with Apple's [Microsoft] Applesoft Basic are also available for those who don't have Integer Basic. These other programs are for continuous album-style playback, simple playback (without editing capabilities), special applications (such as sound effects or song playback in your own programs), and there is an introduction program which describes, plots and plays basic synthesizer concepts.

The Hardware

The two most important parameters of a note are its pitch and duration. Using a synthesizer which has control of only pitch and duration for each note, recognizable tunes can be played. One of the easiest ways to create pitches is by division. There are simple circuits which will take an input frequency and divide it by a specified integer. (There are more complex circuits which can take an input frequency and multiply it by an integer.) Thus, the easiest way to produce a variety of frequencies (pitches) is to take a very large frequency and divide it by a variety of integers.

A sixteen-bit divider circuit can divide a frequency by any integer from 1 to 65,536. This is what we use in our synthesizer. We use an input frequency of 1,782,000 Hz (Hz is the abbreviation for Hertz, which means "cycles per second"), which is generated from a quartz crystal. This gives us output frequencies from 1,782,000/1 Hz to 1,782,000/65,536 (27.19) Hz. The piano range goes from 27.5 Hz to 4,186 Hz in 88 steps.

The notes of a piano scale are called equal tempered half steps. "Equal tempered" means the frequencies from a geometric progression, each frequency being the frequency of the previous note times a constant. "Half steps" means there are twelve notes per octave (an "octave" being the range in which the frequency of the notes doubles). (The term half step refers slightly to the fact that from one white key on a piano to the next is a "whole step" provided there is a black key in between. Since the black key's frequency is equally spaced between the white keys', and the white keys are a whole step apart, the black key must

be a half step between the white keys.) If we number the piano keys (both white and black) starting with zero and going up by ones, then to form a geometric progression with values starting at 27.5 (Hz) and doubling at each twelve note, the frequency of any note, N, must be 27.5 times 2 to the power of (N/12) Hz. The various frequencies which the synthesizer can produce with integer divisors, D, between 1 and 65,536 are: 1,782,000/D Hz; or, the divisor, D, for any desired frequency, F, will be D=INT(1,782,000/F + 0.5) MAX 1 MIN 65,536. Combining all these handy formulas, we get a formula for all piano scale divisors, D(N), where N is an integer from 0 to 87: D(N)=INT(1,782,000/(27.5 times 2 to the power of (N/12)) + 0.5) MAX 1 MIN 65,536. These divisors must be computed by the software and then programmed into the hardware. Unless we are all using Cray computers with 12.5 nanosecond clock times, some faster method than computing fractional powers will be needed. Fortunately, there is a relatively obscure but powerful algorithm for this

With a computer-controlled synthesizer, each performance can sound exactly like the original. Or, it can be different.

called a "look-up table." For those of you not familiar with this advanced programming technique, it consists of an area of memory in which is located the answer to every possible question of the nature being solved. For the piano-scale problem, there are only 88 answers, so the amount of memory required is small (176 bytes).

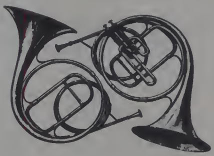
However, we decided to use quarter-steps, which have 24 notes per octave. (Take all those formulas above and change the 12's into 24's, then extend the range of N from 0-87 up to 0-175.) This gives us twice as many notes, but since they are twice as close together we get the same frequency range. Rather than have a range of seven octaves plus four additional notes, like a piano, we decided to add a few more high pitches to obtain eight full octaves (96 half-steps or 192 quarter-steps). Using TRANSPOSE, it is also possible to request notes even higher. Using a simple formula which takes advantage of the octave relationships, the look-up table size can be reduced. This formula is D(N+24)=INT(D(N)/2 + 0.5) when using quarter-steps (for half-steps, replace the 24 with 12). This means that if you have the divisors for the lowest octave (values of N from 0 to 23), you can compute all the others. Best accuracy is obtained using D(N+24 times A)= INT(D(N)/(2 to the power of A) + 0.5) so the rounding is done only once. Fortunately, dividing by 2 to the power of A and then rounding is quite simple in machine language. (All serious music programming is done in machine language [or, more properly, assembly language] since all high level languages present speed problems.)

By feeding the 1,782,000 Hz clock signal into three identical 16-bit programmable divider circuits, it is possible to produce three pitches at once. (The reason for choosing three sets of circuitry is, in this case, because three 16-bit dividers come in one integrated circuit package.) The next most significant aspect of a note is the duration. In our synthesizer system, this is controlled by the software. It programs the dividers for a particular pitch, then waits around for the right amount of time, and then programs the next pitch. This is done with a special "time-sharing" program which will be explained later.

Having conquered pitch and duration, the next parameter needed to improve the synthesizer is volume control. Actually, volume control is a rather insignificant feature. However, if you can control the volume quickly enough, you can make envelopes, which are vastly important and useful. It is important to create "smooth" envelopes which do not suddenly change in loudness. Sudden changes create annoying clicks, which, if you follow computer music synthesizers, you've no doubt heard in new companies' equipment. The hardware for envelope production in our synthesizer is also used for controlling volume, and consists of a special digital-to-analog converter (DAC). A DAC takes an integer, which in this case is output on the Apple bus, and creates a voltage or current as specified by the integer. For example, an input of 1 might produce 1 volt, 2 produces 2 volts, 3 3 volts, and so on. The DAC we use has an input which selects positive or negative values. This input is connected to the square wave pitch output of one of the 16-bit dividers. Thus the output of the DAC changes from positive to negative values at a rate selected by the pitch. This means the output is always centered around zero. Some systems fail to do this, and problems result. For example, a square wave changing between 0 and 5 volts has an average value (or is centered around) 2.5 volts. If a "rest" (no tone output) is implemented by stopping the programmable divider, the output will change to either

0 or 5, and thus the "center" point will change by 2.5 volts. This change produces one of those annoying clicks I mentioned earlier. Rather than stop the divider, we program the volume to zero for a rest. This eliminates the off-center click problem. Another special feature of this DAC circuit is that the outputs of the DAC are exponential. This means that if we send an arithmetic progression of integers to the DAC, it will create a geometric progression of outputs. Both frequency and volume must increase in a geometric progression in order to seem to increase at a constant rate, due to the way human hearing works.

When creating envelopes, the "time-sharing" program comes into play. The first thing this program does is start a timer in the Apple. This timer, which is controlled by one of the paddle knobs, determines the length of a "time period." The program has a "pointer" into the musical score for each part being played. The first such pointer is used to check to see what is next in the score for Part 0. If it is a subroutine call or other special function, it is done, the pointer is advanced, and the next item is done. When a note or rest is finally encountered, the proper pitch and/or volume control programming is done, and the time duration of the note or rest is copied into a special location referred to as the "time remaining." Each part has its own location for time remaining. Then, the next part is processed in the same manner, using pointers, time remaining, and other parameters associated with Part 1 rather than Part 0. If a part is holding a note, its time remaining will be non-zero. In this case, the pointer to the musical score is not needed since it is not yet time to continue with the next



item in the score. Instead, the time remaining is decremented, and the time-sharing program goes on to the next part. Eventually, the time remaining will reach zero, and it is then time for the next note. When the last part has been processed, the program waits for the Apple's timer to indicate that the full time period has been consumed. Then the whole process starts over.

In addition to checking the time remaining and the score pointer, during the processing of each part a computation is done to calculate an envelope for that part. The envelope calculation is rather simple. A "current loudness" is compared to a "desired loudness." If the current loudness is less than the desired loudness, the "attack rate" is added to the current loudness. If it is greater than the desired loudness, the "current decay rate" is subtracted. (Overshoots are detected and eliminated.) Only one addition or subtraction is done in each time period, and the new current loudness is programmed into the volume control DAC. (Each of the three pitch outputs has its own DAC.) When the current loudness reaches the desired loudness, then a new desired loudness is taken from the "current sustain level" and the current loudness tries to reach this new value. By copying the volume level into the current sustain level and the decay rate into the current decay

With a computer-controlled synthesizer, each performance can sound exactly like the original. Or, it can be different.

rate, a new note is started (and the ADS portions of the ADSR envelope will occur automatically). When it is time for the R portion to begin, a zero is copied into the desired loudness and the current sustain level, and the release rate is copied into the current decay rate. Note that the actual volume level is *never* changed directly. It is only changed by the routine which adds the attack rate (or subtracts the current decay rate) to the current loudness. This means that the volume will never change faster than the attack rate (or decay or release rate). As the desired loudness is changed, the current loudness (and thus the actual volume level) attempts to reach the desired level, but only at the programmed rates. Even a rest is created only by setting the desired loudness and current sustain levels to zero (and copying the release rate into the current decay rate).

This concludes the hardware of

our synthesizer, except to say that the three DAC outputs are connected together and zapped into levels acceptable to your stereo system. When using two synthesizers, one can be connected into the Left input and the other into the Right input on your stereo. The software is designed to let you select which synthesizer each part goes to, and thus each part's left or right positioning can be selected (or changed from time to time). When using three synthesizers, special circuitry allows one of the synthesizer's outputs to be heard on both Left and Right, thus becoming Middle (sort of).

At this point, the budget for the hardware has been reached (for a list price of $265), and further sound parameters cannot be controlled without running the price beyond most hobbyists' wildest dreams. However, the next most important feature would be control of waveforms. Like volume control, waveform control is a rather insignificant feature unless you can change the waveforms rapidly. Usually waveforms are created by filters. In an envelope generator, a DAC creates different volume levels by creating an output voltage which is specified by an input integer. In waveform control, filters are used to make certain esoteric changes in the input waveform based on an input integer. By sending the filter the same sort of numbers as one would send a volume control DAC, "wow" type sounds can be created. (However, most filters require that the current note frequency be added into the numbers usually used for envelope control.) A separate program or circuit for generating these numbers is required since you probably don't want the same pattern of numbers for the envelope and waveform control. A discussion of the basic nature of waveforms, how they affect the sound, and how they are created is beyond the scope of this article. It would be long and involved, and perhaps of little value without audible examples.

If you have questions on computer music, you can send them to: Creative Computing Magazine, Questions & Answers, Phil Tubb, P.O. Box 789-M, Morristown, NJ 07960 □

A New Approach To Teaching Music

Computer Aided Sight Reading

David B. Clark
Colette T. Wilkins
D. T. Tuma

Introduction

Computer-based instruction (CBI) for training in music has been to a large extent implemented on large computer systems,[1] or on sophisticated minicomputer systems.[2] It is now well established that certain musical skills can be effectively strengthened through drill and practice exercise via CBI.[3] However, not all educational centers have access to such powerful computer systems; and if they do, the cost is too high for the typical class. In addition, computer centers usually do not allow the connection of user devices — such as a "music box" — to the computer.

Recent technological developments in electronics have brought to the consumer computational capability at low cost in the form of the small computer. In the same manner, the cost of a dedicated, standalone computer system of acceptable power has come within the financial reach of most educational institutions. It is expected that this trend of availability of more computational power per unit cost will continue for many years. Such circumstances should make the use of small computers in education an irresistable force.

This article describes an implementation of a fixed-do sight reading exercise for music students on a low cost, stand alone small computer system. Although the application is specific, the approach has general features of value to people interested in applying CBI on small computers.

When considering the use of small computers for CBI, certain general objectives need to be attained to ensure the success of the implementation:

- The system should be easy to use and not require any computer knowledge on the part of the student.
- The system should be inexpensive and portable.
- The system should provide interactive operation with the user.
- The system should have some graphical capabilities.
- The system should provide the user with immediate feedback as to the user's level of performance.
- The overall experience to the student should be positive so as to induce the student to use the system voluntarily.
- The system should be flexible enough to allow future implementations of other advanced features as the need arises or as the technology advances.

Specific features that were sought to ensure a successful implementation of the sight reading exercise on the computer consist of the following:

- Graphical display of the musical notes
- Generation of different successive exercises
- Exercises in many clefs
- Inclusion of leger lines
- Timing of student performance
- Clear indication of the student's mistakes
- Possibilities for expansion into other areas of musical training, such as ear training.

D. Clark, C. Wilkins, D. Tuma, Carnegie-Mellon University, Pittsburgh, PA 15213.

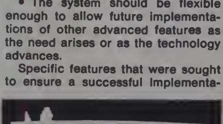


Photo 1

A graphical display of a musical score in progress. The staff, treble clef and three out of ten notes have been displayed. A leger line appears on the third note.

Capabilities

The set objectives are found to be satisfied by a Radio Shack TRS-80 computer system equipped with a Level II Basic Interpreter and 16K RAM memory. This system, selling below $1,000, consists of a typewriter keyboard, a cathode ray tube (CRT) display and a cassette recorder for storage and retrieval of programs. It is expected that in the near future even more appropriate systems may become available at the same price.

The exercise on the TRS-80 is initiated by the user typing RUN on the keyboard. From then on the interactive features of the program provide the user with all the information needed and options available to proceed in the exercise.

The events of a typical exercise proceed in the following order:

1. An Introductory message appears on the CRT. This message describes to the user the lesson to follow and outlines the tasks the user will be expected to perform. The user is asked to press the ENTER key on the keyboard when ready to continue.

2. The list of clefs (treble, bass, soprano, tenor, alto, mezzo-soprano and baritone) is displayed. The user is asked to make a choice by pressing a number corresponding to the desired clef. If the user presses an inappropriate button, an explanatory message is printed and another opportunity given.

3. Following the selection of a clef, the user is asked to indicate by pressing Y or N whether notes on leger lines are to be included in the drill. Again, an appropriate response causes a helpful prompt to be shown on the screen before the question is repeated.

4. Following an acceptable response to the leger line query, the video display is cleared. A five-line staff is drawn, and the clef selected by the student is then superimposed. Ten randomly generated notes are drawn on the staff. Photo 1 shows this in progress for a case in which the user selected treble clef and chose to include notes on leger lines.

All graphics functions are designed as subroutines and are therefore easily usable for other lessons.

5. When all ten notes have been drawn, the message PRESS ENTER WHEN YOU'RE READY TO GO! is shown beneath the score. The user is then given an opportunity to study the score before attempting to sight-read it against a clock. This point in the lesson is illustrated in Photo 2 for a case in which the user selected bass clef and chose not to include leger lines.

6. As soon as the user presses the ENTER key, the previous message is replaced by THE NOTE IS? A timer which records the total time used by the student to identify the ten notes is now initiated. The user presses the key corresponding to the leftmost note on the screen (the keyboard's numeric keys have an overlay marked DO, RE, etc.). If the student's response

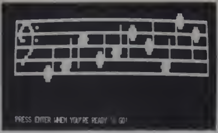


Photo 2

A complete graphical display of a musical score in bass clef without leger lines. The user is being prompted to start the exercise.

is correct, the syllable is momentarily shown after the question mark, and the note is erased. The student then proceeds to the next note. Photo 3 shows this for a lesson involving the soprano clef. If the student's answer is incorrect, the message NO, <syllable student gave> IS WHAT'S FLASHING NOW is shown on the screen. A small block on the staff which corresponds to the syllable given by the student is then flashed for a brief time. Following this, the original message THE NOTE IS? is reprinted and the student is given another opportunity to identify the note. In Photo 4, this feature is demonstrated for a lesson on the tenor clef in which the user incorrectly identified a "re" as "sol."

7. The lesson proceeds in this fashion until the student has correctly identified all 10 notes. Beneath the empty staff, the screen then displays the student's performance results. Numeric results for accuracy and speed are provided, and a message describing tempo is printed. The message YOUR TEMPO WAS GOOD! indicates that the user did not require more than two seconds to identify any single note. For example, a student who made one error in identifying the ten notes, identified all 10 in 15 seconds, and needed three seconds to identify a particular note, would see the following message: YOU GOT ALL 10 NOTES in 11 TRIES FOR A SCORE OF 90. YOUR AVERAGE RESPONSE TIME FOR EACH NOTE WAS 1.5 SECONDS. NEXT TIME, TRY TO MAINTAIN A BETTER TEMPO. After this message is printed, the user is asked to indicate whether another drill is desired. Typing Y will repeat the drill with ten new randomly generated notes, while typing N ends the lesson.

Implementation

The software for the sight-reading lesson is written in TRS-80 Level II Basic, which allows the use of machine language subroutines when faster execution of particular tasks (such as graphics) is desirable. The program occupies 9.2K of RAM space, requiring slightly more at execution. For versatility in future programming, all graphics functions are designed as subroutines and are therefore easily usable for other lessons. These subroutines are machine-dependent and would have to be completely rewritten if another microcomputer were to be used. The subroutines include subroutine STAFF, which draws a five-line staff, CLEF(C), which draws a specified clef, NOTE (H, V), which draws a note at a staff location specified by its horizontal and vertical coordinates, and ERASE (H, V), which erases a specified note. All but ERASE are written using TRS-80 Basic graphics commands, which offer considerable flexibility but execute slowly. Drawing the full score takes approximately 12 seconds. Once the drill has begun, however, notes must be erased quickly, or a moderately adept student could find the system unpleasantly slow. Subroutine ERASE is therefore written to directly access video memory, thus providing a worst-case execution speed of 165ms per note erased.

Classroom results have verified that beginning students are progressing much faster than usual in learning this basic skill.

A graphical display of a musical score in the soprano clef. The first five notes have been correctly identified and duly erased. The user has just correctly identified the sixth note as a sol, and the note is about to be erased.

The low resolution of the TRS-80 graphics (128H by 48V) combined with the need for relatively round notes severely limits the number of notes which can be displayed at once. Given the presence of a clef and reasonable spacing between notes, only ten can

Sight Reading, cont'd . . .

be displayed simultaneously (Photo 2). The vertical display range extends to two leger lines above and below the staff (17 notes in all). This leaves several lines at the bottom of the display for text.

An important design constraint of the software is the ease of operation for the untrained user. One example of this is response prompting coupled with complete error trapping. When a query is made of the user, an explanation is always provided of the type of answer expected (Y or N, a number from 1-7, etc.). An inappropriate or mistyped response from the user does not crash the system, but generates additional helpful prompting and subsequent repetition of the question. Even if the program were erased from memory, it could be reloaded from cassette with a minimum of effort. Another implementation of this design constraint is the writing of special keyboard strobing routines which eliminate the need for the user to type a carriage return following each input. As soon as a key is depressed, appropriate action begins. Since it is desirable to minimize the technical details users are forced to remember, these techniques should be of value to CBI applications in general.

The software can be broken down into the following major routine blocks:

1. Initialization
   a. internal housekeeping
   b. seeding of random number generator
   c. introduction printed on screen
2. Establishing Drill Parameters
   a. query user for desired clef
   b. query user concerning leger lines
3. Drawing the score
   a. draw staff
   b. draw specified clef
   c. draw ten randomly generated notes
   d. wait until user is ready to continue
4. Conducting the drill
   a. accept user inputs
   b. if correct, erase note and proceed
   c. if incorrect, provide feedback and repeat
   d. monitor elapsed time
5. Feedback to user upon completion.
   a. accuracy
   b. speed
   c. tempo
   d. provide option to repeat drill with new notes.

Evaluation

As of this writing, the sight-reading lesson has been in use for several months. Students deficient in sight-reading skills who have used the system are uniformly enthusiastic about the help it provides. The lesson's immediate feedback feature offers a clear advantage over traditional solitary practice, where a student could unknowingly make endless incorrect readings. Students have in general been receptive to the idea of computer drill work. Their suggestions for program improvement have been incorporated whenever possible.

Classroom results have verified that beginning students are progressing much faster than usual in learning this basic skill. Furthermore, students using the machines are often intrigued with the reading of the less common clefs, with the more advanced students using the system to sharpen their skills in these areas. Class time has been freed from the need for drill on clef reading allowing the instructor to cover more stimulating topics. Finally, this simple introduction to computers in music education has stimulated both student and faculty interest in more sophisticated applications within the field.

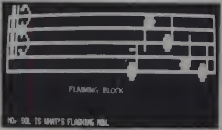


Photo 4
A graphical display of a musical score in the tenor clef. The first five notes have been correctly identified and duly erased. The user has just incorrectly identifed the sixth note. The user is being told of the error and a flashing pointer indicates where the wrong choice falls on the staff.

Future Plans

Current work with the TRS-80 system is centered around the development of a music box which can provide pitches under computer control. At the fundamental level, the concept of a music box emitting pitches synchronized to a visual output is one that truly improves upon the classroom situation, since a teacher cannot simultaneously play a note and write it on the blackboard. Of particular interest is drill in dictations, in which the student is required to identify the pitches just heard. A music box with several voices could provide drill in dictations of several parts.

A critical weakness of the TRS-80 system is its limited graphics capability. For more sophisticated applications, at least two staffs, each containing considerably more than ten notes, must be shown along with text. Also, with better resolution, rhythm notation could be incorporated. Since harmony and counterpoint follow certain well-defined rules of composition, with improved graphics a whole library of musical drills could conceivably be developed and stored on tape. This is not possible on the TRS-80.

Photo 5
TRS-80 keyboard with special "overlays" on first eight digit keys.

Conclusion

We have been successful in implementing a very useful sight-reading exercise for music students on a small computer system, the Radio Shack TRS-80, that is affordable by most schools. The response of the students to the use of the system has been enthusiastic. A qualitative evaluation of student learning on the system shows very positive results. The system has now been in use for several months without any breakdown or major malfunction.

This experience encourages us to proceed with the implementation of other exercises, such as music dictation, on the small computer. However, we perceive a need for a small computer system that has finer resolution graphics than the TRS-80. All indications are that the market should in the near future have such a system widely available at a cost of $1,000 or less.

ACKNOWLEDGEMENT

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10 REM***INITIALIZATION***
20 CLEAR 50:DEFINT A-Z
30 DIM N(10),T(10)
40 RANDOM
45 CLS PRINT CHR$(23):PRINT STRING$(32,"*") PRINT"CARNEGIE-",
  "MELLON UNIVERSITV":PRINT:PRINT'MUSIC EDUCATION SYSTEM" PRINT
   PRINT STRING$(32,"*").FOR J=1TO2000 NEXT J
50 REM**********************************************************
60 REM  INSTRUCTIONS TO STUDENT
70 REM**********************************************************
80 CLS
90 PRINT"WELCOME TO SOLFEGE LESSON #1!  IN THIS LESSON,"
100 PRINT"YOU'LL BE IDENTIFYING NOTES ON A CLEF OF YOUR"
11B PRINT"CHOICE.  AS YOU IDENTIFY EACH NOTE FROM LEFT TO"
120 PRINT"RIGHT, IT WILL DISAPPEAR FROM THE SCREEN  TO ENTER"
130 PRINT"YOUR RESPONSE, PRESS TNE KEY WITH TNE SYLLABLE FOR"
140 PRINT"THAT NOTE  TRY TO ANSWER BOTH QUICKLY AND"
150 PRINT"ACCURATELY, AND STILL MAINTAIN AN EVEN TEMPO!"
160 PRINT:PRINT"WHEN YOU'RE READY TO PROCEED, PRESS ENTER"
170 A$=INKEY$ IF A$="" OR PEEK(17222)<>67 GOTO 170
180 CLS:PRINT"YOU MAY CHOOSE FROM ANY OF THE FOLLOWING CLEFS:"
190 PRINT"1  TREBLE" PRINT"2. BASS" PRINT"3. SOPRANO"
200 PRINT"4  TENOR" PRINT"5. ALTO" PRINT"6. MEZZO-SOPRANO"
210 PRINT"7. BARITONE"
230 PRINT@576,"WHICH CLEF (1-7) WOULD YOU LIKE TO WORK WITH?";
240 A$=INKEY$ IF A$="" GOTO 240 ELSE IF ASC(A$)>32PRINT@621,A$,
250 C=PEEK(17240)+VAL(A$)-77 IF C>0 AND C<8 GOTO 290 ELSE PRINT
260 PRINT"I CAN'T UNDERSTAND THAT!  USE A 1 FOR TREBLE,"
270 PRINT"A 2 FOR BASS, AND SO ON "
280 PRINT@621," "; :GOTO 230
290 PRINT@768,"WOULD YOU LIKE TO INCLUDE LEGER LINES ";
300 PRINT"(TYPE Y OR N)?",
310 A$=INKEY$ IF A$="" GOTO 310 ELSE IF ASC(A$)>32 PRINT@820,A$
320 IF A$="Y" OR A$="N" GOTO 340
330 PRINT@832,"USE Y OR N, PLEASE " PRINT@820," "; GOTO 290
340 IF A$="Y" THEN L=1 ELSE L=0
350 REM**********************************************************
360 REM  GENERATION AND DRAWING OF A MOTIF
370 REM**********************************************************
380 CLS GOSUB 5000 GOSUB 5100
390 FOR J=1 TO 10
400 N(J)=30+6*L-2*RND(11+6*L)
405 IF J=1 GOTO 410 ELSE FOR K=1 TO J-1 IF N(K)=N(J) GOTO 400
    ELSE NEXT K
410 NEXT J
420 FOR J=1 TO 10 H=9+J*11 V=N(J) GOSUB 5200 NEXT J
430 REM***CALCULATE CLEF DISPLACEMENT FACTOR***
440 ON C GOTO 450,460,470,480,490,500,510
450 D=-4 GOTO 545
460 D=-6 GOTO 545
470 D=-2 GOTO 545
480 D=-3:GOTO 545
490 D=-5 GOTO 545
500 D=-7:GOTO 545
510 D=-8
520 REM**********************************************************
530 REM  BEGIN QUIZ OF STUDENT
540 REM**********************************************************
545 PRINT@832,"PRESS ENTER WHEN YOU'RE READY TO GO'"
546 A$=INKEY$ IF A$="" GOTO 546 ELSE PRINT@832,CHR$(30)
550 PRINT@832,CHR$(30) H=20 T(0)=0
560 V=N(INT(H/11)):T(INT(H/11))=0
565 T(B)=T(B)+1
570 REM***FETCH STUDENT'S ANSWER FROM KEYBOARD***
580 PRINT@832,"THE NOTE IS?"
590 A$=INKEY$ IF A$<>"" GOTO 610
600 T(INT(H/11))=T(INT(H/11))+1 GOTO 590
610 G=VAL(A$) IF G<1 OR G>8 GOTO 590
620 ON G GOTO 630,640,650,660,670,680,690,630
630 A$="DO":GOTO 700
640 A$="RE".GOTO 700
650 A$="MI".GOTO 700
660 A$="FA".GOTO 700
670 A$="SOL" GOTO 700
680 A$="LA" GOTO 700
690 A$="SI"
700 PRINT@845,A$
71B REM**********************************************************
720 REM  CHECK STUDENT'S ANSWER
730 REM**********************************************************
740 BF=50
750 FOR OC=0 TO 42 STEP 14
760 PF=38-2*D-2*G-OC
770 IF ABS(V-PF)<ABS(V-BF) AND PF>=0 AND PF<=30 THEN BF=PF
780 NEXT OC
790 IF BF<>V GOTO 850
800 REM***ANSWER WAS CORRECT***
81B GOSUB 5300 PRINT@844,CHR$(30)
820 H=H+11
830 IF H<127 GOTO 560 ELSE GOTO 1010
840 REM***ANSWER WAS INCORRECT***
850 PRINT@832,"NO, ";A$," IS WHAT'S FLASHING NOW "
860 F=POINT(H,BF)
870 FOR J=1 TO 7
880 SET(H-1,BF) SET(H,BF) SET(H+1,BF)
890 FOR K=1 TO 50 NEXT K
900 RESET(H-1,BF) RESET(H,BF) RESET(H+1,BF)
91B FOR K=1 TO 50 NEXT K
920 NEXT J.A$=INKEY$
930 A$=CHR$(31) PRINT@832,A$
940 IF F=0 GOTO 565
950 SET(H-1,BF) SET(H,BF) SET(H+1,BF)
960 GOTO 565
970 REM**********************************************************
980 REM  MOTIF COMPLETED - EVALUATE SCORES
990 REM**********
*********************************************
1000 REM***ACCURACY GRADE***
1010 PRINT@704,"YOU GOT ALL 10 NOTES IN",T(0),"TRIES FOR ",
1020 PRINT"A SCORE OF",INT(1000/T(0))
1030 REM***RESPONSE TIME CALCULATION***
1040 T(0)=0
1050 FOR J=1 TO 1B
1060 T(B)=T(B)+T(J)
1B70 NEXT J
1080 RT'=INT(T(B)/2 57)/100
1090 PRINT"YOUR AVERAGE RESPONSE TIME FOR EACH NOTE WAS",
1100 PRINT RT';"SECONDS"
111B REM***TEMPO EVALUATION***
1120 FOR J=2 TO 1B
1130 IF T(J)>T(1) TNEN T(1)=T(J)
1140 NEXT J
1150 IF (T(1)/25)>=2 PRINT"NEXT TIME, TRY TO MAINTAIN A ",
    "BETTER TEMPO." ELSE PRINT "YOUR TEMPO WAS GOOD'"
1160 PRINT@896,"LIKE ANOTHER TRY (TYPE Y OR N)?",
1170 A$=INKEY$ IF A$="" GOTO 1170 ELSE PRINT@928,A$,
1180 IF A$="Y" GOTO 1250 ELSE IF A$="N" END
1190 PRINT@960,"USE Y OR N, PLEASE",
1200 PRINT@928," ",
121B GOTO 1160
1250 PRINT@704,CHR$(31)
1260 IF C=3 GOSUB 5100
1270 GOTO 390
5000  REM SUBROUTINE *STAFF* DRAWS A STAFF
501B FORB=26TO10STEP-4.FORA=0TO127 SET(A,B) NEXTA NEXTB
5020 FORB=11TO25 SET(B,B) SET(127,B) NEXT0 RETURN
5100  REM SUBROUTINE *CLEF(C)* DRAWS A CLEF
5105  B=10 IF C=3 B=26
5110  IF C=4 0=14
5115  IF (C=6)+(C=7) B=22
5120  ON C GOTO 5125,5150,5180,5100,5180,5180,5150
5125  SET(7,28) FORB=28TO7STEP-1 SET(8,0) NEXTB SET(9,0) SET(10,9)
5130  FORA=0TO9 SET(11-A,11+A) NEXTA SET(2,21) SET(3,23) SET(4,24)
5135  SET(5,24) SET(6,25) SET(7,25) SET(9,25) SET(10,25) SET(11,24)
514B  SET(12,24) SET(13,23) SET(12,21) SET(11,20) SET(1B,19)
5145  SET(9,19) SET(7,19) SET(6,20) RETURN
5150  SET(5,B-2) SET(4,B-2) SET(3,B-2).SET(3,B-3) SET(2,B-3)
5155  SET(2,0-5) SET(3,B-5) SET(3,0-6) SET(4.B-6) SET(4,0-7)
5160  SET(5,B-7) SET(6,0-7) SET(7,B-7) SET(0,0-7).SET(B,B-6)
5165  SET(8,0-6) SET(9,0-6) SET(9,B-5) SET(10,0-5) SET(1B,B-3)
5170  SET(1B,B-2) SET(1B,B-1).SET(10,0+1) SET(9,B+1) SET(9,B+2)
5175  SET(0,B+2):SET(7,0+3) SET(6,B+3) SET(5,B+5) SET(4,B+5)
5177  SET(12,B-6) SET(13,0-6) SET(12,0-2) SET(13,B-2) RETURN
5180  FORA=-7TO7 SET(2,0+A) SET(3,0+A) SET(5,0+A) NEXTA
5182  SET(7,0-6) SET(0,0-6) SET(0,0-7) SET(9,0-7) SET(10,0-7)
5184  SET(11,0-6) SET(12,0-5) SET(12,0-3) SET(11,0-2) SET(10,B-1)
5186  SET(9,B-1).SET(8,0-1) SET(7,0-1) SET(6,0-1) SET(6,B+1)
5188  SET(7,0+1).SET(0,B+1) SET(9,0+1) SET(10,0+1) SET(11,B+2)
5190  SET(12,B+3) SET(12,B+4) SET(12,0+5) SET(11,0+6) SET(10,B+7)
5192  SET(9,B+7) SET(B,B+7) SET(B,B+6) SET(7,B+6) SET(B,B-2)
5194  SET(0,0+2) RETURN
5200  REM SUBROUTINE *NOTE(H,V)* DRAWS A NOTE
5210 FORA=-1TO1 FORB=-2TO2 SET(H+A,V+B) NEXTB NEXTA
5220 FORB=-1TO1 SET(H-2,V+B) SET(H+2,V+B) NEXTB
5230 SET(H-3,V) SET(H+3,V) A=1 IFV>16A=-1
5240 FORB=1TO8 SET(H-3*A,V+B*A) NEXTB IFV>28GOTO5270
5250 IFV>7RETURN
5260 FORB=6TOVSTEP-4 FORA=-4TO4 SET(H+A,0) NEXTA NEXTB RETURN
5270 FORB=30TOVSTEP4 FORA=-4TO4 SET(H+A,0) NEXTA NEXT0 RETURN
5300 REM*********************************************************
5310 REM  SUBROUTINE ERASE   HIGH-SPEED ERASURE OF ANY
5320 REM                     SPECIFIED NOTE
5330 REM
5340 REM  EXECUTION TIME    165 MS (WORST CASE)
5350 REM
5360 REM  REQUIRED INPUTS   H%  (HORIZONTAL POSITION OF NOTE)
5370 REM                        19 < H < 120
5300 REM                        H-20 A MULTIPLE OF 11
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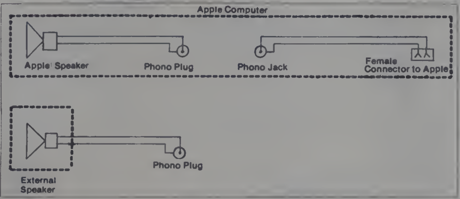
```
5390 REM
5400 REM                    V%  (VERTICAL POSITION OF NOTE)
5410 REM                       1 < V < 39
5420 REM                       V A MULTIPLE OF 2
5430 REM
5440 REM  VARIABLES AFFECTED   M%
5450 REM
5460 REM**********************************************************
5465 V=V+194-PEEK(17315)-PEEK(17316)-PEEK(17317)-PEEK(17310)
5470 ON V/2 GOTO 5480,5530,5580,5620,5660,5700,5730,5770,5810,
     5850,5890,5930,5970,6010,6060,6100,6140
5480 M=15358+INT(H/2) POKE M,128 POKE M+1,128 POKE M+2,128
5490 POKE M+3,128 POKE M+4,128.POKE M+64,128 POKE M+65,128
5500 POKE M+66,128 POKE M+67,128 POKE M+128,128 POKE M+129,128
5510 POKE M+130,128 POKE M+131,128 POKE M+132,128
5520 POKE M+192,140 POKE M+193,140 RETURN
5530 M=15359+INT(H/2) POKE M,128 POKE M+1,128.POKE M+2,128
5540 POKE M+63,128 POKE M+64,128 POKE M+65,128.POKE M+66,128
5550 POKE M+67,128 POKE M+127,128 POKE M+128,128 POKE M+129,128
5560 POKE M+130,128.POKE M+131,128 POKE M+191,140
5570 POKE M+192,140 POKE M+255,176 POKE M+256,176 RETURN
5580 M=15423+INT(H/2) POKE M,128.POKE M+1,128 POKE M+2,128
5590 POKE M+63,128 POKE M+64,128 POKE M+65,128 POKE M+66,128
5600 POKE M+67,128 POKE M+127,140 POKE M+128,140 POKE M+191,176
5610 POKE M+192,176 RETURN
5620 M=15486+INT(H/2) POKE M,128 POKE M+1,128 POKE M+2,128
5630 POKE M+3,128 POKE M+4,128 POKE M+64,140 POKE M+65,140
5640 POKE M+66,140 POKE M+67,140 POKE M+128,176 POKE M+129,176
5650 POKE M+192,128 POKE M+193,128 RETURN
5660 M=15487+INT(H/2) POKE M,128 POKE M+1,128 POKE M+2,128
5670 POKE M+63,140.POKE M+64,140 POKE M+65,140 POKE M+66,140
5680 POKE M+127,176 POKE M+128,176 POKE M+129,176
5690 POKE M+130,176 POKE M+191,128 POKE M+192,128 RETURN
5700 M=15551+INT(H/2) POKE M,140 POKE M+1,140.POKE M+2,140
5710 POKE M+63,176 POKE M+64,176 POKE M+65,176.POKE M+66,176
5720 POKE M+67,176 POKE M+127,128 POKE M+128,128 POKE M+191,131.
     POKE M+192,131 RETURN
5730 M=15615+INT(H/2) POKE M,176 POKE M+1,176 POKE M+2,176
5740 POKE M+63,128 POKE M+64,128 POKE M+65,128 POKE M+66,128
5750 POKE M+127,131 POKE M+128,131 POKE M+191,140
5760 POKE M+192,140 RETURN
5770 M=15678+INT(H/2) POKE M,128 POKE M+1,128 POKE M+2,128
5780 POKE M+3,128 POKE M+4,128 POKE M+64,131 POKE M+65,131
5790 POKE M+128,140 POKE M+129,140 POKE M+192,176
5800 POKE M+193,176 RETURN
5810 M=15553+INT(H/2) POKE M,140 POKE M+1,140 POKE M+64,176
5820 POKE M+65,176.POKE M+126,128 POKE M+127,128 POKE M+128,128
5830 POKE M+129,128 POKE M+190,131 POKE M+191,131
5840 POKE M+192,131 RETURN
5850 M=15617+INT(H/2) POKE M,176 POKE M+1,176 POKE M+64,128
5860 POKE M+65,128 POKE M+125,131 POKE M+126,131 POKE M+127,131
5870 POKE M+128,131 POKE M+129,131 POKE M+190,140
5880 POKE M+191,140 POKE M+192,140 RETURN
5890 M=15681+INT(H/2) POKE M,128 POKE M+1 128 POKE M+62,131
5900 POKE M+63,131 POKE M+64,131 POKE M+65,131 POKE M+126,140
5910 POKE M+127,140 POKE M+128,140 POKE M+129,140
5920 POKE M+190,176 POKE M+191,176 POKE M+192,176 RETURN
5930 M=15681+INT(H/2) POKE M,128 POKE M+1,128 POKE M+64,131
5940 POKE M+65,131 POKE M+126,140 POKE M+127,140 POKE M+128,140
5950 POKE M+129,140 POKE M+189,176 POKE M+190,176
5960 POKE M+191,176 POKE M+192,176 POKE M+193,176 RETURN
5970 M=15745+INT(H/2) POKE M,131 POKE M+1,131 POKE M+64,140
5980 POKE M+65,140 POKE M+126,176 POKE M+126,176 POKE M+127,176
5990 POKE M+128,176 POKE M+129,176 POKE M+190,128
6000 POKE M+191,128 POKE M+192,128 POKE M+193,128 RETURN
6010 M=15745+INT(H/2) POKE M,131 POKE M+1,131 POKE M+64,140
6020 POKE M+65,140 POKE M+128,176 POKE M+128,176 POKE M+129,176
6030 POKE M+189,128.POKE M+190,128 POKE M+191,128
6040 POKE M+192,128.POKE M+193,128 POKE M+254,128
6050 POKE M+255,128 POKE M+256,128 RETURN
6060 M=15809+INT(H/2) POKE M,140 POKE M+1,140 POKE M+64,176
6070 POKE M+65,176 POKE M+126,128 POKE M+127,128 POKE M+128,128
6080 POKE M+129,128 POKE M+189,128 POKE M+190,128
6090 POKE M+191,128:POKE M+192,128 POKE M+193,128 RETURN
6100 M=15873+INT(H/2) POKE M,176 POKE M+1,176 POKE M+64,128
6110 POKE M+65,128.POKE M+125,128 POKE M+126,128 POKE M+127,128
6120 POKE M+128,128.POKE M+129,128 POKE M+189,128 POKEM+190,128
6130 POKE M+191,128 POKE M+192,128 POKE M+193,128 RETURN
6140 M=15937+INT(H/2) POKE M,128 POKE M+1,128 POKE M+61,128
6150 POKE M+62,128.POKE M+63,128 POKE M+64,128 POKE M+65,128
6160 POKE M+125,128 POKE M+126,128 POKE M+127,128
6170 POKE M+128,128 POKE M+129,128 POKE M+190,128
6180 POKE M+191,128 POKE M+192,128 RETURN
```

Sound Apple Hint

Want to hear your Apple a little more clearly? The speaker in the Apple is a 2" unit mounted facing the solid metal of the case. These two things conspire to make the sound much weaker than the speaker driver (amplifier) is capable of producing.

We found the easiest way to increase and improve the sound is to add an external speaker. A small, high effeciency, 8-ohm, 4" to 6" unit in a cabinet is your best bet. There's no point spending $30 or $40 on a high quality unit—Apple sound isn't **that** good. We bought a 5" unit from Radio Shack for $14.95 and it makes an unbelievable improvement.

To retain the portability of the Apple, we made this a plug-in unit. Since the trend these days seems to be to RCA phono plugs and jacks for extension speakers, we used them in this installation. To make the modification, unplug the speaker wire from the board on the right under the keyboard. Cut it about 3" from the plug and put in an insulated RCA phono jack. In the end leading to the Apple speaker, put in an insulated RCA phono plug. If you can't find insulated components, wrap tape around all the exposed metal. You don't want this making contact with anything else inside the Apple. When you want to use the external speaker. plug it into the jack. When you want portability, use the internal speaker.



Comprint 912 Printer

Steven Wexler

Earlier this year COMPRINT introduced its model 912 printer. The 912 uses state-of-the-art zap-matrix technology to provide fast, reliable hardcopy at a price that is difficult to ignore. You would be hard-pressed to find a printer that offers all the features of the 912 for $660!

Photo 1 The COMPRINT 912 Printer.

Zap-Matrix Technology

The 912 uses electrodes connected to a bank of microprocessor controlled capacitors. The electrodes are energized as they pass over electrosensitive paper, leaving a trail of vaporized "blown fuses" to form the characters.

Paper

Presently, COMPRINT uses 8½" wide aluminum-coated paper that has a light silver appearance. The silver color is a drawback for some applications; however, white paper is in the works and should be on the market shortly.

Users with multiple-copy requirements will be glad to know that aluminum-coated paper photocopies well.

Although paper for the 912 costs more than plain paper, this is offset by the lack of need for ribbon, inks, developers, print wheels or other consumables. Just load the paper and go.

Print Quality

The model 912 features a 9 x 12 matrix of overlapping dots for high quality printing. The ASCII character set includes true lower case with descenders. Furthermore, up to 80 characters are permitted on each line.

Speed

At 225 characters per second, 170 full lines per minute, this printer is remarkably fast! In addition, the 912 comes with a 256-byte buffer (2K optional).

How important is speed? For many applications it is very important. Try debugging a long program with slow hardcopy and you will know what suffering is all about! If you do program development, or have a moderate amount of requirement for hard copy, do not underestimate the convenience of speed.

Noise

When it is printing, the 912 makes a fair amount of noise, more than a Silent 700 but less than an ASR 33. However, when the printer is standing by, it is completely soundless! Keep in mind that due to its amazing speed the COMPRINT 912 is in standby mode for more often than other printers in its price range.

Programmable Controls

The printer can be controlled by means of ASCII characters generated by your computer. Eight control characters are utilized: CR, LF, US, GS, RS, FF, and BEL.

CR	Printing stops and does not resume until first character position of next line.
LF	Printing stops and resumes on next line at character position where LF was encountered.
CR-LF	Same as CR.
BEL	An electronic beep is sounded.
FS	Paginate mode. Printer automatically enters this mode when powered on. Printer counts 58 lines (1 page) and inserts 7 blank lines as an interpage separator space.

Steven Wexler, 1634 Buck Hill Dr., Huntingdon Valley, PA 19006.

This is an actual print sample from the COMPRINT MODEL 912 printer for computers and terminals. The 9 X 12 matrix produces exceptional quality printing. Notice the true lower case descenders (g j p q y) and how the characters appear more fully formed than ordinary matrix printer output.

1234567890 @#$%&?+() abcdefghijklmnopqrstuvwxyz ABCDEFGHIJKLMNOPQRSTUVWXYZ

Photo 2. View showing installation (or removal) of the interface board.

RS	Continuous print mode. Overrides paginate mode and points continuously without inserting 7 blank line inter-page separation space.
FF	Form feed. Generates sufficient sequential carriage returns to complete current page.
US	No print mode. Normal I/O handshake occurs but no characters are printed.
GS	On line mode. Clears no print mode.

Interfacing

Interfaces are already available for the IEEE 488 (PET) bus and Comprint's our "Universal Parallel Interface." A serial interface, with both RS-232 and current loop, should be available by the time this review appears.

Closing Comments

The COMPRINT 912 is an excellent, cost-effective printer for most hobby and many business applications. It's a winner! □

Available from Computer Printers International, 340 E. Middlefield Rd., Mountain View, CA 94043

Apple Hi-Res Graphics Made Easy with the VersaWriter

Randy Heuer

Apple II owners have a feature in their computer not found in many other personal computers. This feature is High Resolution (Hi-Res) color graphics. In the Hi-Res graphic mode the screen is subdivided into a grid of 280 x 160 pixels. Each of the pixels can be set to any of six colors (black, white, orange, blue, violet or green). However, many people writing their own programs have tended to shy away from using Hi-Res graphics. I suspect the reason for this is that the only way to access the Hi-Res features in Basic is through HPLOT statements or shape tables. With HPLOT statements you can only draw straight lines. With shape tables, you can create complex shapes but only by using cumbersome binary number tables which will frustrate most potential graphics artists.

In the past there was only one practical solution to the problem. This was the digitizer or bit-pad type device made by several companies. These devices are very nice and, if the proper software was provided, they made Hi-Res graphics much easier. However, for many people the cost of these devices was too prohibitive, with prices starting at over $500. In many cases this was just too much money for the privilege of using Hi-Res graphics. Most people would rather use $500+ to add a disk drive or printer. However, now there's an alternate solution to this problem.

PHOTO 1
The Versawriter Drawing Board.

The VersaWriter is an ingeniously simple and relatively inexpensive solution to the problem of how to handle complex Hi-Res graphics. The plotting board consists of a 14" x 12" plastic bed with a clear acetate overlay sheet. The original copy of the drawing or diagram is taped (masking tape preferred) to the plastic bed and then covered with a clear sheet. Instead of using a light or pen for tracing the figure on the plotting bed, the VersaWriter uses a double-jointed arm attached to the top of the drawing board at one end and a free, magnifying lens with crosshairs at the other. The VersaWriter resembles a draftsman's pantograph on a smaller scale.

Many people writing their own programs have tended to shy away from using Hi-Res graphics.

At each joint of the VersaWriter's arm is a potentiometer. A cable from the VersaWriter connects the potentiometer. A cable from the VersaWriter connects the potentiometers to the Apple's paddle input. Installing a VersaWriter in your Apple simply requires that you unplug your game paddles and plug the VersaWriter's single cable into the socket. No other special interface is needed.

In this day of very complex digital circuitry and other electronic overkill, the simplicity of the VersaWriter is impressive. Since the arm of the VersaWriter bends in only one direction, each point on the plotting bed corresponds to a unique set of resistances on the potentiometers. All that's needed now is the software to translate the resistances into usable screen coordinates.

The quality of this software is very important and will determine the usefulness of the device. Without user-oriented support software, devices of this type are little more than overly expensive drawing paper. Fortunately, the VersaWriter does not disappoint.

Perhaps the best way to describe some of the features of the software is to provide a list of some of the more useful commands and their actions:

Command	Effect
P	Point Cursor — Moves cursor and displays (x,y) coordinates. Permits rapid drawing of straight lines between two points.
S	Scale of Drawing — Provides independent vertical and horizontal control of drawing size on the screen.
M	Create Shape Table — Create a Hi-Res graphics binary table for use in other programs or with the Hi-Res functions.
T	Transfer Picture to Disk — Saves contents of screen on diskette.
R	Recall Picture from Disk.
Z	Color-in Enclosed Figure — "Fills in" an enclosed figure with the color of your choice.
I	Inspect Shape Table — Allows you to rotate, scale or color an existing figure.

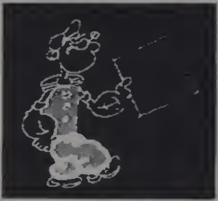


PHOTO 2
A picture of Popeye drawn using the VersaWriter. The slight distortion of the horizontal scale was probably caused by the fact that our VersaWriter was not yet calibrated when this figure was drawn.'

The P (Point Cursor) command is the basic command for moving the cursor about the screen and for drawing straight lines. In addition to displaying a flashing dot at the present

Graphics, cont'd...

position of the point on the screen, a numerical readout of that position is also displayed. An option allows you to draw a straight line between any two points.

The Z command is not only useful, but genuinely fun to use. It allows you to fill in an enclosed figure with any color. Using a somewhat crude search routine to determine whether the cursor has reached the edge of the figure, this command starts filling in the figure from the present cursor position, expanding outward until reaching the edge of the figure. It's intriguing to watch the computer "color in" a drawing just as kids do with crayons.

The M command may be one of the most useful, however,it may take you a while to discover its purpose. A picture

In this day of very complex digital circuitry and other electronic overkill, the simplicity of the VersaWriter is impressive.

on the screen can be stored in the computer's memory two ways. When the entire screen is loaded or saved (R or T commands), the contents of the memory locations corresponding to the screen are copied. However, there's another way to store a figure in the Apple memory. Portions of the Hi-Res screen can be stored as shape tables. Using a somewhat complex method of binary numbers, the shape table offers some unique advantages. The primary advantage being that shapes stored in one configuration can be enlarged, rotated and moved about the screen with relative ease. The M command in the VersaWriter allows you to produce shape tables from figures you've produced on the screen.

Once a shape table has been created and stored on a disk, it can be used in other Basic programs. Using the Hi-Res functions, these shapes can be manipulated within Basic with relative ease.

PHOTO 3

Photos 3 & 4 are examples of how even the very non-artistic author can make pretty pictures with the VersaWriter. I wonder what a person with real artistic talent could do?

To use the VersaWriter you need an Apple II computer, Disk II, Applesoft in ROM and a minimum of 32k of memory. Since the VersaWriter's software uses page one of the Hi-Res screen, ROM Applesoft must be used. This means that you must have one of the following computer configurations in order to use theVersaWriter: Apple II

PHOTO 4

with a floating point ROM card, an Apple II Plus or Apple II with a multi-language card.

Being rather simple in design, your VersaWriter should have good longevity unless you drop your 19" Color TV set on it. Of course, like any precision tool, mistreatment can damage the device. One of the programs included in the VersaWriter software package is used for calibrating the drawing board and I recommend it be run from time to time to recalibrate the device. Unless you damage the VersaWriter through mistreatment, though, I would not think

PHOTO 5

Perhaps the most useful command, the Create Shape Table (M) command is shown here scanning the letter A from the drawing in Figure 4. This process takes several minutes. However,once completed the shape table for this figure can be used in many ways (see Figure 6).

any type of maintenance would normally be necessary. The VersaWriter comes with a 90 day warranty on parts and labor.

The only real complaint I can raise about the VersaWriter is the documentation. The 8½" x 11" instruction manual is only five pages long. This is hardly adequate for the Hi-Res graphics novice. Much greater emphasis should be given to the shape table commands in particular. Examples of how to use shape tables should be provided so the person new to Hi-Res graphics understands the differences between the screen memory and shape tables. In addition, a section on how to incorporate the VersaWriter drawing board into other programs (games, pointers, etc.) is

It's intriguing to watch the computer "color-in" a drawing just as kids do with crayons.

warranted. Altogether, I think a manual three or four times longer than the present one would not be unreasonable.

Still, the VersaWriter is a tremendous value. Its cost is $249 plus $5 shipping (and sales tax for California residents). While the VersaWriter may not be adequate for some high-precision digitizing applications (remember, the VersaWriter uses potentiometers as inputs and these analog devices are not necessarily perfectly linear throughout their range), most

PHOTO 6

Using the shape table created by the Versawriter (in Figure 5), the A can now be enlarged, rotated, colored or moved about the screen.

people will be impressed by the capabilities of the device. We at *Creative* intend to make significant use of our VersaWriter in the future.

VersaWriter was offered briefly at an introductory price of below $200, however, this did not include applications software. The list price at this time is $250 and includes two disks of software. The applications disk includes programs to calculate distances and areas, add upper and lower case text using five character sizes, and add electronic and digital symbols for "drawing" schematic or logic diagrams.

For more information on VersaWriter, contact either of the following: Rainbow Computing, 9719 Reseda Blvd., Northridge, CA 91324 or Peripherals Plus, 119 Maple Ave., Morristown, NJ 07960. □

Life is like playing a violin solo in public and learning the instrument as one goes on.

Hardcopy Graphics Software from West Coast Consultants

CURVE

Laura McLaughlin

Have you ever looked at a new peripheral that appeared on the market, gotten excited about all the fancy things you could do with it and then felt utter disappointment when you perused the manual and discovered that the software interface was practically non-existent? We've all heard the old adage, "The computer is only as good as the software that runs it." Well, this is especially true for some of the more sophisticated I/O devices that are becoming available at an affordable price.

Most of us do not have either the specific knowledge necessary or the time available to develop the complicated software that is required to make one of these peripherals a really useful addition to our computer system. Therefore, we do without it. If your interest has been in one of the new low-cost digital plotters, there is now a solution.

West Coast Consultants is marketing a hardcopy graphics package which they call CURVE. More than a simple set of point and line plotting routines, it will allow you to produce professionally finished graphs both from tabular data and of mathematical equations programmed in Basic. Available for the Apple II, PET and TRS-80, the software is definitely user-oriented, requiring almost no programming knowledge. It is also very flexible, providing a myriad of options for controlling parameters such as size and color.

The initial menu gives you six functions from which to choose. They include:

Cartesian Equation	Y = F(X)
Parametric Equation	Y = F(T) : X = G(T)
Polar Equation	R = F(S)

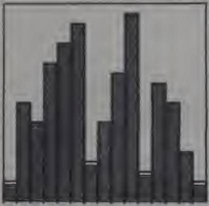
Data Points from Keyboard
Bar Graphs
Alphanumeric Characters

In each case, you are carefully prompted for the input data and the option selections. It should be noted that, while the user interface is very well done, a prior knowledge of graphing techniques is necessary to understand the input requirements.

Curve allows you to produce professionally finished graphs both from tabular data and of mathematical equations programmed in Basic.

Also, if trying to use one of the first three functions, a knowledge of mathematical equations and how they would be stated in Basic is required.

When plotting graphs (functions 1-3,5), you are given a good deal of flexibility as to how they will be drawn. Both the X-axis and Y-axis may be either linear or logarithmic. You may plot on grid lines or a box frame with or without tic marks. Both the size and position of the plot region are user specified. Scale numbers along any axis are optional. Also, you may specify the color to be used for each component of the graph (and will be prompted to change the pen to the correct color at the appropriate time during the actual plotting operation). For mathematical equations the plot may be drawn as a solid line, dashed line or repeating character of your choice. Bar graphs may be shaded at a user specified density.



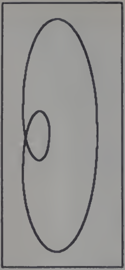
An upper-case alphanumeric character set may be used for labels on the axes, descriptive text or titling. Under software control, the user may specify size, font and position (although this may also be done manually). Two fonts are available standard and bold. You may also have the text written vertically or horizontally.

The CURVE program documentation consists of step by step examples for each function available. It is complete and reasonably easy to understand.

Although this software has many features, there are times when any generalized package falls short of meeting our particular needs. Perhaps we need a function not provided or would like to integrate some of the routines into a specific program. Well, West Coast Consultants has considered that and also markets the CURVE subroutines as a separate package.

Sixteen subroutines are provided that let you control the plotter with relative ease. A list of them follows:

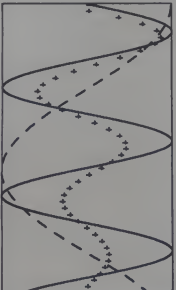
- Initialize Plotter
- Raise Pen
- Lower Pen
- Move Pen to (X,Y)
- Move Pen an Incremental Distance
- Return Pen to (X0,Y0)
- Move Pen to Lower Left Corner and Exit
- Change Color of Pen
- Draw Frame Around Plot Region
- Generate Axis with Grid Lines or Tic Marks
- Label Axis with Scale Numbers
- Plot Character at (X,Y)
- Plot Equation or Data Points
- Plot a Bar Graph
- Shade a Bar Graph
- Write Text Field beginning at (X,Y)



While the user interface is very well done, a prior knowledge of graphing techniques is necessary to understand the input requirements.

As with the CURVE program, the documentation supplied with these subroutines is very complete. All variables used within a routine are listed along with an explanation of their internal function. If a value must be preset for any variable before a routine is called, a description of its impact is given. Moreover, sample programs using the subroutines are provided.

The software was designed to run with the HIPLOT plotter manufactured by Houston Instruments. However, according to West Coast Consultants, it should be sufficiently general so that it could be readily modified to run with other "dumb" digital plotters.



The only real problem encountered with the package was related to the hard-coding of the slot number (an Apple II version was used for evaluation) to turn on the plotter. Rather than defining a variable at the beginning of the program, a constant was used wherever needed in the program. Because of this, if your serial interface was in a slot other than 1, you would have to go in and physically change those statements within the program. The information necessary to do this was provided, but it is a time consuming and error prone process.

There is one more thing to keep in mind. Even running at 4800 baud, it takes quite a while to plot a complete graph. However, this is really due to the hardware rather than the software. By using features such as bold type, grid lines and high resolution (0.005 inch step size instead of 0.01) only when really necessary, you can keep the time to a minimum.

All things considered, it appears that this package could be a very effective software tool. It is user-oriented and very flexible. Anyone with a need for or interest in sophisticated hard-copy graphics applications may get further information from:

West Coast Consultants, 1775 Lincoln Blvd., Tracy, CA 95376. □

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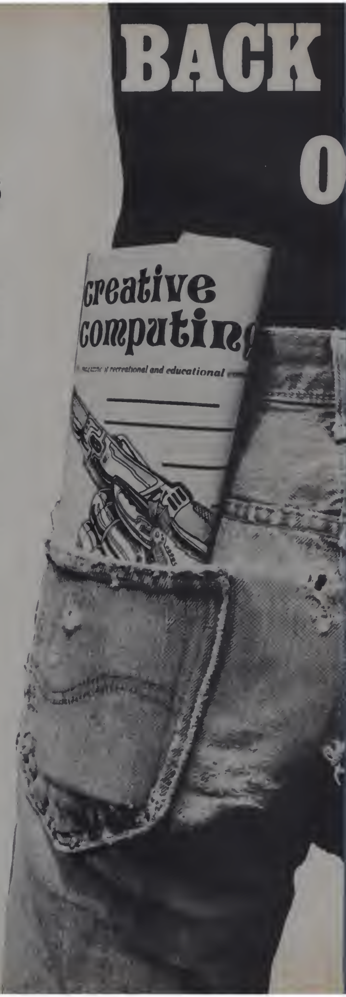

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CIRCLE 350 ON READER SERVICE CARD

Graphics Goodies: The Case for Polar

Steve Rogowski

Microprocessors have spawned a new generation of hardware for home use. Disk drives, voice synthesizers, fancy interfaces, faster memories are a reality. Perhaps the most exciting happening involves graphics devices. High quality color, superior resolution in both screens and plotters are now available. And at prices which the home hobbyist can begin to afford. Even the ADM-3A, that inexpensive workhorse terminal,can be made into quite an acceptable graphics terminal with the addition of a single board.

As with everything else, software is needed to get the most from the hardware. So unless you're willing to settle for SNOOPY pictures made from lighting up dots on the screen you'll need to know a little about the mathematics of producing designs, graphs, charts, curves and the like. It takes a dedicated microprocessor system and some memory to light up an entire screen in a meaningful way. This is precisely what is done by home video games.

A very simple software package—one that only allows you to draw straight lines—is all you really need to do some exciting graphics. This article will try to familiarize you with some elementary principles of computer graphics. Some suggestions about the merits of using polar coordinates—even with rectangular (*X/Y*) devices—might prove helpful to even the sophisticated graphics user.

Raster and Vector

There are basically two kinds of graphics screens—*raster* and *vector*. A typical raster device might have a screen with about 75,000 individual dots or picture elements (*pixels*, for short). Cheaper screens may have considerably fewer. By exciting a phosphorescent coating on the inside of the screen any one or combination of the pixels can be lighted.

You will find it frustrating, if not impossible, to program the lighting of individual dots each time you wish to draw a line or curve. It's kind of like programming in machine language—lots of control but hours of work.

So most vendors offer software packages which automatically light up the right pixels to draw a line, or a box, or make letters, numbers and symbols. This graphics software may consist of a package of subroutines which when called from a program in BASIC, PASCAL, FORTRAN or whatever, will automatically light up the proper dots to draw a line between two coordinate pairs or draw a line with a specified length. Figure 1 shows a raster graphics screen and how a line on that screen might look. One of the difficulties with raster devices is that resolution is poor. You can see that a diagonal line has steps. The length of the line is also limited by the distance between the dots.

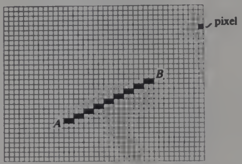

Figure 1 **Raster Screen**

Vector graphics devices allow access to any point on the screen. In fact the screen is not really divided into individual points. The entire surface is available for drawing. The only limitation is the glow of the phosphorus. Two points really close together will both glow brightly enough to appear as one point. In this scheme an electron beam actually streaks across the screen in a diagonal path leaving a trail of glowing phosphorus and producing a nice smooth straight line (see figure 2). These devices are more accurate and more expensive than raster devices because the plates and associated circuitry which deflect the electron beam must be able to locate any point on the screen and not just scan up and down as with *raster* devices.

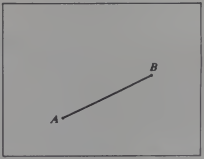

Figure 2 **Vector Screen**

Stephen J. Rogowski, Computing Center, State University of New York, Albany, NY 12222.

Graphics Goodies, cont'd...

The *vector* screen may be arbitrarily divided up like a coordinate system but this is for the sake of screen addressing and not because each of those number pairs represents a unique physical structure on the screen. Vector devices are more like blackboards. While raster devices are like the modern scoreboards we see at professional baseball games. They consist of individual lights and not continuous tones.

The hardware takes care of addressing the vector screen in such a way that smooth lines are stroked out by the beam. If you can draw straight lines, you can draw anything. In fact, there are no such things as curved lines, only a series of very short straight ones; so if you can only have one subroutine let it be one that draws straight lines.

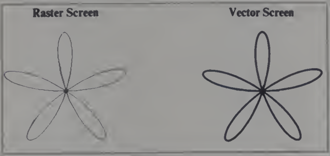

Figure 3

The rest of this article will be dedicated to techniques for fitting those straight lines together to make curves and designs. Raster or vector, either can be used; the effect may be a bit different for each but the results will be essentially the same.

Screens and Plotters

As we have said, most screens and plotters are X/Y devices. They locate points by moving x units horizontally and then y units vertically. For a plotter, a servo (little motor) may move a pen along a track (y) as it rotates a drum (x) to achieve the effect. Ultimately all devices usually want to be told the location of the points to be connected by a coordinate pair—(x,y) in the rectangular coordinate system. Some devices insist on allowing only positive integers because the screen or plotter page is really only the first quadrant (upper right hand corner) of the Cartesian coordinate system. Others allow the origin to be placed anywhere, thus allowing access to the other three quadrants.

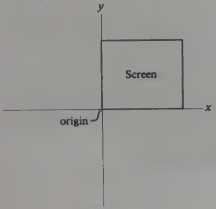

Figure 4

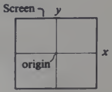

Figure 5

The Case for Polar

Despite these requirements it is still possible to use another scheme for computing the coordinates of points to be connected—polar coordinates. You'll still have to give the graphics device rectangular pairs but that can be done just before plotting with a simple conversion. Believe it or not, for many designs it's easier to think and compute in this alternate system. Here's what polar coordinates are all about.

The figures below show the point P in rectangular coordinates (figure 6) and in polar. Instead of using a horizontal and vertical deflection to locate points, a polar system uses the distance r of the point from the origin and then an angle of rotation θ about which that radius r must be rotated to locate the point. Notice the different form which each type of graph paper takes.

Rectangular Coordinates

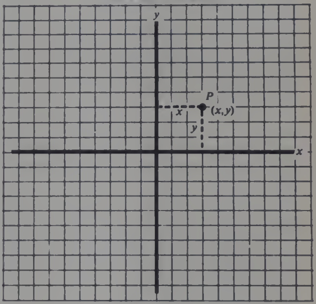

Figure 6

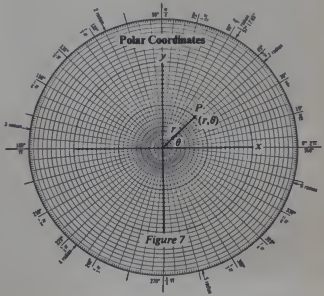

Figure 7

Graphics Goodies, cont'd...

A point P in rectangular has one unique representation. The point (3,3) will always name the same point and the only way to name that same spot is (3,3). However, in polar many pairs can be used to name the same point: $(3\sqrt{2},45°)$, $(3\sqrt{2},405°)$, etc., are all polar forms for (3,3).

It's easy to go from one system to the other if you remember a few simple relationships. Consider figure 8, where both forms of the point P are placed on a single graph.

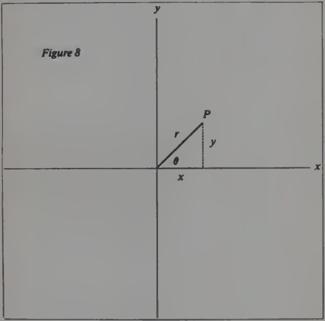

Figure 8

Since

$$\sin\theta = y/r \text{ and } \cos\theta = x/r,$$

we can say that:

$$x = r{\bullet}\cos\theta \text{ and } y = r{\bullet}\sin\theta$$

Rectangular Conversion

This is how conversion to rectangular takes place. Develop r and θ and then plug them into the relationship above to get an x and a y. The mathematics will allow θ to be in degrees or radians but most computer systems require angles to be in radians before sines or cosines can be found. A radian is 57.295778°. There are 2π radians (360°) in a circle—because 2π is the circumference of a circle with a radius of 1—and $360/2\pi = 57.295778....$

Further, since $r^2 = x^2 + y^2$ from the right triangle relationship of Pythagoras we get:

$$r = \sqrt{x^2 + y^2}$$
and
$$\theta = \tan^{-1} y/x$$

Use these formulas to go from rectangular to polar. Remember, $\tan^{-1}$ is the same as ATAN or ATN (arctangent).

Certain kinds of designs are better done in rectangular from the start. It is obvious that (2,2); (-2,2); (-2,-2) and (2,-2) when connected will form a square. But can you rattle off the six coordinate pairs for a hexagon in rectangular? In polar they topple trippingly from the tongue (see figure 9).

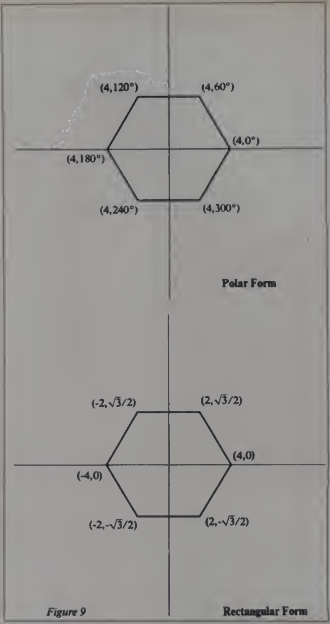

Figure 9

Almost any circular figure can be done more easily in polar. Consider the circle itself. Here's what you would have to do to draw a circle entirely in rectangular coordinates. For a circle with a radius of 2 the equation is:

$$x^2 + y^2 = 4$$

So we can infer that $y = \sqrt{4 - x^2}$. In generating the values for y, x goes from 2 to -2. The square root on the right is going to produce two values for each x—one negative, one positive—because a circle is not a function. These numbers correspond to points in the bottom and top halves of the circle respectively. All the points necessary to draw the circle will be there but they don't fall out of the relationship conveniently. What we will have to do is save the points for the bottom half and then reverse their order so that we don't draw the curve as two halves. Although there's nothing wrong with drawing the curve in pieces, I like to see curves drawn continuously both for the beauty of them (I do indeed like to watch them being drawn) and to optimize pen movement for complex designs with slower devices.

Graphics Goodies, cont'd...

Polar Circle

That same circle is a *piece of cake*—sorry!—in polar. Just set the radius = 2 and vary θ from 0 to 360°. Convert from (r,θ) to (x,y) to complete the process. The short FORTRAN program below will draw a circle with radius = 2.

```
      DIMENSION X(360),Y(360)
      R = 2.
      INCR = 1
      CALL ORIGIN (6.,5.)
      DO 99 IANG = 0,360,INCR
      RADIAN = IANG/57.295778
      X(IANG) = R*COS(RADIAN)
 99   Y(IANG) = R*SIN(RADIAN)
      CALL VECTOR (X,Y)
      CALL ENDPLT
      STOP
      END
```

The ORIGIN call places the origin in the center of the screen, (if we assume the screen to be 12" × 10"). We have converted to radians just before converting to rectangular. The VECTOR call simply connects the points in the arrays X and Y pair-wise, i.e. $(X(1), Y(1))$ is connected to $(X(2), Y(2))$, etc. A LINE or SCRIBE call, which draws a single line at a time could have been placed inside the loop if no array scanning subroutine was available.

Actually we haven't drawn a circle, just a 360-gon. But the human eye can't tell unless the resolution of the device gives it away. In fact, a simple modification to the variable *INCR* will allow the program to draw any regular polygon with n sides by setting $INCR = 360/n$. In FORTRAN, INCR must be a whole number but other small modifications to the program will allow any value of n.

Rotations a Snap

Another advantage to using polar coordinates is for doing rotations. Suppose we wanted to turn the hexagon from figure 9 counterclockwise by 30°. In polar all we need do is add 30° to each θ before conversion to rectangular. We get figure 10. We could also start the loop at 30° instead of 0° and accomplish the same thing.

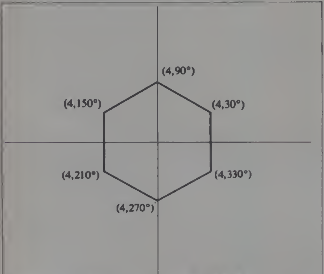

Figure 10 **30° Rotation**

No matter what application you have, the easiest way to rotate a figure, even with all coordinates already in rectangular, is to convert to polar, add the angle of rotation to each pair and convert back to rectangular. Translation of axes and shifting are still easier in rectangular.

A decided advantage also accrues to polar coordinates for certain classes of curves whose polar equations are considerably less complex than their rectangular forms. Consider the polar rose in figure 11. It's polar equation is:

$$r = a \cdot \cos 1.5\theta$$

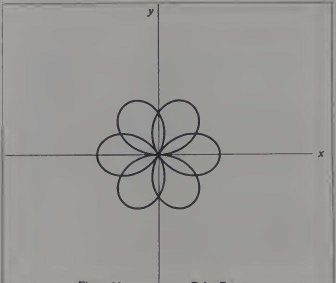

Figure 11 **Polar Rose**

It's rectangular equation is a 10th degree polynomial:

$$(x^2 + y^2)[2(x^2 + y^2) - a^2]^2 - a^4(x^3 - 3xy^2)^2 = 0$$

The cardioid in figure 12 has polar equation:

$$r = 2(1 - \cos\theta)$$

while its rectangular form is:

$$(x^2 + y^2 + 2x)^2 = 4(x^2 + y^2)$$

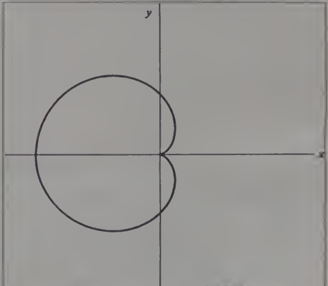

Figure 12 **Cardioid**

Graphics Goodies, cont'd...

Spirals are especially simple in polar. The *Spiral of Archimedes* has polar equation:

$$r = a\theta$$

In rectangular it's:

$$(x^2 + y^2) = a^2[\tan^{-1}(y/x)]^2$$

Try These

If you want to have some fun with designs try plotting polar roses. These are equations of the form $r = a \cdot \cos n\theta$ where a is a constant. Figures 3 and 11 show polar roses. The left hand rose in figure 3 was drawn on a TERAK 8510A raster scan graphics screen. The program is given below in PASCAL. It will draw any rose you specify. Most plots of these roses consider only integral values of n. Some of the prettiest roses result from n rational (fractional). So the program asks for values of p and q, where $p/q = n$. It uses the TURTLEGRAPHICS capability of PASCAL where lines are drawn by an imaginary TURTLE who *moves* and *turns*.

```
PROGRAM JEFF;
USES TURTLE;
VAR YY,XX,IP,IQ,SUM:INTEGER;P,Q,N,C,D,R,B,X,INC,PI,TWOPI,MAXVAL:REAL;A:CHAR;
BEGIN
N: = 1.0;
WHILE N > 0.0 DO BEGIN
TURTINIT;
PI: =3.14159;
 TWOPI: =2.0*3.14159;
INC: =TWOPI/200.0;
B: =0.0;
PENCOLOR(WHITE);
WRITELN(' ENTER S FOR SINE, C FOR COSINE ROSE, THEN ENTER P AND Q');
READLN(A,P,Q);
IF P = 0.0 THEN EXIT(JEFF);
N: =P/Q;
IF N = 0.0 THEN EXIT (JEFF);
IP: =TRUNC(P);
 IQ: =TRUNC(Q);
SUM: =IP+IQ;
IF ODD(SUM) THEN MAXVAL: =Q*TWOPI ELSE MAXVAL: =Q*PI;
IF A = 'S' THEN BEGIN
WHILE B< = MAXVAL DO BEGIN
R: =110*SIN(N*B);
C: =R*COS(B);
D: =R*SIN(B);
XX: =TRUNC(C);
YY: =TRUNC(D);
MOVETO(XX,YY);
B: =B+INC;
END;
END ELSE BEGIN
WHILE B< = MAXVAL DO BEGIN
R: =110*COS(N*B);
C: =R*COS(B);
D: =R*SIN(B);
XX: =TRUNC(C);
YY: =TRUNC(D);
IF B = 0.0 THEN BEGIN
PENCOLOR(NONE);
MOVETO(XX,YY);
PENCOLOR(WHITE);
END;
MOVETO(XX,YY);
B: =B+INC;
END;
END;
TURTEND;
END;
END.
```

Curves other than polar roses can be drawn by substituting the relationships below for the line:

R: = 110*COS(N*B);

The value of a below determines the size of the figure. We used 110 in the PASCAL program, but you should adjust that value according to your device.

Try these:

$r^2 = a^2 \cos 2\theta$	*lemniscate of Bernoulli*
$r^2 = a^2/\cos 2\theta$	*rectangular hyperbola*
$r = a(1 + \cos\theta)$	*cardioid*
$r = a(1 + \frac{1}{2}\cos\theta)$	*ellipse*
$r = a(\frac{1}{2} + \cos\theta)$	*limacon*
$r = a\theta^\circ/100$	*Archimedean spiral*
$r = 100a/\theta^\circ$	*reciprocal spiral*

There are so many directions to proceed with graphics. Designs and curves are really quite easy to produce with a simple understanding of what's going on. Home computer systems are a much more exciting proposition with graphic attachments.

The mathematics of producing curves is discussed in detail in the following books:

E.H. Lockwood. *A Book of Curves*. Cambridge: Cambridge University Press, 1961.

Robert C. Yates. *Curves and Their Properties*. NCTM, 1974.

Steve Rogowski. *Computer Clippings*. Palo Alto, CA: Creative Publications, 1975.

H. Cundy and A. Rollett. *Mathematical Models*. Oxford: Oxford University Press, 1961.

Samuel Selby, ed. *CRC Standard Mathematical Tables*. Cleveland, OH: The Chemical Rubber Co., 1965.

The Intricate Graphs of the Polar Functions

Richard T. Simoni, Jr.

For those of us who could never get past trigonometry as taught in the schools, let alone make it into analytic geometry, the personal computer and its graphic display offer new hope for understanding — Here's a nice introduction.

Most graphics-generating devices which can be interfaced with personal computers depend upon the generation of several rectangular ordered pairs (x,y) for the plotting of points. Therefore, most of us tend to stick rigidly with the rectangular coordinate system, forgetting that other interesting coordinate systems can be used just as well and converted to rectangular coordinates for use with the graphics devices. One of the most interesting type of function to plot on graphics hardware are polar coordinate functions. Their fascination lies in analyzing the intriguing designs and patterns that these functions create.

What Are Polar Functions?

To get a basic understanding of polar functions, one must first look at the polar coordinate system itself. Instead of determining the position of a point in a plane by vertical and horizontal distances from an origin, points are located by the distance r from the point to the origin and the angle 0 between one axis and the ray from the origin to the point, as shown in Figure 1. While the rectangular system uses ordered pairs (x,y), the polar system uses ordered pairs (r,0). Positive angles are measured counterclockwise from the positive axis; negative angles are measured clockwise. Similarly, a negative distance r will locate the point in the quadrant opposite that of the specified angle 0, as in the example in Figure 2. This

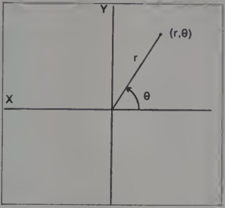

Figure 1
Points are located by a distance r from the origin and an angle 0 in the polar coordinate system. These points are written as ordered pairs (r,0).

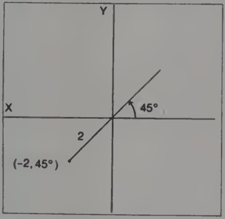

Figure 2
The point specified by the ordered pair (-2, 45°) is located in the third quadrant since 45° is in the first quadrant and r is negative.

quadrant shift is one of the main reasons many polar functions plot so beautifully.

The method used in graphing polar functions is similar to that used in rectangular graphing. Just as a function f(x) can be graphed by trying different values of x and solving for y, so can the function f(0) be graphed by trying different values of 0 and solving for 4. Of course, in order to plot these polar functions on to many graphics devices, the polar coordinates must be converted to rectangular coordinates.

Luckily, the transition is easily made from radius and angular data to standard x and y values. As seen in Figure 3, a line is drawn from the origin of the graph to the desired point. Another line is then drawn from the point down perpendicular to the x-axis, forming the altitude of a triangle whose trigonometric properties can be used to solve for the x and y coordinates of the point.

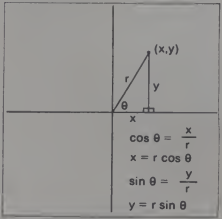

Figure 3
Equations for converting the radius r and angle 0 into their equivalent rectangular coordinates.

Polar functions, just like their rectangular counterparts, are generally written with one variable isolated, most often the distance r, thus expressing the function in terms of 0. Some advantages are to be gained by using polar functions in certain applications. For example, the general formula of a circle with its center at the origin, $x^2+y^2=r^2$, is reduced to a simple r=a in polar form.

Richard T. Simoni, Jr., 29 Farnham Park Drive, Houston, TX 77024.

Graphs, cont'd...

A Computer Program to Graph Polar Functions

Almost without exception, the most interesting polar function graphs involve those functions which are periodic, that is, those whose values repeat after a certain interval. The most common periodic functions that can be introduced to the polar system are the trigonometric properties of sine and cosine. They are perfectly suited for application of both polar functions (which are expressed in terms of an angle 0) and small-computers Basic interpreters (most of which employ the intrinsic functions SIN and COS). Since both sin(x) and cos(x) have periods of 2π radians, solving for the corresponding value of r, and converting the angle and radius data into x and y coordinates for the graphics display device.

The program presented here is written for the Apple II computer, which has the capability to display graphics on a television monitor with a resolution of 280 x 180. The program is written in Applesoft II Basic, which is compatible with most other small-computer Basics. The function to be plotted is defined in the first line of the program, and must be expressed in terms of 0, which has been called Q in the program for lack of a better symbol.

After defining the function, the user is asked to input a step and a scale. The step is the interval in degrees that the program uses in incrementing 0 and 0 to 2π radians. In choosing the appropriate step, the user must decide whether the interest lies in the accuracy of the graph or in the speed with which it is drawn. A smaller step will plot the function more accurately, but with less speed than would be the case with a higher step value. Usually, a step value of 1° is the best tradeoff between speed and accuracy. A step value of 0.1° is usually sufficiently small to provide the best possible accuracy on the Apple's display, while a step value of 3° will provide excellent speed for quick viewing of the graphs. The scale is a relative factor which is altered by the user to allow the pattern to fill most of the screen. Without this factor, some functions might appear too small on the screen, while others might be too large to plot. The proper scale will be between 10 and 100 for most functions. After supplying a step and scale, the user has to specify whether or not the x and y axes should be included in the screen display. While the axes are sometimes useful in understanding why a particular function produces a certain pattern, they are not always aesthetically pleasing.

```
10 OEF FNR(Q)=COS(4*Q)
20 W=0
30 HOME · INPUT "STEP? ".A
40 INPUT "SCALE? ".S
50 HOME
60 INPUT "DO YOU WANT TO SEE THE X-Y AXES? ";A$
70 IF A$="YES" OR A$="Y" THEN W=1
80 HGR2
90 IF W<>1 THEN 130
100 HCOLOR=2
110 HPLOT 0.96 TO 279.96
120 HPLOT 140.0 TO 140.191
130 HCOLOR=3
140 FOR I=0 TO 360 STEP A
150 T=I/57 3
160 Y=FNR(T)*SIN(T)
170 X=FNR(T)*COS(T)
180 Y=INT(Y*S)   X=INT(X*S)
190 IF I=0 THEN HPLOT 140+X.96-Y
200 HPLOT TO 140+X.96-Y
210 NEXT I
220 ENO
```

Listing 1
The Applesoft II Basic program which graphs a given polar function on the screen. The function to be plotted is specified in line 10.

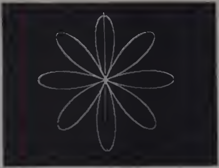

Photo 1a
The graph of the equation R=COS(4*Q).

Photo 1b
The graph of R=SIN(4*Q). Note the phase shift between this graph and the graph of Photo 1a.

The program begins its plot routine with the FOR statement in line 140. This loop increments the angle through 360 degrees by the step value input earlier by the user. Line 150 converts the angle to radians for use with the intrinsic trigonometric functions. Lines 160 and 170 calculate the distance r and combine it with the angle T to generate the equivalent rectangular coordinates. Line 180 sizes the coordinates in accordance with the scale as previously input by the user. Lines 190 and 200 plot the coordinates on the screen.

If the program immediately stops before plotting anything, it is likely that the program has attempted to plot a point which is not physically on the screen. This can usually be remedied by running the program with a different scale value.

Several interesting comparisons can be made between some of the resulting patterns which represent the graphs of the given functions. Photos 1a and 1b dramatically show the inherent phase shift between the trigonometric functions sine and cosine. While the x and y axes virtually split the "leaves" of one graph, the "leaves" of the other graph fall directly between the axes. Photos 2a and 2b illustrate that doubling the angle's coefficient in the function also doubles the number of times the pattern is repeated through the full 360 degrees of the circle. Photos 3a and 3b serve to illustrate the importance of the step value. Though both patterns were generated from the same function, a definite difference can be detected in

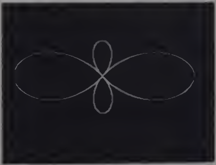

Photo 2a
The graph of R=COS(2*SIN(Q)).

Photo 2b
The graph of R=COS(2*SIN(2*Q)). Note in comparison with Photo 2a that doubling the angle's coefficient also doubles the number of times the pattern is repeated.

Photo 3a
The graph of R=COS(SIN(100*Q)), with a step value of 1 degree.

Graphs, cont'd...

Photo 3b
A more accurate graph of R=COS(SIN(100*Q)), generated with a step value of 0.1 degree

the pattern of Photo 1a (step value = 1 degree) and the pattern of the more accurate Photo 1b step value = .1 degree). In this case, the speed gained by using a higher step value caused a severe reduction in the accuracy of the final graph. Photos 4 and 5 are further examples of aesthetically pleasing designs that can be produced by this program.

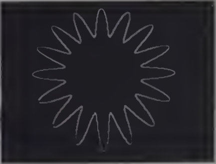

Photo 4
The graph of R=COS(SIN(8*Q)).

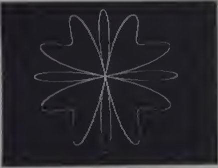

Photo 5
The graph of R=COS(4*SIN(2*Q)).

While the mathematics involved has its interesting aspects, the real attraction of this program is the exploration of the infinite number of patterns which can be produced through the use of different functions. Almost nothing can match the enjoyment of watching the line being plotted take an unusual and unexpected turn which ultimately produces an even more complex and mind-stimulating pattern than the one before it. It is yet another example of man's interest in mathematics and its products. □

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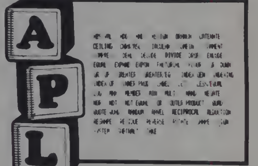

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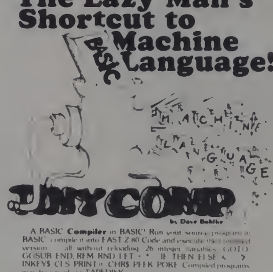

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Apple II Kaleidoscopes

Richard C. Vile, Jr.

Here's a colorful program that gives you a chance to explore the inner logic of folded pictures—and Integer Basic.

At one time or another, everyone has enjoyed a kaleidoscope. The symmetry of the ever-shifting patterns of color holds an endless fascination. This article will show you how to create a virtually endless variety of kaleidoscopic display programs for the Apple II low resolution graphics display. The language used for the examples will be Apple Integer Basic, although the programs could be converted to Applesoft.

The Apple II low resolution graphics display easily accomodates the generation of kaleidoscopic displays. The principle of a kaleidoscope is to replicate a basic pattern by reflection about several exes, thus producing a larger pattern with several identical subdivisions. The basic approach is illustrated in Figure 1. A square of even integral side length is sub-

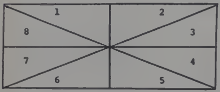


Figure 1

divided into four equal subsquares. Each of those is in turn split into two parts by drawing in the two principal diagonals of the original square. The resulting figure contains eight congruent triangles, which we number as indicated and refer to as *octants*.

Richard C. Vile, Jr., 3467 Yellowstone Dr., Ann Arbor, MI 48105.

Let us suppose that the original square is 2n units on a side. For example, the Apple II low resolution graphics display (with mixed text on the bottom four lines) is 40 units on a side: $n = 20$. Let us assume further that we divide the square into rows and columns, numbering each from 0 to $k = 2n-1$. Then for each unit in octant 1, we have the following information:

$$0 \leq \text{ROW} \leq n-1$$
$$0 \leq \text{COL} \leq n-1$$
$$\text{ROW} \leq \text{COL}$$

For any such point with coordinates (ROW,COL) we may systematically generate a collection of eight points which are configured kaleidoscopically as follows:

1. Form a subrectangle within the original display, with sides parallel to the original display, "equidistant" from the original sides, and with the selected point as the upper left hand corner. This yields the following points:

(ROW,COL)
(ROW,k-COL)
(k-ROW,COL)
(k-ROW,k-COL)

2. For each of the four corners of the square so formed, generate another point by reflection around the upper left to lower right diagonal. This point will be located in the "companion" octant. Octants x and y are companions if their numbers sum to 9 (1+8, 2+7, 3+6, 4+5). The generated point will have the coordinates obtained by simply interchanging the co-ordinates of the original point:

(COL,ROW)
(k-COL,ROW)
(COL,k-ROW)
(k-COL,k-ROW)

For the Apple II display, if the original point was (X,Y), we get the eight points:

(X,Y)	(Y,X)
(X,39-Y)	(39-Y,X)
(39-X,Y)	(Y,39-X)
(39-X,39-Y)	(39-Y,39-X)

The procedure is illustrated geometrically in Figure 2.

By choosing several points in the first octant, and generating the seven companion points for each, kaleidoscopic patterns may easily be created. Let's consider several ways to

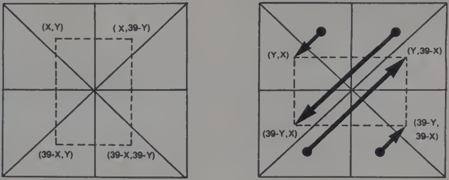


Figure 2

systematically select the "seed" points. Note: It actually does not matter where the original point is located. The eight points generated as described will all lie in the original square, and there will be one in each octant, unless ROW = COL. In that case, the reflected points coincide with the originals and only *four distinct* points appear.

How to create a virtually endless variety of kaleidoscopic display programs for the Apple II low resolution graphics display.

First Method

The first method generates one seed point for each ROW of the 40x40 display. It is accomplished by filling in detailed statements in the followint "sketch code" program:

```
For I = 0 TO 32767
FOR ROW = 0 TO 39
    Compute COL as a function
    of I and ROW.
    PLOT (ROW,COL) and its
    seven companion points.
    (Optionally) Change colors.
NEXT ROW
NEXT I
```

This technique leads to widely differing characters in the resulting kaleidoscopes, depending on the function chosen to compute COL. Here is just a sample of the possibilities:

```
COL = (ROW + I) MOD 40
COL = ABS(I-ROW) MOD 40
COL = (ROW*I) MOD 40
COL = ABS:ROW-ABS(I-ROW))
      MOD 33
```

Note that the values computed by the functions *must* be reduced using the MOD function. If this were not done, the resulting (ROW,COL) combinations would frequently lie outside the permissible range for the screen display. The functions illustrated do not all necessarily satisfy the condition ROW $\leq$ COL, but this really does not matter as the note above indicates. Enforcing that condition by using an IF statement and recomputing the COL value when ROW > COL would not enhance the appeal of the display, but would slow its rate of production. In fact, it could in the worst case result in NO display at all if ROW > COL were always true! In practice, the inner loop in the sketch may be replaced by one of:

```
FOR ROW = 0 TO 19
FOR ROW = 39 TO 0 STEP -1
FOR ROW = 19 TO 0 STEP -1
```

with slight but occasionally interesting differences.

Second Method

This method abandons the sequential consideration of ROWS taken by the first method and instead computes the ROW value as well as the COL value. The sketch program looks formally similar to the first, but now the inner loop index serves only to produce values for the independent variable J. The bounds of the inner loop now are chosen in such a way as to produce reasonable variety in the resulting kaleidoscope: i.e. if the inner loop runs through too many values, then the value of the outer loop index will not change rapidly enough and the same points in the display could be generated over and over.

```
FOR I = 0 TO 32767
FOR J = 0 TO 19
  Compute ROW as a function
    of I and J
  Compute COL as a function
    of I and J
  PLOT (ROW,COL) and its seven
    associates
  (Optionally) Generate color change
NEXT J
NEXT I
```

This method lends itself to considerable experimentation, since a pleasing pattern results from the appropriate *combination* of ROW and COL functions. A good way to proceed is to fix on a "good" COL function from method one and try different COL functions with it.

Third Method

This method is quite similar to the second method. It differs in that the functions used to compute ROW and COL have additional variables. For example, an extra inner loop depending on, say K, may be added and its index variable used as an extra independent variable. In addition, the variables ROW and COL may themselves be used as independent variables. An example using this technique:

```
FOR I = 0 TO 32767
 FOR J = 0 TO 39
  FOR K = 19 TO 0 STEP -1
   ROW = ABS(I-ABS(J-ABS(K-J)))MOD 21
   COL = (ROW + I + J + K) MOD 33
   PLOT "eight points"
   "Change color"
  NEXT K
 NEXT J
NEXT I
```

Subdividing the Kaleidoscope

The basic methods may be used with a *subdivided* display consisting of four subdisplays, each 20x20 in size. Since 20 is also an even number, each of the subdisplays may be used to generate its own kaleidoscope. The simplest application of this technique will generate eight points in the first subdisplay, then replicate them in the other subdisplays by applying appropriate *translations*.

In order that the first eight points lie in the upper left quadrant of the screen, the following conditions must be imposed:

$$0 \leq ROW \leq 19$$
$$0 \leq COL \leq 19$$

The eight basic points will then have coordinates:

(ROW,COL)	(COL,ROW)
(ROW,19-COL).	(19-COL,ROW)
(19-ROW,COL)	(COL,19-ROW)
(19-ROW,19-COL)	(19-COL,19-ROW)

Quadrant I Kaleidoscopic PLOT Points

In order to duplicate these eight points in Quadrants II, III and IV, respectively, a *translation factor* must be added to their coordinates. We illustrate how to derive these factors by discussing Quadrant II.

In Quadrant II, the row coordinate of each point corresponding to a basic point remains the same. Thus, the translation factor for the row coordinate, DR, is equal to 0. Each column coordinate of a basic point must be increased by 20 in order to obtain the corresponding point in Quadrant II. Thus the translation factor for the column coordinate, DC, is equal to 20. These facts may be summarized in the "equation":

Quadrant II ← Quadrant I + (0,20)

Similarly,

Quadrant III ← Quadrant I + (20,0)

Quadrant IV ← Quadrant I + (20,20)

Applying these transformation equations to the basic eight point cluster in Quadrant I yields:

(ROW,COL + 20)	(COL,ROW + 20)
(ROW,39-COL)	(19-COL,ROW + 20)
(19-ROW,20 + COL)	(COL,39-ROW)
(19-ROW,39-COL)	(19-COL,39-ROW)

Quadrant II Cluster

(ROW + 20,COL)	(20 + COL,ROW)
(ROW + 20,19-COL)	(39-COL,ROW)
(39-ROW,COL)	(20 + COL,19-ROW
(39-ROW,19-COL)	(39-COL,19-ROW)

Quadrant III Cluster

Kaleidoscopes, cont'd...

By writing PLOT statements to generate each of the 32 points listed, the basic techniques of Methods One, Two and Three may be used to generate four-fold kaleidoscopes. It is imperative, however, that the seed point, (ROW,COL), does lie in the first quadrant; otherwise, RANGE ERRORS will result. The functions used to generate ROW and COL should therefore always reduce their results using the MOD function in order to guarantee proper location of (ROW,COL).

More Than One Function at a Time

Returning to Method One, notice how the inner loop may vary from 0 to 19 or 0 to 39. Another general technique is to use two (or more) different functions while generating ROW and COL values on a given pass through the inner loop. There are different ways to achieve the alternation; for example:

- Choose randomly between the functions.
- Strictly alternate between the functions.
- Split the use of the functions in halves.
- Use a third function to determine the alternation.

In this section we will detail the method of "splits" and the method of "leaves." The basic idea of splits is

The basic methods may be used with a subdivided display consisting of four subdisplays, each generating its own kaleidoscope.

to use one set of functions to calculate ROW and COL as long as $0 \leq J \leq SPLIT$ and then to switch to another set of functions while $SPLIT + 1 \leq J \leq 39$. SPLIT is chosen to be some value between 1 and 38 (why not 39?), and J is the index of the inner loop. When programming the splits technique, one may query the user for the value of SPLIT, choose the value of SPLIT randomly, or compute SPLIT by yet another function. An example of the latter approach is given in the listings. The idea behind leaves is to alternate (inter-*leave*) the use of the ROW and COL computing functions. The method of alternation may itself be varied, with the most popular being *strict* alternation between two sets of functions. Either the splits or the leaves techniques may be superimposed on the three basic methods and one may use a full kaleidoscope or a four-fold kaleidoscope.

Sample Implementations

Listings 1 and 2 give examples of the splits and leaves techniques for a full screen kaleidoscope. The rest of the article contains lists of some of the functions that have been used by the author. The surface has just been scratched here; much more sophistication and control can be devised by elaborating on the methods con-

```
*** SYNTAX ERR
>LIST
    0 REM  METHOD OF SPLITS
    1 REM  SUBTITLED SNOWFLAKES
    2 REM  NOTE COMPUTATION OF SPLIT VALUE
    3 REM  AND REGENERATION OF DISPLAY
    4 KBD=-16384:CLR=-16368
   10 GR : PRINT : PRINT : PRINT
   15 COLOR= RND (15)+1
   20 FOR I=1 TO 32000
   25 SPLIT=5+(I MOD 5)*(I MOD 3) MOD 13
   30 FOR J=0 TO SPLIT
   40 ROW= ABS (I- ABS (J-I)) MOD 10+ ABS (SPLIT- ABS (J-SPLIT)) MOD
      30
   50 GOSUB 1050
   60 NEXT J
   90 FOR J=SPLIT+1 TO 19
  100 ROW= ABS ( ABS (SPLIT- ABS (I-SPLIT)) MOD 20+SPLIT- ABS (I- ABS
      (J-I)) MOD 20+SPLIT) MOD 30
  110 GOSUB 1050
  120 NEXT J
  125 IF (I MOD 8)#0 THEN 130
  126 FOR DE=1 TO 500: NEXT DE
  127 GOSUB 1070
  128 GR : COLOR=8
  130 NEXT I
 1050 PLOT ROW,J: PLOT 39-ROW,J
 1055 PLOT ROW,39-J: PLOT 39-ROW,39-J
 1060 PLOT J,ROW: PLOT J,39-ROW
 1065 PLOT 39-J,ROW: PLOT 39-J,39-ROW
 1070 X= PEEK (KBD): IF X>=128 THEN GOSUB 1500
 1080 IF ( RND ( PDL (0)+2)=0) THEN GOSUB 2000
 1090 RETURN
 1500 POKE CLR,0: IF X#141 THEN 1505: GR : COLOR=8: RETURN
 1505 IF X# ASC("Q") THEN 1510: TEXT : CALL -936: END
 1510 IF PEEK (KBD)<128 THEN 1510
 1520 POKE CLR,0: RETURN
 2000 P1= RND (4):P2= RND (4):R= RND (2)
 2010 COLOR=P1*R+(1-R)*P2
 2020 RETURN
```

Listing 1

```
>LIST
    1 REM  METHOD OF LEAVES-THREE FOLD INTERLEAVING
    2 KBD=-16384:CLR=-16368
   10 GR : PRINT : PRINT : PRINT
   15 GOSUB 1000
   20 FOR I=500 TO 32767
   25 IF I MOD 2 THEN 30
   26 FOR J=17 TO 0 STEP -1
   27 GOTO 32
   30 FOR J=0 TO 17
   32 IF I MOD 2 THEN 36
   35 ROW=((I MOD 40)* ABS (40-I) MOD 40) MOD 40: GOTO 50
   36 IF (I MOD 3) THEN 40
   38 ROW=J+(I MOD 3)+(I MOD 5): GOTO 50
   40 ROW=((I*J) MOD 20+(I+J+1) MOD 20) MOD 33
   50 PLOT ROW,J: PLOT 39-ROW,J
   55 PLOT ROW,39-J: PLOT 39-ROW,39-J
   60 PLOT J,ROW: PLOT J,39-ROW
   65 PLOT 39-J,ROW: PLOT 39-J,39-ROW
   70 X= PEEK (KBD): IF X>=128 THEN GOSUB 500
   80 IF ( RND ( PDL (0)+2)=0) THEN GOSUB 1000
   85 NEXT J
   90 NEXT I
  500 POKE CLR,0: IF X#141 THEN 510: GR : GOSUB 1000: RETURN
  510 IF X# ASC("Q") THEN 515: TEXT : CALL -936: END
  515 IF PEEK (KBD)<128 THEN 515
  520 POKE CLR,0
  530 RETURN
 1000 P1= RND (4):P2= RND (4):R= RND (2)
 1010 COLOR=R*P1+(1-R)*P2: RETURN
```

Listing 2

Kaleidoscopes, cont'd...

tained herein, and quite precise control over the character of the final displays arrived at. Some exercises are suggested for further exploration.

Explorations

1. Implement a 16-fold kaleidoscope.
   Hint: Use a subroutine to generate points in a 10x10 subdisplay obtained by adding appropriate DR and DC values to the basic eight points from the upper left hand 16th of the screen:
   (ROW,COL) (COL,ROW)
   (ROW,9-COL) (9-COL,ROW)
   (9-ROW,COL (COL,9-ROW)
   (9-ROW,9-COL) (9-COL,9-ROW)
   Call the subroutines from a pair of nested loops:
   FOR DR = 0 TO 30 STEP 10
   FOR DC = 0 TO 30 STEP 10
   or generate DR, DC combos randomly.
2. Implement kaleidoscopes which alternate between full screen and four-fold subdivision of the screen.
3. Implement four-fold kaleidoscopes which use different sets of functions for different subdisplays. Some symmetry may be retained by using one set of functions for quadrants I and IV and another set of functions for quadrants II and III.
4. In the splits technique, incorporate the SPLIT value into the ROW AND COL generating functions.
5. Find new variations on the basic methods.
6. If you have a disk, write a control program which allows user interaction in the selection of various combinations.
7. Use the EXEC command to switch functions dynamically while a program is running. Figure out a way to "capture" (see DOS 3.2 manual) key lines in the file to be EXEC'ed in to effect the change. Perhaps this can be combined with the CHAIN command in some clever ways.

Either the splits or the leaves techniques may be superimposed on the three basic methods and one may use a full kaleidoscope or a four-fold kaleidoscope.

List of Functions (Anywhere you see ROW, you can also use COL):

```
ROW = (I*J) MOD 20
ROW = (J*J + 3*J + 7) MOD 40
ROW = ABS(I - SGN(J-9)*(J+2)) MOD 35
ROW = ((I-SGN(J-9)*J) MOD 13 +((1-SGN(13-J))*(I+2))MOD 17
ROW = ABS(I - SGN(J-10)*J)MOD 25
ROW = ABS(13-I+J) MOD 20 + ABS(27-I+J) MOD 10
ROW = ABS( ABS(I - ABS(2*I-2*J))) MOD 20
ROW = ABS(2*J - ABS( 2*I - ABS(2*I-J))) MOD 33
ROW = ABS( J* (J * (J *(J MOD 40)MOD 40)MOD 40)MOD 40 - I)MOD 33
ROW = ABS( ABS(30-J)-ABS(J-ABS(17-I))+RND(2)) MOD 31
ROW = ABS( I *(J * ABS(I-J))MOD 33 - J*3) MOD 31
ROW = ABS(ABS(30-2*J)-ABS(I-ABS(J-2*J))) MOD 21
ROW = ABS(I - ABS(J-COL)) MOD (COL+1) MOD 40
ROW = ABS(COL-J)MOD 21
```

Notes:

1. The above may be varied by changing numerical coefficients.
2. Combinations of the above may be made when generating both ROW and COL by functions.
3. Complexity may be added by combining the above functions with each other and additional functions to generate new ones.
4. The values in the MOD parts of the above list may need changing for four-fold or sixteen-fold kaleidoscopes. □

The Vibrating String— A Simulation of Motion

William E. Bennett

The realistic simulation of harmonic motion by computer is difficult to accomplish using the Basic language. Although Basic is a powerful tool, the price paid for convenience is slow computation. The only real alternative, if Basic is too slow, is to write the time-critical parts of the program in assembler (machine) language.

The vibration of a string is a kind of motion that can be simulated by the use of a simple algorithm. This can be of value in teaching, if it is realistic, since the concept of standing waves and harmonics is difficult to illustrate by other means. We will first present a Basic program for this simulation and then give the equivalent assembler language program. The latter program is short enough so that one should be able to compose it with T-Bug on the TRS-80 if an assembler is not available.

The vibration of a string is a kind of motion that can be simulated by the use of a simple algorithm.

A simulated string is suspended vertically on the TRS-80 screen. It consists of 48 segments. The top and bottom segments are held in place while the remaining 46 are free to move. Any middle segment is constrained by a force which is proportional to its distance from its nearest neighbors.

The string is "plucked" by moving the top segment to either side a brief time to set the string in motion. The condition of each segment is given by the two variables, X and V. The variable X gives the horizontal position of each segment and the variable V gives the velocity. The Basic program for the vibrating string is as follows:

```
  5 'THE VIBRATING STRING
 10 DEFINT I
 20 DIM X(47),V(47)
 30 CLS:FOR I=0 TO 47
 40 X(I)=63:V(I)=0
 50 SET(X(I),I):NEXT I
 60 A$=INKEY$
 70 IF A$="" GOTO 140
 80 RESET(X(0),0)
 90 IF A$="X" GOTO 30
100 IF A$="R" THEN X(0)=83
110 IF A$="L" THEN X(0)=43
120 IF A$="M" THEN X(0)=63
130 SET(X(0),0)
140 FOR I=1 TO 46
150 AC=X(I-1)+X(I+1)-2*X(I)
160 V(I)=V(I)+AC/2:NEXT I
170 FOR I=1 TO 46:RESET(X(I),I)
180 X(I)=X(I)+V(I)
190 SET(X(I),I):NEXT I
200 GOTO 60
```

When this program is run, things happen very slowly, too slowly in fact, to give a feeling for what is going on. Plucking is accomplished by typing "R" to move the top segment to the right, "L" to move it to the left, and "M" to move it back to the center. The program is re-started by typing "X." The purpose of listing this program is to illustrate the simple calculations involved and to serve as a comparison to the assembler language program. The assembler program is nearly a direct translation of this Basic program but is more than 100 times faster. It was designed to fit into the upper 1K of a 4K TRS-80 computer. This leaves ample room for T-Bug or for the Basic program we will give later.

To key the assembler program with T-Bug, start with M4C00 and then enter 3E 00 32 AF 4C F3 . . . etc., to the very end (line 1400). Then save it on tape with the PUNCH command (P 4C00 4D1E 4C00 STRG enter).

The program starts at hexadecimal 4C00 (decimal 19456). Those having the use of disk systems and an assembler should move it to, say, 7C00. Line 100 should be changed to "ORG 7C00H," and line 140 to "LD SP,7FFFH."

When the string is "plucked" by pressing the left or right arrow keys, a disturbance is created. This disturbance travels along the string and reflects at each end. The shape of the wave soon changes, giving a motion to the string which is a combination of its various modes of vibration. One can simulate particular modes of vibration by periodic plucking. The string has no friction and will continue to move until the up-arrow is pressed. Also, the way the arithmetic is handled gives roll-around. This is, if the wave motion goes off the screen, it re-appears on the opposite side.

This program gives quite a realistic effect. It will soon be found that plucking always gives a mixture of harmonics. Pure harmonics will be illustrated later. Stringed instruments are designed to damp unwanted harmonics while reinforcing desired ones.

A step by step documentation of the program is given below. We should explain the form of the variables X and V for clarification. Each of these is a two byte number of the form "N.M." One byte, N, is an integer and ranges from 0 to 127, the normal TRS-80 horizontal numbering. The second byte, M, is a fraction. A value of X near the center of the screen would be, in decimal form, 63.0; one halfway between positions 63 and 64 would be 63.5. For each of the 48 values of X and V, two bytes are used. The one at the higher address is N.

William E. Bennett, 708 Diana Ct., Iowa City, IA 52240.

LINE

100 The starting address

110-120 Set the flag "MOB" to indicate that this is a run-alone program.

130 Disable interrupts. This is needed for disk systems to turn off the clock interrupt. It is good housekeeping anyway.

140 Establish the stack pointer.

150-190 The equivalent of Basic CLS. Clear the screen.

200-240 Set all V values to zero.

250-270 If this is a Basic subroutine skip the next step.

280-350 Set all values of X to 63. This is equivalent to:
FOR I=0 TO 47:X(I)=63:NEXT I

360-370 Call the subroutine SET which will SET all string segments on the CRT screen.

380-480 Read the keyboard to see if the specific keys ←, →, or ↑ are pressed.
↑ = Restart the program or return to the Basic program.
← = Change the value of X(0) to 53.
→ = Change the value of X(0) to 73.

490-500 Initialize the FOR loop. This loop terminates at line 710 and is equivalent to:

```
10 FOR I=1 TO 46
20 V(I)=V(I)+(X(I-1)+X(I+1)
   -2*X(I))/2
30 NEXT I
```

The index register IX initially points to X(0) while IX+96 points to V(0).

510-520 Load X(I-1) into register pair DE.

530-540 Load X(I+1) into register pair HL.

550 Add X(I-1)+X(I+1) giving the sum in register HL.

560-570 Load X(I) into register pair DE.

580-590 Multiply X(I) by two.

600 Clear the carry flag since SBC will subtract it.

610 Subtract HL - DE giving the result in HL.

620-630 Divide HL by two.

simple vibration

640-650 Load V(I) into register pair DE.

660 Add HL and DE giving the sum in HL.

670-680 Store the new value of V(I).

690-700 Bump the pointer for X(I) and V(I).

710 This corresponds to the NEXT I.

720-730 Change X(0) to 63 in case it was changed by ← or →.

740-750 Call subroutine SET. If register C is zero, the subroutine will do the following sequence for each string segment:
RESET a string segment
X(I)=X(I)+V(I)
SET the string segment

760 Go back, read the keyboard, and do the next time cycle.

770-790 Check to see if this program is run-alone or is a Basic subroutine. If it is run-alone, start over.

800-810 If this is a Basic program subroutine, then recover the Basic stack pointer and return to that program.

820 The point for a Basic program to enter this subroutine. Save the Basic stack pointer. Good housekeeping again.

830-840 Set the flag "MOB" to indicate that this is now a subroutine of a Basic program.

850 MOB is the flag. If zero, it means that this is a run-alone program. If one, it is a Basic subroutine.

860 BSP is the saved Basic stack pointer.

870-920 These are masks for each of the six pixies in a graphics word.

930 Initialize the register pair DE to contain the CRT line pointer. It now points to horizontal line zero.

940 Initialize the FOR loop. This loop terminates at line 1200. This loop is equivalent to:

```
10 FOR I=0 TO 47
20 HL=INT(X(I)) (well, sort of)
30 IF C=0 GOTO 70
40 SET(HL,I)
50 IF C=3 GOTO 110
60 C=0:GOTO 110
70 RESET(HL,I)
80 C=1
90 X(I)=X(I)+V(I)
100 GOTO 20
110 NEXT I
```

950 Initialize register IY to point to the first pixie mask.

960 Initialize register IX to point to X(0), IX + 96 points to V(0).

970-1000 Load the integer portion of X(I) into the register pair HL. Mask off the sign bit. This will give a number between zero and 127, the normal horizontal graphics range.

compound vibration

1010 Divide L by two. This gives the number of the graphics word (0 - 63). The remainder, which is now the carry flag, tells which of the two pixies to SET or RESET.

1 2

1020-1050 Place the correct mask for the particular pixie in register A.

1060 Add the CRT line pointer to HL. The register pair HL now will point to the screen graphics word to be altered.

1070-1080 Are we supposed to SET or are we to RESET? If RESET, go to line 1270.

1090-1100 SET the pixie.

1110-1120 If we are to SET only, skip the next line.

1130 Prepare C for the next SET, add, RESET the sequence.

1140-1150 Where are we on the graphics character?

1
4
16

If 16, go to line 1220 to fix things up for the next CRT line.

1160-1170 Increment the mask pointer.

1180-1190 Bump to the next X(I) and V(I).

1200 This corresponds to the NEXT I.

1210 Exit subroutine SET.

1220 Reset the mask pointer.

1230-1250 Bump the CRT line pointer to the next line.

1260 Go to the loop end at line 1180.

1270-1290 RESET the pixie.

1300 Set C to flag the next part of the sequence.

1310 Save the CRT line pointer.

1320-1330 Load V(I) into register DE.

String, cont'd...

1340-1350	Load X(I) into register HL.
1360	Add X(I)+V(I) giving the result in HL.
1370-1380	Save the new value of X(I).
1390	Recover the saved CRT line pointer.
1400	Go back and SET the new point.
1410	The storage for X values. (4D1F-4D7E)
1420	The storage for V values. (4D7F-4DDE)

A simulated string consists of 48 segments. The top and bottom segments are held in place while the remaining 46 are free to move.

The Z-80 instruction set makes programming of this type quite straightforward. The index registers IX and IY are particularly useful as pointers to data, while the other registers are used for arithmetic and logic.

The Best of Both Worlds

The assembler program was written so that it can act as a stand-alone program or as a subroutine for a Basic program. We can then use a Basic program for the things which it handles best and the Assembler program for things we want to do in a hurry or that are difficult to do with Basic.

The following Basic program generates pure harmonics or mixtures of harmonics which are then transferred to the storage area for the X values of the assembler program. The basic program then calls the assembler program as a subroutine which creates the display.

```
 10 'HARMONICS GENERATOR
 20 DEFINT I-N:PI=3.141593/47:CLS
 30 DIM H(3)
 40 'LOAD STARTING ADDRESS OF
     SUBROUTINE 4CAG
 50 POKE 16526,166:POKE 165527,76
 60 INPUT"WHAT THREE HARMON-
     ICS";H(1),H(2),H(3)
 70 'SET N TO POINT TO X(0)
 80 CLS:N=19743   'THIS IS 4D1F
 90 FOR I=0 TO 47
100 X=63
110 FOR K=1 TO 3
120 X=X+20*SIN(I*PI*H(K))
130 NEXT K
140 'CONVERT X TO THE TWO
     BYTE FORM
150 IA=INT(X)
160 IB=INT((X-IA)*256)
170 IA=IA AND 255
180 'SHOW THE STRING
190 IC=IA AND 127:SET (IC,I)
200 'NOW STORE THE X VALUE
210 POKE N,IB
220 N=N+1
230 POKE N, IA
240 N=N+1:NEXT I
250 'JUMP TO THE SUBROUTINE
260 J=USR(J)   'J IS A DUMMY
270 GOTO 60
```

The program was designed to accept integral values of the harmonics, but one can try others. A single harmonic can be generated by any combination of it with zeroes. For example, 2,2,2 or 2,0,0 gives the second harmonic. Due to the limited resolution, 48 segments, and the speed of the display, the upper limit of the harmonics which can be readily recognized, is about 12. Above 12, some interesting patterns are formed. An important consideration is the Nyquist frequency, harmonic 47. At this frequency there are two segments per sine wave cycle. Above this frequency, no higher harmonics can be represented and the net result is a harmonic of frequency less than the Nyquist frequency.

Combinations of two harmonics can be introduced by combining any of the two numbers with zero. For example, 2,3,0 or 2,2,3. Some of the very high harmonics, such as 45,6,0, give very interesting patterns, but are unstable causing the string to "explode." This can be prevented by reducing the amplitude. To do this, change statement 120 to a lower amplitude. For example:

```
120 X=X+8*SIN(I*PI*H(K))
```

This "explosion" is the result of an overflow of the velocity of segments at high frequency. The assembler program could be revised to avoid this, but we wished to keep it as short as possible.

Three harmonics can be combined in any order. For example: 3,4,5

Assembler Programs

```
4C00           00100        ORG   4C00H
4C00 3E00      00110        LD    A,0
4C02 32AF4C    00120 STRA   LD    (MOB),A
4C05 F3        00130        DI
4C06 31FF4F    00140        LD    SP,4FFFH
4C09 21003C    00150 STRB   LD    HL,3C00H
4C0C 11013C    00160        LD    DE,3C01H
4C0F 01FF03    00170        LD    BC,3FFH
4C12 3680      00180        LD    (HL),80H
4C14 EDB0      00190        LDIR
4C16 217F4D    00200        LD    HL,CV
4C19 11804D    00210        LD    DE,CV+1
4C1C 015F00    00220        LD    BC,95D
4C1F 3600      00230        LD    (HL),0
4C21 EDB0      00240        LDIR
4C23 3AAF4C    00250        LD    A,(MOB)
4C26 CB47      00260        BIT   0,A
4C28 200E      00270        JR    NZ,STRD
4C2A 211F4D    00280        LD    HL,CX
4C2D 0630      00290        LD    B,48D
4C2F 11003F    00300        LD    DE,3F00H
4C32 73        00310 STRC   LD    (HL),E
4C33 23        00320        INC   HL
4C34 72        00330        LD    (HL),D
4C35 23        00340        INC   HL
4C36 10FA      00350        DJNZ  STRC
4C38 0E03      00360 STRD   LD    C,3
4C3A CDB84C    00370        CALL  SET
4C3D 3A4038    00380 STRE   LD    A,(3840H)
4C40 E668      00390        AND   104D
4C42 2811      00400        JR    Z,STRH
4C44 CB5F      00410        BIT   3,A
4C46 2051      00420        JR    NZ,EXIT
4C48 CB6F      00430        BIT   5,A
4C4A 2004      00440        JR    NZ,STRF
4C4C 3E49      00450        LD    A,73D
4C4E 1802      00460        JR    STRG
4C50 3E35      00470 STRF   LD    A,53D
4C52 32204D    00480 STRG   LD    (CX+1),A
4C55 DD211F4D  00490 STRH   LD    IX,CX
4C59 062E      00500        LD    B,46D
4C5B DD5E00    00510 STRI   LD    E,(IX)
4C5E DD5601    00520        LD    D,(IX+1)
4C61 DD6E04    00530        LD    L,(IX+4)
4C64 DD6605    00540        LD    H,(IX+5)
4C67 19        00550        ADD   HL,DE
4C68 DD5E02    00560        LD    E,(IX+2)
4C6B DD5603    00570        LD    D,(IX+3)
4C6E CB23      00580        SLA   E
4C70 CB12      00590        RL    D
4C72 A7        00600        AND   A
4C73 ED52      00610        SBC   HL,DE
4C75 CB2C      00620        SRA   H
4C77 CB1D      00630        RR    L
4C79 DD5E62    00640        LD    E,(IX+98D)
4C7C DD5663    00650        LD    D,(IX+99D)
4C7F 19        00660        ADD   HL,DE
4C80 DD7562    00670        LD    (IX+98D),L
4C83 DD7463    00680        LD    (IX+99D),H
4C86 DD23      00690        INC   IX
4C88 DD23      00700        INC   IX
4C8A 10CF      00710        DJNZ  STRI
4C8C 3E3F      00720        LD    A,63D
4C8E 32204D    00730        LD    (CX+1),A
4C91 0E00      00740        LD    C,0
4C93 CDB84C    00750        CALL  SET
4C96 C33D4C    00760        JP    STRE
4C99 3AAF4C    00770 EXIT   LD    A,(MOB)
4C9C CB47      00780        BIT   0,A
4C9E CA094C    00790        JP    Z,STRB
4CA1 ED7BB04C  00800        LD    SP,(BSP)
4CA5 C9        00810        RET
4CA6 ED73B04C  00820 ENTRY  LD    (BSP),SP
4CAA 3E01      00830        LD    A,1
4CAC C3024C    00840        JP    STRA
4CAF 00        00850 MOB    DEFB  0
4CB0 0000      00860 BSP    DEFW  00
4CB2 01        00870 VPX    DEFB  1
4CB3 02        00880        DEFB  2
4CB4 04        00890        DEFB  4
4CB5 08        00900        DEFB  8
4CB6 10        00910        DEFB  16D
4CB7 20        00920        DEFB  32D
4CB8 11003C    00930 SET    LD    DE,3C00H
4CBB 0630      00940        LD    B,48D
4CBD FD21B24C  00950        LD    IY,VPX
4CC1 DD211F4D  00960        LD    IX,CX
4CC5 DD7E01    00970 SETA   LD    A,(IX+1)
4CC8 E67F      00980        AND   7FH
4CCA 6F        00990        LD    L,A
4CCB 2600      01000        LD    H,0
4CCD CB3D      01010        SRL   L
4CCF 3805      01020        JR    C,SETB
4CD1 FD7E00    01030        LD    A,(IY)
4CD4 1803      01040        JR    SETC
4CD6 FD7E01    01050 SETB   LD    A,(IY+1)
4CD9 19        01060 SETC   ADD   HL,DE
4CDA CB41      01070        BIT   0,C
4CDC 2824      01080        JR    Z,SETG
4CDE B6        01090        OR    (HL)
4CDF 77        01100        LD    (HL),A
4CE0 CB49      01110        BIT   1,C
4CE2 2002      01120        JR    NZ,SETD
4CE4 0E00      01130        LD    C,0
4CE6 FDCB0066  01140 SETD   BIT   4,(IY)
4CEA 200B      01150        JR    NZ,SETF
4CEC FD23      01160        INC   IY
4CEE FD23      01170        INC   IY
4CF0 DD23      01180 SETE   INC   IX
4CF2 DD23      01190        INC   IX
4CF4 10CF      01200        DJNZ  SETA
4CF6 C9        01210        RET
4CF7 FD21B24C  01220 SETF   LD    IY,VPX
4CFB 214000    01230        LD    HL,64D
4CFE 19        01240        ADD   HL,DE
4CFF EB        01250        EX    DE,HL
4D00 18EE      01260        JR    SETE
4D02 2F        01270 SETG   CPL
4D03 A6        01280        AND   (HL)
4D04 77        01290        LD    (HL),A
4D05 0E01      01300        LD    C,1
4D07 D5        01310        PUSH  DE
4D08 DD5E60    01320        LD    E,(IX+96D)
4D0B DD5661    01330        LD    D,(IX+97D)
4D0E DD6E00    01340        LD    L,(IX)
4D11 DD6601    01350        LD    H,(IX+1)
4D14 19        01360        ADD   HL,DE
4D15 DD7500    01370        LD    (IX),L
4D18 DD7401    01380        LD    (IX+1),H
4D1B D1        01390        POP   DE
4D1C C3C54C    01400        JP    SETA
0060           01410 CX     DEFS  96D
0060           01420 CV     DEFS  96D
0000           01430        END
00000 TOTAL ERRORS
```

String, cont'd...

or 6,5,4. Again, for high harmonics such as 44,45,46, reduce the amplitude to about 8. To give a straight string, enter 0,0,0.

Some persons who have run this program have tried to "break" the string by stimulating large oscillations of the first harmonic. They did not succeed. Try the following:

```
120 X=X+100*SIN(I*PI*H(K))
```

and then enter 1,1,1.

It is up to the programmer's imagination as to what functions to try. For example:

```
120 X=X+20*(SIN(I*PI*H(K))↑2)
        or
115 EX=(1-I)/10
120 X=X+40*(SIN(I*PI*H(K))*
    (2.71828↑EX)
```

Try any function where X(0) and X(47) are nearly equal to 63. You can devise a kind of mobile screen-graphics art.

The upper limit of the harmonics which can be readily recognized is about 12.

To prepare a tape, first produce the assembler program with T-Bug or an assembler. Store it on tape with a name such as STRG. Then copy the above Basic program and save it following the Assembler program, using a name such as "S." On power-up of a Level II system do the following:

```
MEMORY? 19455        enter
READY
>system              enter
*? strg              enter
*?                   enter
?SN ERROR
READY
>cload "S"           enter
READY
>run                 enter
```

To run the program as a stand-alone program do the following:

```
MEMORY?              enter
>system              enter
*? strg              enter
*?/19456             enter
```

(If saved by T-Bug *?/ enter) □

cosmic twang

Typewriter Cartoons

Richard Galbraith

Even before computers began to curse the Red Baron or ask "What me worry?" I was fascinated by pictures created using the letters on a typewriter. I would get ideas for such typewriter cartoons, and rough them out on graph paper. Unfortunately, my typing skill is only slightly greater than my artistic talent, so none of these ideas were ever translated into anything I could show off.

The arrival of home computers has allowed me to indulge in my elusive artistic endeavor. I wrote a little skeleton program to translate the columns on graph paper to printed typewriter characters. My first effort was a fortieth birthday card for a friend (Figure 1). The response was tremendous, but not printable. Since then, I have created a number of other cartoons for my own pleasure and for my kids. Once I have a rough line drawing, or have found an appropriate picture to trace or project onto graph paper, I can translate it into data statements for my program and refine the printout in an evening. Copies of the cartoon can then be typed out by my computer (a TRS-80) in a couple of minutes to impress friends.

Skeleton Program

The skeleton program is designed to be a flexible vehicle which provides for routine handling of a common process while allowing custom alterations to spruce up each individual use. The central problem in creating typewriter cartoons is the proper alignment of the letters on each line. A simple way to describe the position of a series of letters is to specify the starting column (T in Figure 2) and the number of consecutive letters (length or L). The skeleton program keeps track of the current print position (P) and moves to the next set of characters by printing a string of spaces (line 230). To help spot bad entries, an error message is displayed on the screen if the current position ever gets ahead of the next starting column. Next, a string of the designated typing character is printed (C$ in line 240) and the program loops back to read the next set of columns. The end of a line is signalled by any starting number greater than 200 (line 210). This transmits a carriage return and resets the current position counter to the initial margin. Since I am not too good at centering pictures until I see them, the margin is a variable (M in line 50) which I can easily adjust to slide the cartoon into the center of the page.

Most of my cartoons use only 4 or

Figure 1

Richard Galbraith, 2124 E. Fremont Dr., Tempe, AZ 85282.

```
          CARTOON

10    REM   SKELETON FOR PRINTING PICTURES
20    REM   BY R. GALBRAITH  AUGUST 1979
25    REM
50       CLEAR1000
        :M=1
        :P=M
100      CLS
        :PRINTTAB(5)"name of picture"
110      PRINT
        :INPUT"PREPARE PRINTER & PRESS ENTER";Z$
200      READT
210      IFT>200THENLPRINT
        :P=M
        :GOTO200
220      IFT=0GOTO300
230      T=T-1
        :IFT>PTHENLPRINTSTRING$(T-P," ");ELSEPRINT"ERROR  T=";T;" P=";P

240      READL
        :P=T+L
        :LPRINTSTRING$(L,C$);
250      GOTO200
300      READC$
        :IFC$="END"THEN500ELSEGOTO200
500   REM END OF DATA ROUTINE
900      FORI=1TO12
        :LPRINT
        :NEXT
999      END
1000 REM  DATA FOR EACH PRINT LINE FOLLOWS
```

Figure 2

5 different print characters. The skeleton program still must provide some way to change the character that is being printed. This is accomplished by using a data pair of O,X where X is the next character to be printed. This combination changes the value of C$ (lines 220 and 300). The special pair of O,END is used to signal the end of the data and transfer control to the ending routine.

Drafting Pictures

To illustrate the use of the skeleton, we will walk through the process of setting your computer to type a self-portrait. First, we need a sketch such as Figure 3. This sketch was done with consideraby more care than my usual efforts in anticipation of its public appearance. The sketches for 'Bear Thoughts' (Figure 4) and the 'Knight' were simple line drawings with numerous erasures. Greater care in the initial sketch will generally reduce the amount of time spent altering DATA statements after the first draft is printed, but the only thing you will normally want to show in public is the final cartoon that your computer whips out at the press of a button.

Standard graph paper will cause some problems in getting the right proportions. Standard typing spaces are one-sixth of an inch tall and only one-tenth or one-twelfth of an inch wide. If you are using elite type, you should put two letters across in each square of graph paper. For the 10 pitch

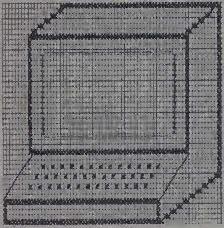


Figure 3

type used by most computer printers, it is best to use a report layout (or printer spacing chart) form designed for use for full-scale computers.

To translate the picture into DATA statements, start by specifying the first character to be used by entering O,X. The first series of X's is described by the starting column and length of

Figure 4

consecutive printing: 21,50. Since that is the end of the line, the next entry is 999. The next line starts with a pair of X's (20,2), then skips over to column 68 for two more entries (68,1 and 70,1) before the end of the second line. To simplify debugging, I match the print row number to the Basic line number. The full set of DATA statements for the computer self-portrait is shown in Figure 5. Appending these to the skeleton program produces the picture shown in Figure 6.

Getting Fancy

While the skeleton handles the routine print positioning, a little extra effort lets you spruce up and personalize each cartoon. Slogans or messages can be printed above or below the cartoon by inserting statements between 110 and 200 (for starting messages) or between 500 and 900 (for final messages). In our sample program (Figure 7), lines 510 through 530 print 3 black lines and the message "Honor Thy Computer!!" below the cartoon. CHR$(01) and CHR$(02) are used by Integral Data Systems printers to shift to enhanced characters and back to normal type face. For use with Radio Shack's Line Printer II, CHR$(01) should be replaced with CHR$(14) and line 530 should be omitted since the printer returns to normal mode after each LPRINT command.

Embedding text within the cartoon is a little more complicated. One solution is to use negative numbers in the DATA statements to invoke a branch to a special subroutine (see line 225). If multiple text lines are to be embedded within the same cartoon, the absolute value of the negative entry can be used to distinguish the different messages (line 410). To maintain the proper alignment, it is important to

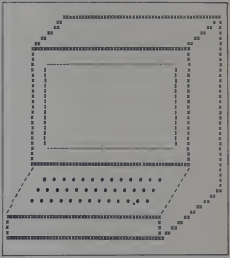


Figure 6

increment the position counter (P) by the number of spaces used in printing the message.

Our completed computer portrait allows the user to specify a six-line message to appear on the screen of the printed computer. Lines 120 to 160 accept the message for each run. Negative numbers (-1 through -6) are inserted in the appropriate points in the Data (lines 1016, 1018, 1020, 1022, 1024 and 1026) to direct the program to the routine which prints the messages (lines 400-420).

Writing this description of the process has taken longer than writing the program and producing the final result (Figure 8). The artistic merit of this cartoon is debatable. Instead of

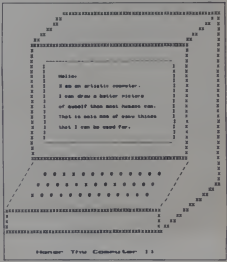


Figure 8

Cartoons, cont'd...

voicing your criticism or copying my primitive work, modify the program to create your own masterpieces. They can be as simple as this self-portrait or more complicated. The only limitations are your imagination and/or tracing ability. □

```
DATA

1000 REM  DATA FOR EACH PRINT LINE FOLLOWS
1004     DATA 0,X,21,50,999
1005     DATA 19,2,68,1,70,1,999
1006     DATA 18,2,66,2,70,1,999
1007     DATA 16,2,64,2,70,1,999
1008     DATA 14,2,62,2,70,1,999
1009     DATA 12,2,60,2,70,1,999
1010     DATA 11,50,70,1,999
1011     DATA 11,1,60,1,70,1,999
1012     DATA 11,1,60,1,70,1,999
1013     DATA 11,1,0,-,16,40,0,X,60,1,70,1,999
1014     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1015     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1016     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1017     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1018     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1019     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1020     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
1021     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
1022     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
1023     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1024     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
1025     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1026     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1027     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1028     DATA 11,1,0,1,15,1,56,1,0,X,60,1,70,1,999
1029     DATA 11,1,0,-,16,40,0,X,60,1,70,1,999
1030     DATA 11,1,60,1,70,1,999
1031     DATA 11,1,60,1,70,1,999
1032     DATA 11,50,70,1,999
1033     DATA 0,/,11,1,60,1,0,X,70,1,999
1034     DATA 0,/,10,1,59,1,0,X,70,1,999
1035     DATA 0,/,9,1,0,@,15,1,18,1,21,1,24,1,27,1,30,1,33,1,36,1,39,1,
         42,1,45,1,48,1,51,1,0,/,58,1,0,X,70,1,999
1036     DATA 0,/,8,1,57,1,0,X,70,1,999
1037     DATA 0,/,7,1,0,@,13,1,16,1,19,1,22,1,25,1,28,1,31,1,34,1,37,1,
         40,1,43,1,46,1,49,1,0,/,56,1,0,X,69,2,999
1038     DATA 0,/,6,1,55,1,0,X,67,2,999
1039     DATA 0,/,5,1,0,@,11,1,14,1,17,1,20,1,23,1,26,1,29,1,32,1,35,1,
         38,1,41,1,44,1,47,1,0,/,54,1,0,X,65,2,999
1040     DATA 0,/,4,1,53,1,0,X,63,2,999
1041     DATA 0,/,3,1,52,1,0,X,61,2,999
1042     DATA 3,49,59,2,999
1043     DATA 3,1,51,1,57,2,999
1044     DATA 3,1,51,1,55,2,999
1045     DATA 3,1,51,1,53,2,999
1046     DATA 3,50,999
1047     DATA 0,END
```

Figure 5

```
PORTRAIT

10   REM   SKELETON FOR PRINTING PICTURES
20   REM   BY R. GALBRAITH  AUGUST 1979
25   REM
40      DIM M$(6)
50      CLEAR1000
       :M=-4
       :P=M
100     CLS
       :PRINTTAB(5)"SELF-PORTRAIT"
110     PRINT
       :INPUT"PREPARE PRINTER & PRESS ENTER";Z$
120     CLS
       :PRINT"I WILL DISPLAY UP TO SIX LINES OF TEXT ON MY SCREEN."
       :PRINT"EACH LINE IS A MAXIMUM OF 32 CHARACTERS LONG."
       :PRINT
130     FOR I=1 TO 6
       :PRINT"ENTER LINE #";I;" (PRESS 'ENTER' IF NO MESSAGE)."
140     LINE INPUT M$(I)
       :IF LEN(M$(I))=0 THEN 200
150     IF LEN(M$(I)) > 32 PRINT"TOO LONG — ENTER NO MORE THAN 32 CHA
```

Cartoons, cont'd...

```
          RACTERS"
         :GOTO140
 160      NEXT I
 200      READT
 210      IFT>200THENLPRINT
         :P=M
         :GOTO200
 220      IFT=0GOTO300
 225      IF T<0 THEN 400
 230      T=T-1
         :IFT>PTHENLPRINTSTRING$(T-P," ");ELSEPRINT"ERROR  T=";T;" P=";P

 240      READL
         :P=T+L
         :LPRINTSTRING$(L,C$);
 250      GOTO200
 300      READC$
         :IFC$="END"THEN500ELSEGOTO200
 400      LPRINT"     ";
         :P=P+4
 410      T=ABS(T)
         :L=LEN(M$(T))
         :LPRINT M$(T);
         :P=P+L
 420      GOTO 200
 500    REM END OF DATA ROUTINE
 510      FOR I=1TO3
         :LPRINT
         :NEXT
 520      LPRINTCHR$(01);TAB(10)"Honor Thy Computer !!"
 530      LPRINTCHR$(02)
 900      FORI=1TO12
         :LPRINT
         :NEXT

 999      END
 1000 REM  DATA FOR EACH PRINT LINE FOLLOWS
 1004     DATA 0,X,21,50,999
 1005     DATA 19,2,68,1,70,1,999
 1006     DATA 18,2,66,2,70,1,999
 1007     DATA 16,2,64,2,70,1,999
 1008     DATA 14,2,62,2,70,1,999
 1009     DATA 12,2,60,2,70,1,999
 1010     DATA 11,50,70,1,999
 1011     DATA 11,1,60,1,70,1,999
 1012     DATA 11,1,60,1,70,1,999
 1013     DATA 11,1,0,-,16,40,0,X,60,1,70,1,999
 1014     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
 1015     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
 1016     DATA 11,1,0,I,15,1,-1,56,1,0,X,60,1,70,1,999
 1017     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
 1018     DATA 11,1,0,I,15,1,-2,56,1,0,X,60,1,70,1,999
 1019     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
 1020     DATA 11,1,0,I,15,1,-3,56,1,0,X,60,1,70,1,999
 1021     DATA 11,1,0,I,15,1,56,1,0,X,60,1,,0,1,999
 1022     DATA 11,1,0,I,15,1,-4,56,1,0,X,60,1,70,1,999
 1023     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
 1024     DATA 11,1,0,I,15,1,-5,56,1,0,X,60,1,70,1,999
 1025     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
 1026     DATA 11,1,0,I,15,1,-6,56,1,0,X,60,1,70,1,999
 1027     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
 1028     DATA 11,1,0,I,15,1,56,1,0,X,60,1,70,1,999
 1029     DATA 11,1,0,-,16,40,0,X,60,1,70,1,999
 1030     DATA 11,1,60,1,70,1,999
 1031     DATA 11,1,60,1,70,1,999
 1032     DATA 11,50,70,1,999
 1033     DATA 0,/,11,1,60,1,0,X,70,1,999
 1034     DATA 0,/,10,1,59,1,0,X,70,1,999
 1035     DATA 0,/,9,1,0,@,15,1,18,1,21,1,24,1,27,1,30,1,33,1,36,1,39,1,
           42,1,45,1,48,1,51,1,0,/,58,1,0,X,70,1,999
 1036     DATA 0,/,8,1,57,1,0,X,70,1,999
 1037     DATA 0,/,7,1,0,@,13,1,16,1,19,1,22,1,25,1,28,1,31,1,34,1,37,1,
           40,1,43,1,46,1,49,1,0,/,56,1,0,X,69,2,999
 1038     DATA 0,/,6,1,55,1,0,X,67,2,999
 1039     DATA 0,/,5,1,0,@,11,1,14,1,17,1,20,1,23,1,26,1,29,1,32,1,35,1,
           38,1,41,1,44,1,47,1,0,/,54,1,0,X,65,2,999
 1040     DATA 0,/,4,1,53,1,0,X,63,2,999
 1041     DATA 0,/,3,1,52,1,0,X,61,2,999
 1042     DATA 3,49,59,2,999
 1043     DATA 3,1,51,1,57,2,999
 1044     DATA 3,1,51,1,55,2,999
 1045     DATA 3,1,51,1,53,2,999
 1046     DATA 3,50,999
 1047     DATA 0,END
```

Figure 7

Blot

Donald-Bruce Abrams

Description: Blot is a program designed to produce selectively weighted random-dot drawings. The user can specify an overall shading ranging from totally white to totally black. In addition, he may select certain rectangular areas and shade them relative to the whole. Finally, he may create functions of the form Y=F(x) and select matching results to be shaded differently, too. He may select (on a rectangular range with axes chosen by user) the shading to take place on points which exactly match Y=F(x), points where y is less than F(x) or points where y is greater than F(x).

The user may select any combination of the features described abcve, with the exception of the overall shading, (which is mandatory and input at the start of the program). Shading is done in six degrees, ranging from " " to "■"(white to black). Shadings are done randomly; the user requests merely a *degree* of shading, and leaves the specific location of characters to the program.

The program as implemented allows the user to select picture size in inches, with a maximum size of 12 * 18 inches. Since such a size requires a rather large array (on DEC LA36 printers, character densities are 6 rows/inch and 10 columns/inch), BLOT creates a virtual array, which it deletes at the end of execution. If your computer does not have such an array/filing capability, you should either decrease the maximum size or modify the program to use standard basic files (which are much slower).

This program was written in Basic-Plus on a DEC 11/70 computer operating under the RSTS/E VO6-3 operating system.

Comments: The statement "&" is used as a short form for "PRINT." Lines 60-70 describe and create the temporary file BLOTFL which is used as a virtual array and then is killed upon completion of the picture.

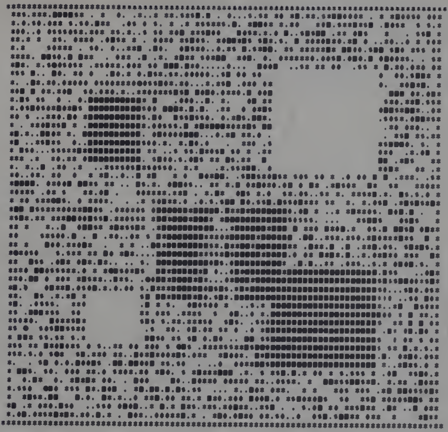
Line 10 (here "10 DEF FNA(X)=(121-X**2)**.5") is used to define the function to be used in "equation shadings."

The exclamation point (!) is used to indicate that the rest of the line is to be treated as a comment. □

Donald-Bruce Abrams, 501 E. 79 Street, New York, NY 10021.

```
LIST
BLOT6   10:52 AM        30-May-79
10 DEF FNA(X)=(121-X**2)**.5
50 ! WRITTEN BY DON ABRAMS
60 DIM#1,P(120,120)
70OPEN "BLOTFL" AS FILE #1— If your com
80!  REVISED 10/5/78
90!  REVISED 10/30/78
110 PRINT:PRINT
120 PRINT "THIS IS A PROGRAM DESIGNED TO PRINT GRAPHIC BLOTS ON"
130 PRINT" A WEIGHTED RANDOM SCALE."
140 INPUT "ENTER  THE PICTURE WIDTH, THEN HEIGHT";W;H
150 W1=INT(W*10): H1=INT(H*6)
155FORG=1 TO W1:FOR H=1 TO H1:P(G,H)=0:NEXTH:NEXTG
160 PRINT" THE BIGGER THE NUMBER, THE LIGHTER THE PICTURE."
170 INPUT " WHAT WEIGHTING DO YOU WANT (FROM 0 TO .9999999";F
180GOSUB 320
185GOTO 400
187PRINT"PRESS CARRIAGE RETURN TO CONTINUE.":INPUTC5:&:&:&:&
190 PRINT:PRINT:PRINT
200 PRINT :PRINT: FOR C=1 TO W1+3:PRINT"*";: NEXT C
210 PRINT "*"
220 FOR L =1 TO H1
230 PRINT " *";
240 FOR C=1 TO W1
250 RANDOMIZE
260Z3=(F+P(C,L))*RND*2.5
270 IF Z3>1 THEN PRINT " "; ELSE IF Z3>.8 THEN PRINT ".";  ELSE IF Z3>.6
    THEN PRINT "#"; ELSE IF Z3>.4 THEN PRINT "$"; ELSE IF Z3>.2
THEN PRINT "*"; ELSE PRINT "■";
280 NEXT C: PRINT "*": NEXT L
290 FOR C=1 TO W1+4: PRINT "*";: NEXT C
300 PRINT :PRINT :PRINT
310KILL "BLOTFL":GOTO32767
320INPUT"ENTER THE NUMBER OF SHADED AREAS";S
325IF S=0 THEN RETURN
330FOR S1=1 TO S
340INPUT"FROM WHICH TO WHICH COLUMN";C1,C2
350INPUT"AND ROW TO ROW";R1,R2
360INPUT"AND WEIGHT: ADVISED -.9<X<.9";V
370FOR C3=C1 TO C2:FOR R3=R1 TO R2: P(C3,R3)=V
380NEXT R3:NEXT C3:NEXT S1:RETURN
400INPUT"ENTER THE NUMBER OF EQUATION SHADINGS YOU WISH TO DO";E
410 IF E<1 THEN 187
415FOR E1=1 TO E
420INPUT"ENTER THE COLUMN THAT WILL BE THE Y AXIS";C1
430INPUT"ENTER THE ROW THAT WILL BE THE X AXIS";R1
440PRINT"AT THIS POINT, HIT CONTROL-C AND TYPE A LINE OF THE FORM"
450PRINT"10 DEF FNA(X)=<SOME EQUATION, SUCH AS X**2)"
470PRINT"THEN TYPE GOTO 500 TO CONTINUE"
480GOTO480
500PRINT"DO YOU WISH SHADED AREAS TO:"
510PRINT"1) EXACTLY EQUAL EQUATION:Y=F(X)"
520PRINT"2) Y<F(X), AS IN CASE OF A CIRCLE"
530PRINT"3) Y>F(X), AS IN CASE OF HOLOW CIRCLE"
540INPUT T5
541INPUT"ENTER LOWER AND UPPER X BOUNDS";B1,B2
542INPUT"ENTER LOWER AND UPPER Y BOUNDS";B3,B4
545INPUT"ENTER THE WEIGHT FOR AREA: ADVISED -.9<W<.9";V
550 FOR G=1 TO W1
560G3= G-C1 !THIS IS THE EFFECTIVE X COORDINATE
562 IF G3<B1 OR G3>B2 THEN 602
563I3= INT(FNA(G3)+.5)
567 FOR H=1 TO H1
570H3=H-R1 !THIS IS THE EFFECTIVE Y COORDINATE
575IF H3<B3 OR H3>B4 THEN 600
590ON T5 GOSUB 1000,2000,3000
600NEXTH
602 NEXTG
604NEXT E1
650GOTO 187
1000IF I3=H3 THEN P(G,H)=V
1010RETURN
2000 IF I3>H3 THEN P(G,H)=V
2010RETURN
3000IF I3<H3 THEN P(G,H)=V
3010RETURN
32767END

Ready
```



```
Ready

      RUN
      BLOT6    10:54 AM          30-May-79

      THIS IS A PROGRAM DESIGNED TO PRINT GRAPHIC BLOTS ON
       A WEIGHTED RANDOM SCALE.
      ENTER  THE PICTURE WIDTH, THEN HEIGHT? 8,8
       THE BIGGER THE NUMBER, THE LIGHTER THE PICTURE.
       WHAT WEIGHTING DO YOU WANT (FROM 0 TO .9999999? .5
      ENTER THE NUMBER OF SHADED AREAS? 4
      FROM WHICH TO WHICH COLUMN? 15,24
      AND ROW TO ROW? 11,18
      AND WEIGHT: ADVISED -.9<X<.9? -.45  —the black box in upper left
      FROM WHICH TO WHICH COLUMN? 15,24
      AND ROW TO ROW? 34,39
      AND WEIGHT: ADVISED -.9<X<.9? 999   —white in lower left
      FROM WHICH TO WHICH COLUMN? 50,69
      AND ROW TO ROW? 8,23\32\19^R
      8,19                                —white in upper right
      AND WEIGHT: ADVISED -.9<X<.9? 999
      FROM WHICH TO WHICH COLUMN? 50,69
      AND ROW TO ROW? 31,42
      AND WEIGHT: ADVISED -.9<X<.9? -.45  —black in lower right
      ENTER THE NUMBER OF EQUATION SHADINGS YOU WISH TO DO? 1
      ENTER THE COLUMN THAT WILL BE THE Y AXIS? 40
      ENTER THE ROW THAT WILL BE THE X AXIS? 24
      AT THIS POINT, HIT CONTROL-C AND TYPE A LINE OF THE FORM
      10 DEF FNA(X)=<SOME EQUATION, SUCH AS X**2)
      THEN TYPE GOTO 500 TO CONTINUE
      ^C

      Ready

      10 DEF FNA(X) = X**2
      GOTO 500
      DO YOU WISH SHADED AREAS TO:
      1) EXACTLY EQUAL EQUATION:Y=F(X)
      2) Y<F(X), AS IN CASE OF A CIRCLE
      3) Y>F(X), AS IN CASE OF HOLOW CIRCLE
      ? 2
      ENTER LOWER AND UPPER X BOUNDS? -12,12      —gray parabola on black rectangle
      ENTER LOWER AND UPPER Y BOUNDS? 0,20\02\10^R  in the center
      0,10
      ENTER THE WEIGHT FOR AREA: ADVISED -.9<W<.9? -.4
      PRESS CARRIAGE RETURN TO CONTINUE.
      ?
```

GRAPHIC A-MAZES

S. N. Afriat

Remember the witless hours you've spent tracing mazes? Here's a witty approach that makes them and traces them—with ideas you may be able to use elsewhere.

Amazing is a program found in David Ahl's *Basic Computer Games* (p3).* It was done by Jack Hauber, of Windsor, Connecticut, and generates mazes of the old-fashioned sort that often have been layed out in gardens and have box-hedges for walls. The computer generates the maze in memory, and when that is done the result is printed out. Dashes, colons and capital I simulate the verticals and horizontals of the walls, so a standard alphanumeric printer can be used. (A similar program by Paul Wennberg recently appeared in *Microcomputing*, Nov '79, 122-23.) The graphic device used there is simply the asterisk.

Here is a program that shows the maze throughout the process of generation, and uses graphic characters to represent the walls. At any point a wall can approach from any or all, or none, of four directions. Therefore, excluding the blank, there are 2^4-1 = 15 possible wall-connections at any point, and that number of graphic characters are needed to show them.

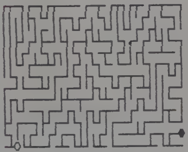
The program is done for the Exidy Sorcerer, and 11 of the needed graphics are standard. The remaining four for a single wall-connection from any one of the four directions can be programmed, exploiting the Sorcerer's facility for doing that. Any computer that has these needed graphics, either as standard or has programmable characters to make up any shortage, would serve just as well.

The printer is optional but if one is used it should be a graphic one. The AXIOM EX820 graphic printer has been used here, and the machine code driver program that enters as a USR subroutine is stored starting at address 0000. Calling this subroutine causes the screen to be printed.

The 1920 memories for the Sorcerer's 30X64 video screen, or the screen block, are associated with a similar block in user workspace, the score block. The address in the score block for the middle of the screen, which is used as origin, has been taken as U = 16384. This corresponds to U + D = -2977 in the screen block where D = -19361 is the displacement between the blocks.

The method of the program depends on converting connection codes stored in the score block into graphic codes, that are then stored in the screen block to make corresponding graphic characters appear on the screen.

A-Maze



Any point has four neighbors, in directions, N, E, S and W which are numbered 1, 2, 3 or 4. A connection code for a point in the maze is a five-bit binary

$$B = e_4 e_3 e_2 e_1 e_0$$

that tells, firstly, with which neighbors it is connected, $e_i = 1$ meaning it is connected with the neighbor in direction I. Secondly, it tells if the point permits transit when backtracking, $e_0 = 0$, or is blocked because a backtrack has already passed through it, $e_0 = 1$. A connection code being odd or even therefore tells whether the point is blocked or not, and an unblocked point can be blocked by adding 1 to its connection code. Connection codes, that completely describe the maze at any stage of formation, are stored by Poke-ing their decimals in the score block. To represent a maze graphically these have to be converted into graphic characters that show the connections at any point visually.

Eleven of the standard graphics of the Sorcerer are useful. These are └ | ├ ┼ and the others of this type representing connections with two or more neighbors. All we lack are four characters that represent connection with just one neighbor: -, I and two others similar. These can be made with the user-defined graphics or by overwriting four of the unused standard ones. The first four user-graphics have been adopted.

The numbers 0-15 represent the decimals for the quotients on division by 2 of all the possible even connection codes for unblocked points. The array E(I) (I = 0 to 15) is defined so that E(C/2) is the ASCII code of the graphic corresponding to any even connection code C. Therefore, to turn the connection code in a score register M into a graphic on the screen, all you need do is

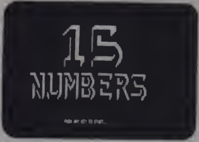
Poke M + D, E(Peek(M)/2)

The array D(i) (i = 0 to 4) gives the memory displacements 0, -64, 1, 64,

*Basic Computer Games, edited by David H. Ahl, Creative Computing Press, 1978

S. N. Afriat, 452 Roxborough Ave., Rockcliffe Park, Ottowa, Ontario K1M OL2

Software for the TRS-80



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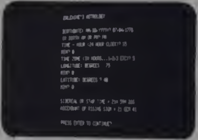

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A-Mazes, cont'd...

```
0 REM      AMAZE
1 REM
2 REM Graphic A-Mazes
6 REM (C)1979  SN Afriat
90 CLEAR 1000:GOSUB 1000
99 REM----- main pgm
100 POKE M+D,132
110 FOR I=0 TO 4:M(I)=M+D(I):P(I)=PEEK(M(I)):NEXT
200 P=P(0):B=16:T=0
210 FOR I=1 TO 4:IF P(I)=0 THEN T=T+1
215 NEXT:IF T=0 THEN 400
220 T=INT(RND(1)*T+1):FOR I=1 TO 4:IF P(I)=0 THEN T=T-1
230 IF T>0 THEN NEXT
300 J=I+2:IF J>4 THEN J=J-4
310 POKE M,P+2^I:POKE M(I),P(I)+2^J
320 POKE M+D,E(PEEK(M)/2):IF G=0 THEN G=1:POKE M+D,136
330 M=M(I):GOTO 100
400 P=P(0):B=16:FOR I=4 TO 1 STEP -1:B(I)=0:IF P>=B THEN B(I)=1:
P=P-B
410 B=B/2:NEXT
450 FOR I=1 TO 4
460 IF B(I)=0 OR P(I)/2<>INT(P(I)/2) THEN NEXT:FE=1
470 IF 1-FE OR 1-FI THEN POKE M+D,E(P(0)/2)
480 IF FE THEN 3000
510 POKE M,P(0)+1:M=M(I):GOTO 100
999 REM----- init sbr
1000 PRINT CHR$(12),,"A-Maze"
1005 H=25:K=60:R=1
1007 U=16384:D=-19361
1010 PRINT:INPUT"width, height";K,H:H=INT(H/2):K=INT(K/2)
1012 INPUT"enclosed";FB
1015 INPUT"inhabited";FI
1017 IF FI THEN INPUT"two";FT
1020 INPUT"for chance";R:R=RND(-R):INPUT"copy";C
1024 REM----- init screen reg
1025 PRINT CHR$(12);
1030 FOR J=1 TO 2*K-1:K$=K$+CHR$(151):B$=B$+CHR$(32):NEXT
1040 FOR J=1 TO 31-K:T$=T$+CHR$(19):NEXT
1050 K0$=T$+CHR$(188)+K$+CHR$(189):K1$=T$+CHR$(190)+K$+CHR$(191)
1060 B$=T$+CHR$(162)+B$+CHR$(162):FOR I=1 TO 14-H:PRINT:NEXT
1065 PRINT,," A-Maze"
1067 IF 1-FB THEN PRINT CHR$(17);:GOTO 1075
1070 PRINT K0$:FOR I=1 TO 2*H-1:PRINT B$:NEXT:PRINT K1$
1075 PRINT CHR$(1);
1099 REM----- init score reg
1100 FOR I=-H TO H:FOR J=-K TO K:Q=0
1110 IF I=-H OR I=H OR J=-K OR J=K THEN Q=1
1115 POKE U+ 64*I+J,Q:NEXT J,I
1120 DIM M(4),P(4),B(4),D(4),E(15)
1129 REM----- init move fm D & connect.code/graphic map E
1130 FOR I=0 TO 4:READ D(I):NEXT:FOR I=1 TO 15:READ E(I):NEXT
1140 DATA 0,-64,1,64,-1
1150 DATA 192,193,190,194,162,188,180,195,191,151,178,189,185,18
7,173
1159 REM----- init graphics
1160 FOR I=-512 TO -481:READ J:POKE I,J:NEXT
1165 DATA 8,8,8,8,8,0,0,0
1170 DATA 0,0,0,0,15,0,0,0
1175 DATA 0,0,0,0,8,8,8,8
1180 DATA 0,0,0,0,248,0,0,0
1199 REM----- random start
1200 I=INT(RND(1)*(2*H-1))-H+1:J=INT(RND(1)*(2*K-1))-K+1
1210 M=U+64*I+J
1230 RETURN
1999 REM----- printer
2000 IF C THEN POKE 260,0:POKE 261,0:DUMMY=USR(0)
2010 RETURN
3000 IF FT THEN GOSUB 1200:POKE M+D,136
3010 GOSUB 2000
3020 END
READY
```

AMAZE

1000 Initialize screen and score blocks
H rows and K cols (default 25 and 60)
addresses U and U + D
1025 Print maze boundary on screen
1100 block all points on boundary
1130 D(I), I = O any position and I = 1, 2, 3, 4 displacements N, E, S, W
E(I) ASC11 code for graphic representing connection code 2*I
1160 form 4 needed non-standard graphics
1200 random start, goto 100
2000 copy subroutina
Main Program
100 current position M
110 check connection with neighbors
210 count free neighbors
215 If none then goto backtrack at 400
200 otherwisa choose one at random
go thare and register the naw connections
300 from-connection I datarmines to-connection J
310 register new connections in score block
320 put corresponding graphics on screen
G = 0 means first move; then mark the starting-point
330 new current position, goto 100
400 start backtrack
410 decode at M, B(I) showing connections
500 end if nowhere to go, otherwise go there
510 new current position, goto 100

-1 for no displacement and N, E, S and W.

With these facilities the routine goes as follows: if M is the score register for the current point, search the four neighbors. If any are unoccupied, as shown by a zero connection code, choose one at random and move there, updating the connection codes for the two points involved by adding the suitable power of two to each, and showing the changes on the screen in the way just mentioned. With I as the displacement from one to the other

J = I + 2: IF J>4THENJ = J-4

determines the opposite displacement J from the other to the one and these powers of 2 must be added to the connection codes. If, instead, all neighbors are occupied, the search then is for a both connected and unblocked neighbor. From the nature of the algorithm there will be just one, unless the maze is complete, when there is none. If there is one, backtrack to it, at the same time inroducing a block in the position that is left by adding 1 to its connection code. That is all there is to the procedure. Initially the boundary of the maze is drawn using the dimensions that are input. All points on it are blocked by being given connection code 1, and all points inside it are given a 0 showing they are unoccupied. Then an initial point is chosen at random and the maze starts forming.

A hollow dot marks the starting-point and a filled-in one shows the current point as it moves randomly,

A-Mazes, cont'd...

about two or three steps a second, into unfilled neighbors or backtracks when there is none. A main point of this program is just watching it run. The backtrack guidance is amazing because of the invisible intelligent blocks that seal off already-entered braches and prevent it from going up them again.

After touching every point within the maze boundary at least once and at most twice, the moving point returns to where it started. That point can be retained in the final picture optionally, to show the maze with its original inhabitant and not completely deserted. It means nothing otherwise, because logically any other point could have been the starting point, and being meaningless it adds mystery.

A connection code being odd or even tells whether the point is blocked or not, and an unblocked point can be blocked by adding 1 to its connection code.

Given any two points within the walls of the maze it is always possible to go from one to the other, and the puzzle is to do that by the shortest path. Such a path cannot have loops. There is one path that goes everywhere in the maze just once or twice and returns to itself. The solution to any puzzle will be a part of it with the loops left out. There are two such paths. Then, beside avoiding or eliminating loops, the puzzle is to find the shorter one.

The only function of the outer boundary of the maze is to keep the traveling point within the chosen area. But that is done by the blocks registered in connection-codes that are stored in the score memories, so there is no need to print the boundary, and doing that is made an option.

A dual point of view is to regard the walls as the path. Then the puzzle is to find a route between any two points. The original point can be one, and a further option with the program is to have it choose the other, so there are two distinct inhabitants of the maze at the end. The two points that separate at the start momentarily join together again at the end, as usual. The traveling point returns, like Ulysses from the long journey, to the point of departure. Only now Penelope, always a dubious character, makes an escape. □

three dimensional grapics

Chris King

You are Red Leader flying down a tunnel on the surface of the Death Star in your X-wing fighter pursuing an Imperial Force pilot in his tie-fighter. Moving your plane, by manipulating a joystick, he is lined up in the cross hairs. The pressing of a button, a burst of light, he is gone.

All this and more is possible with the use of virtually any graphics display device and some tricky software. Here is most of the information required to make the necessary three-dimension to two-dimension coordinate transformations needed in graphic art, games, architectural drawings and anything else one might wish their computer to draw.

Basically, this set of routines takes a three dimensional figure (with the X coordinate assumed to be coming toward you, Y going horizontally to the right, and Z vertically), rotates the figure any number of degrees, elevates it (again, any number of degrees — even below the X-Y plane) and transforms this to two dimensions. Following this, the X and Y coordinates of the 2D image are moved toward the point of view a distance directly proportional to the distance from the plane of view, thus making the illusion of perspective or depth. Line blockage is too complex and requires too much time in computations for most purposes, so it has not been included with these algorithms.

To start with, we rotate the figure. To do this, the rotated plane is broken down into new X and Y components (Fig. 1). Using the grid slightly rotated theta degrees, the horizontal component projection of the X axis is the sine of theta and the vertical component would be the cosine of theta; while for the Y axis, the horizontal is the cosine of theta and the vertical is the sine of theta. Therefore, if you started with an X origin of 0_x, subtracting the horizontal component of X and adding that of Y, the resulting X, or X_2, would be $0_x - X_1 \sin 0 + Y_1 \cos 0$ (where X_1 and Y_1 are the original values). Likewise, with a Y origin of 0_y, subtracting both vertical components, Y_2 becomes $0_y - X_1 \cos 0 - Y_1 \sin 0$. We now have the X-Y plane rotated.

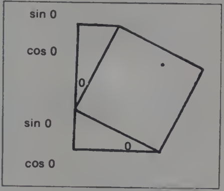


FIGURE 1

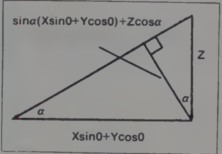


FIGURE 2

Now for the angle of elevation. When a plane is looked upon at a given angle alpha (Fig. 2), the latest vertical dimension, Y_2, is change at the rate of the sine of alpha for its projection. The equation is now $Y_2 = 0_y - \sin\alpha (X_1 \cos 0 + Y_1 \sin 0)$.

To get the Z dimension inserted, simply multiply Z times the cosine of alpha for its projection and add this to Y_2. Note that in no manner is the X coordinate affected by elevation or by the Z altitude. You now have a two-dimensional projection of the three dimensions of space.

Care should be taken that the cubical be rotated around its very center. Otherwise, it would have to be rotated, then shifted over in some cases, requiring a lot of conditional branching. If it is preferable to have the origin in a corner, add or subtract a displacement to make it that way only in effect.

So far we have the capability of drawing any three-dimensional point, or sets of points, in a cube. But the farther away an object is, the smaller it appears to be (Fig. 3).

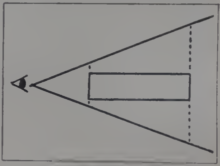


FIGURE 3

Making objects seem smaller with distance is done by bringing all points toward the point of view, or where your line of sight is in space. So you must first find the point of view on the cartesian plane upon initiation of the program by using the previously defined equations.

Next, we need to find the distance from the plane of view. Refering back to the equation for Y_2, the vertical distance of the rotated X-Y plane was $X \cos 0 + Y \sin 0$. The distance projection

Chris King, Rt. #2, Box 67, Greentop, MO 63546

3-D, cont'd...

of this through elevation angle alpha, where the projection is the opposite side and the original distance is the hypotenuse, would be for distance D:

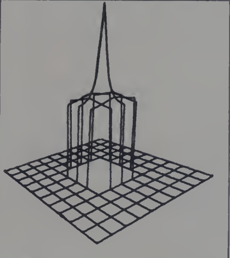
$D = \cos\alpha\,((X_p - X_1)\cos 0 + (Y_p - Y_1)\sin 0)$

See Fig. 4. The Z projection onto the distance would be $(Z_p - Z_1)\sin\alpha$ with Z as the hypotenuse and the projection as the adjacent side. Adding the two, the overall distance from the plane of view is:

$D = \cos\alpha\,((X_p - X_1)\cos 0 + (Y_p - Y_1)\sin 0) + (Z_p - Z_1)\sin\alpha.$

This is the total distance to the point X_1, Y_1, Z_1 from the plane which contains the point X_p Y_p, Z_p and perpendicular to the line of sight.

As was previously stated, both the X and Y coordinates of the Cartesian plane are moved toward the point of view on this plane a distance directly

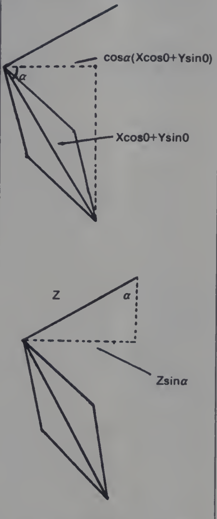


Z1=0.5/(0.1+(X1-5)↑2+(Y1-5)↑2)+5
IF SGN(X1-3)-SGN(X1-7)+SGN(Y1-3)-SGN(Y1-7)=4 THEN Z1=0

proportional to the distance from the plane of sight. Firstly, we get the X and Y distances from the point of view, which would simply be the difference between the X coordinates and between the Y coordinates of the point of view and the point. These are then divided by the distance. But if the distance were zero, an error would be flagged. And if the distance were less than one, the image would actually be enlarged. To resolve these problems, the distance is first checked to be less than zero, and if so, the point totally ignored. To this we add 1 to prevent division by zero. This system also allows sight "to the front of the lens" (zero distance).

The perspective distance from the line of sight we now have is added back to the two-dimensional coordinates of the point of sight on the plane. To allow a varied angle of view, the distance may be multiplied by a constant to make things much smaller with the same distance.

Some problems may arise when implementing these algorithms on a vector graphics system. If the end-points of lines exceed the boundaries of the display field, only the displayed length should be calculated.



$D=\cos\alpha((X_p-X_1)\cos 0+(Y_p-Y_1)\sin 0)+(Z_p-Z_1)\sin\alpha$

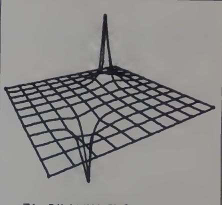
FIGURE 4

In many instances, it would be advantageous to daisy-chain points of a line. For instance, starting at point (X_1, Y_1, Z_1), captive on to points (X_2, Y_2, Z_2) and thence to (X_3, Y_3, Z_3), instead of drawing two separate lines. This avoids calculating the middle point twice.

In Program A, I have developed a system which scans a 10 by 10 grid map of the X Y plane. The points of the grid are elevated a distance Z for the values of X and Y for the specific equation. Naturally, any figure may be drawn using the previously described algorithms.

You should have little trouble making it run on most Basic or other high level languages. I have had it up and running on a Honeywell 1640 with a Hewlett Packard point and vector plotter for quite some time now, and it has not yet crashed.

With its remark statements, the program is for the most part self-



Z1=.5/(.1+(X1-5)↑2+(Y1-5)↑2)

explanatory (note that this computer accepts either REM or information set off in "'"). For reasons of variable acceptance, 0_x and 0_y have become 01 and 02, as X_p, Y_p and Z_p become P1, P2 and P3.

In line 190, S is the size of the dot matrix divided by a constant. For a figure with no depth and rotated and elevated to a maximum size this constant is approximately 17.5. But with depth, this constant decreases to maintain a full size picture.

The plotter I use takes commands PLTP (plot point), PLTL (plot line), and PLTT (plot terminate). Following this it accepts a series of paired four-digit coordinates. The program is set up to position the pen at the beginning of the line with PLTP then initiate line drawing with PLTL through the use of an IF statement.

It would be wise, of course, to perform each needed trigonometric function but once, assigning them to variables. This would speed the system up, as would many other things, but for comprehensibility I haven't bothered. For real time display, the program would almost certainly have to be implemented in machine language, requiring multibyte variables.

To put the icing on the cake, many enhancements might be possible: line blockage, shadowing, reflection, light location and intensity would be included. Also, a simple multiplier and addition of a displacement would allow zooming and panning. □

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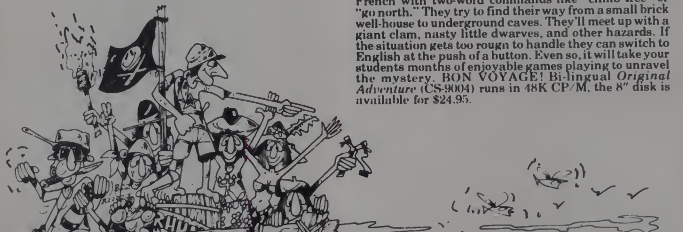

Creative **Computing** offers a wide variety of uncomplicated user-oriented educational programs. **Study Made Easy** for the PET (CS-1202) will create study drill tapes for any subject automatically. The computer guides you, step by step, through the entry of questions and multiple choice answers. The package includes three prepared drills. From U.S. Presidents to Lacrosse rules, the versatile programs of **Study Made Easy** will create study drills for you automatically. It's well worth the price of $14.95.

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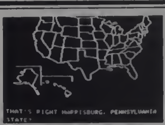
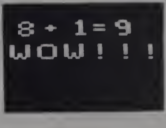
Computer Assisted Instruction Programs



U.S. Map



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The series (which is based on models developed by The Huntington Two Computer Project) exposes students to problem solving in real world situations. **Ecology Simulations-1** (CS-3201) explores methods of population management. Students can cooperate to save the Wild West bison from extinction in **Buffalo.** The comprehensive introduction to modeling concepts is completed in **Pop, Sterl,** and **Tag.**

Ecology Simulations-2 (CS-3202) explores problems in environmental and health sciences. In **Malaria, Pollute, Rats,** and **Diet** the user can attempt to end water pollution, rats in a city slum, or to design a healthy diet. **Social and Economic Simulations** (CS-3204) allows students to experiment with a microcomputer version of the well-known "Limits to Growth" project in **Limits** or compete against each other in the bicycle industry in **Market; U.S. Pop** lets students investigate demographic concepts.

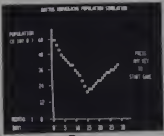
The series is designed for the 16K TRS-80 Level II and is attractively packaged in a vinyl binder. Included is a study guide which relates the material to current controversies, stimulates classroom discussion, and provides sample exercises. The series is also available on disk: **Ecology Simulations-1** (CS-3501), **Ecology Simulations-2**(CS-3502),and **Social and Economic Simulations** (CS-3508). At a modest $24.95 each, with quantity discounts available, the series becomes an affordable necessity.

"In the classroom, this should be an ideal learning tool. Not only can students work on the mathematical effects of population growth but they can also see the social and ecological effects of any decisions they make..."

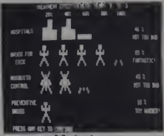
"The manual is extremely well done. It provides necessary background information on each program and encourages the student to think about the social aspects of each program rather than just the mathematical processes."

80 Software Critique on
Ecology Simulations-1
Jan-March 1980

Ecology Simulations-2



Rats



Malaria

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CIRCLE 300 ON READER SERVICE CARD

Sorcerer Graphics

Emiliano DeLaurentiis

Since the introduction of Exidy's Sorcerer, which **Creative Computing** reviewed (Vol. 5:1), the Sorcerer has received very little exposure. One reason is that the Sorcerer's versatility and capabilities have not been fully explored.

I would like to outline special features which make the Sorcerer a particularly enjoyable computer and to designate some areas of exploration for the computing community.

To begin, I must mention that the Sorcerer **does** make a cost-effective machine. For example, simply compare, item by item, the costs to update the minimal configuration of the Apple computer to the capabilities of the Sorcerer (e.g., RS232, serial and parallel interfaces, dual cassette motor control, numeric keypad, programmable characters, interchangeable ROM) and it will be clear that you pay less for a Sorcerer. Consider also the outstanding graphics (512 X 240 points), number of characters per line and lines per screen (64 characters/30 lines) and expandability (S100 bus) which ensure your freedom from manufacturer lock-in and obsolescence of hardware. Any prospective purchaser of a small computer should take such considerations into account especially because the uses of a small computer are never fully realized until you own one.

But what are the fun parts of the Sorcerer? First, it has a very fast Basic (standard Altair) which will allow superb graphic animations; second you may program up to 128 graphic characters allowing simulation of movement, for example, or whatever else your imagination comes up with. In fact, I highly recommend any one of the programs that allow character generation directly on the monitor screen. Quality Software advertises such a program under the trade name **Shape Maker** in this publication, although programming characters may be done using the resident Monitor program. Animation simply involves programming graphic blocks (8X8 bit bytes) of successive movements, and then Poking a video location with each successive movement. (To Poke the screen use decimal locations from -3968 to -2049.)

This is just one of the possibilities of the Sorcerer as received from the manufacturer. I will not discuss any other, for my intent here is to stimulate interest and imaginative activity in Sorcerer programming, not to delineate them. Programmers at all levels of experience should not ignore these graphic capabilities (for they make a small computer enjoyable) nor should they hesitate to investigate other areas of Sorcerer Magic. For example, interpreters designed to produce graphic animations would do well with the Sorcerer's very dense graphics; and educational and personal applications programs could easily be produced to truly enhance the Sorcerer's uses at home.

Interpreters designed to produce graphic animations would do well with the Sorcerer's very dense graphics.

Following is a short program which produces a swirling kaleidoscope on the Sorcerer using random fluctuations in the built-in graphic and alphanumeric characters to produce a pleasing effect. □

Emiliano DeLaurentiis, 11466 Olier St., Montreal North, Quebec, Canada H1G 3P1.

Sorcerer Kaleidoscope

```
100 REM By Emiliano De Laurentiis,
      Montreal
110 ON INT(RND(3)*6) GOTO 200,
      250, 300, 350, 400
120 E=RND(1)*256
130 F=RND(2)*10
140 FOR I=F TO G
150 A=A-65: B=B-63: C=C+65:
      D=D+63
160 FOR J=0 TO I+INT(RND(4)x3)
170 POKE A+J,E: POKE B+J*64,E:
      POKE C-J,E: POKE D-J*64,E
180 NEXT J: NEXT I
190 G=0: GOTO 110
200 A=-3041:B=-3040:C=-2976:
      D=-2977
210 G=10:PRINT CHR$(12)::
      POKE-3968,32: GOTO 120
250 A=-3504:B=-3503:C=-3439:
      D=-3440
260 G=4: GOTO 120
300 A=-3473:B=-3472:C=-3408:
      D=-3409
310 G=4: GOTO 120
350 A=-2608:B=-2607:C=-2543:
      D=-2544
360 G=4: GOTO 120
400 A=-2577:B=-2576:C=-2512:
      D=-2513
410 G=4: GOTO 120
500 END
```

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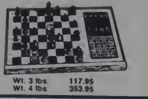

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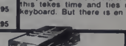

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Animation in Level II Basic

Daniel Lovy

Good animation on the TRS-80 is usually limited to one or two moving points. Graphic blocks are SET, a new position is calculated and they are RESET. The result is a dot that appears to move on the screen. This makes for a nice missile or depth charge. Unfortunately, when a larger figure, say six blocks, is to be moved around things do not work out quite right. Six blocks must be SET and RESET and, more importantly, six new positions must be calculated. All this takes time. The animation becomes slow and choppy, even with Level II's faster graphics. For any real-time, arcade style programs. the programmer must either learn machine language or be content with missiles and depth charges.

Yet, do not despair. Level II Basic has a feature that is not documented in the manual. String variables can be used to store graphics. By doing so, space ships and star bases can be PRINTed rather than SET.

As you know (or maybe you don't, so this is a good time to find out), graphics are handled in the TRS-80 by the use of graphic codes. It uses these codes much like ASCII codes. POKEing a 67 into the video memory makes a C appear on the screen. POKEing a number between 129-191 makes a funny looking shape appear. By using the CHR$ function it is possible to store these shapes or groups of shapes as string variables.

To animate a small figure, first design it and choose the proper graphic codes.

EXAMPLE:

```
A$ = CHR$(191) + CHR$(191)
(Yes, it is legal)
```

Now whenever A$ is PRINTed a block of 12 graphic blocks will appear. By using a variable that contains blanks you can get rid of the large square by PRINTing that variable in the same place. This is much easier and quicker that SETting and RESETting 12 blocks separately.

To animate a small figure, first design it and choose the proper graphic codes (more on that later) and store it in a string variable, then set up another variable of blanks to erase it. Use the PRINT@ statement to place the figure where you want it, calculate its next position, then erase it. Doing it this way saves having to individually position each block in the figure.

Using the PRINT@ statement to position and move the object has one drawback. It uses a single number to position characters on the screen. This makes calculation of movement a little cumbersome. A grid type system (two variables) is easier to work with. Here is an equation that will convert from a grid system to a linear one:

```
N = Y*64 + X
Y is between 0 and 15
X is between 0 and 63
```

Movement can be plotted in terms of X and Y, then converted to a single variable to be used with the PRINT@ statement.

Hoping to make things clearer , I've written a very short program which demonstrates this type of SET-less animation.

```
1 CLS:X = 30:Y = 6: Y1 = 1
10 A$ = CHR$(166) + CHR$(132)
20 B$ = "  " (2 spaces)
30 W = Y*64 + X
40 PRINT@ W,A$;
45 IF Y<2 OR Y>13 THEN 70
47 IF X<2 OR X>59 THEN 80
50 PRINT@ W,B$;
55 X = X + 3*X1:Y =Y + Y1
60 GOTO 30
70 Y1 = -Y1: R = RND(3):
   X1 = 2 - R:GOTO 50
80 X1 = X1: R = RND(3):
   Y1 = 2 - R:GOTO 50
```

Line 1 Sets things up

10 Puts the four block character into A$

20 B$ will be used to erase it

30 Converts from grid coordinates to a linear one

40 Prints all four blocks in one statement

The limitations of a computer are related only to how sneaky the programmer can get.

45-47 Checks to see if it should bounce

50 Erases the figure

55 Moves it one more unit on the grid

60 Keeps it moving

70-80 Computes bounce

This type of graphics allows for more experimentation with the shape of the figures. Change line 10 to this;

```
10 A$ = CHR$(RND(62) + 129) +
CHR$(RND(62) + 129)
```

Now each time the program is run a different shape will be used (delete line 20 and run it).

Daniel Lovy, 2398 Hulett Road, Okemos, MI 48864

Animation, cont'd . . .

Not only graphics, but also characters can be animated in this way. Add these two lines:

```
10 A$ = "(−)"
20 B$ = "   "  ' (3 spaces)
```

The only problem that remains now is determining the proper graphic codes to use. Here is a short utility program that takes care of that:

```
10 CLS
20 PRINT@256, "INPUT NUMBER"
30 INPUT N
40 IF N>30 THEN 100
50 Y = INT(N*.1)
60 X = N − Y*10
70 SET(X,Y)
80 GOTO 20
100 FOR M = 15360 TO 15364
110 A = PEEK(M)
120 PRINT A
130 NEXT
```

Design your figure on a grid like this;

0	1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29

When the program asks for a number, input the numbers from this grid. When you are finished enter a number greater than 30. The proper graphic codes will appear on the screen (32 is a blank).

This type of animation runs much

For any real-time, arcade style programs, the programmer must either learn machine language or be content with missiles and depth charges.

faster than if SET and RESET are used. It gives more time to the other functions of the program. It also proves that the limitations of a computer are related only to how sneaky the programmer can get. □

Many a live wire would be a dead one except for his connections.

One of these days is none of these days.

Poke Graphics on the TRS-80

James P. MacLennan

Introduction

Graphics incorporated in computer programs are always a "plus" in any type of program. They considerably liven up any text program, be it a stoic and serious business program or a fast and frivolous game program. As the old saw says, "A picture is worth a thousand words!"

Most Level II TRS-80 programmers can use SET and RESET for graphs, random points, etc., in simple programs, but some more complex graphics, when drawn with SET commands, are too slow.

The Level II manual mentions POKE graphics for speeding up operation, but does not go much further into this subject. Using ASCII graphics codes, you may speed up graphics displays up to 6 times. The myriad possibilities for this type of graphics deserve looking into much more.

Begin With The Basics

In using POKE graphics, you assign ASCII graphics codes to video memory addresses. The beginning address is 15360, and the end address is 16383. Using the ASCII graphic code 191, which signals "all bits on," type in this short program to show how fast you can fill up the screen:

```
10  FOR X=15360 TO 16383
20  POKE X,191
30  NEXT X
40  GOTO 40
```

Be careful when POKEing any information! An indiscriminate POKE can disrupt your program or something even worse! Don't POKE beyond those limits!

To POKE graphically, you must know what the ASCII graphics codes are, and what character they stand for. Run this program:

```
10  FOR X=129 TO 191
20  PRINT X;:PRINT CHR$(X),
30  NEXT
40  GOTO 40
```

While line 40 is busily looping, a good idea is to copy all the codes with their corresponding numbers on a copy of the Video Display Worksheet (Appendix E of the Level II Manual). This comes in **very** handy for a chronic POKEr, as having to run the display program to find out which character you need gets too tedious to be practical.

Now, armed with a graphics code table and memory address locations, we delve deeper into the POKE graphics game.

Draw That Grid

For some, a basic grid might be drawn in the following manner:

```
10  FOR X = 0 TO 120 STEP 20
20  FOR Y = 0 TO 36
30  SET (X,Y):NEXT Y,X
40  FOR Y = 0 TO 36 STEP 6
50  FOR X = 0 TO 120
60  SET (X,Y):NEXT X,Y
70  GOTO 70
```

This seems a little slow, but by using POKE graphics, the process is speeded up immensely:

```
100  CLS:X=131
110  FOR A=15360 TO 16128 STEP 128
120  FOR Q=A TO A+59
130  POKE Q,X:NEXT Q,A
135  POKE Q,129
140  X=151
150  FOR A=15360 TO 16000 STEP 128
160  FOR Q=A TO A+50 STEP 10
170  POKE Q,X:NEXT Q,A
180  X=149
190  FOR A=15424 TO 16064 STEP 128
200  FOR Q=A TO A+60 STEP 10
210  POKE Q,X:NEXT Q,A
220  FOR A=15420 TO 16124 STEP 128
230  POKE A,X:NEXT X
240  GOTO 240
```

For specific memory addresses, there is an easy method to get the correct number. Looking back to our video worksheet, we find each "print position" numbered. This numbering is used in determining what the number is that you need for using PRINT@ statements. By simply adding 15360 to this number, you get the correct memory address for that part of the screen.

A Moving Ball

Try this program:

```
  5  CLS:DIM A(20)
 10  FOR A=1 TO 20
 20  READ A(A)
 30  NEXT
 40  FOR X= 1 TO 20
 50  POKE A(X), 140
 60  POKE A(X), 32
 70  NEXT
 80  GOTO 40
100  DATA 15446,15449,15452,15457,
       15460
110  DATA 15526,15593,15658,15722,
       15849
120  DATA  15974,16034,16031,16026,
       16022
130  DATA 15954,15888,15823,15695,
       15570
```

Now let's dissect it line by line.

Lines 10-30 spin an array of specific memory addresses.

Line 40 POKE a set of graphics blocks in the middle of each addressed area.

Line 60 uses the ASCII code for "space" to turn off these blocks.

Line 70 starts the whole process over again.

This method can be put to very Interesting uses: spinning a roulette ball, bouncing around a billiard ball, turning a wheel and many more.

One Last Mind-Blower

Type in this program:

```
10  CLS:A=191:L=15360:B=32
20  R=PEEK(14420)
30  G=L
40  IF R=8 L=L-64:IF L<15360 L=L+64
50  IF R=16 L=L+64:IF L>16383 L=L-64
60  IF R=32 L=L-1:IF L<15360 L=15360
70  IF R=64 L=L+1:IF L>16383 L=16383
80  POKE L,A:IFR=0 THEN 20
90  POKE G,B:GOTO 20
```

Statements 40 through 70 are very important in this type of program. They are used to insure you are not POKEing where you shouldn't.

Here, the PEEK command is used to see what key is being pressed. It is similar to the INKEY command, but in this program you can hold the keys down to move the "paddle." The POKE command's power is exhibited best here. Try to substitute different ASCII values for A and B to draw pictures, etc.

Summary

POKE graphics are a very powerful asset to writing eye-catching programs and save time in drawing graphics. Not many people know how to use them, but they are an important part of Level II's capabilities and can be fun to work with. □

James MacLennan, 6073 Hudson Ave., San Bernardino, CA 92404.

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All Osborne & Associates programs are fully-documented by their three extensive books - "General Ledger," "Accounts Payable & Accounts Receivalbe," and "Payroll with Cost Accounting." (These TRS-80 programs do not include the cost accounting system.) These books are available for $20 each. Please include $3.00 per book for first class shipping (otherwise sent book rate).

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4. Mercenary Commander has you as a soldier of Maximillian, the Mexican King. Try to keep the villages under French rule and put down the rebellion.

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This is the third in the trilogy which started with "Galactic Empire" and then "Galactic Trader." In the time of revolution you must use diplomacy to make alliances, implement social change and fight the bureaucracy if you want to conquer the galaxy.

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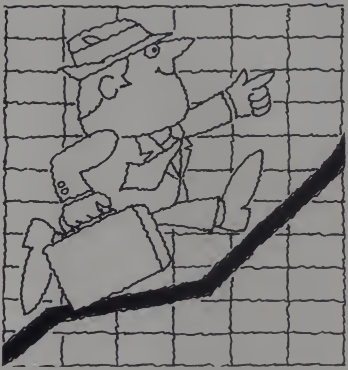
CIRCLE 175 ON READER SERVICE CARD

Stock and Listed Options

Part 2-Stock Option Maneuvers and Program OPGRAPH.



Alfred Adler, Ph.D.

Review of Part 1

In Part 1 of this series we introduced the reader to stocks and the stock market. We pointed out that a share of common stock is not a debt instrument, as is a bond, but rather represents part ownership in a venture. The stock market was introduced as a place where buyer and seller, or their representatives, meet and engage in an auction. Brokers were discussed as the usual form of representatives, and the reader was introduced to the harsh realities of life in the form of the ubiquitous commission. The differences in possible investment attitudes were touched on briefly, and the question moved on to puts and calls and the listed option markets. One or two of the more obvious option strategies were mentioned and a table was presented comparing the profits and losses that could be realized by various modifications to these strategies.

Stocks may be bought or sold; calls may be bought or sold; and puts may be bought or sold. All strategies consist of these maneuvers, singly or in combination.

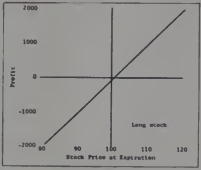


FIGURE 1

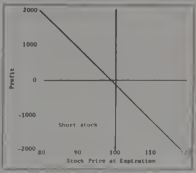


FIGURE 2

Given the background material presented last month, we can now proceed to an examination of a few of the interesting investment alternatives made possible with listed options.

More On Puts And Calls

Old fashioned puts and calls, as discussed in Part 1 of this series, are of no interest anymore to most people; the newer listed options are so much more versatile. Henceforth, in this series, 'options' means listed options, only.

Before proceeding let us again review the rights and responsibilities that go with the sale or purchase of puts and calls. The buyer of a call has purchased the right to buy 100 shares of the underlying stock at the exercise price up until the day the option expires. He is not required to do so, but he can do so if he chooses. In other words, the buyer of the option has the option. The seller of a call has only the responsibility to deliver the stock if called, that is, if the buyer exercises the option. If the stock has risen markedly, he may not want to, however, the transaction is at the discretion of the buyer. The buyer of a put has purchased the right to sell 100 shares of the underlying stock at the exercise price up until the day the option expires. He is not required to do so, but he can do so if he chooses. Once again, the buyer of the option has the option. The seller of a put has only the responsibility to accept the stock if put to him, that is, if the buyer exercises the option. If the stock has fallen markedly, he may not

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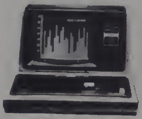

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Stock, cont'd...

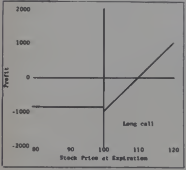


FIGURE 3

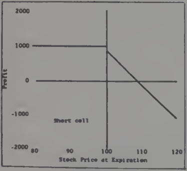


FIGURE 4

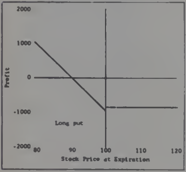


FIGURE 5

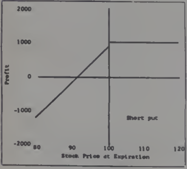


FIGURE 6

want to, however, the transaction is at the discretion of the buyer. The buyer of an option is the owner of the option and can use it as he chooses. The only alternative the seller has, if the market goes against him, is to repurchase the option, thus terminating its existence. At this point such a repurchase would probably be at a loss.

Program OPGRAPH presents a graph or a table, as the user chooses, of profit including all commissions, versus stock price at option expiration.

The Six Basic Maneuvers

There are six basic maneuvers that can be performed with stocks and options. Stocks may be bought or sold; calls may be bought or sold; and puts may be bought or sold. All strategies consist of these maneuvers, singly or in combination.

Each of these six maneuvers can be represented graphically on a plot of profit versus stock price on expiration day, and such a representation is by far the quickest and easiest way to see the bottom line at a glance. Let us examine these six plots in some detail.

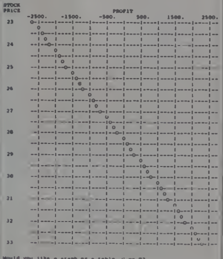
Since option commissions run (very roughly) of the order of 10%, each way, as opposed to (again very roughly) more like 1% for stocks, it is apparent that commissions can sometimes, in an option transaction, convert a profit to a loss. In any event, commissions cannot be ignored in analyzing a strategy. For this reason the following discussion and the following figures include the effects of commissions.

If we buy, or go long, a stock, we have a profit if the stock price rises and we have a loss if it falls. If the price remains unchanged we have a loss, commissions again, both ways. These effects are shown in Figure 1. If we sell, or go short, a stock, the opposite occurs. We have a profit if the price falls and a loss if the price rises. We of course again have a loss if the price remains unchanged. This is illustrated in Figure 2.

Long and short positions in puts and calls are a bit more complicated. If we buy a call with an exercise price of 100, the call expires worthless if the stock price on expiration day is 100 or less. We therefore have a total loss of

FIGURE 7

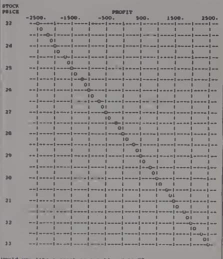
```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****

************ S T O C K  &  O P T I O N  D A T A ***********

Stock Symbol, Remarks : MMA
No. shares owned? 0; and price per share? 0
No. shares bought? 500; and price per share? 28

No. calls sold? 0; exercise price? 0; and premium? 0
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 0; exercise price? 0; and premium? 0
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 23
At what stock price should the graph end?   33
What minimum profit should the graph show? -2500
What maximum profit should the graph show? 2500
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (if this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 9 would be
   much better.) :0

************************** G R A P H **************************
```



```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

FIGURE 8

```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****

************ S T O C K  &  O P T I O N  D A T A ***********

Stock Symbol, Remarks : MMA
No. shares owned? 500; and price per share? 28
No. shares bought? 0; and price per share? 0

No. calls sold? 0; exercise price? 0; and premium? 0
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 0; exercise price? 0; and premium? 0
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 22
At what stock price should the graph end?   33
What minimum profit should the graph show? -2500
What maximum profit should the graph show? 2500
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (if this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 9 would be
   much better.) :0

************************** G R A P H **************************
```



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Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
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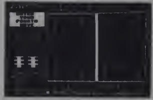

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☐ **3-D SURFACE PLOTTER:** Explore the ELEGANCE and BEAUTY of MATHEMATICS by creating HI-RES PLOTS of 3-dimensional surfaces from any 3-variable equation. Disc save and recall routines for plots. Menu driven to vary surface parameters. Demos include BLACK HOLE gravitational curvature equations. Specify Disc (32K) or no disc (16K) version $19.95

☐ **ACTION ADVENTURE GAMES SERIES: Entire series $49.95**

☐ **RED BARON:** Can you outfly the RED BARON? This fast action game simulates a machine-gun DOG-FIGHT between your WORLD WAR I BI-PLANE and the baron's. You can LOOP, DIVE, BANK or CLIMB in any one of 8 directions - and so can the BARON - in HI-RES graphics (16K). $19.95

☐ **BATTLE OF MIDWAY:** You are in command of the U.S.S. HORNETS' DIVE BOMBER squadron. Your targets are the Japanese carriers, Akagi, Soryu and Kaga. You must fly your way through ZEROS and AA FIRE to make your DIVE BOMB run. In HI-RES graphics (16K). $19.95

☐ **SUB ATTACK:** It's April, 1943. The enemy convoy is headed for the CORAL SEA. Your sub, the MORAY, has just sighted the CARRIERS and BATTLESHIPS. Easy pickings. But watch out for the DESTROYERS - they're fast and deadly. In HI-RES graphics (16K) $19.95

☐ **SEND FOR FREE CATALOG** – All programs run on Apple II with Disc and Applesoft ROM Card and require 32K RAM unless otherwise noted. Detailed instructions included. Orders shipped within 48 hours. Card users include card number. Add $1.50 postage and handling with each order. California residents add add 6½% sales tax. Make checks payable to:

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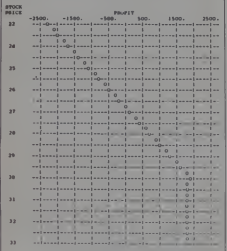
Stock, cont'd...

the call premium regardless of the stock price, as long as it is 100 or less. If the stock price is greater than 100, the loss is less, since the call is not completely worthless. If the stock price on expiration day is more than 100 by the amount of the premium on the call plus the commission (per share), we break even. At progressively higher stock prices, we have a progressively greater profit. Figure 3 displays these effects.

If we sell, or go short, a call, the profit and loss picture just discussed reverses itself. That is, profit becomes loss, and loss becomes profit. Since we have sold the call, the buyer is now the one who has a loss if the stock price at expiration is equal to or less than the exercise price of the call, and if he has a loss then we have a profit. Similarly, if

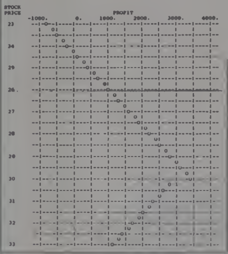
FIGURE 9

```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****
************* S T O C K  &  O P T I O N  D A T A ***********

Stock Symbol, Remarks : NWA
No. shares owned? 300; and price per share? 28
No. shares bought? 300; and price per share? 30

No. calls sold? 6; exercise price? 30; and premium? 2.5
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 0; exercise price? 0; and premium? 0
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? T

Readability of table is best when difference between
starting and ending stock price is evenly divisible by 10.
At what stock price should the table start? 23
At what stock price should the table end?   33

************************** T A B L E **************************

           <- - - - - - P R O F I T    F R O M - - - - - ->
STOCK      STOCK    STOCK    CALLS    CALLS    PUTS    PUTS    TOTAL
PRICE      OWNED    BOUGHT    SOLD    BOUGHT   SOLD   BOUGHT   PROFIT

 23.00   -1500.   -2200.   1450.      0.      0.      0.    -2250.
 24.00   -1200.   -1900    1450.      0.      0.      0.    -1850.
 25.00    -900.   -1600    1450.      0.      0.      0.    -1050.
 26.00    -600.   -1300.   1450.      0.      0.      0.     -450.
 27.00    -300.   -1000.   1450.      0.      0.      0.      142.
 28.00       0.    -700.   1450.      0.      0.      0.      742.
 29.00     300.    -400.   1450.      0.      0.      0.     1342.
 30.00     600.    -100    1450.      0.      0.      0.     1942.
 31.00     900.     197.    669.      0.      0.      0.     1781.
 32.00    1200.     492.     68.      0.      0.      0.     1761.
 33.00    1500.     792.   -531.      0.      0.      0.     1703.

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 23
At what stock price should the graph end?   33
What minimum profit should the graph show? -2500
What maximum profit should the graph show? 2500
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (If this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 9 would be
   much better.) :0

************************** G R A P H **************************
```

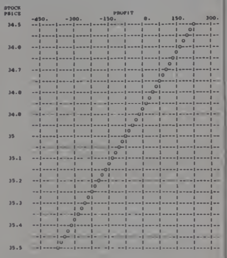


```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****
************* S T O C K  &  O P T I O N  D A T A ***********

Stock Symbol, Remarks : NWA
No. shares owned? 300; and price per share? 28
No. shares bought? 300; and price per share? 30

No. calls sold? 12; exercise price? 30; and premium? 2.5
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 0; exercise price? 0; and premium? 0
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? T

Readability of table is best when difference between
starting and ending stock price is evenly divisible by 10.
At what stock price should the table start? 23
At what stock price should the table end?   33

************************** T A B L E **************************

           <- - - - - - P R O F I T    F R O M - - - - - ->
STOCK      STOCK    STOCK    CALLS    CALLS    PUTS    PUTS    TOTAL
PRICE      OWNED    BOUGHT    SOLD    BOUGHT   SOLD   BOUGHT   PROFIT

 23.00   -1500.   -2200.   2013.      0.      0.      0.     -795.
 24.00   -1200.   -1900    2913.      0.      0.      0.     -195.
 25.00    -900.   -1600.   2913.      0.      0.      0.      405.
 26.00    -600.   -1300.   2913.      0.      0.      0.     1005.
 27.00    -300.   -1000.   2913.      0.      0.      0.     1605.
 28.00       0.    -700.   2913.      0.      0.      0.     2205.
 29.00     300.    -400.   2913.      0.      0.      0.     2805.
 30.00     600.    -100.   2913.      0.      0.      0.     3405.
 31.00     900.     192.   1229.      0.      0.      0.     2321.
 32.00    1200.     482.     29.      0.      0.      0.     1721.
 33.00    1500.     792.  -1171.      0.      0.      0.     1121.

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 23
At what stock price should the graph end?   33
What minimum profit should the graph show? -1000
What maximum profit should the graph show? 4000
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (If this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 9 would be
   much better.) :0

************************** G R A P H **************************
```



```
Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 34.5
At what stock price should the graph end?   35.5
What minimum profit should the graph show? -450
What maximum profit should the graph show? 300
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (If this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 9 would be
   much better.) :0

************************** G R A P H **************************
```



```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

FIGURE 10

the stock price is above the exercise price the buyer has a progressively lower loss and then a profit. We therefore, as sellers, have a progressively lower profit and then a loss (see Figure 4).

Long and short put positions can be graphed similarly. If we buy a put, we have the privilege of putting, or selling the stock to the seller at the exercise price anytime before expiration. If the stock price at expiration is equal to or greater than the exercise price, the put premium is a total loss. If the stock price is less than the exercise price, the put is not completely worthless and we either have a lesser loss or, if the stock price is less than the exercise price by more than the amount of the premium and the commission (per share), then we have a profit. Figure 5 illustrates this case. If we sell a put, again the profit and loss picture reverses, as it did in the case of a call. Where the put buyer has a profit, we have a loss and vice versa. This is shown in Figure 6.

Note that the graph for a short call position (Figure 4) is similar to the graph for a long call position (Figure 3) with the profit and loss scale reversed. Similarly, the graphs for short and long put positions are similar except for reversal of the profit and loss scale. Further note that the graph for a long call position (Figure 3) is similar to the curve for a long put position (Figure 5) with the stock price scale reversed about the exercise price. The graph for a short call position (Figure 4) is similarly related to the graph for a short put position (Figure 6).

The discontinuities at the exercise price are due to the commission that is suddenly incurred when the options are exercised. Such commission, of course, may slightly alter the aforementioned perfect symmetries by introducing a small loss bias at stock prices beyond the exercise price.

Program OPGRAPH

Program OPGRAPH presents a graph or a table, as the user chooses, of profit including all commissions, versus stock price at option expiration. A request for a graph will provide the user with the total net profit picture. A request for a table will provide not only the total net profit, but also a breakdown of the profit at each stock price into each of the basic positions mentioned at the beginning of this section.

Before running, a bit of personalization must be provided by the user.

Stock, cont'd...

The program, as supplied, computes commissions assuming a 35% discount from the customary rates. This should be adjusted by the user to meet his needs in accordance with the instructions supplied with the program.

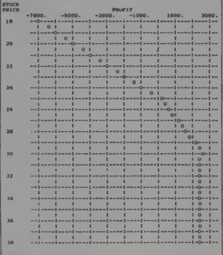
Following the RUN command the program will prompt the user to furnish the STOCK & OPTION DATA. As can be seen from the sample outputs further on in this article, the stock and option data consists of the numbers of shares of common stock owned and bought and the per share price, and the number of calls and puts bought and sold, the exercise prices, and the premiums. Following the entry of the stock and option data the user will be asked to choose between a table and a graph. If a graph is selected, the user will be asked to choose the stock price range and the profit range over which the graph will be presented. Since the grid has ten intervals in the profit direction and twenty intervals in the price direction, readability of the graph is greatly enhanced by requesting a profit range evenly divisible by five and a price range evenly divisible by ten. Because of their importance, these warnings are repeated in the prompts.

With a computer program we can turn our attention away from the mechanics of computation and explore the effects of combination strategies.

If a table is selected, the user will be asked to choose the stock price range only. Since eleven prices are printed in the table, again readability is enhanced by requesting a price range evenly divisible by ten. This warning is also repeated in the prompts. The table itself consists of eight columns of data. The first of these is stock price. The next six columns provide the profit, including commission, due to stock owned, stock bought, calls sold, calls bought, puts sold, and puts bought, if any, respectively. The eighth column gives the total net profit due to all of these activities.

Following either the table or the graph, the program comes back with "Would you like a graph or a table, G or T ?" thus affording the user the opportunity of repeatedly examining in detail any particular area of the original output. This feature might, for example, be used to determine the breakeven stock price to a high degree of accuracy.

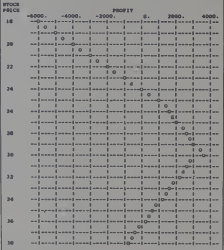
```
 you want instructions?
STOP IN LINE 11
READY
BYE
 2DO4GREADY
RUN

******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****

************ S T O C K  &  O P T I O N  D A T A **********

Stock Symbol, Remarks : NBL - 3/78
No. shares owned? 0; and price per share? 0
No. shares bought? 500; and price per share? 27.5

No. calls sold? 5; exercise price? 30; and premium? 1.875
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 5; exercise price? 25; and premium? 1.375
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 18
At what stock price should the graph end?   38
What minimum profit should the graph show? -7000
What maximum profit should the graph show? 3000
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (If this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 9 would be
   much better.) :0


************************** G R A P H *************************
```




```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

FIGURE 11

```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****

************ S T O C K  &  O P T I O N  D A T A **********

Stock Symbol, Remarks : NBL - 2/78
No. shares owned? 0; and price per share? 0
No. shares bought? 500; and price per share? 27.5

No. calls sold? 10; exercise price? 30; and premium? 1.875
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 5; exercise price? 25; and premium? 1.375
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 18
At what stock price should the graph end?   38
What minimum profit should the graph show? -6000
What maximum profit should the graph show? 4000
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (If this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 9 would be
   much better.) :0


************************** G R A P H *************************
```




```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

FIGURE 12

Sample Runs

In order to demonstrate program output let us start off with something simple like a plain old long position in stock. Figure 7 presents a graphical output for the purchase of 500 shares of Northwest Airlines (NWT) at $28 per share. Note that a loss is shown at a stock price of $28. This is the buy side commission. Figure 8 shows a graphical output if 500 shares of NWT are already owned. Note that now there is no loss at $28, since no commission is involved.

Combination Strategies — Calls, Covered and Uncovered

Now that a computer program is available to do all the hard work, we can turn our attention away from the mechanics of computation and explore the effects of combination strategies.

One of the commonest strategies used and one that we have already mentioned is that of "covered call writing." This is perhaps the most conservative approach possible. It consists of buying the underlying stock and then selling calls against the long position. If no more calls are sold than stock is owned, that is, no more than 1 call is sold per 100 shares of stock owned, the calls are all "covered." This means that no matter how high the stock goes before option expiration, if the seller is called (the options are exercised) he has the stock to deliver. If he had sold more calls than he had stock to deliver, a sharp rise in the price of the stock, followed by exercise of the option, would force the call writer (seller) to have to go out into the market to buy the stock at the high price and then deliver, because he is required to, at the exercise price. This is the stuff of which financial disasters are made. For this reason selling calls in excess of the stock one owns is more risky. Selling calls without owning any of the underlying stock, called selling "naked options," is comparable to Russian roulette (see Figure 4.)

Suppose we own 300 shares of NWT at $28 per share, we buy 300 more at $30 per share and then sell 6 calls, exercisable at $30, for a premium of $2.5. Figure 9 shows tabular and graphical results for this combination. Note that even though half the stock was owned at $28, and the other half was bought for $30 plus commissions,

Stock, cont'd...

we now have a profit at stock prices above $26.75 per share. This can be stated as, "we have a downside breakeven at $26.75," or "we have downside protection to $26.75," or "we have 2.25 point of downside protection ($29 average price minus $26.75)." The proceeds of the sale of the calls, of course, is what shifts the breakeven point down.

On every count, lower downside breakeven, higher upside breakeven, and greater profit across the board, the sale of covered straddles is superior to the sale of covered calls.

At stock prices at or below $30 per share only the buy side stock commissions are included, since exercise is not expected to occur. At stock prices above $30 per share however, both buy and sell side stock commissions are included since exercise is assumed. The discontinuity in the graph in Figure 9 at $30 reflects this sell side commission. In either case only sell side call commissions are included, since the problem did not assume a closing option transaction (calls bought back).

Now let us assume that instead of 6 calls we sell 12 calls against the same long stock position. Tabular and graphical results for this strategy are shown in Figure 10. Notice that the additional revenue from the 6 extra calls not only increases the overall profit but also lowers the downside breakeven point below that of Figure 9. Also, an upside breakeven point now appears. This is due to the fact that if the stock moves above $30 per share and the 12 calls are exercised, 600 extra shares must be acquired in the market place (possibly at more than $30 per share) and delivered at $30. Further, there is the extra round trip commission on those 600 shares. Again the discontinuity at $30 is due to the additional sell side commissions.

In order to accurately evaluate the upside breakeven point, we make another run on Program OPGRAPH, requesting a graph between stock prices of 34.5 and 35.5. The results are shown in the second graph in Figure 10, and reveal the upside breakeven point rather accurately at $34.875.

The sale of 12 calls against 600 shares of stock is referred to as selling calls at a "hedge ratio" of 2, and will be discussed more fully next month when Program OPTION is presented.

Combination Strategies — Covered Straddles

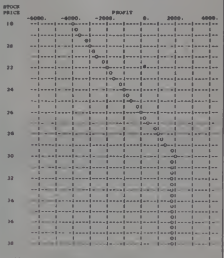
We come now to the author's favorite maneuver: selling a straddle. A straddle is a combination of a call and a put on the same stock with the same expiration dates and the same or different striking prices. Sometimes the case where the striking prices are different is referred to as a spread. However, the term "spread" is very general, and there are so many different kinds of spread, that the author prefers to refer to these maneuvers as straddles even when the striking prices are different. This seems to be the perfect (ha!) strategy for a stock which is active and fairly volatile within narrow limits. We want an active and volatile stock since the option premiums are higher on such stocks than on stick-in-the-muds. We want narrow limits since profits lie in, and close to, this range; losses lie on either side. Profits are maximized if the stock remains between the limits.

Throughout most of 1978 Heublein (HBL) was greater than $25 but less than $30. The seller of a covered call exercisable at $30 appeared to have a winner, and the seller of a put exercisable at $25 also appeared to have a winner. The stock itself appeared to be a safe enough investment at say $27 or $28, and even a good investment at below $25. If the stock were owned in sufficient quantity to cover the calls, there would be no upside risk. If the stock went down and the puts were exercised, that did not appear to be a calamity either. Therefore, 500 shares of HBL were bought at $27.5, 5 calls exercisable at $30 were sold for $1.875, and 5 puts exercisable at $25 were sold for $1.375. Such a combination of maneuvers can be referred to as a covered straddle. A sample run on Program OPGRAPH giving graphical results of these transactions is shown in Figure 11. Note the lower breakeven point at $24.9 per share, and the absence of an upside breakeven point. Note further that the maximum profit is attained at $30 per share. The discontinuous drop in profit just above $30 is due to the sell side commission that will be incurred when the calls are exercised. This type of discontinuity is common in all the following graphs which, incidentally, are all plotted using the same scales to facilitate comparisons. The break in the curve at $25 is due to the put (see Figure 6).

If it is deemed unlikely that the stock price will rise much above $30 per share, it might be desirable to sell twice as many calls, that is, sell puts

FIGURE 13

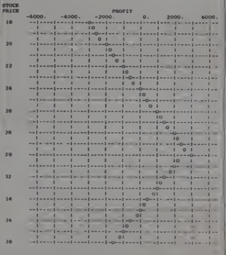
```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****

************ S T O C K & O P T I O N  D A T A ***********

Stock Symbol, Remarks : HBL - 2/78
No. shares owned? 0; and price per share? 0
No. shares bought? 500; and price per share? 27.5

No. calls sold? 5; exercise price? 30; and premium? 1.875
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 0; exercise price? 0; and premium? 0
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 18
At what stock price should the graph end?   38
What minimum profit should the graph show? -6000
What maximum profit should the graph show? 4000
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (if this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 0 would be
   much better.) ;0

************************** G R A P H **************************
```



```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

FIGURE 14

```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****

************ S T O C K & O P T I O N  D A T A ***********

Stock Symbol, Remarks : HBL - 2/78
No. shares owned? 0; and price per share? 0
No. shares bought? 500; and price per share? 27.5

No. calls sold? 10; exercise price? 30; and premium? 1.875
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 0; exercise price? 0; and premium? 0
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 18
At what stock price should the graph end?   38
What minimum profit should the graph show? -6000
What maximum profit should the graph show? 4000
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (if this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 0 would be
   much better.) ;0

************************** G R A P H **************************
```



```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

Stock, cont'd...

1:1, but sell calls 2:1. A sample run with this modification is shown in Figure 12. The downside breakeven point drops slightly to $24.1 and now for the first time an upside breakeven point appears at $36.3 per share. Note the greatly increased profit potential over most of the stock price range compared to Figure 11. Again notice the break in the curve at $25 due to the puts.

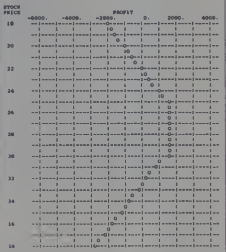
It is interesting to compare the sale of covered straddles with the sale of covered calls. Figures 13 and 14 show the profit picture for the sale of covered calls against the same stock position. The hedge ratios are 1 and 2, respectively, as before. Note that the profit, over the entire stock price range is reduced by the net put premiums. On every count, lower downside breakeven, higher upside breakeven, and greater profit across the board, the sale of covered straddles is superior to the sale of covered calls. The price paid for this superiority is the greatly increased rate of loss as the stock price falls below $25. However, as discussed above, if the stock is considered to be a reasonable buy at $25 per share, this is hardly a cause for alarm.

Uncovered Straddles

If it is considered very unlikely that the stock price will exceed $30 per share, it might be that the safety of owning the underlying stock can be dispensed with. In other words, one might consider selling uncovered straddles. This is, of course, a somewhat dangerous course of action, but on the other hand has the tremendous advantage that no investment is required, only the underlying equity in the account. Sample runs, made on Program OPGRAPH for uncovered straddles, are presented in Figures 15 and 16. In both figures puts have been sold at a hedge ratio of 1; calls have been sold at 1 in Figure 15 and at 2 in Figure 16. Note that the maneuver with the higher hedge ratio on the calls produces higher profit, and lower breakeven points, both upside and downside. Comparison with Figures 11 and 12 reveals that the breakeven points, both upside and downside occur at lower stock prices when the straddles are uncovered than when they are covered. There is no reason why puts could not also have been sold at higher hedge ratios. This would, of course, produce a further increase in profit, along with a narrowing of the profitable stock price range.

Being 'whipsawed' Is only slightly preferable to being keelhauled.

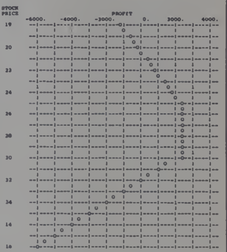
```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****
************ S T O C K  &  O P T I O N  D A T A ***********

Stock Symbol, Remarks : HBL - 2/79
No. shares owned? 0; and price per share? 0
No. shares bought? 0; and price per share? 0

No. calls sold? 5; exercise price? 30; and premium? 1.875
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 5; exercise price? 25; and premium? 1.375
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 18
At what stock price should the graph end?   38
What minimum profit should the graph show? -6000
What maximum profit should the graph show? 4000
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (If this RUN
   started at the top of the page, about 11 should work
   very nicely; if you printed a table first, 9 would be
   much better.) ;0

************************* G R A P H *************************
```




```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

FIGURE 15

```
******* Program OPGRAPH - by Alfred A. Adler, Ph.D *****
************ S T O C K  &  O P T I O N  D A T A ***********

Stock Symbol, Remarks : HBL - 2/78
No. shares owned? 0; and price per share? 0
No. shares bought? 0; and price per share? 0

No. calls sold? 10; exercise price? 30; and premium? 1.975
No. calls bought? 0; exercise price? 0; and premium? 0

No. puts sold? 5; exercise price? 25; and premium? 1.375
No. puts bought? 0; exercise price? 0; and premium? 0

Would you like a graph or a table, G or T? G

Readability of graph is best when difference between
starting and ending stock price is evenly divisible by 10,
and difference between maximum and minimum profit is evenly
divisible by 5.
At what stock price should the graph start? 18
At what stock price should the graph end?   38
What minimum profit should the graph show? -6000
What maximum profit should the graph show? 4000
How many lines would you like to skip so that the graph can
   start at the beginning of the next page? (If this RUN
   started at the top of the page, about 33 should work
   very nicely; if you printed a table first, 9 would be
   much better.) ;0

************************* G R A P H *************************
```




```
Would you like a graph or a table, G or T?
STOP IN LINE 50
READY
```

FIGURE 16

As it turned out, the stock did not even approach $30 per share through several cycles of selling covered straddles. It was felt that the money tied up in the underlying stock was not well invested and the stock was disposed of. This decision turned out to be correct and the stock stayed within the $25 to $30 range, both the puts and the calls expired worthless, and the whole operation was repeated through several cycles, making the maximum profit each time. The stock ultimately drifted slowly upward, exceeding $30 sufficiently slowly that no problems occurred, and the game was obviously over.

There is one ever present danger in selling straddles. It is that the stock will move in either direction sharply, causing the seller to react by covering the option on the affected side, whereupon the stock reacts sharply the other way, leaving the seller with egg on his face and worse, a diminished pocketbook. This is known as being 'whipsawed' and is only slightly preferable to being keelhauled. Since a rise in stock price will drive the premium on the call up and that of the put down, and vice versa, a way to severely limit such possible losses is to cover both options in the event that it becomes necessary to cover either.

Conclusion

It is clear that certain combination strategies can increase the probability of profit and at the same time decrease risk. We have only lightly touched a very few of the almost limitless number of possibilities. Candidates for such maneuvers must be carefully examined however, since both the opportunity for profit and the risk are very sensitive to the variables and the commissions. The calculations associated with such examination are, unfortunately, lengthy and tedious, especially when commissions are included, which they obviously must be. A computer program such as OPGRAPH can reduce this effort by orders of magnitude and permit the examination of many opposed maneuvers in a short time. □

Program OPGRAPH, along with the other 3 programs to be presented in this series, is currently available on cassette for TRS-80 16K Level II from Creative Computing Software, and on North Star disk, either single or double density, from the author. An Applesoft version is currently being written, and it is anticipated that in the near future other versions will be forthcoming.

for Apple II Low-Res Color Graphics

A Shape Maker

W. B. Smith

Possible Modifications

This program generates a separate PLOT statement for each plotted point. An improved version of the program could compute HLIN and VLIN statements for graphics where there are many consecutive plots in horizontal or vertical order.

This program was written to allow the user to have the fun of creating shapes for games, educational programs etc. and then leave it up to the computer to write the laborious series of 'Plots' required to define the different shapes.

Hardware Requirements

Apple II computer with at least 16K of RAM.

Loading the Program

Enter Basic with 'Control-B' and set 'Lomem: 3072.' Load the program from the keyboard or tape recorder in the usual manner. Start the program with 'Run.'

Using the Program

The program will clear the screen to the 40 x 40 matrix graphics mode with a green spot in the middle. Move the green dot to the area of the screen you would like your shape by holding Paddle #1 button depressed and operating keyboard keys 'L' (Left) 'R' (Right) 'U' (Up) 'D' (Down). Now, to draw the shape, release paddle button and, using the same keys, the shape will appear as white dots. To erase just press paddle button and go over the white area in green. (when copying the shape to memory the computer ignores all of the green areas, remembering only the white). The maximum number of white dots allowed in the shape is 109, the counter keeps track and if you exceed this number just wipe a few off.

W. B. Smith, RR #3 Gibsons, BC Canada VON-IVO

When you have finished type 'Q' (Quit) and the Apple will ask you what "Key Name" you want to use for the shape, type any one letter or number and then the return key.

The Apple will now go to work writing a subroutine for your shape and when finished will display the line numbers and 'Plots.' To store this subroutine in your program use the '→' (Right Arrow) and 'Repeat' keys to move the cursor to the end of each line then hit 'Return.' If the shape you have drawn is more than 55 dots, after storing the first page, type 'Run 700' and the second page will appear ready for the 'Right Arrow' Treatment.

To check the shape type 'Run 900,' answer the computer's question regarding key name and hit 'Return.' Type 'Run' to create another shape.

The various shapes are now in the program as subroutines with first line numbers which are the same as the ASCII 'Key Letter' DEC equivalent times ten. For example, to call up a shape with a-key name 'S'

```
GR    or you may use
COLOR = 10
GOSUB ASC ("S") * 10
END
GR
GR
COLOR = 10
GOSUB 2110
END
```

If you have finished making shapes and now want to get on with your own program, delete lines 1 to 999 (type "DEL 1,999") your 'Shape maker,' and you are left with the subroutines.

Notes

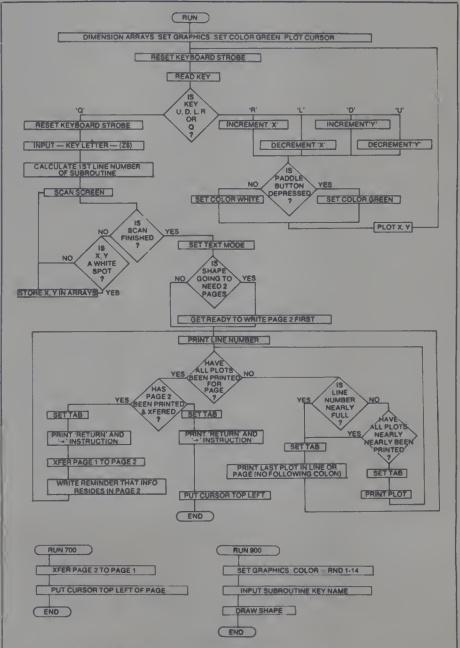
The following lists key names against subroutine first line numbers.

A	1930
B	1940
C	1950
D	1960
E	1970
F	1980
G	1990
H	2000
I	2010
J	2020
K	2030
L	2040
M	2050
N	2060
O	2070
P	2080
Q	2090
R	2100
S	2110
T	2120
U	2130
V	2140
W	2150
X	2160
Y	2170
Z	2180

If you make a shape of more than 55 dots and the screen goes blank hit 'Reset,' CNTL C and set Lomem: 3072 (this should already have been done).

Shape, cont'd...

```
LIST
  5 GR : COLOR=4: X=20:Y=20: DIM
     A(110): DIM B(110): DIM Z$(
     )
  6 PRINT "TYPE Q TO QUIT DRAWING SH
     APE": PRINT "ENSURE #    IS LESS
      THAN 110 ": PRINT "TO ERASE HOL
     D PADDLE BUTTON PRESSED"
 10 PLOT X,Y
 15 POKE -16368,0
 20 KEY= PEEK (-16384): IF KEY>
     127 THEN 30
 25 GOTO 20
 30 IF KEY=213 THEN Y=Y-1
 35 IF KEY=196 THEN Y=Y+1
 40 IF KEY=210 THEN X=X+1
 45 IF KEY=204 THEN X=X-1
 50 IF KEY=209 THEN 70
 55 IF PEEK (-16287)<=127 THEN
     COLOR=15: IF PEEK (-16287)>
     127 THEN COLOR=4
 58 IF SCRN(X,Y)=15 THEN F=F-1
 60 PLOT X,Y
 61 IF SCRN(X,Y)=15 THEN F=F+1
 64 TAB 9: VTAB 22: PRINT F
 65 GOTO 15
 70 POKE -16368,0
 74 PRINT
 75 INPUT "PLEASE TYPE LETTER KEY OF
     SHAPE DRAWN ",Z$
 76 PRINT "APPLE IS NOW SCANNING SHA
     PE"
 80 L= ASC(Z$)*10
 85 FOR X=0 TO 39: FOR Y=0 TO 39
     : IF SCRN(X,Y)=15 THEN GOSUB
     100
 90 NEXT Y,X
 95 TEXT : GOTO 130
100 A(C)=X:B(C)=Y
120 C=C+1: RETURN
130 L=L-1: CALL -936:CV=2:CH=1
140 IF C>55 THEN GOTO 150
145 GOTO 160
150 L=L+6:D=55: GOTO 170
160 L=L+1
170 TAB (CH): VTAB (CV): PRINT
     " ";L
175 CH=CH-5
180 IF C=D THEN GOTO 600
200 IF D MOD 11=10 THEN 250
210 IF (C-1)=D THEN GOTO 250
215 CH=CH+11: IF (CH+11)>40 THEN
     GOSUB 500
220 TAB (CH): VTAB (CV): PRINT
     "PLOT ";A(D);",";B(D);":"
230 D=D+1
240 GOTO 200
250 CH=CH+11: IF (CH+11)>40 THEN
     GOSUB 500
260 TAB (CH): VTAB (CV): PRINT
     "PLOT ";A(D);",";B(D)
270 D=D+1:CV=CV+1:CH=1
280 IF D<110 THEN GOTO 160
290 PRINT "TOO MUCH DATA": END
298 TAB 7: VTAB CV: PRINT "RETURN"

299 IF F<56 THEN 301
300 VTAB 22: TAB 1: PRINT "
     "
301 VTAB 23: PRINT "RUN '->' TO END
     OF LINE# AND HIT RETURN": TAB
     1: VTAB 1
304 END
400 REM  SUBROUTINE TO CHANGE LAST L
     INESWHEN PAGES FULL
405 IF F=109 THEN GOTO 450
410 TAB 1: VTAB CV: PRINT "
     "
415 TAB 1: VTAB CV: PRINT ":RETURN"

430 RETURN
450 TAB 12: VTAB 21: PRINT ":RETURN"
     : PRINT "                 ": RETURN
500 CV=CV+1:CH=1
502 RETURN
600 IF C<56 THEN GOTO 298
601 TAB 7: VTAB CV: PRINT "RETURN"
     : VTAB 23
602 PRINT "RUN '->' TO END OF LINE#
     AND HIT RETURN"
603 IF F>99 THEN GOSUB 400
605 POKE 60,0: POKE 61,4: POKE
     62,255: POKE 63,7: POKE 66,
     0: POKE 67,8: CALL -468
620 CALL -936
630 L=(( ASC(Z$)*10)-1)
635 VTAB 1
636 PRINT "FOR PAGE 2 TYPE 'RUN 700'
     "
638 VTAB 22: PRINT "
     "
640 CV=2:CH=1
650 D=0:C=55
690 GOTO 160
700 TAB 1: VTAB 1
705 POKE 60,0: POKE 61,8: POKE
     62,255: POKE 63,11: POKE 66
     ,0: POKE 67,4: CALL -468
710 GOTO 704
900 GR : COLOR= RND (14)+1
901 PRINT : PRINT : PRINT : PRINT
     : PRINT
905 INPUT "TYPE KEY OF SHAPE TO BE D
     ISPLAYED ",Z$
910 L= ASC(Z$)*10: GOSUB L
950 PRINT "TO DRAW A NEW SHAPE TYPE'
     RUN',TO DISPLAYA SHAPE ALREADY M
     ADE TYPE 'RUN 900'"
960 END
970 REM  PROGRAM BY BILL SMITH
980 REM  GAMBIER ISLAND  B.C.
990 REM  CANADA
9999 END
```



NOTES: VARIABLE 'F' KEEPS TRACK OF THE NUMBER OF WHITE DOTS WHILST SHAPE IS DRAWN
VARIABLE 'L' IS THE LINE NUMBER
VARIABLE 'C' HOLDS THE NUMBER OF 'PLOTS' TO BE WRITTEN IN EACH PAGE
VARIABLE 'D' HOLDS THE NUMBER OF 'PLOTS' ACTUALLY WRITTEN

Futurists will Explore Possible Events Of 1980s

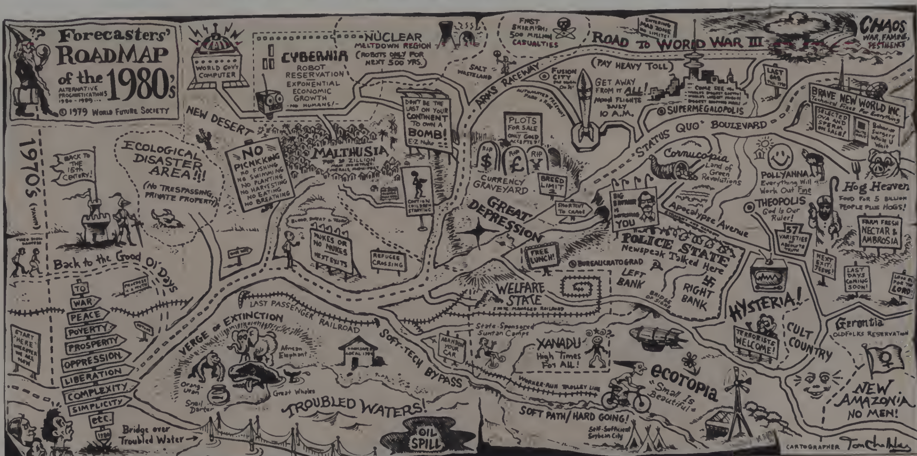
The 1980s will be the focus of a major conference in Toronto, Canada in July.

Called the First Global Conference on the Future, the meeting will convene some 4,000 scholars, decision-makers and other futurists from around the world for a week of deliberations on the theme "Through the 80s: Thinking Globally, Acting Locally."

The conference is being organized by the World Future Society and the Canadian Futures Society.

Top thinkers and doers will address the conference, including: Italian industrialist Aurelio Peccei, founder of the Club of Rome; Filipino official Rafael Salas, now head of the United Nations' population activities; German author Robert Jungk; Indian urban planner Rashmi Mayur; French social scientist Bertrand de Jouvenel; Argentine economist Andre van Dam; Canadian communications theorist Marshall McLuhan; Swiss economist Bruno Fritsch; and United States' policy analyst Herman Kahn; author-diplomat Harlan Cleveland; public opinion analyst Florence Skelly; environmentalist Lester R. Brown and more.

For information, write: World Future Society, 4916 St. Elmo Avenue, Washington, DC 20014, U.S.A.



Map of the 1980s: The World Future Society recently published this "Roadmap of the 1980s." Society president Edward Cornish explains: "The map is humorous but makes an important point. The decade we have just entered contains enormous possibilities and we face a great many important decisions that will determine whether we have a good or bad future."

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To include your store in Creative Computing's Retail Roster, call the Advertising Department at (201) 540-9168.

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Inside Space Invaders

James Hussey

FLASH! The United States has been overrun by an alien horde — in case you hadn't noticed. Fortunately they're safe in ROM.

I first saw the game at a pizza parlor and was attracted by the noise and the crowd of people. Within five minutes I was convinced that I had to learn how it worked. Fifty-five alien invaders were attacking the planet, marching across and down the screen, dropping missiles. The player defended the planet with 3 laser bases, which he used one at a time. As one base was hit and destroyed another took its place. He had three chances.

The game is "Space Invaders" by Taito Corporation of Japan. They have been making the game since June of 1978 and have had it marketed by the Midway Manufacturing Company here in the U.S. since October of that year. Since its introduction the game has taken on the air of a cult. Players quickly find that the game becomes more exciting as one gets better. And they can keep playing as long as they don't make those three fatal moves allowing their laser bases to be destroyed. Time is no factor, only skill (and lots of quarters).

Players score by varying point values of the marching invaders. As the aliens are hit they disappear from the screen and the remaining aliens begin moving faster and dropping their missiles more often. All the while there is a pulsing, musical beat in the background which begins to beat faster and faster as the invaders pick up speed. Players find that their hearts begin to

beat in sync with this pulsing sound. And above the descending aliens is a mystery saucer which flies teasingly by, daring the player to hit it.

Research indicates that close to 300,000 Space Invader units have been installed in some 70,000 locations in Japan. The general press in Japan is looking at the Invader phenomena with some concern, citing cases of students neglecting their studies and youngsters turning to juvenile delinquency to support their game-playing. In the U.S. there are about 60,000 games in the field, and orders are still flowing in. The distributors are finding it hard to keep up with the orders. "The average game is on the market 3 to 4 months," says Stan Jarocki, Director of Marketing for Midway. "A game lasting 6 months is Utopia. 'Space Invaders' has been out for 17 months and shows no signs of slacking off."

What causes this interest in, and even fanatical obsession with, a technologically simple video game? Several factors seem to contribute to the attraction. The challenge of maneuvering a defender against seemingly innumerable odds is a definite plus. The musical pulse of the attackers that beats faster and faster as they get closer and fewer in number adds a dimension of excitement and tension.

But the most likely reason for enthusiasm is trying to figure out the program Taito has used in the four IC chips which make up the main electronics of the game. It didn't take long (though it did take lots of quarters) to discover that the mystery saucer has a definite rather than random selection of point values. It yields scores of 50, 100, 150 and 300 points depending on when it is hit. Of course the serious

Since its introduction the game has taken on the air of a cult. Players quickly find that the game becomes more exciting as one gets better.

player wants to get 300 every time. Experimentation showed that the scores rotate in a sequence of fifteen numbers. There are eight 100s, four 50s, two 150s and one 300. Shooting the saucer every fifteenth shot gets the 300 score. To get 300 the first time and set up the sequence the player has to hit the saucer twenty-three shots after the start of a new screen.

Other techniques of success were inferred. Shooting the side rows first slows the downward march, giving the defender more time to resist the onslaught. And the longer it takes the

James Hussey, P.O. Box 712, Fairbanks, AK 99707

Invaders, cont'd...

aliens to march down, the more high-scoring mystery saucers appear. The game becomes decidedly more complex than first assumed.

When the aliens get to the last row prior to destroying the laser bases, they are so close that there is no space for missiles to appear. But it's not as easy as it seems.

As the defenders become successful at clearing the board of the fifty-five aliens, they find that instead of the game ending, a new screen of fifty-five invaders will appear, this time closer and shooting more missiles! Subsequently they find that the third screen is the same as the second and that each new pair of screens — fourth and fifth, sixth and seventh, eighth and ninth — are one row closer than the last two. (If the aliens reach the ground the laser bases of the defender self-destruct and the game ends.) The tension continues to build!

Fortunately, one last trick helps keep Invader experts from losing hope. When the aliens get to the last row prior to destroying the laser bases, they are so close that there is no space for missiles to appear. The defenders are safe to shoot without fear of being hit. But don't think that it's cheating, it's not as easy as it seems. It takes expert shooting and rapid reflexes to keep from being hit, because as soon as the alien is shot the one behind it begins

firing missiles. Should the player manage to clear the screen that ninth time, the program rewards him with still another fifty-five aliens, but this time starting from the original distance away. A slight reprieve.

Initially the manufacturers thought that four-digit scoring would be sufficient. Players could get an extra laser base if they scored over 1,000 points but Taito didn't think that a score of 10,000 would be reached. Little did they understand their creation. It wasn't long before scores of 5,000 were commonplace and records were being set in the 15,000 point range. The high score to date in the U.S. is just over 95,000 (witnessed and reported to Andy Ducay, Midway service manager). And that is only one third of the reported scores from the home country of Japan! Some players have gone so far as to construct a rating system of expertise, ranging from a space recruit (who scores 1,000) up to Admiral 3 (clearing the screen of invaders 25 times).

As successful as "Space Invaders" continues to be, Midway is not resting on its successes. "Deluxe Space Invaders" is now on the market with added challenges. And a new game, "Galaxian," by the Namco Company of Japan, is being introduced for those skillful players who have mastered Space Invaders. The true enthusiast need not fear for new horizons to conquer. □

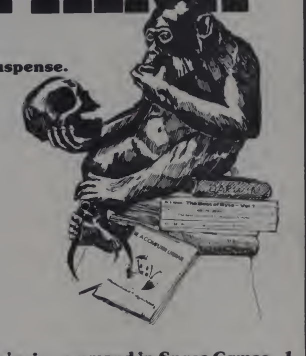
Note: Under license from Astar International, Creative Computing Software is selling the original "Space Invaders" game for the Apple Computer under the name "Super Invasion."

ACTION, STRATEGY, AND FANTASY—
for the SERIOUS games player

Brain Games - 1 demands ingenuity.

Two players bombard radioactive material with protons and electrons until it reaches critical mass and sets up a ***Nuclear Reaction. Dodgem*** *requires you to outmaneuver another player to get your pieces across the board first.* ***Dueling Digits*** *and* ***Parrot*** *challenges your ability to replicate number and letter sequences.* ***Tones*** *lets you make music with your Apple (16K) CS-4004 $7.95.* ***Strategy Games*** *and* ***Brain Games*** *are on one disk (16K) CS-4503 $14.95.*

THINK



Strategy Games - 1 keeps games players in suspense.

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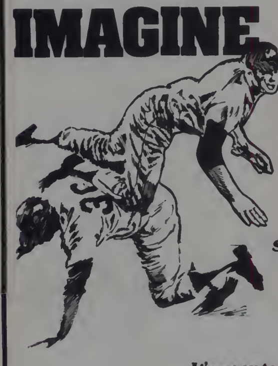
IMAGINE



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Triple Trip Revisited

In the March issue (page 166) we ran a calculator game called "Triple Trip." It required that any three-digit number be transformed into three like digits by using only one digit already in the number and any of the four arithmetic operations of the calculator. David DeWan of Computer Solutions in Newton, Mass. writes that he wrote a Basic program that finds the shortest sequence to the triple number for all starting numbers from 100 to 999. His first run took an embarassing 18 hours, but his final program taking advantage of range limits discovered in earlier runs required only 16 minutes. The 100-line program uses 30K bytes (15K words) on an HP 3000 and consists mainly of tables, pointers and flags.

Worst case numbers requiring six moves to reach triple digits include 403, 511, and 613. Every other number requires 5 or fewer operations.

Here is a portion of David's output.

```
308 - 3 =  305 - 3 =  302 x 3 =  906 - 9 =  897 - 9 =  888
309 / 3 =  103 + 3 =  106 + 6 =  112 - 1 =  111
310 x 3 =  930 x 3 = 2790 - 7 = 2783 - 8 = 2775 / 5 =  555
311 + 3 =  314 + 1 =  315 / 3 =  105 + 5 =  110 + 1 =  111
312 / 3 =  104 + 1 =  105 + 5 =  110 + 1 =  111
313 + 3 =  316 + 3 =  319 + 9 =  328 + 2 =  330 + 3 =  333
314 + 1 =  315 / 3 =  105 + 5 =  110 + 1 =  111
315 / 3 =  105 + 5 =  110 + 1 =  111
316 + 3 =  319 + 9 =  328 + 2 =  330 + 3 =  333
317 + 1 =  318 / 3 =  106 + 6 =  112 - 1 =  111
318 / 3 =  106 + 6 =  112 - 1 =  111
319 + 9 =  328 + 2 =  330 + 3 =  333
320 + 3 =  323 + 2 =  325 + 5 =  330 + 3 =  333
321 / 3 =  107 - 1 =  106 + 6 =  112 - 1 =  111
322 + 3 =  325 + 5 =  330 + 3 =  333
323 + 2 =  325 + 5 =  330 + 3 =  333
324 + 3 =  327 + 3 =  330 + 3 =  333
325 + 5 =  330 + 3 =  333
326 + 3 =  329 x 2 =  658 + 8 =  666
327 + 3 =  330 + 3 =  333
328 + 2 =  330 + 3 =  333
329 x 2 =  658 + 8 =  666
330 + 3 =  333
331 - 1 =  330 + 3 =  333
332 - 2 =  330 + 3 =  333
333
334 - 4 =  330 + 3 =  333
335 - 5 =  330 + 3 =  333
336 - 3 =  333
337 - 7 =  330 + 3 =  333
```

1

2

3

Making a PET

David Ahl

In March, 1980 following the West Coast Computer Faire, I looked in on the new Commodore plant in Santa Clara.

1. Here's the start of the assembly line where transformers, switches and wiring harnesses start their journey.
2. A transformer is affixed to the bottom chassis.
3. Non-automated component insertion.
4. Components are automatically inserted into the main printed circuit board.
5. Start of the wave soldering process.
6. In wave soldering, boards travel on a moving conveyer belt over a molten, circulating pool of solder.
7. Assembly and checkout.
8. Final burn-in. The racks of systems in the background are all running software exerciser programs.

5

4

6

7

8

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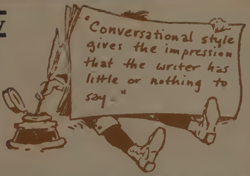
Effective Writing

Carl E. Whitney

Awkwardness



The next time you read the "Compleat Computer Catalogue" in this magazine, notice how efficiently it conveys information. There's no beating around the bush, no hesitation. "Xyqiq Systems has announced the Toothmaster 42X-125, an electric toothbrush driver for the S-100 bus." "Thrifty Disk Products has entered the under-$100 hard disk market with its 50-megabyte V-V1." "A Comprehensive Personal Development System, including levitation, psychokinesis, and time travel, has been unveiled by . . ."

You can learn a lesson from these new-product announcements, which some journalists call "blurbs." You can learn how to pack information into your writing, how to come to the point, how to avoid ambiguity and awkwardness.

Here is the first sentence from an article entitled "Personal Estate Planning" and written by Larry Buss for the February issue of *Creative Computing*: "If the breadwinner in your family were to die today, would his or her estate adequately provide for your current and future family needs?" This is no-nonsense, blurb-like writing; it gives one the feeling that Mr. Buss is almost out of breath, as if he had a wealth of information and not much time in which to communicate it. Let's imagine what he might have written:

"Say, hacker! Suppose that balky disk finally got to you, and you went power-down with a heart attack. Would your old lady have enough coin to pay the rent?"

This is "conversational style," which is currently in vogue among writers. If used skillfully by an authority or public figure, this style is effective. But you'll do well to avoid it, concentrating instead on making your writing as fact-filled as possible. This is a matter of logic — the same kind of logic that designs a circuit with the minimum number of components, a program with the minimum number of instructions. Think of how the word "elegance" is used in mathematics, engineering and programming. It means simplicity, freedom from distraction. Similarly, elegant and unawkward writing is straightforward; it injects nothing into the prose that won't contribute to the communication of fact, idea, or feeling.

Degenerate "conversational style" gives the impression that the writer has little or nothing to say; our second awkwardness is the digression, which results when the writer tries to say too much.

"The ideal microcomputer, if it existed, would have a huge amount of RAM — infinite, preferably, with sub-nanosecond access time — and, if bubble memories weren't available, four disk drives, a printer, or, perhaps, two — one thermal and one impact — plus every game that's ever been invented in ROM cartridges."

The reader has to go over this like a circuit diagram in order to get the message. Yet people do write this way, because this is how the mind thinks. No sooner do you get an idea — "four disk drives" — than another idea comes up — "a bubble memory would sure be nice." Consequently, your first drafts will always have digressions and useless parenthetical remarks, and you'll have to rewrite order out of chaos, unless you're Norman Mailer. Whether you drop a parenthetical remark, let it stand, or integrate it into the text depends on what facts and ideas you want to stress. If you had some material on bubble memories, then an ingenious way to rewrite the above mishmash would be:

"The ideal microcomputer would have infinite RAM, four disk drives, two printers — one thermal, one impact — and plenty of games in ROM.

"'Why no bubble memory?' you ask."

The reader's attention is now on bubble memories. He's primed.

Notice that the idea of sub-nanosecond access time has been dropped. Enough is enough; you don't have to put all your ideas on paper. You can often straighten out a wayward manuscript simply by eliminating extraneous material.

Another change in the digression-laden sentence leads us to an important class of literary indiscretions: ambiguity. On reading the clause, "plus every game that's ever been invented in ROM cartridges," the reader first sees the nonsensical meaning. Clearly, games are invented in offices, not in ROM cartridges, and it takes only a split-second for the correct meaning to come through. But if you're a truly careful writer, you'll go to any lengths to avoid even minor ambiguities. Today's readers are in a great hurry, and every time you trip them up, you incur a costly bit of ill will.

Always be on the lookout for ambiguities, and be prepared to spend hours on them, for cleaning up some of these things is sheer hell. The only useful rule is to put descriptive material close to the thing it describes. Above, the problem was that "in ROM cartridges" seemed to be modifying "invented"; the solution would be: ". . . and, in ROM cartridges, every game that's ever been invented." This "proximity principle" explains why split infinitives — "Do you want to rapidly gain an understanding of digital electronics?" — are acceptable, while floating participles — "Soldering iron in hand, the circuit board lay before him." — are not.

Another common type of awkwardness is the convoluted sentence. Here, the problem is not ambiguity but complexity.

"The problem with Basic is not so much the GOTO statement, which is a simple control mechanism, the need for which is recognized by all authorities, as the lack of subroutine linkage which would enable users to invoke utility routines that had been written, perhaps in a far different problem-solving environment, by others with little initial thought that their solutions might one day be valuable to others."

The "nesting" of relative clauses (who, which, that) is what makes this sentence a "house that Jack built." Try to avoid even a second level of relative clauses. "A programmer who writes code" is fine. "A programmer who writes code that contains errors" is inferior to "a programmer who writes bad code." And "a programmer who writes code that contains errors which should not have been made" is convoluted.

Carl Whitney, 846 Bush St #3, San Francisco, CA 94108

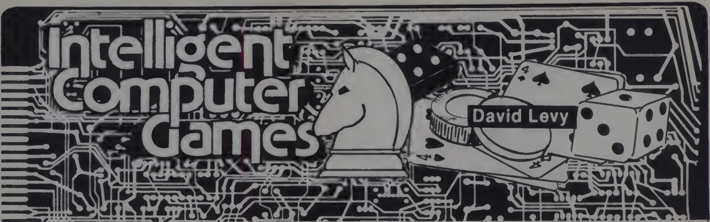
How to say it? This depends on the direction you're taking. "A programmer who writes bad code, who makes careless errors, and who always comes to work late, will not long remain on the payroll of this firm." Here the relative clauses are not nested, but parallel.

Last month we noted the power of parallel, *list-like* constructions. And here we are again. So let's go out on a limb; let's risk being taken for Artificial Intelligence fans who, late at night when no one is watching, program in Lisp. Let's say that *the list is the ideal form of communication.* A new product blurb is just a list of specifications. A computer program is just a list of statements. Leo Tolstoy's *War and Peace* is just a list of characters and events.

By this analysis, awkwardness is whatever obscures the list. "Conversational style," unless skillful, distracts from the list. Digression destroys the list. Ambiguity and convolutedness obscure the relationship of things within the list.

This idea can be taken too far, but you can do worse than to think of what you write as just a list.

Next: The Secret Life of Paragraphs. □



Correspondence is welcome. Letters with interesting questions and ideas will be used in the column along with a response. No personal replies can be made. Send to: David Levy, 104 Hamilton Terrace, London NW8 9UP, England

Those readers who have followed the previous articles should now have a good understanding of the principles of tree searching. We have already introduced the concept of the evaluation function (sometimes called the scoring function), but up to now only simple functions have been considered. In this article we shall look at evaluation functions for more complex games and the reader will learn how to devise his own evaluation functions. We shall consider some simple methods of learning, and illustrate a method that allows the program to improve its own evaluation function.

How Good is Good?

Show a chess master a position from a game of chess and he will most likely make some comment about which side has the advantage. He might say "White is slightly better," or "Black has a clear advantage," or "White is winning." Press him further and he will tell you why it is that White is slightly better; perhaps the reason will be simple, such as White has an extra knight, or maybe it will be more subtle, such as Black having the inferior pawn structure (or even more specifically, a pair of "doubled pawns"). In the language of chess players, all of the master's comments will mean something. But when we write a chess program we have to put some numerical value on advantages such as an extra knight or a superior pawn structure, and the accuracy with which we can do this is one of the principal factors in determining the strength of our program. The result of our efforts to quantify various forms of advantage is a device called an evaluation function, and for all interesting games the evaluation function is part of the key to successful programming.

In an earlier article I suggested a simple evaluation function for noughts and crosses, the justification for which lies in the fact that only rows, columns or diagonals with moves by one player only (and not his opponent) are of any real interest. Once a row has one move by each player, that row is of no further use to either of them. I did not get this evaluation function from a World Champion noughts and crosses player, I made it up by taking a brief look at the underlying structure of the game. Alas, chess, checkers, backgammon, etc., etc., are all far too complex for such a simple approach to be possible. We must therefore rely, for our evaluation function, on the advice of experts, either spoken or in books.

There are three stages in building a useful evaluation function for a complex game, and I shall illustrate these stages by using chess as my example.

Identifying the Important Features

In order to be able to tell a good position from a bad one, it is first necessary to know what features to look for. If you know nothing about chess, and you and I both look at the same position, I will be able to make a fairly accurate assessment of which side has the advantage and by how much, simply becuse I know what to look for. You will be looking at the same thing but will not understand what you see. But suppose I were to tell you that the most important thing in chess is material — how many pieces each player has on the board, and that the player with the most pieces usually wins. Then you can count the pieces, and if White has 16 pieces but Black has only 8 you will hazard a guess that White is doing quite well, and in general you will be correct. I could further advise you that the pieces have different values: that a queen was worth 9 pawns, a rook 5, a bishop or knight 3, and that the king was beyond normal values. Then you could look at a position and fairly easily tell which side, if any, was ahead on material. You may know nothing else about chess but at least you can make a meaningful, first order estimate of which side is ahead and by how much.

If it were possible for a chess program to search a tree 200-ply deep, an evaluation function with material as its only feature would almost certainly be sufficient to enable the program to play better than Bobby Fischer. But such is the nature of the game that a 20-ply search is not yet realistic, let alone 200-ply, so our evaluation function must have more features.

In order to discover which features of a game are important, you may do one or both of two things. You may read some books on the subject, in the search for general advice (heuristics), and you may ask someone who is expert in the game. In answer to your question "What else is important in chess, apart from material?" you may well receive the reply "Control of the central squares." On investigating further you discover that pieces in the center can move to, or attack, more squares than pieces on an edge or in a corner. And pieces that attack central squares may eventually be able to move to a central square, so attacking central squares is a useful thing to do.

Further questioning, and/or reading, will reveal that if your pieces are getting in each other's way they will not be able to do very much, whereas if they have plenty of scope to move they will be more likely to help you improve your position, so you have already learned that it is important for your pieces to have as many moves as possible.

Everyone knows that the king is the most important piece in chess, so obviously one should look after one's own king. Expert advice will tell you to keep your king away from the center of the board until the final stage of the game has been reached; castle during the opening stage so as to put your

Games, cont'd...

king nearer a corner, where it will be safer than on its original square; and do not rashly advance the pawns in front of your king once you have castled. You can learn all this from any decent book on the game.

A fifth feature whose importance is often underestimated, is pawn structure. Good chess players know that "isolated pawns," that is, pawns which do not have any supporting pawns on adjacent columns, are weak, because if the opponent attacks them they can only be defended with something more valuable than a pawn, and it is always best to use your less valuable pieces for defense. Also, it is usually a disadvantage to have "doubled" pawns, i.e., two of your own pawns in front of each other, since they will not be able to defend each other and the front one will block its colleague's path.

To summarize this stage of function building: Read some good books on the game and try to get advice from a strong player. You need to know which features in a position are important, and you need to understand why they are important so that you can measure roughly how much of each feature is present in a position.

Quantifying the Features

I have already explained how to measure the material situation in a chess position. The scale of values: queen=9, rook=5, bishop=knight=3, pawn=1 is a very useful guide. Some programmers find that giving the bishop a value between 3 and 3½ leads to a more accurate assessment, but it is useful to work with integer values since integer arithmetic is faster than floating point. So if you do decide to use non-integer values, scale everything up so that the final calculations are all integer.

These values of 9, 5, 3 and 1 are known to work well, though there is no logical explanation as to why they are better than some other set of values. It has simply been shown, throughout the modern history of chess, that a knight is worth roughly three pawns, but that a player with four pawns is better off than a player with a knight, while the man with only two pawns will probably lose to the man with the knight.

Features other than material are not so easy to quantify. This is probably because the material count is something that can be performed quickly by anyone who can add, while a count of (say) the number of squares that your pieces attack is not an easy matter for a human player to accomplish when thinking ahead. Because human players do not use any method of quantifying center control, mobility, etc., when playing games against each other, there exists no well tested set of values for these features. We must therefore devise our own set.

In an earlier article I gave a simple evaluation function for solving the 8-puzzle. Since the object of the exercise is to move tiles from their present location to some target location, it seems logical to measure the merit of a configuration by summing the straight line distances that the tiles need to be moved before they will all be on target. Similarly, for any feature in any other game, we look for a logical explanation of why that feature is important, and this will often lead us to a possible method of quantifying the feature. In chess, as we have discovered, control of central squares is important because from the center of the board a piece exerts more influence (i.e., it attacks more squares) than it does from an edge or corner square. So to determine the relative values of the squares, from the point of view of center control, we should, perhaps, count how many moves can be made by each piece, on each square, when the remainder of the board is empty. Of course the remainder of the board is never empty, and sometimes it is very cluttered, but this approach does have a logical foundation and provides us with a first order measure of central square values. A detailed discussion of this method can be found in Jack Good's paper, to which I refer in the bibliography.

Let us assume that we decide to assign square values as follows: each of the four central squares counts 4, those next nearest the center count 3, the next group 2 and those on the edge of the board count 1. We might then count the total center control for a player by summing the square values on which his pieces stand, or by summing the values of all the squares that his pieces attack. This may sound like a rather ad hoc statement, but the quantification of features is something of a trial and error process. Since you are a computer programmer you must have a logical mind, so apply some logic to the feature in question and you will come up with a quantification that will serve as a useful model.

1	1	1	1	1	1	1	1
1	2	2	2	2	2	2	1
1	2	3	3	3	3	2	1
1	2	3	4	4	3	2	1
1	2	3	4	4	3	2	1
1	2	3	3	3	3	2	1
1	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1

Possible square weightings to indicate center control value.

How easy or difficult it is to quantify a feature varies enormously. To take some more examples from chess: mobility (the freedom of movement of the pieces) may be measured simply by counting how many moves each player has at his disposal. In fact mobility is the second most important feature in chess, and if you plot (White's mobility - Black's mobility) throughout a master game, you will almost certainly discover that whoever wins the game has a lead in mobility throughout much of its duration. The two key elements of pawn-structure, isolated pawns and doubled pawns, are also easy to measure — we can simply count them. But what about king safety? This is not so easy because there are so many aspects of the position to take into consideration. The king is usually safest when it hides behind a few of its own pawns, but when these pawns advance they offer considerably less protection. A king is normally much safer near a corner of the board, but not if the opponent has many of his pieces trained on that particular corner. It is usually advisable to castle early in chess, to put the king into safety, but if queens are exchanged during the first few moves it may be better to leave the king nearer the center, since it will be relatively safe during the middle-game and better placed for the end-game. With so many factors to take into consideration, the quantification of a feature such as king safety can be rather prone to error, but some attempt to quantify is essential, so do not be put off if you encounter difficulties of this sort.

Weighting the Features

Having decided which features to include in your evaluation function, and worked out a suitable method of quantifying each of them, you must then decide which of them are the most important, and assign some numerical weighting to each feature to indicate its importance relative to the other features.

Let us suppose that we are writing a chess program and that we have decided to employ only two features in our evaluation function — material and mobility. We quantify material using the scale of values given above (9,5,3,3,1) and we measure mobility by counting how many moves each side

Games, cont'd...

can make from a given position. Let us denote the material difference (program's material - opponent's material) by Ma, and the mobility difference (program's mobility - opponent's mobility) by Mo. If we were to compute a score for a chess position simply by adding Ma and Mo, the result would be unrealistic. The reason for this is that one unit of material (in our case one pawn) is not of equal value to one unit of mobility (a move). A pawn is more valuable than a move (other things being equal) and so we must weight the material feature accordingly, multiplying Ma by some numerical weighting WMa. If we set WMa at 3, we are telling the program that one pawn is equivalent to three extra moves, so if it sees an opportunity to increase its mobility score by 4, the program would be willing to sacrifice a pawn to do so.

The best method of arriving at a good set of weightings for an evaluation function is to start with values that seem to be in the right range, and then improve these values in the light of the program's performance. With our two-featured chess function, if we were to play a number of games we would almost certainly discover that with WMa set at 3, the program would not be sufficiently careful about its own pieces, and that as WMa was increased to 5 or 6 the program's performance would also improve. The task becomes more difficult and more time consuming when using a multi-feature function. I would recommend building up your function slowly, starting with two features and getting their weightings adjusted satisfactorily, then adding a third feature and adjusting its weighting while keeping the other two constant, then add your fourth feature, and so on. Obviously you should start with the two most important features, and then add new ones in descending order of importance. As you add each new feature you should carry out some experiments, if you have sufficient memory, by playing the new version of the program against the previous one. You may discover that the addition of a particular feature, while giving a more accurate position assessment, results in such an increase in computation that the program can search only a much smaller tree and that the end result is weaker play.

Making your Program Learn

You will have gathered from the previous paragraph that it is often a very time consuming and difficult matter to reach an optimal set of weightings for your evaluation function. One way to help overcome this is to make the program learn from its experience and improve its own evaluation function!

A simple example is the case of our two-featured chess function:

WMa X Ma + Mo

We could modify our program so that it was able to play against itself, using two different values of WMa in each of the two "versions" of the program. If we start out in total ignorance, we could make WMa=1 in version 1, and WMa=100 in version 2. We then set the program to play a large number of games against itself, in half of which version 1 would be White and in the other half it would be Black. At the end of the series we would discover that version 1 had lost almost all, if not all, of the games. (I have already explained that one pawn is worth much more than one move.) We then set WMa to be 2 in version 1 (or we could reduce WMa in version 2) and keep the other value constant. After another series of games we would find that version 1 still lost very heavily, but possibly not quite so heavily as in the first series. If WMa were kept at 100 in version 2, we would discover that as the value of WMa reached 3 in version 1, version 1 would start to win a few games. When it reached 4 or 5 its results would improve considerably, and by the time WMa was 6 it would possibly be outscoring the version with WMa=100 because, although material is more important than mobility, there are situations in which the sacrifice of a pawn or two can advantageously increase a player's mobility, and WMa=100 will never recognize those situations.

This process of adjusting the weighting in accordance with the program's results can, of course, be fully automated, so you could switch on at night, go to sleep for a week, and when you woke up your program would be playing like a Grandmaster. But with more than two features in the evaluation function this type of learning process can be difficult to operate — the self learning reaches a local peak in the n-dimensional surface representing the various possible weightings and their results (n is the number of features), and it becomes difficult to climb out of the local peak in the search for a global peak. A method of overcoming this problem was discovered by Arthur Samuel, author of a famous draughts (checkers) program, but more about that in a moment. First I would like to describe a simple method of learning called "Boxes," which can be applied to equally simple games with surprisingly effective results.

Boxes

Boxes is a method of decision making that allows for a certain amount of program learning. A task (such as making the best move in a game) is split up into a number of sub-tasks (such as making a move in a particular game position) and a box is assigned to each sub-task. Inside the box is the information that is used by the program to guide its decision, and this information can be updated in the light of the program's experience.

Boxes was originally tested on the game of noughts and crosses. Donald Michie has calculated that there are 288 essentially different positions with which the player moving first may at some time be confronted. To each of these 288 positions is assigned one box (matchboxes were used) and inside each box there are a number of beads. The beads each have a number on them, the numbers indicating vacant elements in the noughts and crosses array (i.e., places in which the boxes "program" can make its next move). If one box corresponds to a situation in which elements 1, 2 and 3 are vacant, then that box will start out life with an equal number of "1 beads," "2 beads" and "3 beads."

When this box is opened (i.e., when the "program" has to make a move from the configuration corresponding to that box), a bead is drawn out at random, and the move is made according to the number on that bead. The bead is then replaced but the "program" makes a note of the fact that this box was used, and that the bead chosen was (say) numbered 2. When the game is over, the boxes which were opened during the game are referred to again. If the "program" won the game, then each box used during the game has one bead added to it, the number on the new bead corresponding to the move made from that box. If the game was a draw the contents of the box remain unchanged, but if the game was lost then one bead is removed from each box in order to reduce the probability that the same move will be played again should that situation ever arise in a future game.

The interested reader is referred to the paper (1968) by Michie and Chambers, which is mentioned in the bibliography. The authors describe how the boxes method, with some modification, learned so well that it could win at noughts and crosses between 75% and 87% of the time when it had played a series of 1,000 games against a program which played first in every game and always moved at random. Of course methods such as this are far too simple to be able to cope with games of the complexity of chess or bridge, but it is interesting to see how effective a learning mechanism it can be in a simple environment.

Samuel's Draughts Program

Probably the most famous game playing program up to the late 1960s was the draughts (checkers) program written by Arthur Samuel of I.B.M. I shall be discussing Samuel's work in some detail in a future article so here I shall restrict myself to a description of two methods of learning which the program employed.

The simpler of the two methods is called rote learning. Each time the program conducts a tree search from a position (the root of the tree), it provides an evaluation of this position based on the results of the look-ahead search. This evaluation is therefore more accurate than the evaluation which would be achieved by applying the evaluation function directly to the root position, and so the evaluation of the root position is stored, together with the position itself, and when the program next encounters the same position, but as a terminal node, instead of applying the evaluation function to the terminal node it looks up the stored evaluation. The process is relatively fast, since the positions can be hash coded and stored in such a way as to make retrieval easy, and it results in more accurate play because the evaluation taken from the store is more reliable than a superficial evaluation. The obvious disadvantage of this method, from the micro-user's point of view, is the large memory required to make effective use of the rote learning process. (By the time that the program reached the peak of its playing ability, quite a high proportion of all reasonable draughts positions were in its store, and the program played at or near championship level.)

A more generalized approach to learning was Samuel's method for the self-modification of the weightings in the evaluation function. Samuel used the argument that if an evaluation function were ideal, the score obtained by applying the function directly to a position would be the same as the score obtained as a result of a look-ahead search *from* that position. The fact that the two scores are often different was employed in the following way.

Let us assume that our evaluation function has three features, A, B and C, and that the features are weighted with WA, WB and WC, respectively, so that the whole function is expressed as:

$$(A \times WA)+(B \times WB)+(C \times WC)= \text{score}$$

where A, B and C are the quantities present of each feature. We shall denote the backed-up score for a root position by S_b, and the score which was backed-up to that same position during the previous tree search (two ply ago) as S_p. Note that if the tree-search is normally n-ply, the score S_b will be the result of an n-ply search whereas the score S_p, although arrived at during an n-ply search, is only the result of a search to depth n-2. S_b is therefore a more reliable score than S_p.

Samuel computed, for each such pair of values, the difference, which he called delta. If S_b-S_p (i.e., delta) was positive, then he argued that S_p was in error and terms in the evaluation function which contributed positively should have been given more weight, while features which contributed negatively should have been given less weight. Whenever delta was negative he used the converse argument that features which contributed negatively should have been given more weight, and those which contributed positively should have been weighted less.

Samuel kept note of the correlation existing between the signs of the individual feature contributions (i.e., the signs of A, B and C) and the sign of delta, and he updated these correlation coefficients after every move of a game. He then selected the feature with the largest correlation coefficient (other than material advantage, which is always the most important feature), and he set the weighting for this feature at a prescribed maximum value, with the weightings of the other features adjusted in accordance with their correlation coefficients. In fact, Samuel set all the weightings to be integer powers of 2, so that if the ratio of two correlation coefficients lay between n and n+1 then the ratio of their feature weightings would be 2^n. (If a correlation calculation gave rise to a negative sign, the sign associated with the weighting itself would be reversed.)

The obvious advantage of Samuel's generalized learning method is that it can be implemented on a small computer with little difficulty, because it is not necessary to store an enormous number of board positions. When your program makes a move from the root of the tree you need only store all the 2-ply positions in the relevant part of the tree, together with their backed-up scores. (In chess this would normally be in the region of 36 positions, in checkers probably less than 10). A problem arises when the alpha-beta algorithm prunes off the branch actually selected by the program's opponent, since the relevant 2-ply position will not have been stored, but it is reasonable to argue that this will only happen when the opponent makes a mistake (or a move which the program thinks is a mistake), so such instances could be ignored. More accurately, if the program's opponent makes an unexpected move, before computing its reply move, the program could first re-examine the relevant part of the tree from the previous root position, searching along the path represented by the opponent's move. This refinement would permit the program to take into consideration the S_b and S_p comparison for positions which, in the first instance, had been pruned away.

Task for the Month

Write a noughts and crosses program, using an evaluation function in which the features are:

- c_3: The number of cross' "3-rows" (i.e., the number of rows with 3 crosses in it).
- c_2: The number of cross' 2-rows (2 crosses and an empty space).
- c_1: The number of cross' 1-rows (1 cross and two empty spaces).
- n_3, n_2 and n_1: Corresponding features for noughts.

Your program should perform a 3-ply exhaustive search (without alpha-beta pruning) and the evaluation function should start with all weightings equal. Modify your exhaustive search noughts and crosses program ("Task of the Month" March '80) so that it can act as a sparring partner for the present program, and set the two programs playing each other. After every move of every game, the 3-ply search program should modify its weightings using Samuel's method. After each game print out (or display, if you have no printer), the result of the game and the new weightings in the evaluation function. Observe how the 3-ply program improves its performance. □

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Samuel, A.L. **Some Studies in Machine Learning Using the Game of Checkers.** I.B.M. Journal of Research and Development, vol. 3, 1959, pp 211-229. (reprinted, with minor additions and corrections, in Computers and Thought, edited by Feigenbaum and Feldman, McGraw-Hill, 1963).

Outpost: Atari

George Blank

There can be no better time to introduce a column on the Atari Computer than in an issue dedicated to graphics and music. After all, when you have a computer that has built in musical capability for four part harmony and high resolution color graphics with the ability to plot 158 columns and 80 rows in a choice of 16 colors, that is a graphics and music computer!

Visicalc Available

That does not mean that the Atari is limited to graphics and music. At the San Francisco Computer Faire, Adam Osborne conferred the small computer industry's most prestigious (only?) award, the noble White Elephant, upon Software Arts for the development of Visicalc. The award, for significant contributions to the industry, recognized the program as the first $150 program that justified the purchase of a $10,000 computer. So, if you need an excuse to buy an Atari 800, Visicalc is available.

Star Raiders

That is the excuse you give the Internal Revenue Service, your accountant, and your husband. Truthfully, the reason you bought your Atari was to play Star Raiders (TM), the most addictive computer game yet developed.

The game comes as a ROM cartridge with a lavishly illustrated twelve page instruction manual at a cost of $59.95. In addition, you need to purchase a joystick, costing $19.95 for two. The joysticks are not sturdy, and get heavy use, so you can use the spare.

George Blank, Foster Road, Milford, NH 03055

Study of the instruction manual takes about 45 minutes and is essential to adequately understand the game. However, if you have someone available who already knows Star Raiders, it can be learned in 5 minutes by demonstration, if the demonstrator will then give up the machine. That brings you to the point of understanding. To truly master the game might take years.

Your mission is to defend your star bases from the Zylon fighters. You do this by locating the enemy on the Galactic Chart, turning on your defense shields, hyperwarping through space to the enemies' sector, and engaging them in combat until the best man, woman, or Zylon wins.

You are rated upon your performance based upon the level of play you have chosen, the number of enemy destroyed, the length of time it took you, the number of your starbases that have been destroyed, and the amount of energy you used. Final ratings range from Garbage Scow Captain, class five to Star Commander, class one, with 60 different possible ratings. There are four levels of play, from novice to commander.

The graphics and the sound effects are brilliant. Stars whiz past you, your engines whoosh and your torpedoes explode, your klaxon sounds a red alert, and the enemy fighters speed past you, coming from all angles and all sides, firing their exploding torpedoes. Enemy fighters explode in clouds of blue particles, while the sky flashes red whenever you sustain a hit.

The instrumentation of your ship is also impressive. In addition to your Galactic Chart, which is updated by sub-space radio, your color coded instruments tell you the range to the enemy being tracked on the x, y, and z axis, your velocity, shield status, energy level, the condition of your photon torpedoes, engines, computer, long range scan, and your sub space radio. Your target aquisition computer helps you to steer while hyperwarping through space, as well as indicating the relative position and range to enemy fighters. In addition, upon your request it will shift automatically from forward to aft views from your ship as enemy fighters pass by on attack runs. The joystick allows you to climb, dive, veer right and left, and to combine vertical and horizontal movement, while twenty more keys on the keyboard control speed and function selection.

Star Raiders requires a color monitor or television, as much of the information is color coded and does not show up in black and white. I cannot pin down any definite bugs, although it is often hard to orbit a star base, and I did have a system lockup once in the middle of a game that required me to turn the power off and on again and restart the game.

This game goes beyond the quality of the games you see in video arcades. The sound effects, color, and action are just as good, the physical environment is a bit less impressive, but the real change is the strategy. Since an arcade game must produce $10 an hour in revenue, those games have to be active and short. Grand strategy is not possible. A home computer does not suffer from the same constraint, so the

Outpost, cont'd...

game can actually be better, and Star Raiders is better. The true video arcade addict can justify the purchase of an Atari 400 in a few months of unspent quarters.

If you have an Atari, buy this game! If you don't have an Atari, sell your car (you'll never leave home again anyway), put your children up for adoption so they won't take over the computer, and buy one. Then play Star Raiders until the last stardate fades into the collapse of the universe.

Photo 1

Atari Sound

As a programming feature this month, I'd like to discuss the Atari SOUND command. The format for the sound command is as follows:

SOUND (Voice) , (Pitch) , (Distortion) , (Volume)

You can have up to four voices, or notes, that can be played at the same time, numbered from 0 to 3. Each voice is totally independent of the others.

Pitch can range from 0 to 255, with high C at 29 and low C at 243. Distortion (timbre) can take any even number from 0 to 14. The value 10 gives a pure tone, while other values are used for sound effects. Volume can range from 1, which is hard to hear, to a loud 15. If you are using three or four voices, you should limit the total volume to 32 or less to avoid distortion. To turn the sound off, use the command END or set the volume for that voice to 0.

This program will demonstrate the range of sound available, displaying the value on the screen so that you can note sound effects you would like to use. Really good sound effects will mix several voices.

```
10 FOR A = 0 TO 14 STEP 2
20   FOR B = 0 TO 255
30     SOUND 0, B, A, 8
40     PRINT"SOUND 0, ";B;", ";A;", 8"
50       FOR C = 1 TO 250 : NEXT C
60   NEXT B
70 NEXT A
```

I like SOUND 0, 6, 0, 8 : SOUND 1, 21, 0, 8 : SOUND 2, 27, 0, 8 : SOUND 3, 40, 0, 8 for an explosion, SOUND 0, 17, 8, 8 for a Phaser, SOUND 0, 30, 8, 14 for a gun shot, SOUND 0, 70, 2, 8 for a truck motor, SOUND 0, 145, 2, (1 to 12 to 1) for an airplane motor, and SOUND 0, 12, 4, 10 for a machine gun, but I am sure you will have your own choices.

Three Dimensional Graphics

Tim Hays has developed a 3 dimensional computer graphics package for Atari computers with the ability to take a data base and view it from different angles. There are four programs in the package, and the fourth one includes a demonstration that was a traffic stopper at the Computer Faire, (see Photo 1), especially in one display that showed the space shuttle in high resolution graphics from 4 different angles.

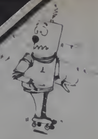
In order to create your own display, you must dust off your high school geometry and enter the x,y,z coordinates of the starting and ending point of each line. Then you specify the color you desire, the coordinates of the viewer's locations, and the pitch, bank, and heading for the drawing. The program then calculates the screen starting and ending point for each line and plots it. The program is very sophisticated, and has the ability to calculate partial lines when the lines run off screen.

The program will run on an Atari 400 for low resolution color graphics, but requires 16K of memory for high resolution, and 24K for the demonstration program. A manual, with listings, is provided, and the listings are good study material for programming technique.

The 3-Dimensional Graphics package is a good buy at $29.50 plus $1.50 postage and handling from Sebree's Computing, 456 Granite Avenue, Monrovia, CA 91016. □

Its what you learn after you know it all that counts.

TRS-80 LEVEL II



Board Games-1, CS-3001 (16K)

• Mugwump $7.95

Mugwump is a board game which uses a 10x10 grid on which four friendly Mugwumps are hiding. Your mission is to locate these mysterious animals and capture them.

• Flip Disc

Are you an Othello freak? Flip Disc is a program which will turn your computer into an excellent opponent. Three different skill levels, (good, expert, and genius), provide an introduction for the novice and continuing interest for the experienced player.

• Wumpus

In game 1, you scour a network of underground caves in search of the prized Wumpus. Bagging a Wumpus wins the game, but if you accidentally stumble into his cave, the Wumpus will enjoy a tasty dinner of sauteed computer freak.

• Wumpus 2

If you master the dodecahedron cave network in Wumpus 1, you may proceed to Wumpus 2 which allows you to choose from five different caves, or you can design your own.

• Qubic

Qubic is a three dimensional Tic Tac Toe game. The game is played in a 3 dimensional cube (4x4x4). The object is to outwit the computer and place four pieces in any straight line.

• Backgammon

This is the TRS-80 adaptation of the popular board game. Backgammon uses graphics and all the standard backgammon rules, not a strange computer variation. The computer is your opponent in this version, written by Scott Adams of "Adventure" fame.

WRITE FOR...
FREE
SOFTWARE CATALOG

Space Games-3, CS-3002 (16K)

• Ultra-Trek $7.95

Ultra-Trek is a fast-paced version of Star Trek, complete with "real time" action graphics, lasers, Nilon space mines, high energy photon torpedoes, enemy ships that move, and an experimental ray which does something different each time you use it. You must act quickly to save yourself and the Federation.

• Star Lanes

Imagine yourself the president of an intergalactic shipping company. If you're successful, you may be named Imperial Advisor on Economic Affairs. Entrepreneurs: to your ships.

• Star Wars

If you hate Darth Vader, you'll love Star Wars. This real time game is fun for aliens of all ages. May the Force be with you!

• Romulan

Your mission is to destroy an invading Romulan space craft. Maneuver through space and around stars looking for the deadly enemy, but be careful! The nasty Romulans fire back.

How To Order

Send order and payment to **Creative Computing**, P.O. Box 789-M, Morristown, NJ 07960. Add $1.00 shipping and handling per order (foreign, $2.50) N.J. residents add 5% sales tax. Visa, MasterCharge and American Express orders welcome. For faster service, call in your bank card order toll free to: **800-631-8112.**(In NJ, call (201) 540-0445.)

sensational software

Strategy Games, CS-3005 (16K)

• Tunnel Vision $7.95

You are transported into a massive labyrinth and must find the exit or be lost forever. This is an excellent example of three dimensional perspective using TRS-80 graphics.

• Evasion

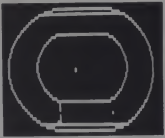
In this real time game, you are pursued around the game board by an evil-looking snake. Variations of play include two different speeds and hyper-jumps which randomly relocate you on the board. Looking for an escape? Try Evasion.

• Jigsaw

Jigsaw is a computer-age puzzle game making extensive use of TRS-80 graphics. The computer generates a random puzzle and puzzle board. Using a combination of deductive reasoning and luck you must fit the graphically represented puzzle piece into place.

• The Masters

Are you a wandering pro or just a Sunday golfer who would like to keep in practice? Once you're on the green, a worm's-eye view is displayed for putting.



• Motor Racing

Motor Racing combines real time racing action with advanced graphics functions. The graphics and animation make Motor Racing fun to watch as well as play.

Adventure

Welcome to an astonishing new experience! **ADVENTURE** is one of the most challenging and innovative games available for your TRS-80.

• Adventureland

You wander through an enchanted world trying to recover the 13 lost treasures and encounter WILD ANIMALS, MAGICAL BEINGS, and many other perils and puzzles.

CS-3008 TRS-80 16K Level II $14.95
CS-3506 TRS-80 48K DISK $24.95
(Includes Pirate Adventure)

• Pirate Adventure

Can you recover LONG JOHN SILVER's lost treasure

CS-3007 TRS-80 16K Level II $14.95
CS-3506 TRS-80 32K DISK $24.95
(Includes Adventureland)

• Mission Impossible Adventure

Will you be able to complete your mission in time? Or is the world's first automated nuclear reactor doomed?

CS-3009 TRS-80 16K Level II $14.95
CS-3507 TRS-80 32K DISK $24.95
(Includes Voodoo Adventure)

• Voodoo Castle

Count Cristo has had a fiendish curse put on him by his enemies. Will you be able to rescue him or is he forever doomed?

CS-3010 TRS-80 Level II $14.95

CS-3507 TRS-80 32K DISK $24.95
(Includes Mission Impossible)

• The Count

You'll love this Adventure; in fact, you might say it's LOVE AT FIRST BITE . . .

CS-3011 TRS-80 Level II $14.95

Economic and Ecology Simulations

The Ecology Simulations series are a unique educational tool. They are based on "simulation models" developed by the Huntington Two Computer Project at the State University of New York at Stony Brook under the direction of Dr. Ludwig Braun. The programs and accompanying documentation are written for self-teaching or classroom use and include background material, sample exercises and study guides. Graphic displays were specially developed by Jo Ann Comito at SUNY and Ann Corrigan at Creative Computing. The Ecology Simulations packages are a remarkable educational application of micro-computers.

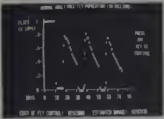
Ecology Simulations-1, CS-3201 (16K)

1. Pop

The POP series of models examines three different methods of population projection, including exponential, S-shaped or logistical, and logistical with low density effects. At the same time the programs introduce the concept of successive refinement of a model, since each POP model adds more details than the previous one.

2. Sterl

STERL allows you to investigate the effectiveness of two different methods of pest control—the use of pesticides and the release of sterile males into the fly population. The concept of a more environmentally sound approach versus traditional chemical methods is introduced. In addition, STERL demonstrates the effectiveness of an integrated approach over either alternative by itself.



3. Tag

TAG simulates the tagging and recovery method that is used by scientists to estimate animal populations. You attempt to estimate the bass population in a warm-water, bass-bluegill farm pond. Tagged fish are released in the pond and samples are recovered at timed intervals. By presenting a detailed simulation of real sampling by "tagging and recovery," TAG helps you to understand this process.

4. Buffalo

BUFFALO simulates the yearly cycle of buffalo population growth and decline, and allows you to investigate the effects of different herd management policies. Simulations such as BUFFALO allow you to explore "What if" questions and experiment with approaches that might be disastrous in real life.

IQ Test, CS-3203 (16K)

IQ tests have been the subject of a great deal of controversy in the past few years. Yet, few of us know our IQ score. Now you can find out with our IQ test.

Taking advantage of the TRS-80's graphic capabilities, this test consists of 60 multiple choice questions. A special machine language routine does the scoring of the test and makes cheating almost impossible.

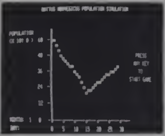
Ecology Simulations-2, CS-3202 (16K)

1. Pollute

POLLUTE focuses on one part of the water pollution problem, the accumulation of certain waste materials in waterways and their effect on dissolved oxygen levels in the water. You can use the computer to investigate the effects of different variables such as the body of water, temperature, and the rate of dumping waste material. Various types of primary and secondary waste treatment, as well as the impact of scientific and economic decisions can be examined.

2. Rats

In RATS, you play the role of a Health Department official devising an effective, practical plant to control rats. The plan may combine the use of sanitation and slow kill and quick kill poisons to eliminate a rat population. It is also possible to change the initial population size, growth rate, and whether the simulation will take place in an apartment building or an entire city.



3. Malaria

With MALARIA, you are a Health Official trying to control a malaria epidemic while taking into account financial considerations in setting up a program. The budgeted use of field hospitals, drugs for the ill, three types of pesticides, and preventative medication, must be properly combined for an effective control program.

4. Diet

DIET is designed to explore the effect of four basic substances, protein, lipids, calories and carbohydrates, on your diet. You enter a list of the types and amounts of food eaten in a typical day, as well as your age, weight, sex, health and a physical activity factor. DIET is particularly valuable in indicating how a diet can be changed to raise or lower body weights and provide proper nutrition.

Social and Economic Simulations CS-3204 (16K)

1. Limits

LIMITS is a micro-computer version of the well known "Limits to Growth" project done at MIT. It contains a model of the world that is built of five subsystems (population, pollution, food supply, industrial output, and resource usage) linked together by six variables: birth rate, death rate, pollution generation, resource usage rate, industrial output growth rate, and food production rate.

2. Market

Market allows two or more people to play the roles of companies who are competing for the market for a particular product: in this case, bicycles.

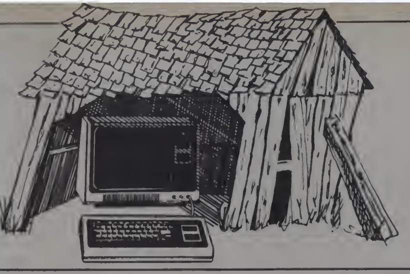
Each player makes marketing decisions quarterly including the production level, the advertising budget, and the unit price of the product for his/her company.

3. USPop

USPOP allows the user to study many aspects of the United States' human demography (population change) including population growth, age and sex distribution. USPOP makes population projections and investigates the consequences of many different demographic changes.

Ordering Information Opposite.

TRS-80 Strings



Stephen B. Gray

This is the 19th TRS-80 column, which contains a few words about the SCRIPSIT word-processing package, Radio Shack's lower-case modification, Line Printer II, a plug to prevent hangups on LPRINT and LLIST, a number-guessing game and a short program that creates a surprise message.

Word Processing With SCRIPSIT

Business use of word-processing systems is expanding rapidly as companies discover the inherent savings of time and money in writing letters and documents electronically.

Xerox recently became the leading manufacturer of word-processing equipment, and others such as Vydec, Lanier, Wang and Digital Equipment Corp. are also doing very well.

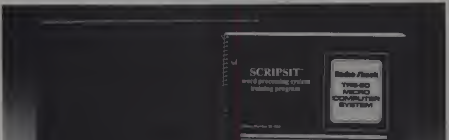
Now Radio Shack offers word processing for the TRS-80, on disk for $99.95, and on tape at $69.95, for 16K Level-II systems.

The SCRIPSIT software lets you compose a letter or write a multi-page document, and then do an incredible variety of editing tasks on the text, before printing it out.

You can correct, change, insert, transpose or delete words, sentences, paragraphs and entire blocks of text, right-justify, center lines, hyphenate words at the end of a line, set tabs, number pages automatically, print headers and footers automatically, print all or part of a text, and that's only part of it.

Using a really fancy instruction such as Global Replace, you can replace every occurrence of a word with another word, such as changing all "Democrat" references to "Republican," and do it with only this:

```
R>DEMOCRAT>REPUBLICAN
```



which will change all mentions of the first, to the second, when you simply press ENTER.

If that sounds powerful, here's another feature of SCRIPSIT that looks almost like magic. You type out the text on the screen, and then if you wish to change the width of the text, just hit BREAK, type in a W- and add the new line width. Then watch the words scurry around to adjust to the new line width, before you can take your finger off the ENTER key.

The Radio Shack word-processing package consists of a binder containing a training program with a manual and six lessons on three audio cassettes, the SCRIPSIT machine-language program on tape or disk, and a tape or disk of several texts to be used in the lessons.

The disk and tape training programs are identical except for the references to the different media. The 60-page spiral-bound manual guides you through the six lessons, which may take you as little as half an hour each in some cases, or up to an hour for some others. All six took me five to six hours to complete.

The first thing to do is to stick 17 press-on labels to the front of some of your keyboard keys. This takes about 20 minutes.

The audio tapes, played on your tape recorder with the earphone and remote plugs removed, provide much material that's not in the manual. So if you want to look up something later, you have an Instruction Summary at the end of the manual, and a separate Instruction Summary Card. These are fine once you've mastered SCRIPSIT, but that may take a while. So you may have to run through some of the lesson tapes several times. SCRIPSIT needs a good reference manual to accompany it. As usual, Radio Shack is a little too skimpy with the written word.

Lesson Five, which I thought would drive me nutty, took well over an

Strings, cont'd...

hour. In my notes, I wrote, "One mistake, and you can't get back to where you were before. There's just not enough information on what you're doing to give you enough knowledge to get yourself out of a bind."

What bothers me most about SCRIPSIT is not being able to see a complicated text layout on the screen before printing it. On many standard word-processing systems, you have the option of seeing a page exactly as it will look when printed, with the page header and footer in place, page number showing, and the text itself set up according to width, justification and centering instructions.

Perhaps 16K isn't enough to include such an option, which would save a lot of printout paper. All you see on the screen for headers and footers, for instance, are things like

```
HE>J=N C=N FR=Y
```

which tells you that there will be a header on the even pages, with text justified, no centering and flush right. But you can't be sure what you're going to get until you've had a lot more experience with SCRIPSIT, or until you see the printout.

But despite the problems I had figuring out how to use SCRIPSIT, I'll probably use it more than any other program I have. It's great for writing letters, and I may even use it for writing this column, because all the corrections and changes and inserts can be made electronically, without having to mark up a bunch of printed pages.

By far the main advantage for me is that I wouldn't have to type up a final copy, a chore most writers hate. Just hit BREAK, P and ENTER, and the entire text is printed out, in page-length format, with all headers automatically inserted on each page. To paraphrase the Radio Shack ad, "Once you've tried TRS-80 word processing, you may never want to use a typewriter again!" You may even be able to make money with a Radio Shack word-processing system, by offering to print computerized letters for a local businessman.

Lower-Case Modification

The SCRIPSIT word-processing system is easier to use if you have Radio Shack install the $99 lower-case modification on your 16K Level-II keyboard.

The conversion makes the text on the screen easier to read, because you get "true lower-case descenders," meaning that the tails of five letters hang down below the printing line, as they do in typesetting:

g j p q y.

The difference on the screen is slight, because the tails hang down only one raster line below the printing line, with the modification. This is only about 1/32 of an inch, but it is enough to make the text easier to read, because otherwise the text will look like what you get with many printers, which squeeze the descenders up into the standard dot-matrix field, so you get

```
Jumping query
```

which can make proofreading a long text a lot more eyestraining than if it were more like

jumping query.

Note that the lower-case modification affects only what you see on your TRS-80 *screen*. Whatever gets printed out, depends entirely on the printer. Only the more expensive ones have "true lower-case descenders."

Also, the lower-case version isn't required for SCRIPSIT. The training tape that provides three recorded texts to work with, has an Uppercase Version on one side, and a Lowercase Version on the other.

The lower-case version, according to Radio Shack, "is NOT intended to be used with existing Radio Shack programs, but may be used with programs you write . . . The lower-case modification may not work with some non-Radio Shack programs."

After the lower-case version is installed, you have to load a machine-language driver program "every time the computer is turned on if you require lower-case capability." (SCRIPSIT includes the Lowercase Driver.) The cassette that comes with the mod has both tape and disk versions on it.

Installing the Lower-Case Mod

With the very kind permission of a Rado Shack vice-president, and of store manager Murray Adelman, I was allowed to watch Steve Benford, service-center manager and technician at the Computer Center at 9 Broadway in Manhattan, while he installed the lower-case modification.

He took about 15 minutes to replace the old character-generator ROM with a new and different one, to replace the single video RAM with two new ones, and to cut a lead on the PC board.

We talked about the difference between Radio Shack's lower-case modification and the mods offered elsewhere. The difference, Benford said, is that the others use the same character generator that's already in the TRS-80, whereas "the Radio Shack conversion has true extenders, which make the display look more natural," as he put it.

While he had the case open, he also installed the free cassette-loading modification (*Creative*, May 1979, p. 130). This is an AGC circuit that allows you to load cassettes with the volume control set anywhere between 3 and 8.

Benford had installed so many of these mods that he was able to do mine in all of five minutes, with the unhurried and careful skill of a born technician.

His skills were put to the test right off, before installing either of the two mods, when he checked out the problem I'd been having for some time with my machine, which on PRINT MEM would come up with anything from 8578 to 15572.

He found the Level-II kit to have been improperly installed, and a wire in the wrong place. (This was one of the first Level-II TRS-80s, and perhaps the kit installations weren't yet going smoothly.)

He ran a memory test, using a special test disk, found something wrong, switched the three ROMs, found them OK, then switched the eight RAMs, found one faulty. Within 18 minutes he'd found the problem and solved it by replacing the faulty RAM.

After then installing the two mods, he ran tests on both, which took a total of three minutes.

The entire operation, fixing the memory problem and installing two mods, took only 55 minutes. The service center at 9 Broadway is a large and airy room, about 20 by 20, with a 10-foot ceiling, and two sides of the room devoted to repair space. A pair of Model I TRS-80s and one Model II were on the bench as permanent checkout machines, along with a Tektronix 465B scope, disk drives and the usual hand tools and soldering equipment.

Benford enjoys his work, and I enjoyed watching him work as, with skillful analysis, he found out what was wrong with my TRS-80, fixed it in a few minutes, and went on to make two modifications in a few more minutes.

Hardware for Word Processing

To use the SCRIPSIT word-processing software, you need a 16K Level-II TRS-80, an expansion interface or a printer interface cable, cassette-tape player and a line printer.

Radio Shack offers a daisy-wheel printer, with high-quality printing, at $2,999.

If your funds are limited, there are other choices. You wouldn't want to use either the $499 Quick Printer or the $219 Quick Printer II, because

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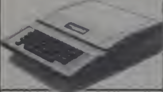

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CIRCLE 161 ON READER SERVICE CARD

Z-80/TRS-80™ Users
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THE Z-80: HOW IT WORKS
(THE PROGRAMMERS PERSPECTIVE)
By Monte Corum
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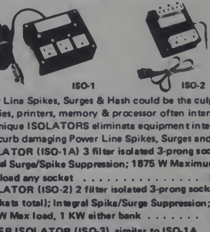
CIRCLE 166 ON READER SERVICE CARD

DISK DRIVE WOES? PRINTER INTERACTION?
MEMORY LOSS? ERRATIC OPERATION?
DON'T BLAME THE SOFTWARE!



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171 South Main Street, Natick, Mass. 01760
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CIRCLE 142 ON READER SERVICE CARD

Strings, cont'd...

although they're inexpensive, the printout isn't suited to word processing.

Both printers use narrow paper coated with a thin layer of aluminum that is vaporized, dot by dot, by a low-voltage discharge from the printhead. Under the aluminum top coating is a black layer that shows through the holes in alphanumeric dot-matrix patterns.

The printout is suitable as a hard copy of programs, but for word-processing applications, you'll have to go to a line printer that uses standard, more easily read paper.

The Line Printer II, at $970, is at the top of the personal computer printers offered by Radio Shack, and at the bottom of the business printers. It isn't meant for heavy, constant use in a business environment, for which you'd need the $1,559 Line Printer I or the $1,960 Line Printer III.

One of the most attractive features of the Line Printer II is that it is the only Radio Shack printer that takes continuous forms, single sheets and roll paper. If you've set up SCRIPSIT to print on single sheets, at the end of each page printing will be interrupted, and the message

```
PRESS ENTER TO PRINT NEXT PAGE
```

will appear on the screen. Insert another sheet of paper in the Line Printer II, press ENTER and away you go.

At one time you needed the $299 expansion interface to attach a Quick Printer or Line Printer to your TRS-80. But now there are active cables, at $59, which do the same job, but cheaper.

Although Radio Shack prefers to present a monolithic front pretending they make everything in the TRS-80 catalog, most of us know that just isn't possible. The Quick Printer, Line Printer I and Line Printer II are made by Centronics Data Computer Corp. of Hudson, NH, as the P1, 779 and 730, respectively.

The 730 uses the same free-flight printhead found in all Centronics computer-grade 700 printers, of which over 100,000 have been installed worldwide. The company is aiming at manufacturing about 100,000-730 miniprinters a year. Centronics has almost 1,000 active OEM customers, of which Radio Shack is one of the biggest.

Stop Computer Hangups

These three words are the motto behind Dick Fuller's latest invention. His RF-II dual-cassette switchbox is the handiest gadget I've found (*Creative*, March 1979, p. 128) for eliminating the plugging and unplugging of cables when you CLOAD and CSAVE, and I use it constantly.

The new LPRINT/LLIST Plug, at $11.95, from Fuller Electronics (7465 Hollister Ave., Suite 232, Goleta, CA 93017) "will allow an LPRINT or LLIST to pass through your TRS-80 without having a printer connected to your interface."

This very simple device, a small female plug that you simply "plug into your interface line-printer port," makes the computer "think there is a printer connected and dumps the data out of the port and returns the keyboard to you."

"Now you can run a program with LPRINTs in it without first moving all LPRINTs if you do not have a printer," as the sheet accompanying the plug puts it. It continues, "If you do have a printer you can now run your programs late at night without using your printer, and avoid the risk of awakening the wife and kids. It is a must when writing a program with LPRINTs in it when you have to run through that area of the program time and time again but do not need a printout."

Can't CLOAD It?

The free Level-II cassette-load modification not only eliminates what previously were sometimes critical volume-control adjustments, but can sometimes permit loading a program that just couldn't be loaded before at all.

This next program is one I managed to load once, and then couldn't load again, before the cassette-load mod. Afterwards, it loaded and ran on the first try.

Bulls/Hits

One of the games available from The Computer Bus (Box 397K, Grand River, OR 44045) is Bulls/Hits, at $9.95 for 4K Level-I or 16K Level-II.

Bulls/Hits is essentially the same as Noddle, a 1968 board game written by Mike O'Toole for Selchow & Richter, the Scrabble company.

Mike wrote other games for Selchow & Richter, and has been making $10,000 to $12,000 a year out of Noddle. His royalty is only five percent, but the game "is sold all over," he says.

Noddle is a forerunner of Mastermind. It is also a descendent of Bulls And Cows (in *101 Basic Computer Games*, edited by David H. Ahl, abbreviated for that book as BULCOW).

BULCOW was not carried over to the microcomputer edition of *Basic Computer Games*, which instead includes Mastermind, as does the TRS-80 edition of the same *Creative Computing* book.

Mike O'Toole's Bulls/Hits can be played by one or two people. In the single-player version, you try to guess the secret four-digit number selected by the computer. According to the Bulls/Hits information sheet, "The computer will indicate under the B column how many digits are in the right position, and under the H column how many right digits are in the wrong position."

In the two-player version, each player can select the secret number for the other to guess, and keep track of the bulls and hits, or let the computer do both.

Strings, cont'd...

In either version, scoring depends on how many turns are needed to guess the secret number.

Bulls/Hits has an "Uncle" option for use by the "hopelessly lost." Penalty points are added to your opponent's score, and you're assigned a new secret number, if you cry "Uncle." The "Challenge" option may be used "if at any time a player suspects the Bulls/Hits information is false . . . If the opposing player provided false information, the offending player is penalized."

You get seven turns in the single-player version. If you try to cheat by inputting 3333, the computer says

```
ILLEGAL GUESS!!
THAT'LL COST YOU YOUR TURN
```

If you don't guess the secret number, the word HEE! flickers on and off at locations all over the right side of the screen (the scoreboard is at the left of the screen in the single-player version).

In the two-player version, the computer doesn't laugh at you if you lose. It just says you've made too many guesses.

At the beginning, the program asks for your name. If you win, the display reads

```
VERY GOOD, STEVE, YOU GOT IT!
```

(that is, if I win), but that happened only once out of every dozen or more games I played.

Another game from The Computer Bus is Black*Stars, a space-grid capture game, for two, three, four or more players, also $9.95 for 4K Level-I or 16K Level-II.

Bulls/Hits is recorded only once on the cassette.

Short Program #10

Phil Ham of North Platte, Nebraska, sent only a Level-II printout, which I've rearranged slightly to make shorter lines, and then renumbered:

```
100 FOR K=1 TO 23
110 READ L
120 A$=A$+CHR$(L)
130 NEXT K
140 CLS
150 R=RND(255)
160 IF R=100 THEN 190
170 PRINT CHR$(R);
180 GOTO 150
190 CLS
200 PRINT CHR$(23)
210 PRINT @ 390,A$
220 FOR T=0 TO 500
230 NEXT T
240 GOTO 140
250 DATA 72,69,76,80,32,73
260 DATA 44,86,69,32,71,79
270 DATA 78,69,32,66,69,82
280 DATA 83,69,82,75,33
```

The first effect of this program when RUN is something like that of the Fox program in last month's TRS-80 column. It creates short random groupings of letters, numbers, and graphics characters at random locations. The difference is that every now and then the screen clears and a message appears, one that will come as quite a surprise to anybody who unknowingly tries to run a program containing these 19 lines.

Lines 100-130 plus 250-280 create a message assigned to A$. Lines 150, 170 and 180 evoke the random characters. In line 160, if the random number generated is 100, the screen is cleared by line 190 and a double-width (line 200) message is shown, at a location determined by line 210. Lines 220 and 230 determine how long the message is displayed. Then lines 240 and 140 clear the screen for more random characters.

Can you figure out what the message is, without running the program? □

Compleat Computer Catalogue

Computers

CP/M COMPATIBLE SYSTEMS

Quay Corporation has added two models to its CP/M-compatible desktop microcomputer series.

Both models utilize the Z80-based, 94F/MPS single board computer and include 32Kb dynamic RAM, expandable to 65Kb; DMA-based disk access; two 5 1/4" flexible disk drives; the CP/M (version 2.0) disk operating system with prom-resident boot program; RS-232 or TTY serial port and a Centronics-compatible line printer.

The Quay 500 system provides a formatted disk capacity in excess of 400 Kilobytes and has a single unit price of \$2500; the 520 system has a formatted disk capacity in excess of 800 Kilobytes and has a single unit price of \$3200.

Quay Corporation, P.O. Box 386, Freehold, NJ 07728. (201) 681-8700.

CIRCLE 351 ON READER SERVICE CARD

THREE SMALL BUSINESS SYSTEMS

A new line of small business computer systems has been introduced by Alpha Micro. The AM series 1011, 1031 and 1051 computers are multi-tasking, multi-user, multi-processor, time-sharing computers. All are designed for large scale programming in Basic and other high level languages.

All three systems include a 16-bit processor with two on-board serial I/O ports and one parallel I/O port. The 64K of dynamic RAM memory standard with each system can be expanded in 64K increments up to one megabyte in the standard chassis.

The standard software package consists of a macroassembler; Alpha Micro versions of Basic, Lisp and Pascal; word processing software and utility programs.

Alpha Micro, 17881 Sky Park North, Irvine, CA 92714. (714) 957-1404.

CIRCLE 352 ON READER SERVICE CARD

6809-BASED SYSTEM FEATURES MULTI-USER 20 MB HARD DISK

Smoke Signal Broadcasting has introduced a 6809-based series of Chieftain Business Sytems featuring multi-user and 20 megabyte hard disk options.

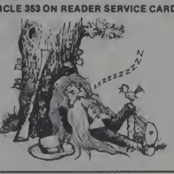
The new system is configured around SSB's Chieftain microcomputer with 64KB of main memory and the DCB-4 disk controller capable of handling four 8" floppy disks, each storing a full megabyte of data. The hard disk provides 10MB of fixed and 10MB of removable storage and can be accessed by up to four users.

The Chieftain series of business systems supports Cobol, Fortran and UCSD Pascal.

Prices range from \$5000 to \$8400. The hard disk and multi-user options are an additional \$8500.

Smoke Signal Broadcasting, 31336 Via Colinas, Westlake Village, CA 91361. (213) 899-9340.

CIRCLE 353 ON READER SERVICE CARD



Terminals & I/O

DOT MATRIX IMPACT PRINTER

DIP, Inc., announces the second model of a series of Data Impact Printer, DIP-84, a low-cost, high reliability, dot matrix impact printer with tractor paper feed.

It features 7 x 7 or expanded 14 x 7 matrix printing, upper/lower case character set, 100 characters per second bidirectional print-out, roll or fan-fold paper and a low profile. The tractor is adjustable for paper width from 2.5 inches to 9.5 inches and is stepping motor controlled.

Complete with microcomputer electronics, DIP-84 is designed to interface directly with mini and micro computers. \$575.

DIP, Inc., 121 Beach St., Boston, MA 02111. (617)482-4214.

CIRCLE 354 ON READER SERVICE CARD

LETTER QUALITY PRINTER INTERFACE

The I/OMaster S-100 Interface Board from MicroPro allows flexible use of either lower cost letter-quality printers, or high speed line printers within the same microcomputer configuration.

Interfacing with the less expensive

OEM versions of the NEC, Diablo and Qume letter-quality printers, I/OMaster can also be used with high speed Centronics/Data Products printers for draft and non-letter-quality applications.

Combining four boards in one, I/OMaster features two each serial and parallel ports as well as an eight level interrupt control and dual interval timer circuitry. $400.

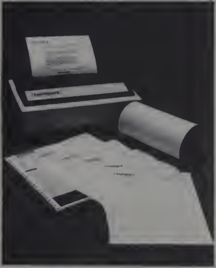
MicroPro International Corporation, 1299 Fourth St., San Rafael, CA 94901. (415) 457-8990.

CIRCLE 355 ON READER SERVICE CARD

SMALL BUSINESS PRINTER

Centronics Data Computer Corp. has introduced the Model 737, the latest addition to its Model 730 small business computer printer family.

The Model 737 prints 7 x 8 dot matrix characters at 10 and 16.5 characters per inch for standard data processing task, and generates N x 9 dot matrix characters in the proportional character spacing used for data and text processing. The adjustable nine-wire free flight printhead prints true lower-case descending characters and underlines. $995.



Centronics Data Computer Corp., Hudson, NH 03051. (603)883-0111.

CIRCLE 356 ON READER SERVICE CARD

COLOR MATRIX PRINTER

Integrex announces the Three Color Serial Matrix Printer type 454C. The microprocessor controlled bi-directional 454C prints 250 characters per second with a single print head on a 9 x 9 matrix. Maximum line length is 155 characters.

Its principal application is in color VDU dumping. Various serial and parallel interfaces are available, including IEEE 488.

Integrex Limited, Portwood Industrial Estate, Church Gresley, Burton on Trent, Staffordshire DE11 9PT England.

THERMAL PRINTER FOR APPLE

Apple Computer, Inc., introduces the Silentype thermal printer, an advanced text and graphics printer for the Apple computer.

The quiet, low-cost peripheral enables Apple II users to print on paper copies of anything that the computer can display on a video monitor or television screen. Printing modes, formats and intensities are all under the user's control.

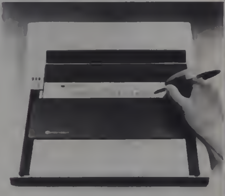
The printer uses a 7-dot thick-film printing element to produce 5 x 7-dot characters and graphics on standard thermal paper. It prints up to 80 characters per line on 8 1/2-inch wide roll-fed paper.

Apple Computer, Inc., 10260 Bandley Dr., Cupertino, CA 95051.

CIRCLE 357 ON READER SERVICE CARD

TERMINAL ACCEPTS HANDWRITING

The Micropad computer terminal allows untrained people to feed handwritten information into a computer or communications system. It is claimed to be the first computer terminal which can accept and recognize hand printing in either ballpoint pen or pencil.



Smaller than a portable typewriter, Micropad has its own built-in microcomputer which recognizes each handwritten character, converts it into ASCII code and transmits it to the host computer via an RS-232/V24 or current loop interface. As each character is accepted by the host, it can be displayed on a 40-character dot matrix display.

Quest Automation, Suite 10006, 575 Madison Ave., New York, NY 10022. (212)486-0282.

CIRCLE 358 ON READER SERVICE CARD

Disk Systems

HARD DISK MEMORY SYSTEMS

Lobo Drives, International has announced three 10-Megabyte winchester technology hard disk memory systems.

The Model 7710 comes complete with IMI 7710 Winchester technology, disk drive, Lobo intelligent controller, precision power supply, interface and related software. It is compatible with most TRS-80, Apple and S-100 disk operating systems, and requires little or no change to system software to operate. $4995.

Lobo Drives, International, 935 Camino Del Sur, Goleta, CA 93017. (805) 685-4546 or (714) 641-1436.

CIRCLE 359 ON READER SERVICE CARD

Peripherals

EXPANSION INTERFACE FOR TRS-80

Lobo Drives, International announces an enhanced expansion interface for the Radio Shack TRS-80.

The Model LX80 has been designed for the serious user who wants to improve and expand the performance and capabilities of the TRS-80. It expands memory storage capacity up to 40 million bytes, provides facilities for up to 32K of RAM and offers a second serial port.

Other features include a parallel Centronics printer port, screen printer port, two microprocessor-controlled bidirectional serial ports and a crystal controlled real time clock. $525.

Lobo Drives, International, 935 Camino Del Sur, Goleta, CA 93017. (805) 685-4546 or (714 641-1436.

CIRCLE 360 ON READER SERVICE CARD

ARITHMETIC PROCESSOR UNIT FOR APPLE

The Model 7811B Arithmetic Processor Unit from California Computer Systems is designed to increase the execution speed of Applesoft II programs and increase the number of math functions available to the programmer. The increased speed allows the Apple to produce more sophisticated high resolution graphics.

The unit plugs into one of the Apple expansion slots. The CCSoft interpreter is then loaded from the diskette provided with the board and the system is ready to execute programs written in Applesoft.

California Computer Systems, 250 Caribbean Dr., Sunnyvale, CA 94086. (408) 734-5811.

CIRCLE 361 ON READER SERVICE CARD

APPLE LIGHT PEN

Aresco, Inc. announces the Lipson Light Pen. It is packaged with 12 Basic programs on cassette tape, a 48-page manual, all the necessary cables and a connector to PDL(0) on the Apple II.

The pen utilizes a cadmium selenide cell for light detection thereby enabling the user to detect and measure varying intensities of light. Hi-res graphics, sound and color are implemented in the demonstration programs, and the user is encouraged to incorporate the demo routines into programs of his or her own design. $24.95.

Aresco, Inc., P.O. Box 1142, Columbia, MD 21044. (301) 730-5186.

CIRCLE 362 ON READER SERVICE CARD

HOME CONTROLLER INTERFACE FOR TRS-80

Small System Software announces the Whistler, a software controlled ultrasonic interface designed to allow complete control of the BSR Home Control System for the TRS-80.

Whistler contains an ultrasonic oscillator and piezoelectric transducer, and is controlled with signals from the tape recorder output port. Cassette software (also compatible with disk systems) included with the Whistler contains all the necessary coding patterns for full control of all BSR functions. $34.95.

Small System Software, P.O. Box 366, Newbury Park, CA 91320.

CIRCLE 363 ON READER SERVICE CARD

RS-232 TURTLE INTERFACE

Terrapin, Inc., manufacturers of the Terrapin Turtle, now provides a pluggable interface from any standard RS-232 line to the Turtle.

The TST-1 plugs into any standard 110 volt wall socket, into any standard serial line, and then into the Turtle, thus making Turtles completely pluggable for TRS-80, Apple, DEC and other computers.

The TST-1 also allows the user to hook up more than one Turtle to a computer, terminal or modem. $150.

Terrapin, Inc., 678 Massachusetts Ave., Cambridge, MA 02139. (617) 482-1033.

CIRCLE 364 ON READER SERVICE CARD

BELL-COMPATIBLE MODEM

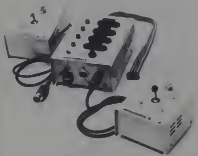
Universal Data Systems announces a Bell-compatible Model 102 modem that enables digital devices (computers and interactive terminals) to communicate with each other via the analog facilities of the public telephone network. The new unit allows full-duplex data communication over an ordinary two-wire circuit at speeds up to 300 bits per second.

The 103LP is independent from the ordinary AC electrical system. All necessary operating power is taken directly from the telephone line. $200.

UDS, 5000 Bradford Dr., Huntsville, AL 35805. (205) 837-8100.

CIRCLE 365 ON READER SERVICE CARD

MICROBOX AND MICROSTIKS FOR APPLE



CJM Industries announces the Microbox and Microstik for the Apple.

The Microbox plugs into the apple game socket. It has four AC outlets which can control external devices by commands from keyboard or programs.

Two heavy duty jones plugs and sockets connect matching joystick modules or Microstiks. Three push-buttons provide additional external input to the Apple.

CJM Industries, Inc., Dept. MB, 316B Victory Dr., Herndon Industrial Park, Herndon, VA 22070. (703) 471-4291.

CIRCLE 366 ON READER SERVICE CARD

REAL-TIME ANALYZER FOR TRS-80 AND APPLE

The VTU02 and AIB232, real-time audio spectrum analyzers for TRS-80 and Apple, respectively, divide the audio spectrum from 200Hz to 20kHz into 31 third-octave bands, and display these bands with their relative amplitudes on the computer CRT. The units can be used for measuring sound and noise levels, for optimizing the equalization of a hi-fi or public address system, for checking the frequency response of audio components, and for speech and sound pattern recognition.

The AIB232 displays the color of each bar under software control.

Eventide Clockworks, Inc., 265 West 54th St., New York, NY 10019. (212) 581-9290.

CIRCLE 367 ON READER SERVICE CARD

Miscellaneous

CASSETTE ERASER

Magnesonics announces the Erasesure cassette erasing unit. To erase a previously used cassette, the user passes it slowly across the erasing field. $24.95.

Also available is Rapid Rewind which will wind a C-60 cassette in 30 seconds. The manufacturer says the device will stabilize cassette tape tension and eliminate binding. $24.50.

Magnesonics Sales, PO Box 758, Ventura, CA 93001. (805) 642-3092.

CIRCLE 368 ON READER SERVICE CARD

CARRYING CASES FOR APPLE AND TRS—80

Computer Textile, Inc. announces rugged, custom-designed computer system carrying cases for both Apple and TRS-80.

The TRS-80 case has room for the TRS-80 keyboard module, expansion interface, two disk drives, power strip, two boxes of diskettes and manuals. It measures 30" x 22" x 9".

The Apple case has room for the Apple computer, 9" Sanyo monitor, two disk drives, power strip, two boxes of diskettes and manuals. It measures 20" x 21 1/2" x 10 1/2". $179.

Computer Textile, Inc., 10960 Wilshire Blvd., Suite 1504, Los Angeles, CA 90024. (213) 477-2196.

CIRCLE 369 ON READER SERVICE CARD

FILING SYSTEM FOR DISKETTES

The Flex-File Page provides a way to file, store and protect flexible disks. It is a non-glare vinyl page with pockets on each side to house two 8" diskettes plus a center pocket to store standard 8 1/2 x 11" sheets of paper, computer printouts or other documentation.

The pages are three-hole punched for storage in standard three-ring binders. $8.95.

BIS, Inc., P.O. Box 969, Brentwood, TN 37027.

CIRCLE 370 ON READER SERVICE CARD

ELIMINATE LIGHTNING AND CHIP BLOWOUTS

It's all too easy to blow out your CPU chip with a light touch after you've shuffled across a carpet. New "StatZap" mats and matting from Crown Industries solve a problem commonly found in offices and plants: static electricity.

Now you can get special computer-room rugs in cranberry red, jungle green Aztec gold, Baltic blue and brownstone. The mats are said to be stain and soil-resistant and still conductive after repeated cleanings. Sizes range from 2'x3' to 4'x10'. These mats and matting have a five-year limited wear warranty.

Crown Industries, 2100 Commerce Dr., Industrial Park, Freemont, OH 43420. (419) 332-5531.

CIRCLE 373 ON READER SERVICE CARD

HEAD CLEANING KIT

Scotch Head Cleaning Diskettes use a wet-and-dry method by which a proprietary cleaning solution is applied to the porous cleaning fabric in the diskette envelope. The cleaning diskette is then run in a normal manner for 30 seconds. $30.

3M, Department DR80-1, Box 33600, St. Paul, MN 55133.

CIRCLE 374 ON READER SERVICE CARD

CONTRAST ENHANCEMENT FILTERS

An easily installed retrofit kit that is said to solve reflection problems and improve display contrast on existing CRT displays has been announced by Polaroid Corporation's Technical Polarizer Division.

The kit consists of Polaroid's CP-70 circular polarizer contrast enhancement filter and self-adhesive mounting brackets that attach to the bezel around the terminal's display screen. $26.

Technical Polarizer Division. Polaroid Corporation, Cambridge, MA 02139. (617) 577-3655.

CIRCLE 371 ON READER SERVICE CARD

APPLE SACK

Apple Sack, a soft vinyl cushioned case, allows for ease in transporting an Apple II, one or two disk drives, game paddles, cables and diskettes in one bag.

Foam within the vinyl gives protection against temperature changes. $85.

Tele-Terminals, Inc., 7216 Boone Ave., N., Brooklyn Park, MN 55428. (800) 328-3072; in Minnesota, (800) 442-3006.

CIRCLE 372 ON READER SERVICE CARD

Vendor Literature

THE SOFTWARE EXCHANGE CATALOG

TSE has announced the publication of its new catalog containing over 100 software items for the TRS-80, ranging from children's games to business systems.

Many programs are available both on cassette tapes and minidiskettes.

The Software Exchange, 6 South St., Milford, NH 03055. (603) 673-5144.

CIRCLE 375 ON READER SERVICE CARD

WORD PROCESSING CATALOGUE

American Word Processing Company announces the 1980 Edition of the 100-page "Guide To Information Processing Accessories and Supplies."

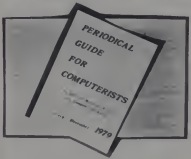
New to its pages are filing and retrieval systems for microforms and disk paks, a low-cost media safe, additional lines of systems furniture, ribbons for microcomputers and WP equipment, more printwheels and thimbles.

American Word Processing Company, 18730 Oxnard St., Tarzana, CA 91356. (213) 705-2245.

CIRCLE 376 ON READER SERVICE CARD

Books and Booklets

PERSONAL COMPUTING INDEX



The January-December 1979 **Periodical Guide for Computerists** indexes over 2000 articles from 20 personal computing and professional electronic publications.

Articles, editorials, book reviews and letters from readers which have relevance to the personal computing field are indexed by subject under 110 categories, and a list of the authors is cross-referenced by subject. $5.95.

E. Berg Publications, 622 East Third, Kimball, NE 69145.

CIRCLE 377 ON READER SERVICE CARD

COMPUTER GRAPHICS DIRECTORY

The first directory devoted exclusively to computer graphics suppliers is now available from The Harvard Newsletter on Computer Graphics, the new twice-a-month periodical published under the auspices of the Harvard University Laboratory for Computer Graphics.

The 1980 directory, to be updated annually, is intended to serve both computer users and vendors that are contemplating a move into graphics as well as those already in the field. $17.

Directory Department, The Harvard Newsletter on Computer Graphics, P.O. Box 89, Sudbury, MA 01776.

CIRCLE 378 ON READER SERVICE CARD

COMPUTER SELECTION HANDBOOK

Decision Resources announces the publication of the **Computer Selection Handbook**. Written specifically for small businesses and consultants, the **Handbook** is a non-technical presentation of a method for selecting computer systems.

It describes how to document small business computer needs, solicit and evaluate vendor proposals, make the selection decision, manage the installation and operation of the new system. $35.

Decision Resources 28203 Ridgefern Ct., Rancho Palos Verdes, CA 90274. (203) 377-3533.

CIRCLE 379 ON READER SERVICE CARD

COMPUTER PERIODICAL INDEX

Dataref announces a reference work for computer professionals. Their cross-reference to computing periodicals provides an index to the major data processing newspapers and magazines.

Advertisements, news items and new product announcements are keyworded, then compiled by subject and vendor. $65.

Dataref, 702 Bloomington Rd., Champaign, IL 61820. (217) 356-4266.

CIRCLE 380 ON READER SERVICE CARD

DATA BASE MANAGEMENT PRIMER

Micro Data Base Systems has prepared a 54-page primer on the subject of data base management.

The primer begins with a description and example of the fundamental CODASYL concepts of sets, record types, data description and manipulation languages and currency indicators. Throughout the primer examples are used to illustrate key concepts.

The primer is free upon request, as long as the supply lasts.

Micro Data Base Systems, Inc., P.O. Box 248, Lafayette, IN 47902. (317) 742-7388.

CIRCLE 381 ON READER SERVICE CARD

Magazines, Newsletters

COMPUTER GRAPHICS INDUSTRY NEWSLETTER

The Anderson Report is offering readers a free sample copy of its latest issue and Inside Report.

Headlining late-breaking developments in the computer graphics industry, including news of new products, people and events, The Anderson Report is aimed not only at equipment and service vendors, but at new and potential computer graphics users faced with selecting equipment and adapting it successfully to specific needs. $60 per year.

Anderson Publishing Company, Simi Valley Business Park, P.O. Box 3534, Simi Valley, CA 93063. (805) 581-1184.

CIRCLE 382 ON READER SERVICE CARD

SOFTWARE DIRECTORY

The Winter 1980 issue of Robert Purser's Magazine contains a software directory for the TRS-80, Apple II, PET, and Atari.

Thirty programs are reviewed, each with at least one photo of the program in action.

The Marin Computer Center continues to do "Game Reviews," a tabulated rating of over 100 games. Also included are articles on word processing, the "Adventure" games, "How to Choose a Good Program," and "A Guide for the Beginner." $4.

Robert Purser, PO Box 466, El Dorado, CA 95623.

CIRCLE 383 ON READER SERVICE CARD

OSI USER'S JOURNAL

PEEK(65), the Unofficial Ohio Scientific User's Journal began publication in January.

Features planned include a Software Exchange, "Peeks and Pokes," user equipment reviews and "Bugs and Fixes." Editorial contributions are invited. $8 for 12 issues.

PEEK(65), 62 Southgate Ave., Annapolis, MD 21401.

CIRCLE 384 ON READER SERVICE CARD

TRS-80 SOFTWARE REVIEWS

A new quarterly publication, **80 Software Critique** is designed to assist a TRS-80 owner in making an intelligent decision about how to spend his software dollar.

A one-year (4 issue) subscription to this collection of reviews of TRS-80 cassette software is $24; the price of a single copy is $7.

80 Software Critique, P.O. Box 134, Waukegan, IL 60085.

CIRCLE 385 ON READER SERVICE CARD

6800 AND 6809 NEWSLETTER

Frontier Computing Inc. announces the **SS-50 Newsletter**, which contains hardware and software features, question and answer columns, news releases, and other articles of interest to the 6800 and 6809 user.

The newsletter is currently issued six times a year by first class mail. Subscriptions are $12 per year. A free sample issue is available on request.

Frontier Computing Inc., 666 North Main, Logan, UT 84321. (801) 753-6530.

CIRCLE 386 ON READER SERVICE CARD

Applications Software

RECREATIONAL, GAMES

Morloc's Tower challenges PET, Apple and TRS-80 owners to rescue a city from the fireballs of Morloc the Mad. Features of the game include graphics, competitive scoring and a choice of three levels of play. $14.95. Automated Simulations, PO Box 4232, Mountain View, CA 94040.

CIRCLE 387 ON READER SERVICE CARD

Gin Rummy 2.0 is said to remember its opponent's plays and adjust its own strategy in response. It allows the player to rearrange his or her hand, keeps score to game level and carries the score over. $14.95. Manhattan Software, Inc., P.O. Box 5200, Grand Central Station, New York, NY 10017.

CIRCLE 388 ON READER SERVICE CARD

BUSINESS

National Software Exchange announces version 2.0 of its **General Business Package** which features general ledger, accounts payable, accounts receivable, payroll and inventory control. The menu-driven package is written in CBasic2. National Software Exchange, 20 Ellerman Rd., Lake St. Louis, MO 63367. (800) 325-8252.

CIRCLE 389 ON READER SERVICE CARD

Using **The Listmaker** from Manhattan Software, the TRS-80 Level II owner can enter up to 400 names or items with five-digit codes to allow detailed identification of groups of names. The program saves to and loads from tape. $9.95. Manhattan Software, P.O. Box 5200, Grand Central Station, New York, NY 10017.

CIRCLE 390 ON READER SERVICE CARD

Fastmail is a mailing list maintenance system for small businesses. It is written in North Star Basic and is designed to be incorporated in the Magic Wand word processing system. $195. Media 2001, P.O. Box 614, Corte Madera, CA 94925. (415) 924-5311.

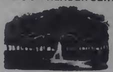
CIRCLE 391 ON READER SERVICE CARD

Mail List File for the TRS-80 automatically converts a mailing list to upper/lower case. It may be contained in any ASCII file including and Electric Pencil. The output file is also Electric Pencil compatible. $3.95. International Data Services, 340 West 55th St., New York, NY 10019. (212) 765-8610.

CIRCLE 392 ON READER SERVICE CARD

Computerware Software Services announces six business programs designed to run on a 40K 6800/6809 computer with SSB DOS and Computerware Random Basic. **Cash Flow Bookkeeping** is a cash-based single entry bookkeeping system which allows the user to define multiple income and expense accounts. **Inventory Control System** maintains part name/number, price, vendor code, category code, location code, quantity on hand, minimum quantity and quantity on order for each item. $149. The Small Business **Accounts Receivable** System provides information regarding the status of customers' accounts. $149. The Small Business **Accounts Payable System** keeps track of cash liabilities by collecting vendor invoice data and reporting cash commitments and payment history. $149. The **Payroll Processing System** calculates and reports payroll information for the business. $149. **Medical Office Business System** will maintain patient account records, prepare billing statements, insurance forms, routine correspondence and present reports for the management and control of an office for one or more doctors. Computerware, 1512 Encinitas Blvd., Box 668, Encinitas, CA 92024. (714) 436-3513.

CIRCLE 393 ON READER SERVICE CARD



Reviews

Stephen B. Gray

Software Engineering For Micros, by T.G. Lewis. Hayden Book Co. Inc., Rochelle Park, NJ. 165 pages, paperback $6.95. 1979.

According to the back cover the author "has now written a book for those interested in writing error-free programs. This book answers the need for more information on software quality, software engineering and structured programming. The author shows the reader how to achieve quality work and what it means to apply discipline in programming. This is accomplished by presenting designs of programs in a high-level language called 'blueprints.' These are relevant to the reader no matter what language is being used. Then the author encourages the mapping of his blueprint language into at least two and sometimes three machine languages, which gives the reader a feel for how to write abstracted ideas and then code them into the notations of a particular machine."

This book, subtitled "The Electrifying Streamlined Blueprint Speedcode Method," was written because software is now a larger part of the total cost of a computer system, because of the increasing complexity of systems, and the need for "programmers of the 1980s to cope with this complexity."

The chapter titles give a good idea of what the book is about: Million-Dollar Programs, Ten-Dollar Computers; Plan Ahead; Never Write a Large Program; Program in Levels of Abstraction; Make It Faster After You Make It Work!; Reinventing the Software Wheels; Kludgecode at the Speed of Light, Speedcode at the Speed of Light; Speedcode at Warp-Factor Five.

Speedcode is the author's name for the "formalized notation" of his "blueprint pseudocode." He says that "the speedcode specifications of a program can be refined into a particular microprocessor assembly language called kludgecode." The Motorola 6800 assembler is used most often as a kludgecode, with the Intel 8080 assembler notation used occasionally.

The next higher level of blueprint is "actually a program suitable for translation by the assembler of a given machine," and "the next [higher] level of refinement is the output from the assembler. It is binary object code, ready to be executed by the microcomputer."

If this makes any sense to you, and if you think you can learn from a book how to write error-free programs, this may be for you. That is, if you're at least a systems analyst.

The author is an associate professor in the department of computer science at Oregon State University.

Pascal With Style: Programming Proverbs, by Henry F. Ledgard, John F. Hueras and Paul A. Nagin. Hayden Book Co., Inc., Rochelle Park, NJ. 221 pages, paperback $6.95. 1979.

The fourth in Hayden's series on programming proverbs (the first three were on Basic, Cobol and Fortran), this is intended for Pascal programmers "who want to write carefully constructed, readable programs. It offers short rules and guidelines for writing more accurate, error-free programs," according to the book cover.

Chapter 2 contains 21 proverbs such as Don't Panic, Start the Documentation Early, Proceed Top-Down, Code in Logical Units, Don't GOTO, Comment Effectively, Produce Good Output, Hand-Check the Program, Have Someone Else Read the Work, and Don't Be Afraid to Start Over. All with many examples.

The remaining three chapters are on Top-Down Programming (with exercises), Program Standards, and Odds and Ends (selecting mnemonic names, recursion, The Case Against Program Flowcharts, exercises, etc.).

The three appendices provide a summary of program standards, Pascal Prettyprinting Standards, and an automatic formatting program for Pascal.

If programming in Pascal is part of your job, you should at least take a look at this book, which contains a great deal of helpful information, along with many samples of Pascal programs that are heavily critiqued.

Programming The 6502, by Rodnay Zaks. Sybex, 2020 Milvia St., Berkeley, CA 94704. 305 pages, paperback $10.95. 1978.

This was the first in a series on programming various MPUs (others include the 8080 and Z80) and is also available in French at $19.50.

The back cover says this "is an educational text designed to teach you programming from the ground up. It starts out with a chapter on Basic Concepts, mostly about binary and other data forms. Questions are scattered throughout the text and at the end of most chapters, to "allow you to test yourself and practice the concepts presented."

Chapter 2, on 6502 Hardware Organization, plunges right into the block diagram, and in many books of this type would be accompanied by a text too complicated for most beginners. But Zaks writes very clearly and simply, and has obviously had much teaching experience.

Chapter 3, Basic Programming Techniques, does a good job of showing how to write a program using the 6502. Much of Chapter 4, The 6502 Instruction Set, is a detailed catalog of instructions and won't mean all that much except to a programmer.

The remaining chapters are on Addressing Techniques, Input-Output Techniques, Input-Output Devices, Application Examples (reading characters, code conversion, sum of a table and seven more), Data Structures and Program Development.

If you need to know the 6502, you may not be able to find a text easier to understand than this one.

The Complete Handbook of Robotics, by Edward L. Safford, Jr. Tab Books, Blue Ridge Summit, PA 17214. 360 pages, paperback $7.95. 1978.

The cover says this book tells "How to design and build ANY kind of robot . . . including ones with microprocessor "brains" — PLUS how to interface robots with computers."

Yes, the book does, in a general way. That is, it's not a cookbook, with schematics containing component values, and sheet-metal diagrams with dimensions, and metalworking details; it has none of these.

This is an ideal book for the beginner with an interest in robotics, because it takes him through the basics of robot mobility, sensors, power sources, robot brains, servomechanisms, radio control and interfacing to a computer.

Chapter 10, Tips on Construction of Hobby Robots, says "We won't give you step-by-step construction guidelines . . . but will try to provide you with some knowledge necessary to build and construct such a machine." It gives a diagram of the basic structure for such a robot, nine general schematics (limit switches for a steering assembly, relay servo system with feedback, etc.), a drawing of an "advanced action manipulator system arm," and a photo of an underwater robot arm.

If you're interested in robots and are looking for a place to start, this book will provide you with an excellent background in the basics, written in a very clear and easily understood fashion.

The only chapter that gets really complicated is An Advanced Look at Sensors, which gets into force equations and LISP functions, which should be no problem if you're good at trig and know a little about programming.

Z80 Instruction Handbook, by Nat Wadsworth. Scelbi Publications, Box 133 PP Stn, Milford, CT 06460. 120 pages, paperback $4.95. 1978.

The preface says "This handbook serves as a practical reference to the industry standard mnemonics, machine code, and usage for each type of instruction provided in the Z80 CPU. It is meant to serve as a practical guide for the novice, intermediate, or professional programmer who has a requirement to work at the machine or assembler language level with a Z80-based microprocessor."

The book consists of three parts. The introduction to the instruction set, nine pages long, looks at registers, flags and notation. The main part of the book, 90 pages long, presents instructions in groups, with a description of their function, ranging from a sentence to a long paragraph.

The appendix consists of 19 pages with the entire instruction set, giving for each one the mnemonic, octal and hex representations, number of CPU clock cycles required to execute that instruction, and the page number in the book on which the instruction is discussed in detail.

The writing is as clear and detailed as is possible in the space provided, in what may be the handiest little book (4 by 7 inches) available on the Z80 instruction set.

Learning Level II, by David L. Lien. CompuSoft Publishing, Box 19669, San Diego, CA 92119. 352 pages, paperback $15.95. 1979.

"Learning Level II picks right up where the Level I TRS-80 User's Manual left off," says the back cover, which isn't surprising, since Dr. Lien wrote both of them.

The Level-II manual supplied with Radio Shack's TRS-80 Level-II computer is a reference manual, with a minimum amount of information, but enough for a user who really knows his way around in Basic. This new book contains much detail of interest to users who know little or nothing about Basic, or who want to know more than provided in the reference manual.

The first 53 pages tell you how to update the Level-I User's Manual provided with the TRS-80 so that it becomes meaningful to the Level-II user.

This is an interactive manual, with many short programs to be run by the user to show him what a particular statement does. Most areas are presented in much more detail than in the reference manual, such as the editor, strings, PEEK and POKE and many more.

The last three chapters are on the expansion interface, real-time clock and dual cassette operation, with details on setup and use.

This is the book for the beginner who's just gotten a Level-II TRS-80, or for anybody who wants to know more about "H for Hack," error trapping, concatenation, string matrices and a great deal more.

Pascal: An Introduction to Methodical Programming, by William Findlay and David A. Watt. Computer Science Press, 9125 Fall River Lane, Potomac, MD 20854. 318 pages, paperback $11.95. 1978.

The primary aim of this book, according to the back cover, is "to teach good programming practice based on Pascal." Its secondary purpose is "to serve as an introduction to the language, for both the novice in computer science and the reader who has already learnt one of the computing languages." (The spelling of "learnt" is due to the authors being in the Computer Science Dept. at the U. of Glasgow.)

This textbook is intended for use with a first course in programming based on Pascal, for readers with no previous exposure to computers and only an elementary math background.

The pace is slow and sure, with the book divided into five parts: First Steps (computers and programming, data types, input and output, Integer and Boolean types, flow of control, programming methodically), More Data Types (ordinal types, REAL type, arrays), More Control Structures (more about flow of control), Subprograms (functions, procedures), More Data Structures (records, packed data and strings, files, sets, pointers and linked lists) and Programming Methodology. The five appendices consist of collected syntax diagrams, reserved words and special symbols, predeclared entities, legible input and output and character sets.

The book consists of photoreduced pages, originally output from a PDP-11/40 printer, very carefully designed for maximum legibility, and written in a clear style that only now and then drops (or rises?) into professorese, such as "read all the names and write them out in lexicographic order." Lexicographic?

Exercises follow each chapter, with answers provided to selected ones.

The book could have been made to look a little less dry, had photocomposition or hot type been used, along with some attractive artwork and layout design, but the book would then cost twice as much.

The programming examples are short and easily understood, and the authors "challenge readers to find any errors in them"!

Microcomputer Systems Principles, Featuring The 6502/KIM, by R.C. Camp, T.A. Smay, and C.J. Triska. Matrix Publishers Inc., Portland, OR. 504 pages, paperback $13.95. 1978.

This book evolved from classroom notes developed for Computer Engineering 437, "Introduction to Microprocessors," taught for several years at Iowa State, where the authors are professors in the EE Dept.

The preface also says, "Since the emphasis is on hands-on experience, it has been necessary to provide an in-depth examination of the system chosen as the principal laboratory vehicle, the KIM-1 microprocessor . The authors have attempted to provide an approach to study of the KIM 1 and its microprocessor, the MCS6502, that will develop understanding capable of easy transfer to other systems, past, present and future "

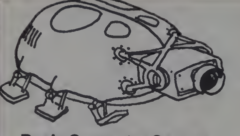
The eight chapters cover Introduction To Microcomputer-Based Design, General Aspects Of Microprocessor-Based Systems (56 pages), The MCS6502 Microprocessor And Peripheral Parts (104 pages), Software Aids, Microcomputer Interfacing And Systems Design, Introduction To The M6800 Microprocessor, Introduction To 8080 Microprocessor and An MCS6502-Based Microcomputer — The KIM-1 (60 pages).

Two appendices provide a user's guide to the MDT 650 Microcomputer Development Terminal, and Operating Principles Of The KIM 1 Monitor And On-Board I/O Hardware

This book is best suited to a person with some computer background, especially in programming (the book jumps right into the 6502 instruction set with no previous preparation), and with a big interest in the KIM-1, which is still being manufactured, according to Commodore

However, a person with the background necessary to understand this book would probably feel greatly limited with a KIM-1, despite its expansion capabilities, and would prefer at least a PET, Apple II or TRS-80. So, unsurprisingly, the book is best suited as a textbook in a computer-engineering course built around a KIM-1.

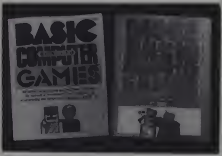
The writing is very clear, and the end-of-chapter problems are good and plentiful, although without solutions. This may be the best textbook on the 6502



Basic Computer Games

Edited by David Ahl, this book contains 101 imaginative and challenging games for one, two, or more players — Basketball, Craps, Gomoko, Blackjack, Even Wins, Super Star Trek, Bombs Away, Horserace. Simulate lunar landings. Play the stock market. Write poetry. Draw pictures.

All programs are complete with listing in Microsoft Basic, sample run and description. Basic conversion table included. 125,000 copies in print. 192 pages softbound. [6C] $7.50.



More Basic Computer Games

Contains 84 fascinating and entertaining games for solo and group play — evade a man-eating rabbit, crack a safe, tame a wild horse, become a millionaire, race your Ferrari, joust with a knight, trek across the desert on your camel, navigate in deep space.

All games come complete with program listing in Microsoft Basic, sample run and description. 192 pages softbound. [6C2] $7.50.

To Order

Send your check for books plus $2.00 shipping and handling per order to Creative Computing, P.O. Box 789-M, Morristown, NJ 07960. NJ residents add 5% sales tax. Visa, Master Charge or American Express are also acceptable. For faster service, call in your bank card order toll free to

800-631-6112
(In NJ, call 201-540-0445)

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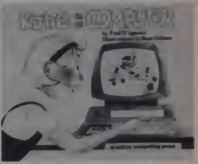

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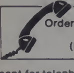

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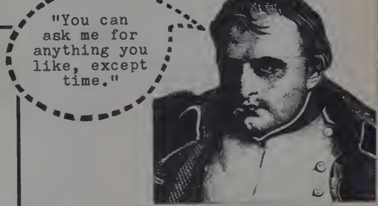

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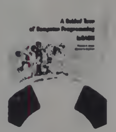

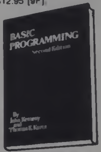

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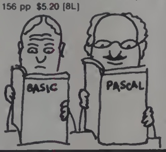

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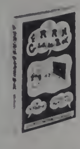

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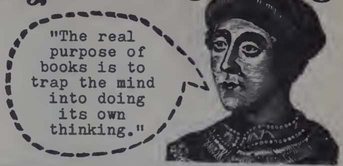

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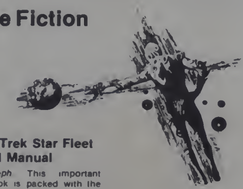

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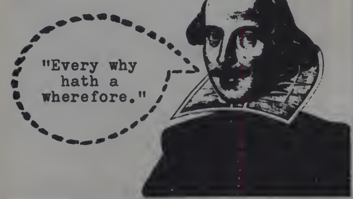

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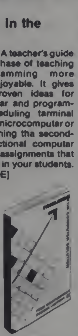

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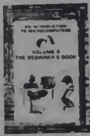

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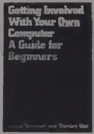

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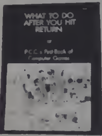

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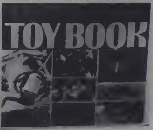

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