Computers & Electronics

FEBRUARY 1983

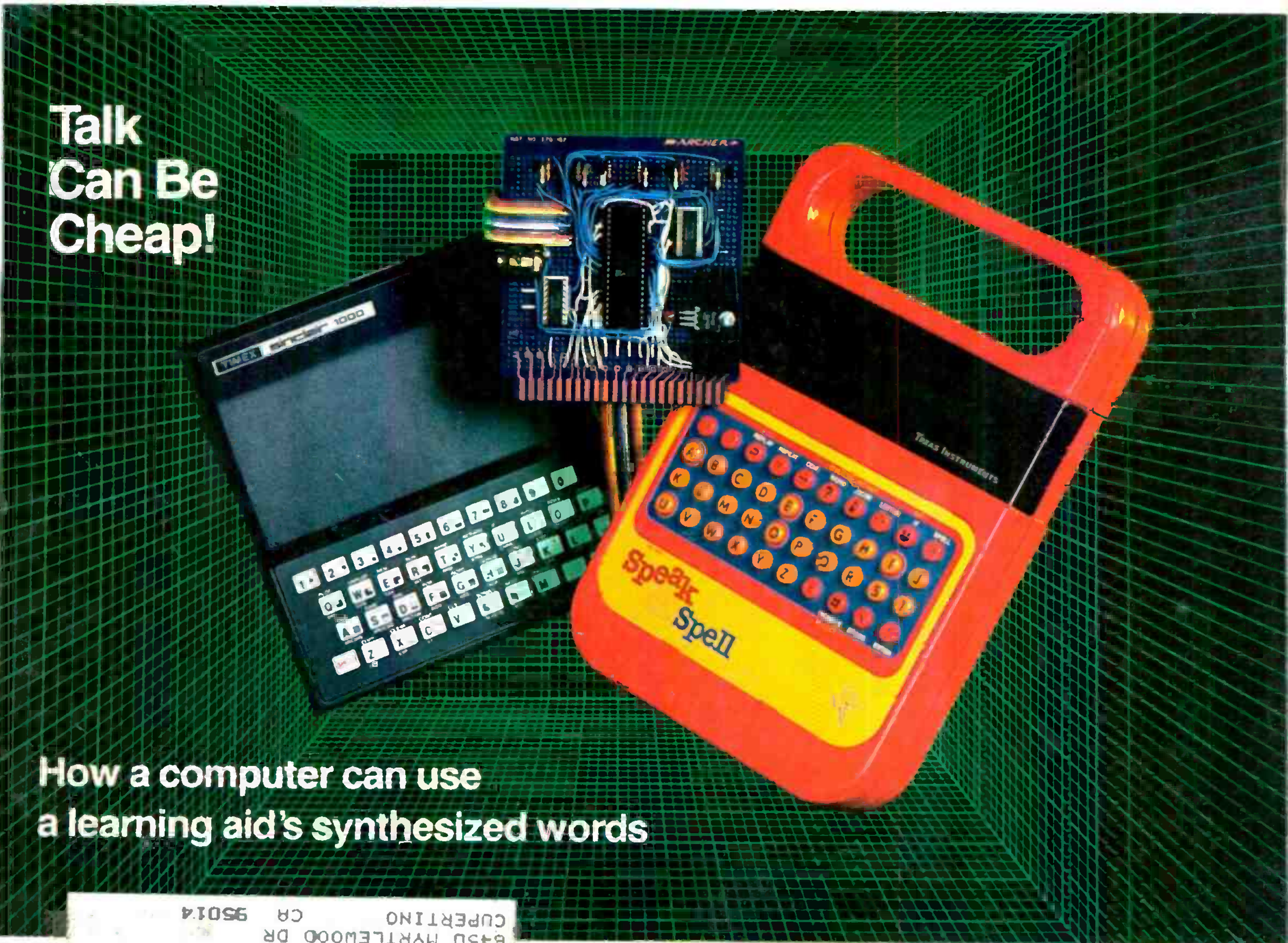
formerly Popular Electronics

$1.25

A Programmable, High-Accuracy Function Generator

The New Briefcase Portable Computers

Measuring Biofeedback Levels on a Microcomputer



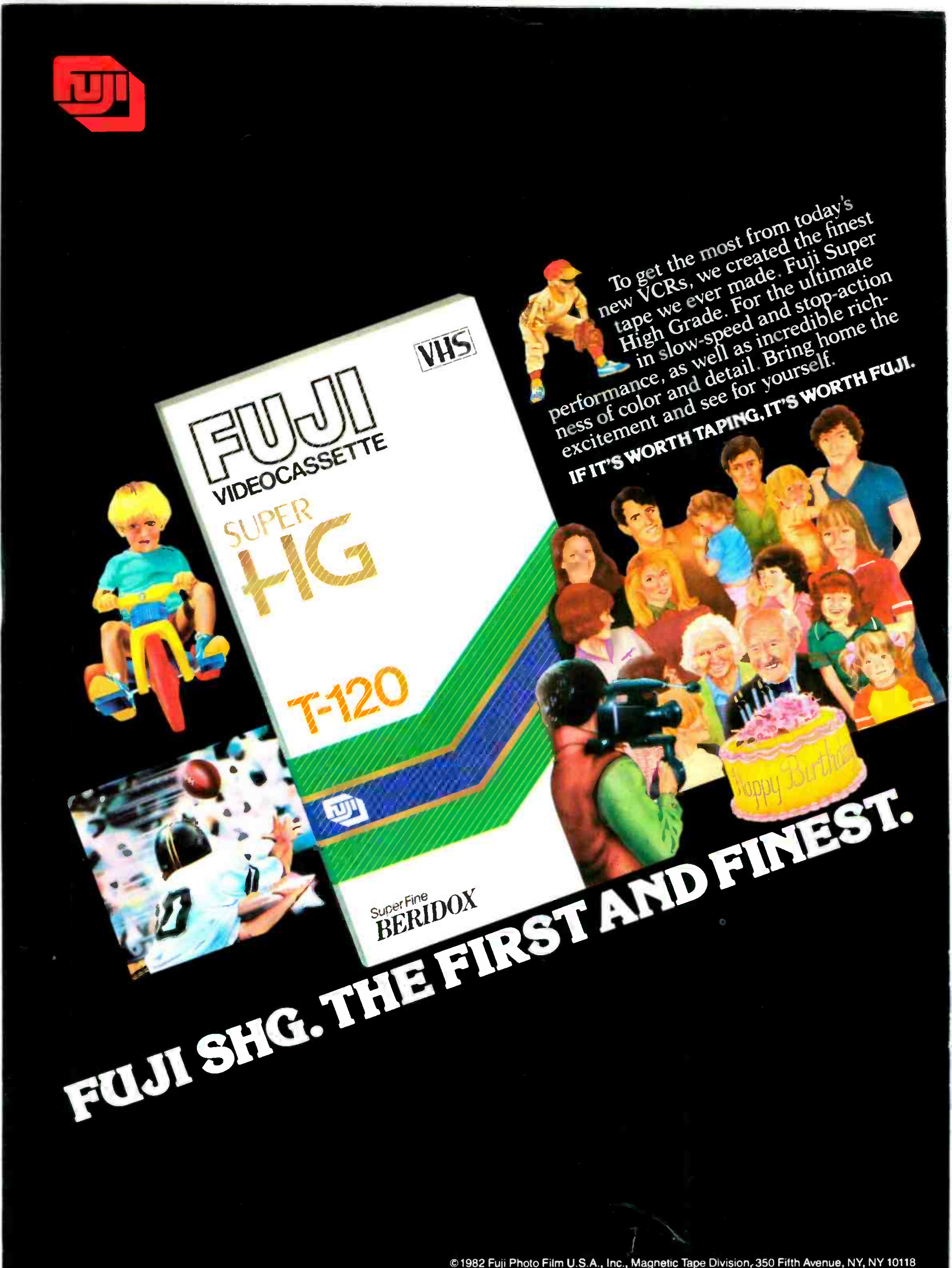
Talk Can Be Cheap!

How a computer can use a learning aid's synthesized words

Tested in This Issue:

CA 25″ TV Monitor/Receiver

an RX-103 FM Stereo/AM Receiver



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VHS
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VIDEOCASSETTE
SUPER
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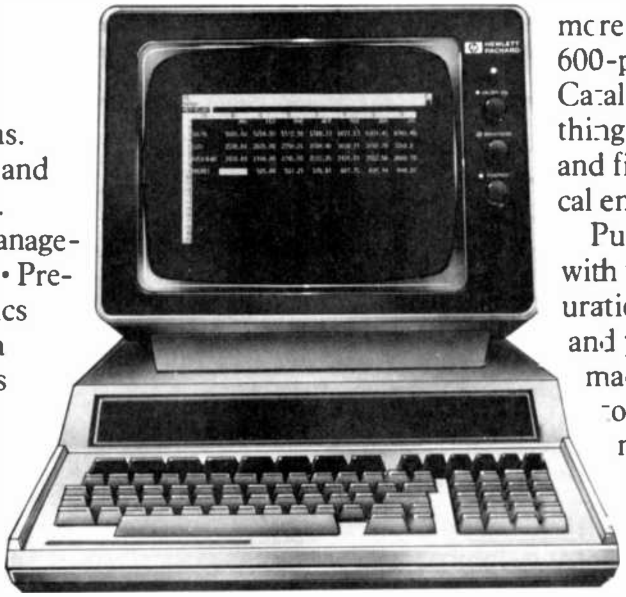
T-120
Super Fine
BERIDOX
To get the most from today's new VCRs, we created the finest tape we ever made. Fuji Super High Grade. For the ultimate in slow-speed and stop-action performance, as well as incredible richness of color and detail. Bring home the excitement and see for yourself.
IF IT'S WORTH TAPING, IT'S WORTH FUJI.
Happy Birthday
FUJI SHG. THE FIRST AND FINEST.

There are five good reasons to buy the new HP-86.



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If you need more, check out our 600-page Software Catalog, for everything from accounting and finance to electrical engineering.

Put that together with the modular configuration of the HP-86, and you've got a machine designed to expand as your needs expand.

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Personal Productivity Pac
A $750 value for $250.

VisiCalc® PLUS is a powerful analytical tool for making quick work of worksheets. And once you do your "what-if" planning, you can turn the result into graphics immediately. (That's the PLUS.)

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All in all, this is an offer designed to meet your essential software needs. And it's the perfect complement to the new HP-86, a personal computer we're really proud of.

Ask your dealer or sales rep about the Personal Productivity Pac, and do some serious comparison shopping.

We're so convinced you'll prefer the HP-86, the software offer stands. Whether or not you buy the computer.

For the authorized HP dealer or HP sales office nearest you, call TOLL-FREE 800-547-3400 (Oregon, Alaska, Hawaii: 503-758-1010).

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VisiCalc is a registered trademark of VisiCorp.
*Suggested retail price. May vary outside U.S.

For professionals on the move.

PG02301 209 A

HEWLETT PACKARD

CIRCLE NO. 54 ON FREE INFORMATION CARD

WHEN WE ANNOUNCED THE COMMODORE 64 FOR $595, OUR COMPETITORS SAID WE COULDN'T DO IT.

THAT'S BECAUSE THEY COULDN'T DO IT.

The reason is that, unlike our competitors, we make our own IC chips. *Plus* all the parts of the computer they go into.

So Commodore can get more advanced computers to market sooner than anybody else. And we can get them there for a lot less money.

WHAT PRICE POWER?

For your $595,* the Commodore 64™ gives you a built-in user memory of 64K. This is hundreds of dollars less than computers of comparable power.

Lest you think that the Commodore 64 is some stripped-down loss leader, a look at its available peripherals and interfaces will quickly convince you otherwise.

SOFTWARE THAT WORKS HARD.

The supply of software for the Commodore 64 will be extensive. And with the optional plug-in Z80 microprocessor, the Commodore 64 can accommodate the enormous amount of software available in CP/M.®

Add in the number of programs available in BASIC and you'll find that there are virtually no applications, from word processing to spreadsheets, that the Commodore 64 can't handle with the greatest of ease.

PERIPHERALS WITH VISION.

The Commodore 64 interfaces with all the peripherals you could want for total personal computing: disk drives, printers and a telephone modem that's about $100, including a free hour's access to some of the more popular computer information services. Including Commodore's own Information Network for users.

RUN YOUR BUSINESS BY DAY.
SAVE THE EARTH BY NIGHT.

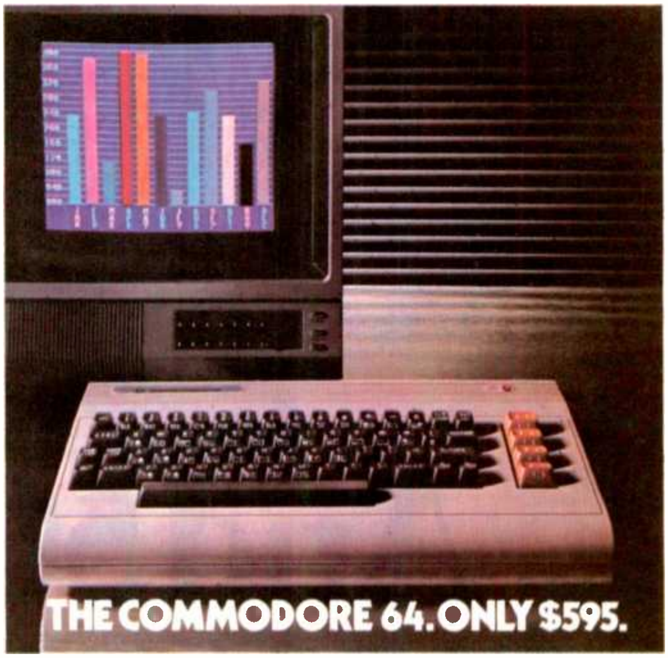
At the end of a business day, the Commodore 64 can go into your briefcase and ride home with you for an evening's fun and games.

Because of its superior video quality (320x200 pixel resolution, 16 available colors and 3D Sprite graphics), the Commodore 64 surpasses the best of the video game machines on the market. Yet, because it's such a powerful computer, it allows you to invent game programs that a game machine will never be able to play; as well as enjoy Commodore's own video game cartridges.

ATTACK, DECAY, SUSTAIN, RELEASE.

If you're a musicologist, you already know what an ADSR (attack, decay, sustain, release) envelope is. If you're not, you can learn this and much more about music with the Commodore 64's music synthesizing features.

It's a full-scale compositional tool. Besides a programmable ADSR envelope generator, it has 3 voices (each with a 9-octave range) and 4 waveforms for truly sophisticated composition and playback—through your home audio system, if you wish. It has sound quality you'll find only on separate, music-only synthesizers. And graphics and storage ability you won't find on any separate synthesizer.



DON'T WAIT.

The predictable effect of advanced technology is that it produces less expensive, more capable products the longer you wait.

If you've been waiting for this to happen to personal computers, your wait is over.

See the Commodore 64 soon at your local Commodore Computer dealer and compare it with the best the competition has to offer.

You can bet that's what the competition will be doing.

Commodore Business Machines
Personal Systems Division
P.O. Box 500, Conshohocken, Pennsylvania 19428

Please send me more information on the Commodore 64™

Name________________ Title________

Company________________________

Address________________________

City________________ State________

Zip_____________ Phone____________

commodore
COMPUTER

CE-2

*Manufacturer's Suggested Retail Price: July 1, 1982. Disk drives and printers are not included in prices. The 64's price may change without notice.
CP/M® is a registered trademark of Digital Research, Inc.

CIRCLE NO. 29 ON FREE INFORMATION CARD

Computers&Electronics

FEBRUARY 1983 VOLUME 21, NUMBER 2

FEATURE ARTICLES

CONSTRUCTION ARTICLES

EQUIPMENT REVIEWS

COLUMNS

DEPARTMENTS

COVER PHOTO BY JAY BRENNER

 Computers & Electronics (ISSN 0032-4485) February 1983, Volume 21, Number 2 Published monthly by Ziff-Davis Publishing Co., at One Park Ave., New York, NY 10016 Richard P. Friese, President; Selwyn Taubman, Treasurer; Bertram A. Abrams, Secretary. One year subscription rate for U.S. and Possessions, $15.97, Canada, $20.97, all other countries, $23.97 (cash orders only, payable in U.S. currency). Second Class Postage Paid at New York, N.Y. 10016 and at additional mailing offices. Authorized as second class mail by the Post Office Dept., Ottawa, Canada, and for payment of postage in cash. POPULAR ELECTRONICS including ELECTRONICS WORLD trademark registered. Indexed in the Reader's Guide to Periodical Literature. Ziff-Davis also publishes Boating, Car and Driver, Cycle, Flying, Popular Photography, Skiing, Stereo Review, Electronic Experimenter's Handbook, and Tape Recording & Buying Guide **POSTMASTER:** Send address changes to COMPUTERS & ELECTRONICS, Circulation Dept. P.O. Box 2774, Boulder, CO 80302. Please allow at least eight weeks for change of address, enclosing, if possible, an address label from a recent issue

EDITORIAL

Beyond Pac-Man

I was both amused and distressed to read a light-hearted article in *TV Guide* (Oct. 9, 1982) relating to home computers and belittling the usefulness of small computers. The author wrote about how 600,000 families spent lots of money and hundreds of hours this past year performing the simplest tasks on computers that are ". . . substitutes for a $10 calculator." He concluded with a list of what American families actually do with their computers: Play Pac-Man.

Obviously this is far from the truth, though there are likely many people who do not make satisfactory use of their personal computers. Regrettably, I thought, the technically unwashed millions who read the story may wholly believe him and, as a result, not give themselves and their families an opportunity to become computer-literate. Moreover, I hoped that the author, with whom I shared *sushi* and other delectables while in Tokyo, did not live out his story line and had the good sense to save writing time and money by composing his article on a computer that has word-processing facilities. Unfortunately, this and other marvelous computer functions were unmentioned in his article.

Mulling over his words some time later, I came to the conclusion that his well-written piece was a wonderful half-article. Aside from the failure to note the many rewarding applications of computers, as well as their educational and other possible benefits, the author missed an opportunity to take the computer industry to task for not producing machines and software for people who are not oriented toward using technical devices.

He could have mentioned people-oriented software such as Valdocs and Lotus 1-2-3, and the new generation of hardware and software coming up that makes computers more people-literate rather than forcing people to become computer-literate. After all, everybody is not psychologically equipped or motivated to learn programming and electronics, or to battle through language barriers and mechanical requirements such as pressing CONTROL and A keys simultaneously to stop a machine. Even readers of special-interest publications such as ours, which has the largest circulation of all in the field, would doubtlessly welcome computers and software that are truly user-friendly. Who needs unnecessary hassles?

Programming for nonprogrammers is not a new force, either. QBE (Query by Example), a language derived by IBM, has been in use since 1978 for users with no programming know-how to work with data bases. IBM's OBE (Office Procedures by Example) uses the same approach for word processing, graphics, and other applications. And Xerox has developed "Smalltalk," which is reputed to be a powerful, flexible language that should be simple for novices to use when canned software for it becomes available.

Recognizing the importance of computers in the typical student's future, some colleges have embarked on a new program that is most interesting. Just as a student must buy textbooks, they have made it compulsory for students to buy a personal computer and pay for it as part of tuition over four years. Clarkson College of Technology, Potsdam, NY, for example, announced that it will issue Zenith personal computers to its 1000 freshmen this year, charging $200 per semester and a one-time $200 maintenance deposit. At the end of four years, title to the computer would pass to the student. Languages available will be BASIC, Fortran, and Pascal, and a spreadsheet software program for financial analysis will be supplied. A word-processing system developed at the college, called "Galahad," will also be used. And networking schemes are being explored. Similarly, Apple, Radio Shack, Commodore, TI, and IBM machines are being implemented in colleges around the country.

Clarkson's president, Robert Plane, observed: "I am convinced that Carl Sagan is correct in predicting that the next development in human intelligence will be a partnership between intelligent humans and intelligent machines."

Clearly, there's more than Pac-Man in the future of American families.

Art Salsberg

Computers & Electronics
formerly Popular Electronics

Editorial and Executive Offices
One Park Avenue
New York, New York 10016
212 725-3500

New York Office
Advertising Director:
Richard Govatski 212 725-7460

Sales:
Tom Ballou 212 725-3578
Ken Lipka 212 725-3580

Midwestern Office
Suite 1400, 180 N. Michigan Ave.,
Chicago, IL 60601 312 346-2600
Sales: Robert Vanek

Western Office
3460 Wilshire Blvd.
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Sales: Ted Welch

Representation in Japan
J.S. Yagi
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603 Ginza Sky Heights Bldg.
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LETTERS

AERO DATA

In your October 1982 issue, the article "Communications Networks for Computers" had people looking for us under the name Aero Net. The name is actually Aero Data. It is one service of our company, Commercial Data Banks Inc.—*Nicholas Ashton, Titusville, FL.*

MAKING PLUG-INS UNIVERSAL

The plug-in circuit "This Is Your Computer Speaking" (September, 1982) is an example of a problem I find with many computer circuits published—it will work with only one system (S-100, in this case). Perhaps it would be possible to describe a computer plug-in in terms of a "kernel" circuit and then describe several interface circuits to it and different types of systems. —*David Wiggins, New Orleans, LA.*

It would indeed be good if all plug-ins worked with all computers. Unfortunately, most design approaches are implemented to meet a challenge for a particular computer. Our December 1982 issue, however, did introduce a "universal" synthesizer for use with RS232C ports. Parallel interfaces for various computers will be published in the future.—Ed.

GIVING PROPER CREDIT

For the article "Carpenter's De-'Light'" (December 1982, p. 82), the name of Robert Romano should have been listed as an author in addition to mine. Also, the polarity of the battery should be reversed. —*Arthur L. Plevy, Edison, NJ.*

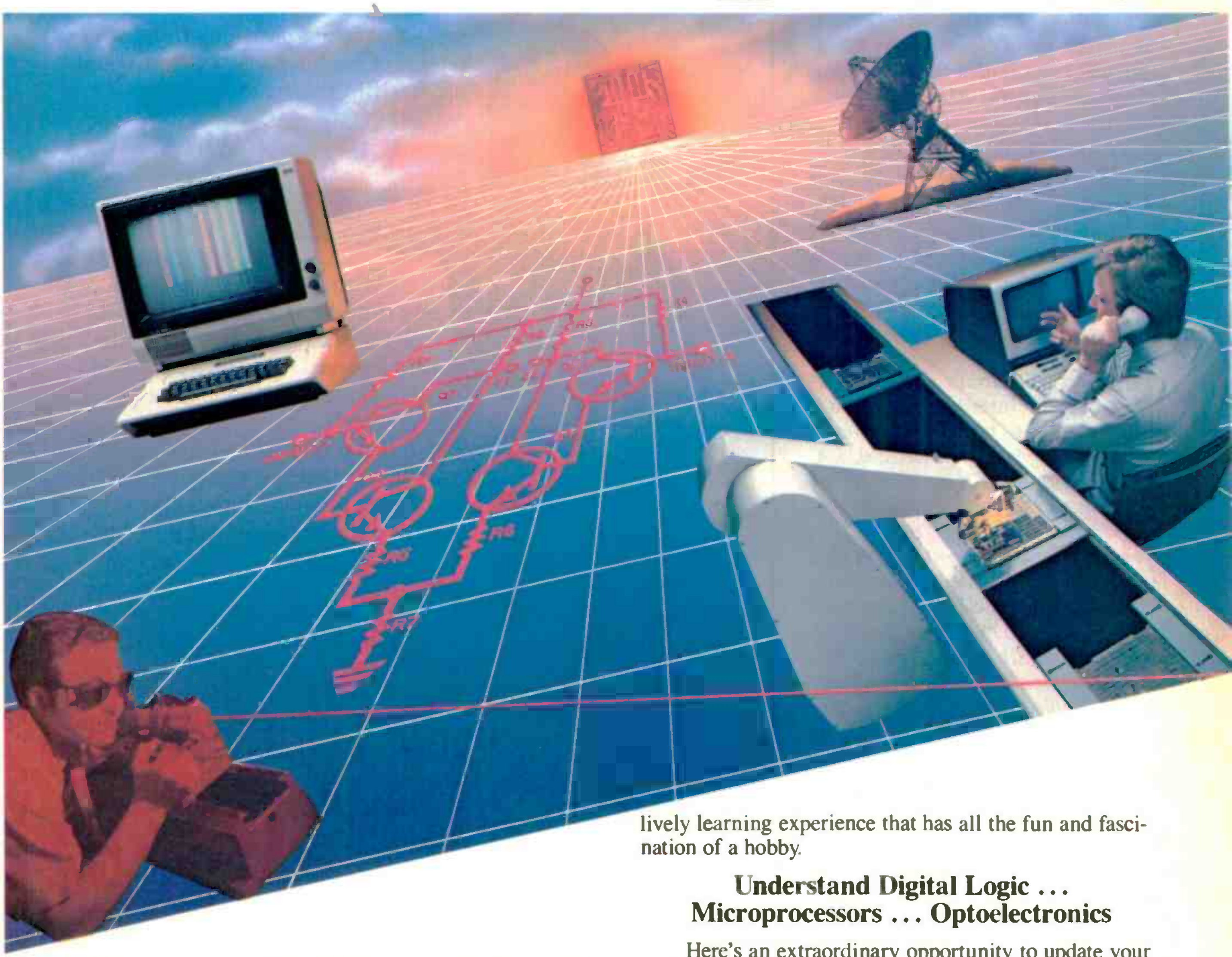
OUT OF TUNE

In "Memory Storage the Megabyte Way" (December 1982), the price of SyQuest Technology's SQ306 hard disk drive should have been $800 and the price of the removable cartridges is $50.

In "Printing Computer Graphics" (November 1982), in Table IV, lines 10 and 30 for the Apple II with Applesoft BASIC should contain a greater-than sign before 127. In Table I, the Heath H25 printer is listed as capable of bit-image graphics, but only has character graphics.

MASTER THE "NEW ELECTRONICS" WITH McGRAW-HILL'S

Contemporary



Now you can meet the challenges of today's incredibly rapid changes in electronics quickly and easily. This professional level electronics learning series is as innovative as the circuitry it explains and as fascinating as the experiments you build and explore!

From digital logic to the latest 16-bit microprocessor, you master one subject at a time with McGraw-Hill Concept Modules sent to you one at a time, once a month, to make up the complete CONTEMPORARY ELECTRONICS SERIES. Each module of the fifteen in the Series is a unique blend of "hands-on" experience, interactive audio cassettes, and vividly illustrated printed support materials. Together they will prepare you for tomorrow's better jobs or advancement in your present position by staying current with today's electronics revolution. Professional in every respect, yet it's a lively learning experience that has all the fun and fascination of a hobby.

Understand Digital Logic ... Microprocessors ... Optoelectronics

Here's an extraordinary opportunity to update your understanding of today's most important technological changes in electronics. You can start from scratch or use the Series to update yourself. You cover the latest integrated circuits, including TTL, CMOS, and ECL digital circuits; op-amps; phase-locked loops; microprocessors; and opto devices such as LEDs and LCDs.

Perform Electronic Experiments

With your first module you'll use the latest digital integrated circuits to build an oscillator circuit that demonstrates digital signals—verified visually by the flash of light emitting diodes (LEDs) and audibly by tones produced through the mini-speaker that is provided.

You'll know the differences (and similarities) between electronics and electricity, learn the concepts applicable to all electronic circuits. With the first module, you will be able to identify the major passive components, like resistors, capacitors, inductors, diodes and

Electronics Series

transformers, and active components such as transistors and integrated circuits.

Each Concept Module goes right to the heart of the matter. You waste no time on extraneous material or outdated history. It's a fast, efficient, and lively learning experience, a nontraditional approach to the most modern of subject matter.

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What's more, when you reach the midpoint of your Series, you will have constructed a professional Prototyping/Design Laboratory which will become a valuable learning tool throughout the remainder of your studies. This Prototyping/Design Lab contains a signal generator, logic switches, pushbuttons, and LED indicators. It rivals professional instruments that are widely used in industrial laboratories for electronic design and development as well as testing and measuring. Because of its versatility, it is an instrument that you will use again and again, even after you have completed your Contemporary Electronics Series.

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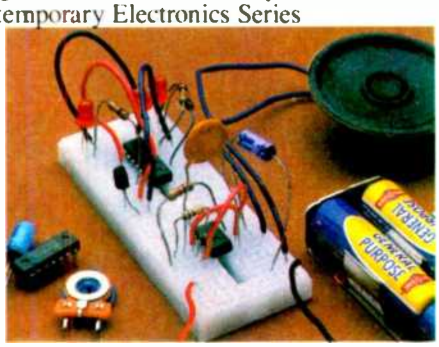
With each new module you'll receive a McGraw-Hill Action-Audio Cassette, a proven successful method of programmed, interactive instruction. Each tape creates a dynamic dialogue that not only quickly communicates the facts, but makes you feel that you're participating, as you respond to questions and listen to problems being solved.

Your ability to rapidly make this knowledge your own is further aided by a strikingly original technique for using diagrams, illustrations, and schematics to drive home points made as you listen to the cassette. The same carefully indexed binder that contains this material also includes the instructions to guide you through hands-on experiments. Finally, having completed the Series, you can be awarded a Certificate of Achievement from the McGraw-Hill Continuing Education Center upon passing an optional final examination.

Update Your Knowledge of the New Electronics

This program is for you whether you're a scientist who can use electronics to improve or speed up your investigations... a teacher who'd benefit from a refresher in contemporary components, circuits and applications ... a manager or supervisor in an electronics related industry or business... an engineer in another field who finds electronics playing an ever more important role in your work... someone looking to find new direction in this wide open field... or the kind of person who wants to understand what's going on in the world around you.

McGraw-Hill's Contemporary Electronics Series offers you the quickest and probably least expensive learning method available today, and the only one with "hands-on" experience.



With your first module you'll receive this professional solderless breadboarding system. It enables you to connect components and build electronic circuits easily and quickly. It's used throughout the series and can be used later to design, build and test your own circuits.

No Risk, No Obligation

And we invite you to prove all this to your own satisfaction—without risk and without committing yourself in any way.

Return the reply card and we'll send you the first module and other materials for a free 14-day examination. If you're not absolutely satisfied, and certain that this is an enjoyable as well as highly effective way to learn, simply return the module to us along with the unpaid bill and that will be the end of it.

If you wish to continue, we'll ship the remaining modules automatically, about once a month, for only $19.95 each plus $2.25 for shipping and handling. Remember, each module comes on the same 14-day free examination basis, with no obligation to pay for any module you don't want to keep.

Return the reply card now. It'll bring you the first module Contemporary Electronic Components and Circuits ... your first step in becoming an expert in the "new electronics." There's no risk or obligation.

If the card is missing write to:

Contemporary Electronics Series
McGraw-Hill Continuing Education Center
3939 Wisconsin Avenue, NW
Washington, DC 20016

NEW PRODUCTS

TRACK BALL

TG Products has announced a video game control for the Apple II and III, Atari 400 and 800, and IBM-PC. The track ball format, often used in arcades, is said to be well-suited for rapid, multiple movement commands since it has a lower control-to-movement ratio than other double-axes controls. $65

Circle No. 92 on Free Information Card

MINIATURE MODEM

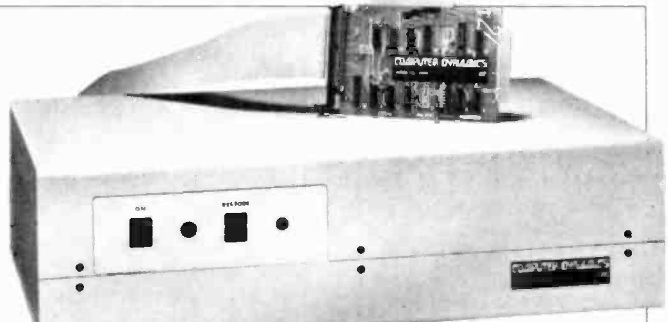
New direct-connect, 300-baud, automatic answer and originate modem , called J-CAT from Novation, measures 5" × 1.9" × 1.3" and plugs into any modular RJ11C phone jack. LEDs indicate status, and an audio beep indicates busy, dial tone, or presence of carrier. $149.

Circle No. 94 on Free Information Card

FRANKLIN PERSONAL COMPUTER

The Ace 1200 has 128K RAM, disk drive (with dual-drive options), disk controller, u/lc capabilities with alpha lock, serial/parallel interface, CP/M card, and color graphics. It is Apple II and CP/M compatible. A dedicated card expands the display to 80 col. x 24 lines. Includes joystick/paddle connector and speaker. $2495 with one disk drive.

Circle No. 93 on Free Information Card



IBM-PC HARD-DISK EXPANSION

The WIN 5-IBM from Computer Dynamics Inc. is a subsystem configured to interface with the IBM-PC under MS-DOS, with a Winchester drive with data capacity of 4.8 megabytes (incl. error detection/correction.) Manufactured and serviced by Shugart. $1695.

Circle No. 95 on Free Service Card

FCC-APPROVED VIDEO MODULATOR

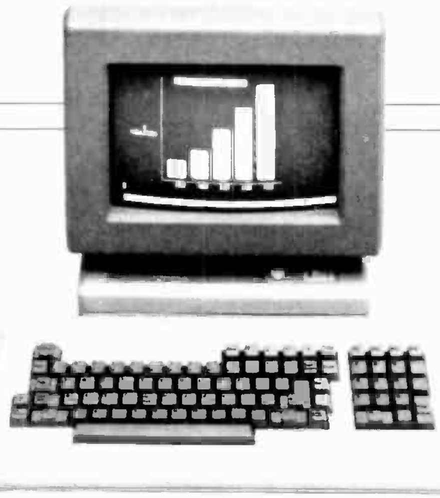
M&R Enterprises' video modulator, Sup'R Mod, permits any computer with standard NTSC video composite output to use a color or black-and-white TV as a monitor. Draws power from a transformer plugged into ac line, with a built-in regulator to ensure stable operation. The Sup'R Mod comes with video cable with standard RCA connectors, plus adapters for use with 75-ohm cable or 300-ohm twinlead. DB-style adapters are available as options. $70.

Circle No. 96 on Free Information Card

ELECTRONIC TYPEWRITER/PRINTER

The Olympia Electronic Compact is a full-featured daisywheel typewriter that's available with RS232 and Centronix interfaces for use as a letter-quality printer with computers. It features 46-character correction memory, three pitch selections, and automatic repeat and relocate. $969 with interfaces and cable; $749 without.

Circle No. 97 on Free Information Card



QUME CRT TERMINAL

Qume's new terminal is the Model 102 with 12" CRT, tilt and swivel display, and detachable keyboard. Has green (amber optional) screen, 25th status line, 9/12 cell resolution, line-drawing character set, four programmable function keys, conversational mode, protected fields, 16 baud-rate selections and unidirectional RS232C port. $695.

Circle No. 98 on Free Information Card

30-MHz DUAL-TRACE SCOPE

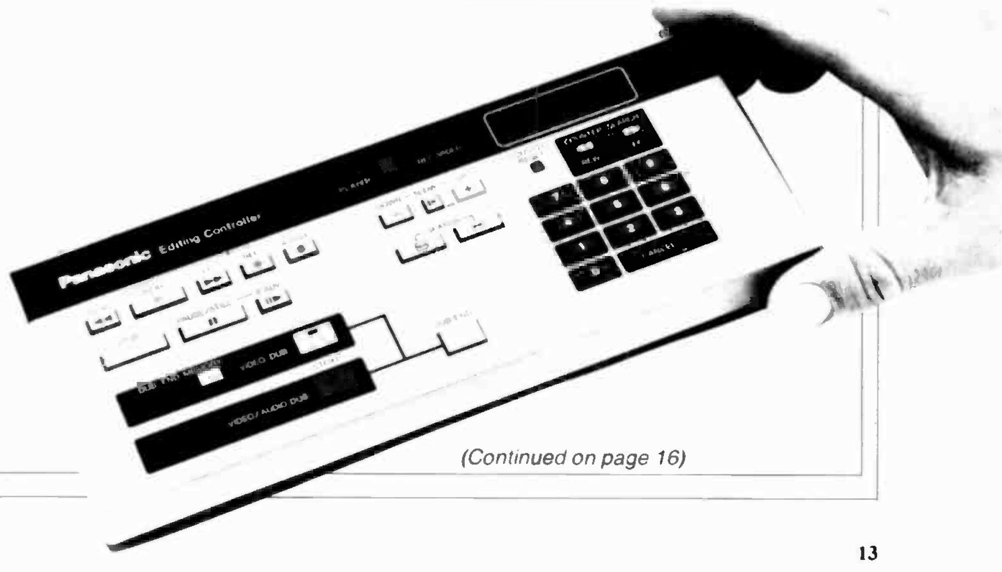
The Soltec Model 530 dual-trace, 30-MHz scope has a 6"-square CRT with internal graticule and scale illumination. The triggering process is reported to be simplified through a patented circuit, claimed to require no adjustments regardless of changes in signal amplitude, frequency, or pulse width. A horizontal sweep magnifier increases sweep rate to 20 ns/div. Other features include a signal delay line to facilitate viewing of the trace's leading edge, a vertical sensitivity selector with a 1 mV/div setting, a vertical mode switch to select Ch. 1, Ch. 2, Chop, Alt, and Add modes independent of sweep rate, and Z-axis input. $895.

Circle No. 99 on Free Information Card

VHS EDITING CONTROLLER

Panasonic's Model PV-R500 VHS editing controller is for home editing with any two PV-5000 VHS recorders. It functions as an assembly editor of audio and video or as an insert editor. A switch indicates which VCR is being operated and permits full 13-function remote control of both. Digital search of specific tape segments is accomplished via a numerical keyboard synchronized with the recorders' tape counters. Independent video and audio dubbing is possible, and a Dub End Memory switch automatically sets the end point. $200.

Circle No. 100 on Free Information Card



(Continued on page 16)

Inside Apple

Apple Computer Inc., 20525 Mariani Avenue, Cupertino, California 95014 Vol. 1 No. 2

For the authorized Apple dealer nearest you, call 800-538-9696 (800-662-9238 in California.)

Fruitful Connections.

There are more people in more places making more accessories and peripherals for Apples than for any other personal computer in the world.

Thanks to those people – in hundreds of independent companies – you can make the humblest 1978 Apple II turn tricks that are still on IBM's Wish List for 1984.

But now we're coming out with our very own line of peripherals and accessories for Apple® Personal Computers.

For two very good reasons.

First, compatibility. We've created a totally kluge-free family of products designed to take full advantage of all the advantages built into every Apple.

Second, service and support.

Now the same kindly dealer who keeps your Apple PC in the pink can do the same competent job for your Apple hard-disk and your Apple daisywheel printer.

So if you're looking to expand the capabilities of your Apple II or III, remember:

Now you can add Apples to Apples.

A joy to behold.

The new Apple Joystick II is the ultimate hand control device for the Apple II.

Why is it such a joy to use?

With two firing buttons, it's the first ambidextrous joystick – just as comfortable for lefties as righties.

Of course, it gives you 360° cursor control (not just 8-way like some game-oriented devices) and full X/Y coordinate control.

And the Joystick II contains high-quality components and switches tested to over 1,000,000 life cycles.

Which makes it a thing of beauty. And a joystick forever.

Gutenberg would be proud.

Old Faithful Silentype® has now been joined by New Faithfuls, the Apple Dot Matrix Printer and the Apple Letter Quality Printer.

So now, whatever your budget and your needs, you can hook your Apple to a printer that's specifically designed to take advantage of all the features built into your Apple. With no compromises.

The 7x9 Apple Dot Matrix Printer is redefining "correspondence quality" with exceptional legibility. With 144x160 dots per square inch, it can also create high resolution graphics.

The Apple Letter Quality Printer, which gets the words out about 33% faster than other daisywheel printers in its price range, also offers graphics capabilities. See your authorized Apple dealer for more information and demonstrations. Because, unfortunately, all the news fit to print simply doesn't fit.

Up the creek without a paddle?

Or lost in space? Or down in the dungeons?

Whatever your games, you'll be happy to know that someone has finally come out with game paddles built to hold up under blistering fire. Without giving you blisters.

Apple Hand Controller II game paddles were designed with one recent discovery in mind:

People playing games get excited and can squeeze very, very hard.

So we made the cases extra rugged. We used switches tested to 3,000,000 life cycles. We shaped them for holding hands and placed the firing button on the right rear side for maximum comfort.

So you'll never miss a shot.

A storehouse of knowledge.

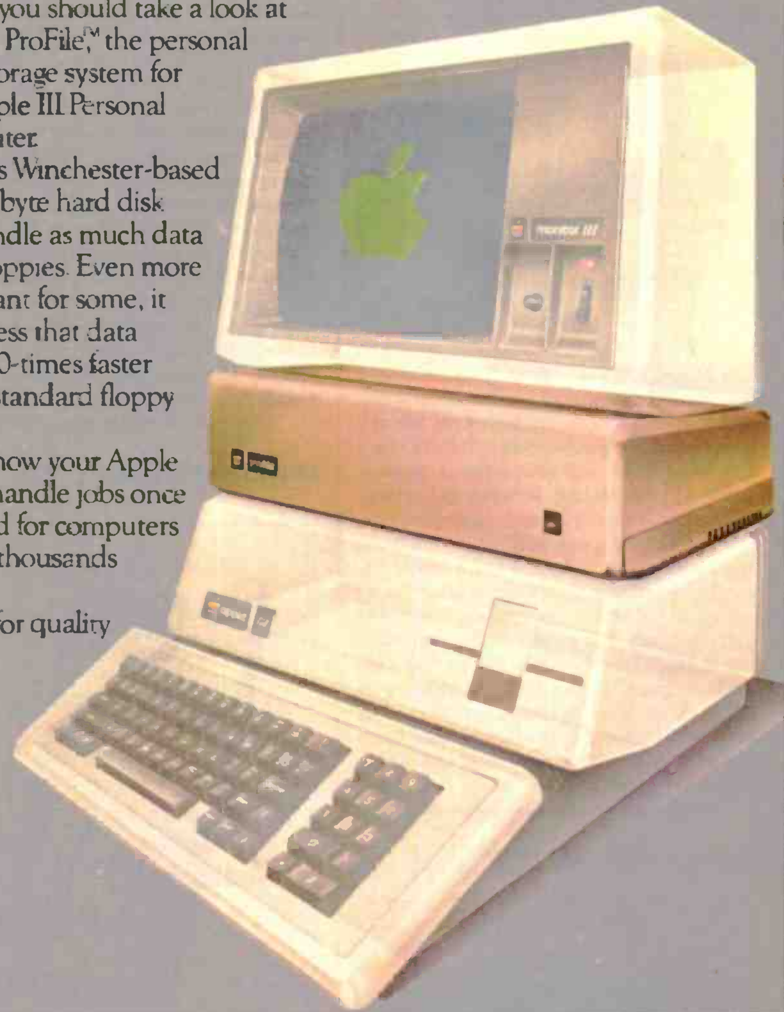
If you work with so much data or so many programs that you find yourself shuffling diskettes constantly, you should take a look at Apple's ProFile,™ the personal mass storage system for the Apple III Personal Computer.

This Winchester-based 5-megabyte hard disk can handle as much data as 35 floppies. Even more important for some, it can access that data about 10-times faster than a standard floppy drive.

So now your Apple III can handle jobs once reserved for computers costing thousands more.

As for quality and reliability, you need only store one word of wisdom:

Apple.



Launching pad for numeric data.

Good tidings for crunchers of numerous numbers:

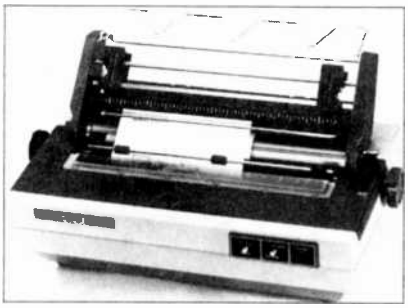
Apple now offers a numeric keypad that's electronically and aesthetically compatible with the Apple II Personal Computer. So you can enter numeric data faster than ever before.

The Apple Numeric Keypad II has a standard calculator-style layout. Appropriate, because unlike some other keypads, it can actually function as a calculator.

The four function keys to the left of the numeric pad should be of special interest to people who use VisiCalc.® Because they let you zip around your work sheet more easily than ever, adding and deleting entries.

With one hand tied behind your back.

RADIO SHACK DAISY WHEEL PRINTER



The Model DWP-410 from Radio Shack is reported to be capable of printing letter-quality documents at over 300 words per minute. It has selectable pitch—either 10 or 12 characters per inch—and proportional spacing. Other features include forward and reverse full and $^1/_2$-line paper feed, underline, programmable backspace, and $^1/_{120}$" minimum space and $^1/_{48}$" line feed. An Automatic Paper Set is said to simplify paper insertion by rolling it to the first line position with the pull of a lever. The printer will accept other 124-character daisy wheels, and an "external program mode" allows the use of wheels with different pitch or special characters. The DWP-410 includes a standard parallel interface and comes with a print wheel and carbon ribbon cartridge. $1495.

Circle No. 105 on Free Information Card

VIDEO TAPE REPAIR

Total Video Supply announces availability of its VideoMate Tape-Mender, reported to be a total system for repairing damaged video tape. The heart of the system is a work station, said to securely hold a Beta or VHS cassette while the tape is being fixed. Pins guide the cassette to the repair area, orienting it with the base side up. Tape movement is accomplished with an external hub drive. A clamping system holds the tape in an alignment track, where it may be cut using special shears or a razor blade, and then spliced with pre-cut adhesive tabs (all included with the work station). $22. **Address:** Total Video Supply, 9181-A Kearny Villa Ct., San Diego, CA 92123.

EXPANDABLE CALCULATOR INTERFACE

Prototech, Inc. has introduced an expansion system designed for the Hewlett-Packard 41C/V calculator. Called the ProtoSystem Interface, it provides control and data signals for peripheral and memory boards. A user can plug in up to 64 Hewlett-Packard ROM, RAM, or extension modules such as the HPIL. Each module can then be programmed to turn on or off. The boards designed to operate with the ProtoSystem allow the user to plug in up to 13 EPROMs containing user programs or Microcode routines; to program the calculator in Microcode (the machine language of the processor in the 41C/V); and to create music and sound effects with a programmable sound synthesizer. The ProtoSystem contains its own battery pack to maintain the RAM and ProtoCoder boards when they are disconnected. The interface costs $150, and the boards range in price from $75 to $175.

Circle No. 106 on Free Information Card

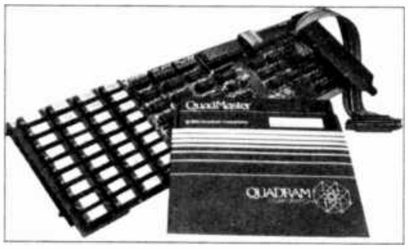
HANDHELD DMM

Philmetric, a new division of Philmore Manufacturing Co., is producing a new 3½-digit, handheld, LCD multimeter, the Model MD-150. It is reported to have a basic accuracy of 0.6% over its 26 voltage, current, and resistance ranges. Ratings are for a maximum voltage of 750 V ac/1000 V dc, and a minimum of 200 mV; current ranges are from 200 μA to 2 A; and resistance ranges are from 200 ohms to 20 megohms. The MD-150 comes with test prod finger guards on the test leads to provide safe handling of high voltages. Also included are a standup easel, carrying case, and a 9-V battery. $90.

Circle No. 107 on Free Information Card

RAM DISK FOR THE IBM-PC

The QuadMaster disketter from Quadram is reported to cut the running time of programs on the IBM-PC personal computer by up to 80%. It is used with the Quadboard four-function expansion card with up to 256K



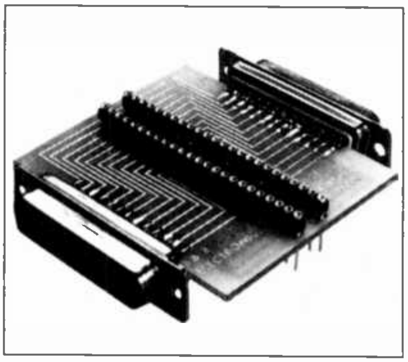
memory and the Quadram drive software diskette. The software provides RAM-disk operation by using a part of the IBM's memory as a solid-state disk drive. Data can be read to and written from this simulated disk just as from an actual disk—only hundreds of times faster, according to the manufacturer. It can be used with DOS 1.0 or DOS 1.1 without any mechanical switch changes. $20.

Circle No. 108 on Free Information Card

CABLE DUCTING

Wallgard over-the-wall cable support ducting from SGL Waber Electric is designed to organize and support ac power cords (up to 14/3 AWG size), telephone cables, and data cables that must be draped along walls. Made of extruded PVC, the one-inch-wide extrusion mounts with a foam adhesive backing, then snaps shut to hold the cables in place. Wallgard is packaged in four 4' lengths. Shorter lengths can be cut to size with a razor; longer lengths can be constructed by adding more segments. $15. **Address:** SGL Waber Electric, 300 Harvard Ave., Westville, NJ 08093.

WIRING ADAPTER



A wiring adapter designed to connect any two RS232 devices in any pattern is offered by B & B Electronics. The unit can be installed temporarily or permanently. Ten plug-in jumper wires are included. $25.

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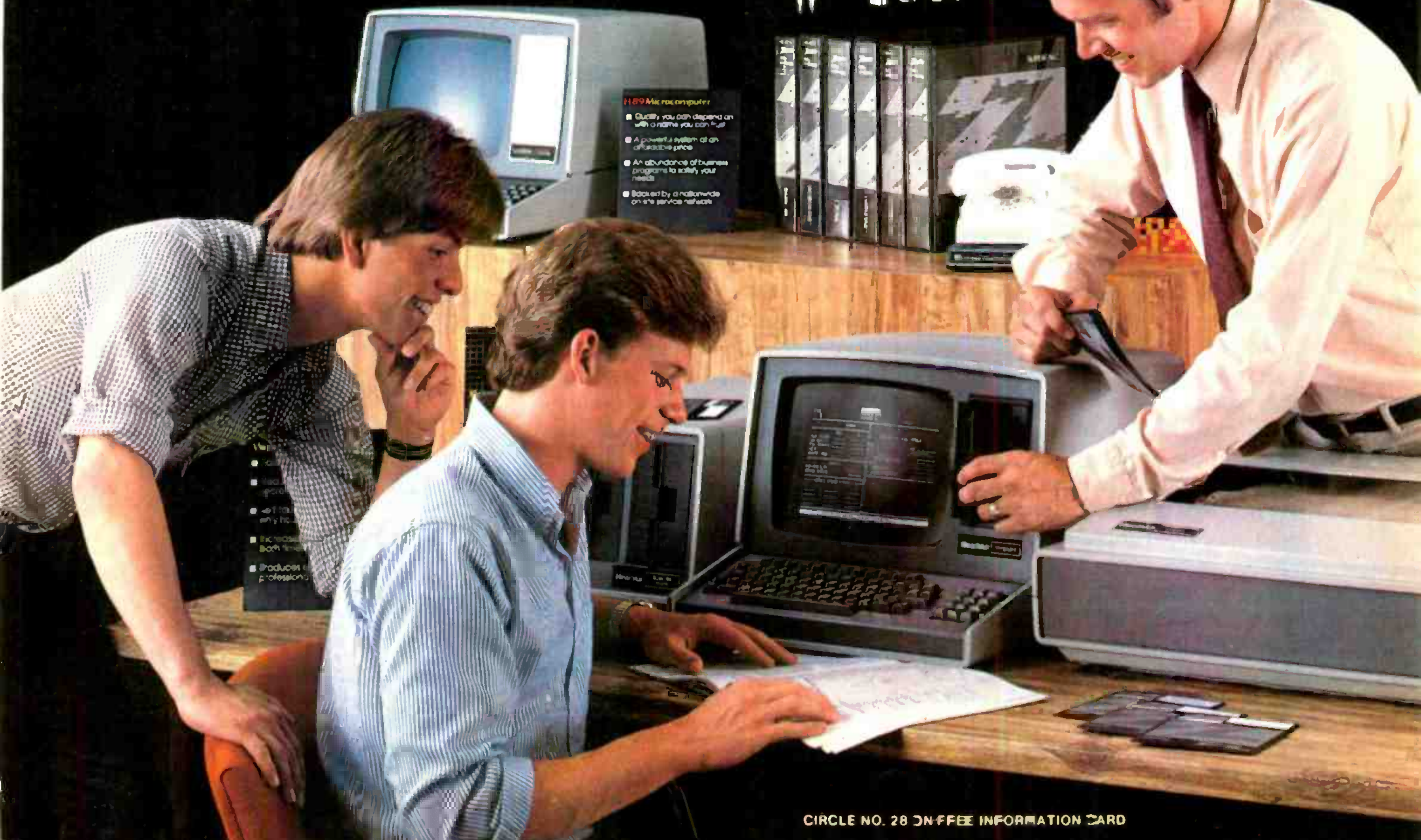


CIRCLE NO. 28 ON FREE INFORMATION CARD

ENTERTAINMENT ELECTRONICS

Better TV Pictures With Comb Filters

By Len Feldman

HAVE you noticed that many TV receivers of recent vintage are delivering far better color pictures than the sets of just a few years ago? You may even be surprised to find that our much-maligned NTSC TV broadcast system is capable of some very good picture definition and color quality *if* its full capabilities are exploited. While the low-cost color TV sets typically offer a resolution of around 250 to 280 horizontal lines, it is possible, within the limitations of NTSC, to achieve horizontal resolution higher than 350 lines. The difference between a 250-line picture and one that offers 350 lines of resolution is analogous to the difference between a photograph printed from a very "grainy" negative and one made from the finest film available or between an 8-mm home movie and a 16-mm semi-professional motion picture.

In older (and present-day low-cost) color TV receivers, the usual method of processing the luminance (brightness) component of the video signal, whose baseband with brightness and color components is shown in Fig. 1, has been to employ a band-rejection or trap filter in the luminance channel. Tuned to the color-subcarrier frequency of approximately 3.58 MHz, the trap removed most of the chrominance (color) and rolled off the response of the luminance channel to that shown in Fig. 2. In receivers of this type, chrominance signal circuitry usually had a pass-band response extending only from about 3.0 MHz to 4.1 MHz, as shown in Fig. 3. This was done to ensure that luminance signals below 3.1 MHz (which would normally overlap the chrominance signals in frequency) would not appear in the chrominance channel.

Picture definition is a function of luminance-channel frequency response; so with response cut off above about 3.0 MHz, horizontal resolution obviously suffers. There are other disadvantages to this approach to the circuit. Since the trap has virtually no rejection of the I-component of the chrominance signal below 3.1 MHz, chrominance signal sidebands tend to interfere with the luminance in areas of fine color detail. Another undesirable effect is "ringing," usually seen as dot-crawl along the vertical edges of a picture. This is especially noticeable in transition areas of the picture that contain highly saturated colors with different hues and brightness levels.

Finally, you can get a "cross-color" effect in areas of the picture that have very fine luminance detail. This occurs because the chrominance circuitry does accept luminance signals in the 3.1-MHz to 4.1-MHz range. The pass-band nature of the chrominance circuit keeps the full bandwidth of the I-signal color component from being used, which in turn reduces the amount of horizontal color resolution that is available.

Interleaving Characteristics. The circuit approach just described fails to take advantage of an important characteristic of the NTSC color TV composite signal. It treats the signal as though it consisted of continuous spectra when, in fact, the luminance and chrominance signals consist of sidebands that are interleaved. The spectral energy of the luminance signal in an NTSC vertically correlated TV picture (no change from line to line) is clustered about harmonics of the horizontal scanning frequency (f_h), with little energy between the harmonics. Chrominance sidebands, on the other hand, are spaced midway between pairs of the harmonics because the color subcarrier frequency is at 227.5 f_h, or half-way between the 227th and the 228th harmonic of f_h. This interleaving of luminance and chrominance signals is illustrated in Fig. 4.

Filters designed with frequency responses that match this sort of spectral distribution could eliminate or greatly reduce the negative effects caused by the "color-trap" approach. The frequency response of such filters (one for the chrominance channel and another for the

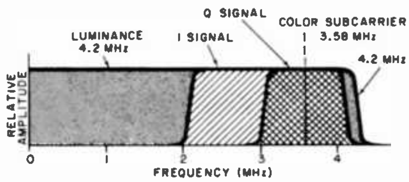


Fig. 1. Frequency spectrum of standard NTSC video signal.

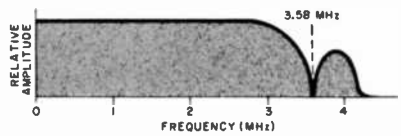


Fig. 2. Luminance frequency response when color burst trap is used.

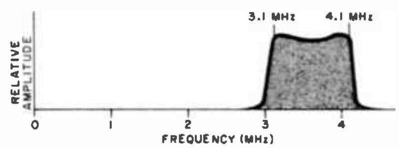


Fig. 3. Frequency response of chrominance channel.

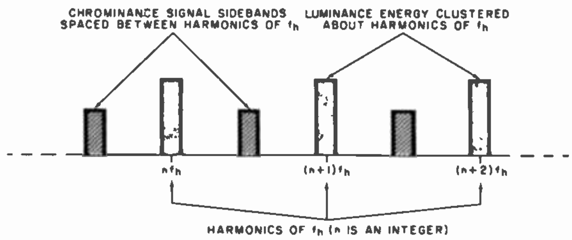


Fig. 4. Luminance and chrominance signals are interleaved on and between harmonics of f_h.

luminance channel) would contain a large number of passbands spaced at intervals of f_h, with stop-bands midway between them. Such a response curve resembles the teeth of a comb, from which the name "comb filter" is derived.

Comb Filters in TV Design. Figure 5 illustrates the basic configuration of a comb filter designed to perform chrominance and luminance signal separation. It consists of a time delay element and two summing networks to combine direct and delayed signals. If the time delay (T) is made equal to the horizontal scanning period ($1/f_h$), the filter's transfer function is maximum at multiples of f (permitting maximum output of the luminance signals), while at the same time the transfer function to the chrominance output is at minimum. The response curves for the two outputs of a basic comb filter are superimposed in Fig. 6.

The luminance output signal of such a filter represents the sum of the picture content of two successive lines. Since the color subcarrier frequency is an odd harmonic of $0.5f_h$, it alternates in phase between corresponding points on successive scanning lines. Accordingly, chrominance signals cancel when the lines are summed, leaving only the luminance signal. The chrominance output, on the other hand, represents the difference in picture content between successive scanning lines. Since the luminance signal is essentially the same for successive lines in a vertically correlated picture, it gets cancelled when the difference is taken. The chrominance signal remains because of the phase alternation of the subcarrier.

Bucket-Brigade (CCD) Comb Filters. One device that particularly lends itself to providing the time delay element needed in a comb filter is the charge-coupled device (CCD) analog shift register, sometimes referred to as a "bucket brigade." It is capable of handling the full 4.2-MHz NTSC video signal bandwidth. The delay time of a CCD depends on a clock-frequency, which can be referenced to the color subcarrier by using a phase-locked loop (PLL) circuit.

A block diagram of a typical CCD comb filter is shown in Fig. 7. The Fairchild CCD321A device used as a time delay element is a 910-bit analog shift register that provides a time delay lasting for exactly one horizontal scanning line when it is driven by a clock signal having four times the color subcarrier frequency (14.3 MHz). When an NTSC video signal is applied to the input, it is first attenuated to proper levels before being applied to the time-delay CCD element. A low-pass filter removes the clock-frequency component from the CCD output signal. The delayed signal is then fed to a phase-splitter, which supplies the two out-of-phase signals to the two summing networks. Each of these networks is also supplied with a direct video signal through variable attenuators. The upper frequency limit of the comb filter is determined by the frequency response of the low-pass filter and the CCD element. The lower limit is determined by the value of any coupling capacitors used in the circuit, and these are made large enough so that time constants are equal to several vertical scanning periods.

Additional Refinements. As already mentioned, the CCD comb filter will provide optimum chrominance and luminance separation for a TV picture that is vertically correlated. Most of the time, though, TV pictures are *not* vertically correlated, and that means that there is some luminance spectral energy present between harmonics of f_h. Attenuation of this energy by the comb filter causes a loss in vertical resolution. This problem can be dealt with in two ways.

The first approach involves restricting the "combing" action to those portions of the spectrum in which chrominance and luminance interleaving actually occurs. By adding a pass-band filter to the comb filter, as shown in Fig. 8, combing is restricted to the range of frequencies containing the color subcarrier sidebands, as opposed to operating over the entire signal spectrum. This technique results in the removal of as little of the luminance information from between the harmonics of f_h as possible.

The second approach maintains comb-filter action across the entire video bandwidth. But it adds a sig-

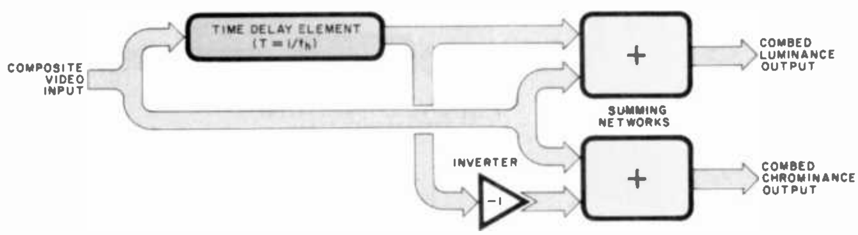


Fig. 5. Block diagram of the basic comb filter.

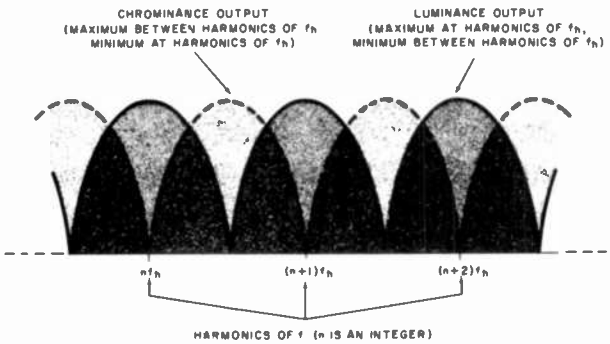


Fig. 6. Frequency responses of outputs of basic comb filter for chrominance and luminance signals.

nal containing some of the luminance information that is removed. Figure 9 illustrates how the chrominance signal obtained at the output of the comb filter is routed through a 2-MHz low-pass filter, which removes it. The net effect for the luminance signal is that comb-filter action occurs only above 2.0 MHz. The output of the low-pass filter represents changes in picture content in the vertical direction, a signal which improves vertical resolution.

In general, the use of a comb filter

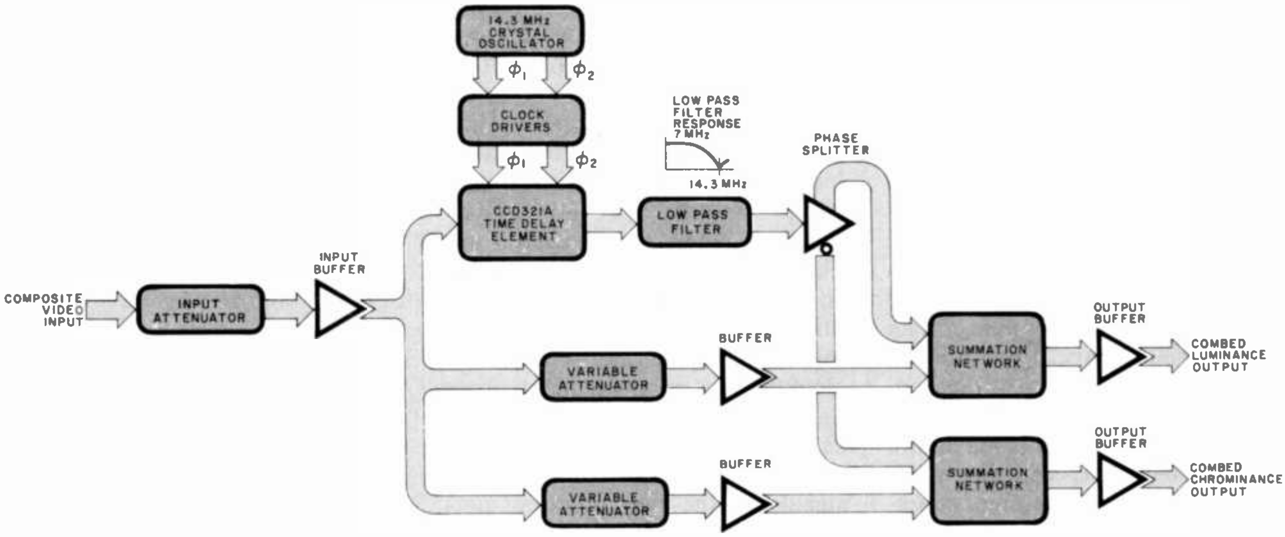


Fig. 7. Block diagram of Fairchild's CCD comb filter.

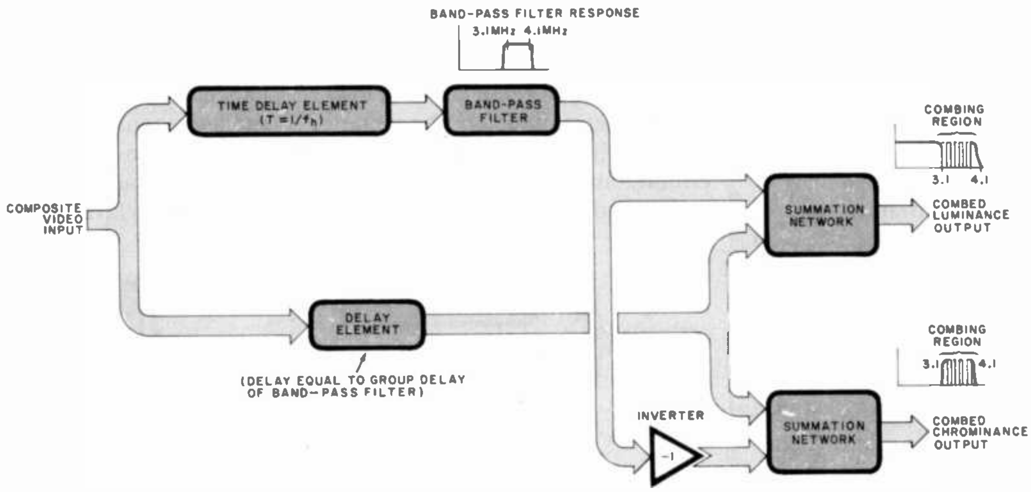


Fig. 8. Comb filter with restricted bandwidth to restore vertical definition.

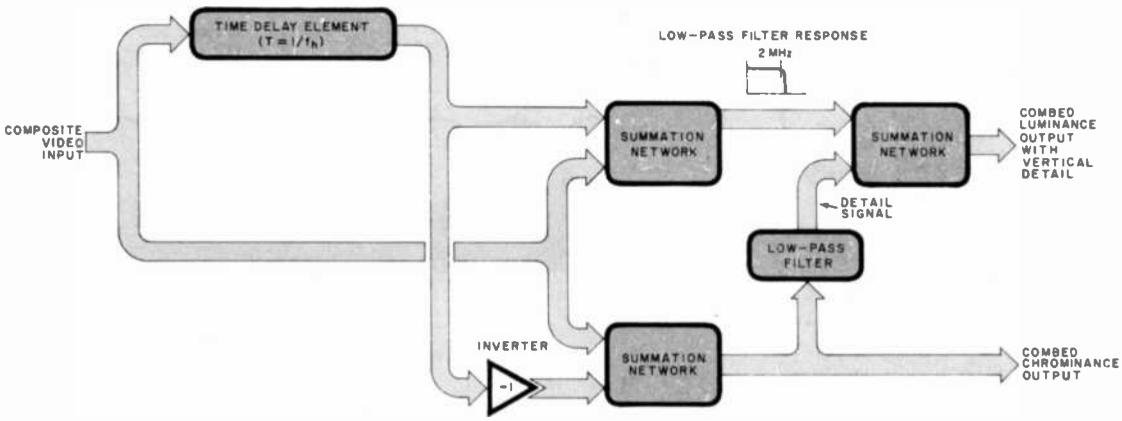


Fig. 9. Adding a "detail signal" to combed luminance output.

still produces some loss in vertical color resolution, but the net improvement in picture quality, particularly in terms of horizontal resolution and picture detail along vertical edges, more than compensates for this.

I am indebted to Fairchild Camera & Instrument Corporation for some of the technical background relating to the use of CCD devices in comb filters. It should be noted that comb-filters can be constructed using other devices, including digital time delay systems employing A/D and D/A converters and appropriate amounts of RAM for time-delaying the video signals. As the cost of digital time delay decreases even further, more and more TV set manufacturers may find it worthwhile to incorporate comb filters. This becomes increasingly beneficial since TV screens are no longer used exclusively for over-the-air reception. Better picture detail is becoming vital for video games and home computer displays.

Until the FCC approves some form of ultra-high-frequency high-definition TV transmission system (such as the 1125-line systems that have been demonstrated at various electronic trade shows), we ought to make the most of the 525-line standard that we presently have to live with. Designing TV sets with comb filters for better horizontal resolution is one worthwhile step that TV set makers can take while we wait for a better TV system. ◊

Luxman RX-103 AM/FM Stereo Receiver

THE Luxman RX-103 AM/FM stereo receiver has digitally synthesized AM and FM tuners and a rated audio output of 90 watts per channel into 8-ohm loads from 20 to 20,000 Hz with no more than 0.018% total harmonic distortion. It features a novel "Servo-Panel" that encloses the front-panel knobs when the set is off, and is retracted by a motor to expose them (together with some pushbutton controls) when it is turned on.

A large window displays the receiver's operating status. The RX-103 comes with a wireless (infrared) remote control unit that is capable of controlling a complete music system from this receiver. The system could include a cassette deck and record player.

The Luxman RX-103 is fairly large and heavy, measuring almost 18" in width and depth, and 6" in height. It weighs 34 pounds. The RC-103 remote control is 6¾"L × 2¾"W × ¾"D, and is powered by two "AA" cells. Suggested retail price $1000.

General Description. The right half of the front panel is finished in satin gold, as are the knobs and buttons within its borders. With the receiver off, the panel is flush with the front surfaces of the knobs. When it is turned on, a whirring sound is heard as an internal motor retracts the right half of the panel about ⅝", leaving the knobs protruding by that amount and exposing a row of slender pushbuttons across the bottom edge of the receiver.

The left half of the front panel is black, as are the numerous pushbuttons within its borders. A narrow, vertical section separating the gold and black panels contains several clear plastic buttons (internally illuminated) for tuning and program selection.

Within the black display window are a number of blue-white luminescent indicators, including a four-digit frequency readout, power output monitors calibrated from 0.01 to 100 watts into 8-ohm loads, a five segment signal-strength indicator, a tuning light that glows when a station is received, and lights showing FM stereo reception and the activation of the memory storage button. Red LEDs in the lower part of the window show the selected preset (memory) channel, which one of the two tape monitor circuits (or the normal source) is being heard, and whether the moving magnet (MM) or moving coil (MC) phono input has been selected.

There is also a status display for the Luxman " C.A.T." (Computer Analyzed Circuitry) system. This is a group of circuits that automatically optimize the FM tuner parameters to suit actual receiving conditions. A high-blend circuit, i-f bandwidth selector, "anti-birdie" (adjacent channel interference) filter, and antenna attenuator are independently activated, according to the received signal strength, noise, and interference conditions. A red LED corresponding to each of these actions glows on the display panel when it is in operation. The C.A.T., as well as the remote control sensor on the panel, can be switched off by pushbuttons. A stereo phone jack is located below the display area.

The rear apron contains phono jacks for all the line-level inputs and outputs, insulated binding posts for two sets of speakers and both AM and FM antennas, and a removable, pivoting AM loop antenna that can be located as needed for best reception. Three of the four ac outlets are switched and there are separate preamplifier output and main amplifier input jacks, normally joined by an adjacent slide switch. DIN sockets permit the connection of the RX-103 to a Luxman cassette deck and turntable for integrated system operation with the remote control unit.

The tuning memory of the Luxman RX-103 has eight buttons that can be assigned to either of two memory banks (A and B) by alternate operations of another button. This permits a total of 16 FM frequencies to be stored in the memories. (Only one memory bank is usable for AM frequencies, but the total capacity of 16 FM and 8 AM channels is considerably greater than that of other receivers we have seen.)

The UP and DOWN tuning buttons step the tuning in increments of

200 kHz (FM) or 10 kHz (AM) each time they are pressed, and the scanning continues for as long as a button is held in. The tuner does not have the band-scanning, signal-seeking capability of some others, although a MEMORY SCAN function is activated when that button is pressed. This steps through the memory channels, pausing on each for 5 seconds unless the button is pressed again to halt the scanning.

The usual receiver control functions of tape monitoring from either of two decks, dubbing (only from Tape 2 to Tape 1), low and high cut filters, and FM mono/stereo selection (with the muting disabled in mono) are provided by the buttons below the "Servo-Panel." In addition, one button selects either the MM or MC phono input (the same input jacks are used for both, but the preamplifier gain and input termination are changed to suit the selected type of cartridge).

The tone-control knobs are center detented, as is the balance control. The loudness control of the RX-103 is unconventional. At one limit of the knob setting, there is no loudness compensation. Rotating it clockwise gradually adds the compensation which is introduced smoothly as the volume control setting is reduced. Optionally, the loudness knob can be adjusted at any given (fixed) volume setting to gradually add the desired amount of compensation.

The RC-103 remote control has 19 flat rectangular buttons, flush with its surface. Many of them relate to tape deck or record player functions. The power button switches the receiver on and off on alternate operations. Two large buttons raise and lower the volume smoothly, with the upper limit being set by the physical position of the receiver's volume control knob. Other buttons select the input source (AM, FM, PHONO, or AUX) and the tape monitor function. A scan button initiates (or halts) the automatic memory scan. Either memory bank can be selected, but there is no way to access any of the memories directly or to tune the receiver from the remote control unit. Finally, a muting button silences the receiver or restores its sound on alternate operations.

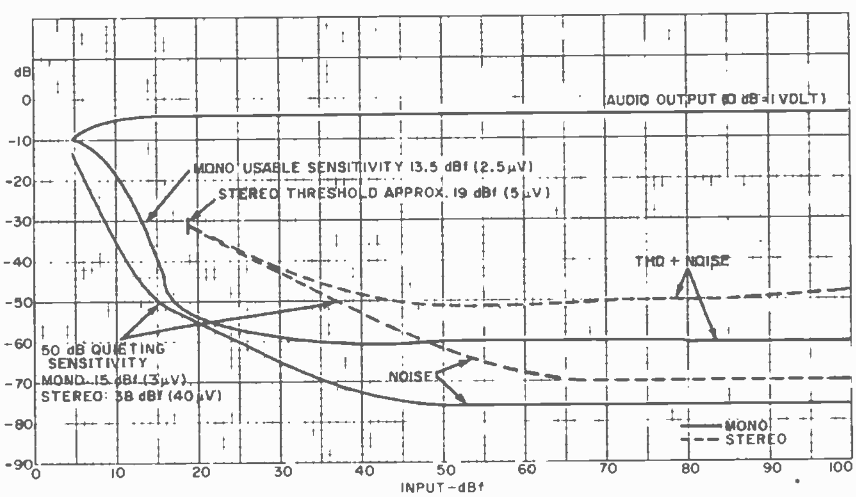
Laboratory Measurements. The FM tuner of the Luxman RX-103 had a Usable Sensitivity (mono) of 13.5 dBf (2.5 μV). The stereo sensitivity was set by the switching (and muting) threshold of 19 dBf (5 μV). The 50-dB quieting sensitivities (mono and stereo) were respectively 15 dBf (3 μV) and 38 dBf (40 μV). The S/N at a 65-dBf (1,000-μV) input was 76 dB in mono and 70 dB in stereo, and the corresponding distortion measurements were 0.1% and 0.28%.

The stereo FM frequency response was +1.4/−0.4 dB from 30 to 15,000 Hz. Channel separation was about 40 dB in the midrange (100 to 5000 Hz), reducing slightly to 34 dB at 30 and 15,000 Hz. The capture ratio was an excellent 1 dB, and AM rejection was 66 dB. Alternate and adjacent-channel selectivity readings were 58 and 4.9 dB (in the wide or "normal" condition of the C.A.T. system). We measured the operating thresholds of the various C.A.T. functions, and found that the high-blend, narrow i-f bandwidth and (adjacent channel interference) filter all came on at about 4 to 6 μV, while the r-f attenuator came on at about 350 μV. No measurements were made with the C.A.T. operating. The FM stereo pilot carrier leakage into the audio was −66 dB, and the tuner hum level was −64 dB. The AM tuner frequency response was down 6 dB at 100 and 2700 Hz.

The audio amplifier output (1000 Hz) clipped at 101.5 W per channel into 8-ohm loads and 102 W into 4 ohms (for which the receiver is not rated). When we attempted to drive 2-ohm loads, the output waveform showed a large number of narrow spikes at its maximum levels, apparently from the operation of an internal current limiting circuit. The maximum unclipped output into 2 ohms was about 16 W per channel. The 8-ohm clipping headroom was 0.52 dB. With the tone-burst signal of the dynamic headroom test, the maximum output was 163 W into 8 ohms, 130 W into 4 ohms, and 16.4 W into 2 ohms. The 8-ohm dynamic headroom was 2.58 dB.

IHF-IM distortion, with 18- and 19-kHz input frequencies, was −87 dB for the second-order product at 1000 Hz, and −72 dB for the third-order products at 17 and 20 kHz (referred to 90 W). The amplifier slew factor was greater than 25, and it was stable with reactive simulated loudspeaker loads.

Distortion at 1000 Hz rose smoothly from less than 0.002% at or below 10 W to 0.013% at the rated 90 W. With 4-ohm loads, distortion was about 0.006% at 10 W, rising to 0.025% in the 50-to-90 W range. As expected, 2-ohm operation resulted in higher distortion as well as lower power, rising from 0.0055% at 1 W to 0.018% at 10 W



Noise and sensitivity curves for FM section of the RX-103.

and 0.025% at 15 W. Across the audio-frequency range, with 8-ohm loads, distortion was between 0.01% and 0.015% from 20 to 20,000 Hz. At reduced power outputs, the distortion was lower for frequencies under 15,000 Hz, and about the same as for full power between 15,000 and 20,000 Hz.

The tone controls had a moderate range, with the low frequencies affected principally below 300 Hz, and the high frequencies above about 5000 Hz. The filter slopes were 6 dB per octave, with −3-dB frequencies of 25 and 6000 Hz. At maximum setting of the loudness control, the response was boosted at both low and high frequencies over much of the volume control range. We were interested to find that adjusting the loudness knob at a fixed volume setting resulted in almost no change in frequency response over the first 25% of the knob rotation, and that the first 75% of the range affected only the low frequency response. In the final 25%, the lows were not increased further, but the high-frequency boost came in rapidly above 3500 Hz.

RIAA phono equalization was flat within +1/−0.5 dB from 20 to 20,000 Hz. The MM phono input termination was 46 kilohms in parallel with a relatively high capacitance of 275 pF.

Amplifier sensitivity (AUX) for a reference output of 1 W was 17 mV and the phono sensitivity was 0.23 mV for MM and 0.018 mV for MC. The respective A-weighted noise levels (referred to 1 W) were −79 dB, −77 dB, and −69 dB. The phono (MM) input overloaded at levels from 188 to 220 mV, depending on the frequency.

User Comment. The actual listening performance of the Luxman RX-103 was excellent, as might be expected from its bench measurements. Since we could find nothing to criticize in its sound or, for that matter, in most aspects of its handling and operation, we will not comment further on those areas of its performance.

Nevertheless, there are some flaws in the design of this product that we cannot ignore. Normally, we prefer not to pass judgment on matters of styling, but we do make an exception when these factors actually interfere with function or add unnecessarily to cost.

Specifically, the "Servo-Panel" is a functionless feature, for which we cannot find any justification. It could be dismissed as a mere oddity, except for the fact that it must have contributed significantly to the price of this receiver. Also, although we have no reason to question the reliability of the motor drive mechanism, the fact remains that it is mechanical and therefore subject to wear. The plight of an RX-103 owner whose panel remains extended can only be imagined! It can be pushed in manually, returning when released, but this is clearly inconvenient. On the aesthetic side, we were also annoyed to find that the knobs exposed by the retracting panel are evidently on long, unsupported shafts, giving them a loose, floppy "feel" inconsistent with the total image of the product (and with its actual construction, which is generally robust and solid).

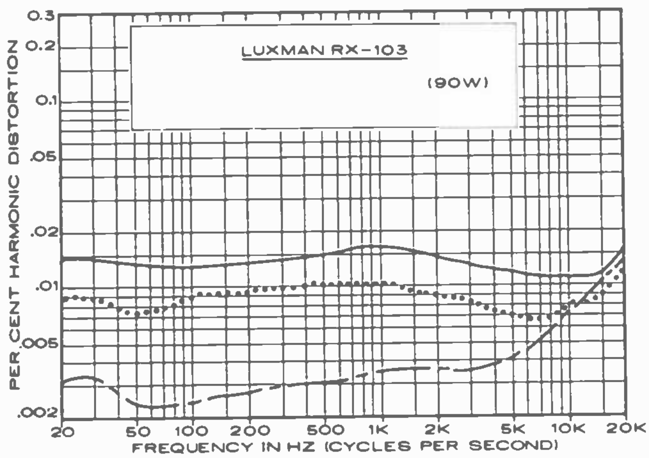
The remote control is in many ways a genuine convenience. Still, it is strange that almost half of its functions are devoted to other Luxman products rather than the receiver. How much more useful it would have been if, instead of having turntable and tape recorder controls, it allowed one to tune the receiver remotely, or at least to select any of the preset memories at will.

Finally, we feel that the amplifiers of the Luxman RX-103 are somewhat "overprotected" by its internal current-limiting circuits. While it is probably impossible to damage the amplifier (we overdrove it and briefly shorted its outputs, which simply shut it down until the fault was removed), it is nevertheless disappointing to find a very husky amplifier that simply cannot drive a low-impedance speaker load.

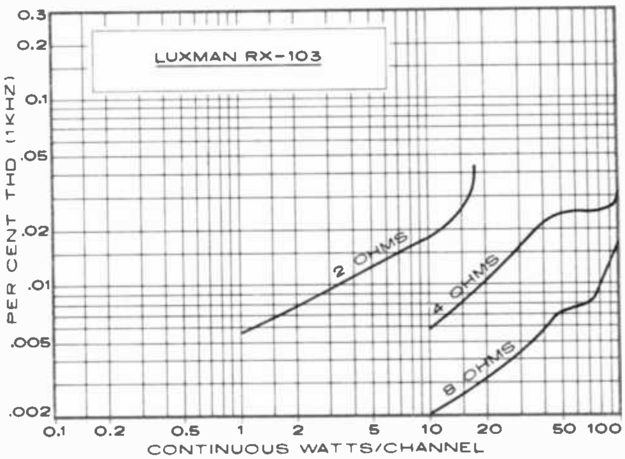
Despite the negative nature of some of our comments, it is important to realize that this is, in most respects and for most users, a perfectly satisfactory product. It looks good and sounds good. We are only unhappy that it is not a lot better, which it easily could have been, and probably for less money.

—Julian D. Hirsch

CIRCLE NO. 101 ON FREE INFORMATION CARD



Harmonic distortion at three power levels.



THD at 1000 Hz, both channels driven, left measured.

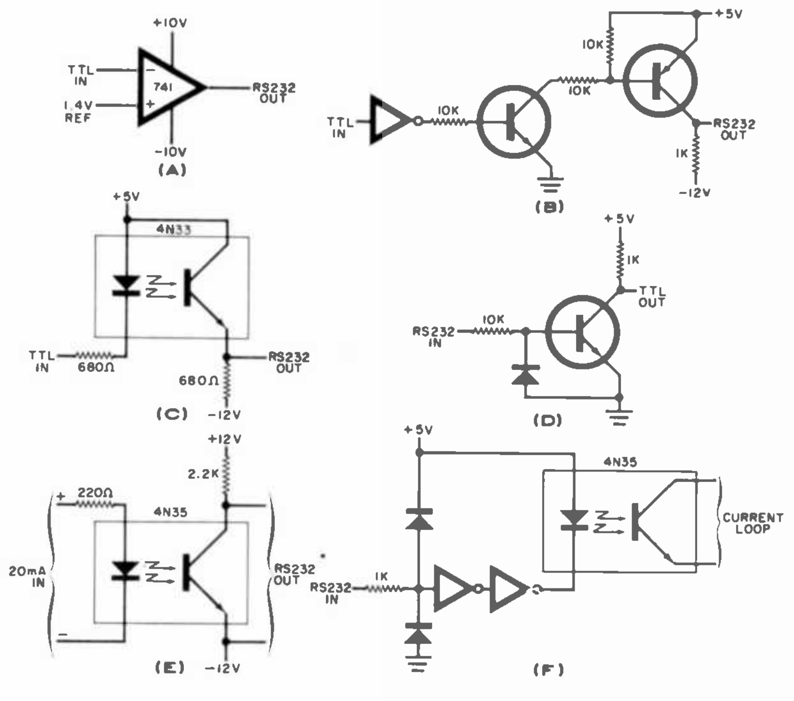
Mixing and Matching Input/Outputs

WHEN you get ready to interface a peripheral to your computer, what's the first problem you face? Probably, it's how to match the mix of I/O parts that are available—TTL, RS232, and 20 mA. In short, you have to figure out a way to allow one to communicate with the other.

If you are ever caught in this fix, take a look at the accompanying illustrations. They show several ways to mix-and-match the three types of I/O.

If, for example, your computer has only TTL access and you need RS232, the circuits of A, B, and C give you a choice, while circuit D illustrates a simple way to convert RS232 to TTL.

On the other hand, if you run into a 20-mA/RS232 problem, then circuit E shows how to convert a 20-mA loop to RS232. The companion circuit shown in F illustrates how to convert an RS232 signal into a switch that can control a 20-mA loop.



When interfacing RS232 to TTL, you can use the circuit at A, B, or C. To convert RS232 to TTL, try the circuit at D. Converting a 20-mA loop to RS232 can be done with E, while the circuit at F is for the reverse situation.

Apple "Jukebox". The Mega-Mate is a companion to the Apple II that uses a single conventional Apple drive in concert with 40 conventional diskettes all supported within a frame. A mechanical mechanism selects the desired diskette, opens the drive door, inserts the diskette, and closes the drive door. This allows up to 5M-bytes of stored data to be accessed. The resident firmware allows accessing any desired diskette. The number of the diskette is displayed on a front-panel 7-segment readout. The unit can be locked. It will soon be available for the TRS-80 Models I and III. $695. Additional diskette magazines are $70. **Address:** Computer Products Inc., Suite 124, 9071 Metcalf, Overland Park, KS 66212 (Tel: 913-648-7849).

IBM Controller. The Asynchronous Communications Controller for the IBM Personal Computer is available with either one or two RS232 ports. It is fully compatible with IBM software and can be used with a modem. It automatically adds and removes start, stop, and parity bits while a programmable baud-rate generator operates between 50 and 9600 baud. It supports a variety of character formats including five, six, seven, or eight characters with 1, 1½, or 2 stop bits and a prioritized interrupt system. The controller runs standard IBM diagnostics. $139 for one line, and $199 for the two-line version. **Address:** Datamac Computer Systems, 680 Almanor Ave., Sunnyvale, CA 94086 (Tel: 408-735-0323).

Apple Hard Disk. The Starfire is a 5M-byte Winchester specifically designed for the Apple II. It can also be used with CP/M (SoftCard required), or Pascal. It can be partitioned into 16 separate areas each under control of a different operating system if desired. Each partition is independent, and can be of any size. Software includes an expanded version of DOS with volume names, write protection, auto-boot, rename, volume directory, freespace directory, catalog, search, and single keystroke operation. Other utilities include locking and unlocking files, deleting and undeleting files, copy and verify status display. An extensive backup utility is also provided. $2495 with controller. A 10M-byte version is $2995 with controller. **Address:** Corona Data

(Continued on page 30)

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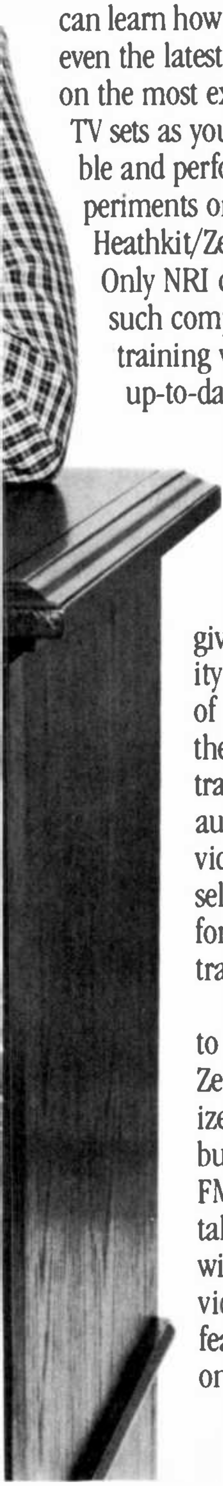

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...HARDWARE (from p. 25)

Systems Inc., Suite 110, 31324 Via Colinas, Westlake Village, CA 91361 (Tel: 213-706-1505).

Advantage Hard Disk. The Advantage stand-alone computer is now available with an integrated 5¼", 5M-byte, Winchester disk storage system that replaces one of the system's floppy disk drives. The system with 5M-byte of hard disk, and one 360K floppy is now available for $6599. **Address:** North Star Computers, Inc., 14440 Catalina St., San Leandro, CA 94577 (Tel: 415-357-8500).

Photo Transmission by Computer. The PhotoCaster permits color or monochrome photos taken with a conventional TV camera to be displayed, processed, and, using a self-contained modem, sent between Apple computers over conventional telephone lines. With an 8-second/photo time, the device allows adding titles and graphics, creation of special video effects, and image enhancement. A high-resolution graphics dump routine provides hard copies. Monochrome photos are processed with a resolution of 128 × 128 pixels and 16 levels of gray. Requires an Apple II with 48K of RAM and one drive. The board is slot independent. The PC-100 PhotoCaster is $499.95, plus shipping. **Address:** Commsoft, Inc., 2452 Embarcadero Way, Palo Alto, CA 94303 (Tel: 415-493-2184).

IBM Controller. Available in both single- and dual-channel models, the controller features a rotating jumper plug to ease communications cabling by switching the transmit and receive signals in the connector and programmable baud rates from 50 to 19,200. The dual-channel option allows an efficient use of limited computer space in applications where one part drives a modem and the other a serial printer. Fully IBM compatible, the controllers supports 5-, 6-, 7-, or 8-bit characters with 1, 1½, or 2 stop bits, even or odd, or no parity. A full prioritized interrupt system controls transmit, receive, error and modem status change interrupts while diagnostic capabilities provide loopback functions. Full duplex is supported, and double buffering eliminates precision synchronization. The single-channel controller is $130; the double-channel is priced at $195. **Address:** Personal Systems Tech., Inc., 22957 La Cadena, Laguna Hills, CA 92653 (Tel: 714-859-8871). ◊

The PhotoCaster transmits photos between Apple Computers.

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Micro-Mainframes Must Have Humongous Memories

I RECENTLY requested a review copy of Concurrent CP/M-86 for the IBM-PC. Digital Research told me that it would be glad to send me one and asked how much memory I had in my PC. "Oh, plenty," I said. "I've got 128K!" "Sorry,"said the representative from DRI. "You need at least 320K!"

Well, I do have a 256K memory board in my computer with 64K of RAM on it; but I suppose I will have to populate it much sooner than I ever thought I would. This is not a commentary on Concurrent CP/M-86. The point is, rather, that we are building software systems that use huge amounts of memory just to hold the operating system—to say nothing of the applications software and the resulting data. As a consequence, our computers are turning into micro-mainframes with megabytes of memory. I don't know if this is a good idea, as I'll explain.

Most micros don't have parity checking or other systems for checking for bad memory conditions during operation. The IBM-PC does use a parity bit, but there is no way to work around a bad bit if one occurs. So we roll along, building bigger and more complicated software systems to use on computers that can run them, which is fine if everything goes OK.

It is no wonder that many software applications developers are turning to Forth, which uses the minimum memory required for any application. During the next few months, I will be looking at the memory utilization of the various software systems I review. This is a parameter I hadn't thought about before and which hasn't really been addressed since we emerged from the world of 8K memory boards.

I've been going to a lot of press conferences lately, called by manufacturers to introduce new computer equipment. The stock phrase at many of these affairs is "IBM compatible." In fact, they talk more about the IBM-PC than their own new machine! However, when you examine the so-called compatibility, it disappears! Sure they run MSDOS or CP/M-86, and they can use some of the same software that has been released for the IBM-PC, but when you ask the big question, "Can I take a diskette out of my IBM-PC and put it into your disk drive and run it?" they hem and haw.

Let's define "software compatible" to include disk format compatibility, otherwise it is meaningless to the user. It must include the function "transportability," or it is not compatible. This applies not only to the IBM-PC, but to all the new machines coming onto the market. I recently heard a sales person for a new computer say that his computer system was compatible with the Xerox 820 *single-density* format. Great! What he didn't say was that this format left no room on the disk for applications and data. That's why Xerox went to double-density. Let the buyer be wary.

One interesting and little-known fact about the IBM-PC compatibility advertised by several manufacturers is that the IBM-PC has three kinds of BASIC. The first is ROM-based and only has I/O capability with the almost-never-used cassette system. The second is a simple disk BASIC that uses most of the ROM BASIC and adds disk I/O and graphics. The third called BASICA is the complete IBM BASIC with all the "bells and whistles." Now the interesting thing about BASICA is that it is not completely contained on the IBM-PC DOS diskette that it is loaded for. It uses much of the ROM BASIC that is in the machine. Now this ROM is only licensed to IBM by Microsoft. They sell something called MSBASIC to go with the MSDOS licensed to other manufacturers. It is *almost* the same as BASICA (called GW BASIC by Microsoft for Gee Wiz!) but it lacks the interface to IBM-PC features.

We called several of the "IBM-PC compatible" manufacturers to find out what they were doing about this. We only got an answer from Columbia Data Products which said it was aware of the problem and has "patches" to MSBASIC to do the same thing, but will introduce its own BASIC at Comdex 1982. It feels this will take care of the problem.

WordStar for CP/M-86 and MSDOS. Micropro International has announced the availability of WordStar, SpellStar, and Mail Merge for 16-bit computers using CP/M-86 and MSDOS. Each of these products will be priced at $250. WordStar is the most popular word-processing system for PC/M-80 computers and has recently been configured for the IBM-PC computer under PCDOS.

Micropro will release these new versions on 8" "standard" disks. We think this is somewhat strange since most of the computers now using CP/M-86 and MSDOS use some form of 5¼" disks! However, they all use different formats so Micropro has taken the easiest way out.

Business Software for the Otrona. The Accounting Plus package from Systems Plus (Palo Alto, CA) has been adapted for the portable Otrona Attache Computer. This package consists of modules

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Z-100 Utility Program. Computer Palace has created a Printer Screen Graphics program for the Zenith Z-100 Computer. The $39.95 Utility Program will make a black-and-white copy of anything on the screen. It currently supports the Epson MS-80 and MS-100 as well as the MPI99G printers. **Address:** Computer Palace, 115 Shorewood Dr., Menomonie, WS 54741.

Software for Sony Computer. Sony intends its new desktop computer, the SMC-70, to be amply supplied with software when it is released. The SMC-70 uses the Sony $3^1/_2$" disk and has color graphics. The operating system will be CP/M-80 version 2.2 with color graphic enhancements. Language support will include Digital Research's CB80, a compiled Business Basic, as well as an interpretive Sony BASIC that supports color graphics, sound, and video disk features. Pilot Plus is another language that will be supported. Other software publishers who have adapted their products to the Sony format include: Visicalc from Visicorp, Condor Data Base Management system and the Structured Systems Accounting Systems. Sony also will issue communications software to enable use of Compuserve, the Source, Dow Jones, and other networks. Sony intends to publish a software catalog listing all the software converted to run on its 3½" disk format. **Address:** Att: Harvey Lawner, Sony Microcomputers, 7 Mercedes Dr., Montvale, NJ 07645.

CP+ The CP/M Manager. Tarus Software has a super utility for CP/M users. It eliminates the jargon and complicated CP/M commands, replacing them with simple English messages and single keystrokes. For example, to copy a disk, you eliminate PIP A:=B: PROGRAM. TEXT [V], and replace it with a keystroke, which brings up the message "CP PLUS DISK FILE COPY" "YOUR CURRENT DISK IS DRIVE A: DRIVE TO COPY TO? B" "FILE NAME OF FILE TO BE COPIED? PROGRAM. TEXT"

CP+ offers HELP for the user when needed and lets him control the printing of computer output through print. This allows the user to call for the next print job while the printer is printing the previous one. CP+ takes about 15 minutes to install and it runs on CP/M versions 1.4 or 2.2. It can be used on just about all the computers that use CP/M-80. I recommend this package to all new users of CP/M. Even for those who can never unlearn the CP/M commands originally drilled into them, this program has enough

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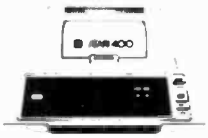

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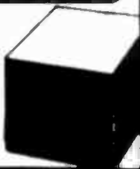

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to offer to make it worthwhile. To those just starting with the 16-bit generation of computers, Tarus Software is releasing a version to be used with CP/M-86 at the Comdex Fall 82 show. This should be in the stores when you read this. **Address:** Tarus Software, 870 Market St., San Francisco, CA.

CP/M Plus Enhances 8-Bit Micros. Digital Research Inc., "owners" of the popular disk operating system, CP/M, announce release of Version 3.0 of the 8-bit version called CP/M-80. They have renamed this CP/M Plus because it adds features designed to enhance both existing computers and new 8-bit designs to take advantage of the increase in memory size made possible by cheap, large-scale memory chips and extended addressing schemes. Also has the ability to use CP/M on the new hard disks in the megabyte range.

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There is also an automatic log-in feature that eliminates the need to reset with CTRL C every time a disk is changed. Complementing all these goodies is a new console I/O redirection facility. Without changing the application program, this feature allows input to come directly from a file or output to be written directly to a file (no more I/O Byte). CP/M Plus now supports up to 16 disk drives, totaling 512 megabytes of storage each with file sizes of up to 32 megabytes. All of these features make CP/M Plus very user friendly and keep 8-bit processors in the running for the next decade.

Pricing for OEM'S has been set at $350 for an evaluation copy. However, it is expected that manufacturers will incorporate CP/M Plus into their product line as they now do and make it available to owners of existing equipment for much less. **Address:** Digital Research Inc., 160 Central Ave., Pacific Grove, CA 93950.

Quick Brown Fox Jumps Over The VIC-20 Keyboard. The Quick Brown Fox is a word processor designed for use with the VIC-20 and Commodore 64 computers. This $65 program will run on even the smallest VIC-20 with 3K and has features not found on systems costing hundreds of dollars more. The software is packaged in a cartridge that plugs into the computer. It includes full line and global editing, text moving, tab and margin settings, right justification, and proportional spacing. It can reformat edited text automatically instead of on a paragraph-by-paragraph basis.

When used with a memory and video expansion for the VIC-20, the software turns this low-cost computer into a full-capability word-processor system. Either a serial or parallel printer can be used and the whole word-processing station should cost less that $2000. Sold wherever VIC-20 and Commodore 64 are sold. **Address:** Quick Brown Fox Software, 548 Broadway, Suite F, New York, NY 10012.

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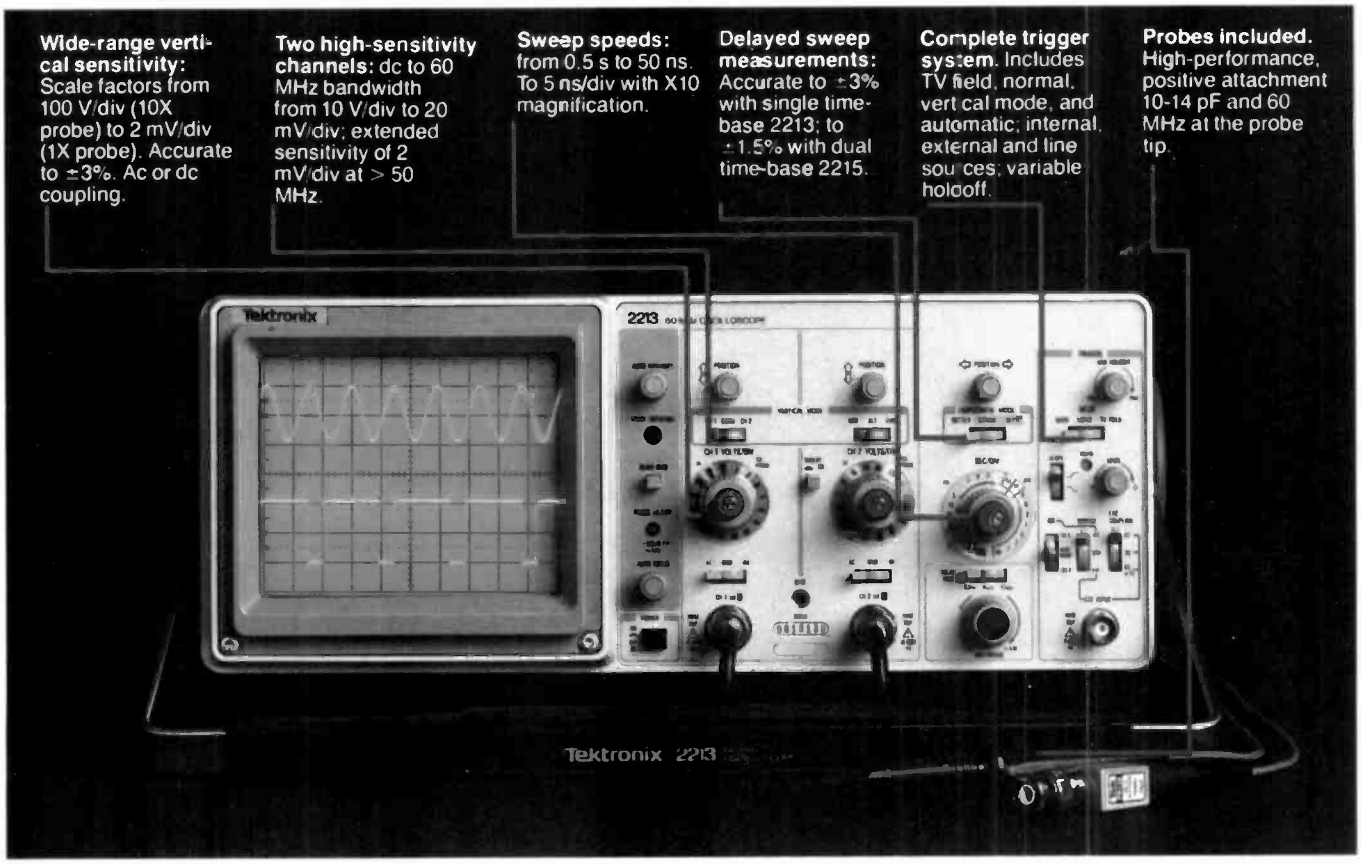

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Computers&Electronics
FEBRUARY 1983

TALK CAN BE CHEAP

Hundreds of words can be "spoken" by a Sinclair or Timex computer when adding an interface and a "Speak & Spell"

By Larry Dighera

A "talking" computer is not necessarily expensive—not if you mate one of the low-cost computers (Sinclair ZX-80, ZX-81, or Timex 1000) with Texas Instruments' popularly priced "Speak & Spell"™ learning device. The combination gives you several hundred clearly articulated words that expand the usefulness of the small computer. All you need to make it happen inexpensively is a simple interface and some software, all described here. Using these ideas, you might design a low-cost security/fire-alarm that vocalizes the nature of a problem ("FIRE," "THEFT," etc.). You could also enhance your computer's portability by making its output audible instead of displaying it on a video screen; write educational programs with truly meaningful student/teacher interaction; spice up computer video games with synthesized speech;

create useful programs for the visually impaired; etc. Here's how it can be done.

System Overview. The Speak & Spell consists of a pushbutton keyboard, microprocessor, display, ROM (contains speech data), voice synthesizer, and loudspeaker. A block diagram of the system is shown in Fig. 1. The microprocessor communicates with the speech units through a 6-line bus with CNTL 1, 2, 4, and 8 forming a 4-bit data bus and PDC (processor data clock) and CS (chip select) forming a control bus. The control commands used in the Speak & Spell are listed in Table I.

The ROM contains the binary-coded speech data for synthesis of the spoken word. Each word has a specific starting address. When it is desired to output a particular word, the ROM address of the beginning of the word is sent to the voice synthesizer in five 4-bit nybbles, preceded by the LOAD ADDRESS (code 2) command. The data is then clocked into the voice synthesizer by the PDC signal. Once the 5-nybble word address is loaded, READ ROM (code 8) and SPEAK (code 10) commands are sent to cause speech to be generated. If the BUSY SPEAKING? (code 14) command is now sent, the voice synthesizer will raise the CNTL 1 line high until it finishes vocalizing.

A schematic of the interface circuit between the computer and Speak & Spell is shown in Fig. 2. The microprocessor in the Speak & Spell uses PMOS devices that operate at −21 V. (A typical I/O line is shown within the processor.) Because PMOS uses passive pulldown resistors, output current is limited. If ground potential is impressed on these lines, no harm will result, regardless of their state.

The Z80A Parallel Input/Output (PIO) chip in the interface used for *IC1* provides two bidirectional I/O ports: port A uses CMOS inverters (*IC2*) and open-collector pnp driver transistors (*Q1* through *Q6*) as the outputs. The emitters of these drivers are connected to the +5-volt line, which is also connected to the positive (COM) of the Speak & Spell. Thus, when a transistor is conducting, the S&S MPU "sees" a logic 1 (0 V); when the transistor is off, the PMOS pulldown resistors bring the line to logic 0.

Port B of the PIO is used for input and receives its signal from *R7* through *R12*, which limit the incoming signal from the Speak & Spell. In addition to interfacing with the Speak & Spell, with appropriate software, the PIO can provide a much-needed parallel I/O capability for the computer, allowing use of joysticks and such functions as music, control, and process monitoring.

Construction. The circuit can be built on a dual 22-contact card similar to the Radio Shack No. 276-154. If you use the same edge-contact arrangement as in the computer, except for the clock line, the card is compatible with ZX bus expansion cards currently available. Use of sockets for the ICs and a miniature phone jack to interconnect the power supply are recommended.

The Speak & Spell draws about 200 mA and the interface about 70 mA at 5 V. If you are using a 16K RAM extension, the larger power supply can handle the extra load. Arrange switching so that both computer and interface power up at the same time. If you elect to use batteries in the Speak & Spell, disconnect the ground line by opening the jumper (see Fig. 2). Recheck the interface circuit before connecting it to the computer.

To make the connections to the Speak & Spell, carefully remove the back plate and locate the 40-pin microprocessor immediately below the display. Pin 1 is in the lower right-hand corner. Connections are made to pins 10 through 14, 36, 38, and the negative terminal of the bat-

(Continued on page 47)

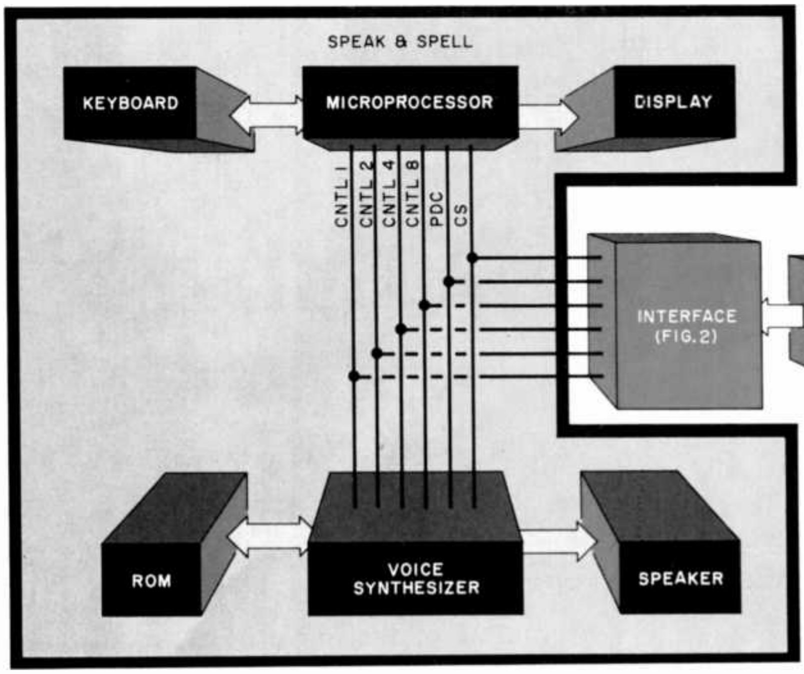

Fig. 1. Block diagram of the Speak & Spell with the interface and ZX-81 computer.

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(Continued from page 40)
tery. Use fine insulated wire to make these connections and work very carefully to avoid creating short circuits.

The nine leads can be terminated in a 14-pin DIP socket, with the cable brought out through the battery compartment. Slip a short length of heat-shrinkable tubing over each wire before soldering it to the DIP socket. Then shrink it over the soldered connection.

The interface is wired to the Z80 microprocessor in the computer as shown in Fig. 2.

Software. Because it is necessary to supply the voice synthesizer with data at a rate beyond the capability of the BASIC interpreter built into the computer, machine language must be used during programming. The programming code given in Table II covers six program modules. The first, labelled PIO, is the initialization routine for the Z80 PIO chip (*IC1*). When power is first applied to the system, the PIO is in an inactive state and must be initialized (told what to do) before it can be used.

The listing in Table II can be entered into the computer using the BASIC program shown in Table III. The three lines without numbers at the beginning of the program are keyed directly into the machine to reserve the top 6K of RAM for the remainder of the program. After entering Table III, run it and enter each number shown in the decimal-code column of Table II, referring to the check sum as you go. If an error is detected, use B to move back. Moving forward without altering the data that has already been entered may be accomplished by entering S (for skip).

At this point, it is possible to test operation of the PIO by entering the following:

```
POKE 26624,62     ;LD A, data

POKE 26625,0

POKE 26626,211    ;OUT port A,A

POKE 26627,1

POKE 26628,201    ;return
```

Now enter:

```
1000 PRINT USR 16514

1010 INPUT A

1020 POKE 26625,A

1030 PRINT USR 26624

1040 GOTO 1000
```

By entering a number between 0 and 63, the six low-order bits of port A are controlled. These can be metered at the outputs of *IC2*. After testing, delete the BASIC programs. At this point, the listing in Table II should still be in the machine; it can be SAVED on cassette for future use.

Not all Speak & Spell ROMs are programmed with the same word addresses. Hence, it is necessary to construct a "word map" for your particular device. One way to find the starting address of a word would be to send the voice synthesizer successive addresses and note which produce usable speech output. However, this tedious method is not necessary since the interface can be used as a form of logic analyzer that allows you to monitor the bus and capture the addresses sent by the microprocessor. This can be accomplished by entering the BASIC program shown in Table IV. The REM at line 1 reminds you that the machine code of Table II should be in the machine.

To locate the address of a particular word, use the DETERMINE WORD ADDRESS routine and press the GO key until you hear that word. Hit any key to start recording (which calls STODATA of Table II) and then operate the REPEAT key to put the address on the bus. The STODATA routine allows taking "snapshots" of the voice synthesizer bus at approximately 12-microsecond intervals and storing this data in the top 5K of RAM. (See RAM Memory Map in Table V.) This data can be graphically displayed via the LOGIC DISPLAY routine in Table IV. Successive frames can be viewed by hitting ENTER, or specific frames can be selected by hitting the appropriate key. You can also choose numerical readout by using the PRINT WORD ADDRESS portion of Table IV.

The machine-code module SPEAK (Table II) is the software driver for speech production. Because Speak & Spell uses CNTL 1, 2, 4, and 8 to turn on the display segments and convey data, there are always extraneous signals on the bus. This "noise" can be minimized by pressing ON, ON, GO. This leaves only the cursor on, which causes CNTL 8 to periodically go high. Because of this, SPEAK contains a trap that waits for the bus to clear before sending data. Once clear, five nybbles, stored in the 1K above RAMTOP, are clocked into the voice synthesizer. Then the READ ROM, SPEAK, and BUSY SPEAKING? control words are clocked in. When finished speaking, the voice synthesizer causes the CNTL 1 line to go low to allow the RESET control code to be clocked in. Finally, PIO port A is configured with all lines low via the OFF program module.

PDC is the machine-code module that clocks in the data presented by SPEAK. When called, it waits approximately 124 microseconds, brings the processor data clock high for 124 μs, then holds the data for 124 μs before returning. The 124-μs timing is effected by the delay loop at 16645 of Table II.

If sentences rather than individual words are required, RAM address 16542 can be POKEd with the location of the next word to be spoken, then SPEAK called again. This is repeated until all words are vocalized It is possible to store more than 200, 5-nybble word addresses in the 1K space above RAMTOP.

TABLE I—VOICE SYNTHESIZER CONTROL COMMANDS

Code	Use	Input/Output
0	RESET	Input
2	LOAD ADDRESS	Input
4	PLACE VOICE DATA ON BUS	Output
6	SPEAK SLOWLY	Output
8	READ VOICE DATA FROM ROM	Input
10	SPEAK	Output
12	BRANCH	Input
14	BUSY SPEAKING?	Output

TABLE II—MACHINE CODE LIST

Address	Label	Mnemonic	Code Decimal	CK Sum	Comment
16514	PIO	LD A,207	62,207	62	Mode control word (Mode 3)
16516		OUT (3),A	211,3	480	Mode control word to PORT A control register
16518		LD A,192	62,192	545	Data direction word:bits 0-5 = out,6&7 = in
16520		OUT (3),A	211,3	948	Data direction word to PORT A control register
16522		LD A,207	62,207	1013	Mode control word (Mode 3)
16524		OUT (7),A	211,7	1431	Mode control word to PORT B control register
16526		LD A,255	62,255	1500	Data direction word:all bits input
16528		OUT (7),A	211,7	1966	Data direction word to PORT B control register
16530		LD A,7	62,7	2035	Interrupt control word: disable interrupts
16532		OUT (3),A	211,3	2253	Interrupt control word to PORT A control reg.
16534		OUT (7),A	211,7	2467	Interrupt control word to PORT B control reg.
16536		RET	201	2675	Return
16537		NOP	0,0,0,0	2675	No Operation
16541	SPEAK	LD HL,0,104	33,0,104	2708	Set NYBL pointer to RAMTOP
16544	AAA	LD BC,0,5	1,0,5	2813	Set NYBL counter = 5
16547		IN A,PORT B	219,5	3037	Get current state of synthesizer bus
16549		ADD A,0	198,0	3240	Set zero flag if no data present
16551		JR Z,AAA	40,250	3280	Wait until data present
16553	BBB	IN A,PORT B	219,5	3749	Get current state of synthesizer bus
16555		ADD A,−8	198,248	3952	Wait until bus clear (CNTL 8↓)
16557		JR Z,BBB	40,250	4240	Loop until bus clear
16559		LD A,CS	62,32	4552	Get Chip Select/reset word
16561		CALL,PDC	205,236,64	4789	Clock in reset
16564		ADD A,2	198,2	5287	2 = "LOAD ADDRESS"
16566		CALL,PDC	205,236,64	5494	Clock in "LOAD ADDRESS" command
16569		SUB,2	214,2	6008	Remove command
16571	CCC	ADD A,(HL)	134	6144	Get NYBL
16572		CALL,PDC	205,236,64	6349	Clock in NYBL
16575		SUB,(HL)	150	6799	Remove NYBL
16576		INC,HL	35	6834	Increment NYBL pointer
16577		DJNZ,CCC	16,241	6850	Loop if less than 5 NYBLs
16579		ADD A,8	198,8	7289	8 = "READ ROM"
16581		CALL,PDC	205,236,64	7502	Clock in "READ ROM" command
16584		ADD A,2	198,2	8000	10 = "SPEAK"
16586		CALL,PDC	205,236,64	8207	Clock in "SPEAK" command
16589		ADD A,4	198,4	8705	14 = "BUSY?"
16591		CALL,PDC	205,236,64	8914	Clock in "BUSY?" command
16594		LD A,CS	62,32	9276	0 = "RESET" command
16596		CALL, PDC	205,236,64	9513	Clock in "RESET" command + CS
16599	DDD	IN A,PORT B	219,5	10032	Get synthesizer bus status
16601		BIT 0,A	203,71	10240	Check bit 0 = 0
16603		JRNZ,DDD	32,250	10343	If bit 0 ≠ 0,then still speaking, so loop
16605		LD A,CS	62,32	10655	0 = "RESET"
16607		CALL,PDC	205,236,64	10892	Clock in "RESET" + chip select
16610	OFF	LD A,0	62,0	11254	0 = off
16612		OUT PORT A,A	211,1	11465	Turn off PORT A
16614		RET	201	11667	Return
16618		NOP	0,0,0,0,0	11667	No operation
16620	PDC	OUT PORT A,A	211,1	11878	Send data to synthesizer
16622		CALL,DELAY	205,5,65	12084	Set up time
16625		ADD A,PDC	198,16	12352	16 = Processor Data Clock
16627		OUT PORT A,A	211,1	12579	Set clock high
16629		CALL,DELAY	205,5,65	12785	Clock pulse width
16632		SUB 16	214,16	13069	Remove Processor Data Clock
16634		OUT PORT A,A	211,1	13296	Let clock fall
16636		CALL,DELAY	205,5,65	13502	Hold time
16639		RET	201	13773	Return
16640		NOP	0,0,0,0,0	13773	No operation
16645	DELAY	PUSH,BC	197	13970	Save NYBL counter
16646		LD C,21	14,21	13984	Initialize delay-loop counter
16648	EEE	DEC C	13	14018	Reduce delay-loop counter by 1
16649		JRNZ EEE	32,253	14050	Loop until time-out
16651		POP,BC	193	14496	Retrieve NYBL counter
16652		RET	201	14697	Return
16653		NOP	0,0,0,0,0	14697	No operation
16658	STODATA	LD, HL,108	33,0,108	14730	Set data pointer to storage address
16661		LD C,5	14,5	14852	PORT B data register address
16663	FFF	IN A,PORT B	219,5	15076	Get current state of synthesizer bus
16665		CP 50	254,50	15335	50 = CS + PDC + "LOAD ADDRESS" command
16667		JRNZ,FFF	32,250	15417	Loop until 50 present
16669	GGG	INI	237,162	15904	Send bus data to storage & increment pointer
16671		LD A,129	62,129	16128	129 = 2's complement of 32512
16673		ADD A,H	132	16389	Test if H byte = 32512
16674		JRNZ,GGG	32,249	16421	Loop until H byte = 32512
16676		RET	201	16687	Return
16677		NOP	0 x 14	16687	No operation
16690				.	End of REM statement

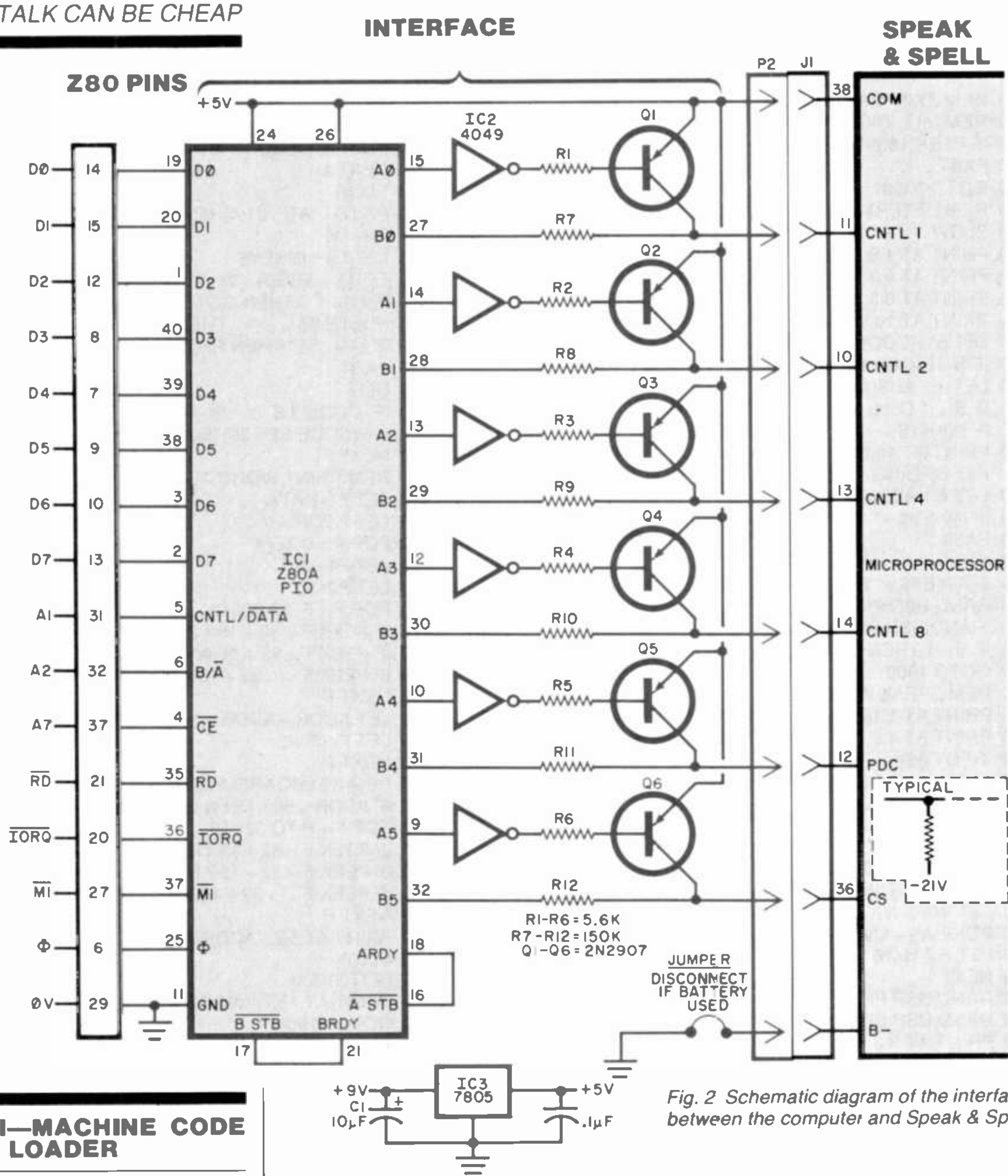

Fig. 2 Schematic diagram of the interface between the computer and Speak & Spell.

TABLE III—MACHINE CODE LOADER

```
     POKE 16389, 104
     NEW
     FAST
  1  REM (178 CHARACTERS)
 10  LET S = -1
 20  LET B = 256
 30  LET A1 = 0
 40  FOR I = 16514 to 16690
 50  PRINT AT 0,0; "ENTER"; I
 60  INPUT A
 70  IF A < 0 THEN GOTO 110
 80  IF A > 255 THEN GOTO 150
 90  SCROLL
100  POKE I, A
110  LET A1 = A1 + PEEK I
120  PRINT I; " = "; PEEK I, A1
130  NEXT I
140  STOP
150  LET A1 = A1 - PEEK (I-1)
160  LET I = I - 2
170  NEXT I
```

PARTS LIST

C1—10-μF, 16-V electrolytic
C2—0.1-μF ceramic capacitor
IC1—Z80A PIO
IC2—4049 hex inverter
IC3—7805 5-V regulator
J1—14-pin DIP socket
P2—14-pin DIP connector
Q1 through Q6—2N2907 transistor
R1 through R6—5.6-kilohm, ¼-W resistor
R7 through R13—150-kilohm, ¼-W resistor
Misc.—Sockets, prototype board (Radio Shack 276-154 or similar), ribbon cable

***Note:** A cassette of software for the project is available from the author at PO Box 12100, Santa Ana, CA 92712, for $6.00. California residents, add sales tax.*

Operation of the BASIC program of Table IV is straight-forward. You will be prompted whenever an input is required. To return to the menu, enter M. When your word map is complete, you can delete all but the REM statement containing the machine code and write your own programs for speech production. To output speech, POKE the addresses of the words you want spoken into the area above RAMTOP, by adding a loop to the SPEAK WORD routine (line 1400) and let the loop incre-

TABLE IV—BASIC PROGRAM ZX-SPEAK

```
   1 REM (Machine Code Here)
1000 REM ZX-SPEAK REV. 3.1
1010 REM (c) L. DIGHERA 1982
1020 IF PEEK 16389 < > 104 THEN STOP
1030 FAST
1040 GOTO 3000
1190 REM DETERMINE WORD ADDRESS
1200 SLOW
1210 PRINT AT 1,9;"WORD LOCATER"
1220 PRINT AT 4,3;"1. . .DISPLAY LOGIC DIAGRAM"
1230 PRINT AT 6,3;"2. . .PRINT WORD ADDRESS"
1240 PRINT AT 10,9;S$(A + 1);"MODE"
1250 LET S = (CODE INKEY$) – 28
1260 IF S = (CODE"M") – 28 THEN RETURN
1270 LET A = ABS(A – 1)
1280 IF S < 1 OR S > 2 THEN GOTO 1240
1290 IF INKEY$ < > " " THEN GOTO 1290
1300 PRINT AT 10,0;H$(A + 1);"ANY KEY TO START
     RECORDING."
1310 LET A = ABS(A – 1)
1320 IF INKEY$ = " "THEN GOTO 1300
1330 FAST
1340 CLS
1350 IF INKEY$ = "M" THEN RETURN
1360 RAND USR PIO
1370 RAND USR STODATA
1380 IF S = 1 THEN GOTO 1650
1390 GOTO 1900
1400 REM SPEAK WORD
1410 PRINT AT 1,10; "SPEAK WORD"
1420 PRINT AT 4,5; "ENTER WORD ADDRESS"
1430 INPUT A$
1440 IF A$ = "M" OR A$ = " "THEN RETURN
1450 LET WA = VAL A$
1460 LET H = 65536
1470 LET AS = 26624
1480 FOR I = 4 TO 0 STEP – 1
1490 LET N = INT(WA/H)
1500 LET WA = WA – N*H
1510 POKE AS + I,N
1520 LET H = H/16
1530 NEXT I
1540 RAND USR PIO
1550 RAND USR SPEAK
1560 PRINT AT 8,3;" ' ' ' 'ENTER' ' ' ' TO
     SPEAK";A$;"AGAIN."
1570 PRINT AT 4,5;" ' ' ' 'N' ' ' ' TO ENTER NEW WORD."
1580 INPUT B$
1590 CLS
1600 IF B$ = "M" THEN RETURN
1610 IF B$ = "N" THEN GOTO 1400
1620 GOTO 1540
1640 REM LOGIC DISPLAY
1650 FOR F = DATA TO 32488 STEP 60
1660 PRINT TAB 3; "** LOGIC SIGNAL DISPLAY**"
1670 PRINT "FRAME:";(F –
     DATA + 60)/60;TAB12;"12US/ ";TAB22;"60 /FRAME"
1680 PRINT AT 3,0;"CS",,,,,,"CK",,,,,,,,
     "C8",,,,,,"C4",,,,,,"C2",,,,,,"C1"
1690 PRINT AT 8,0" # #  + · · + · · "
1700 FOR X = 0 TO 59
1710 LET L = PEEK(F + X)
1720 LET I$ = "72 + ?  "
1730 PLOT X + 4,CODE I$ + INT(L/32)*2
1732 LET L = L – INT(L/32)*32
1734 LET I$ = I$(2 TO )
1736 PLOT X + 4,CODE I$ + INT(L/16)*2
1738 LET L = L – INT(L/16)*16
1740 LET I$ = I$(2 TO )
1742 PLOT X + 4,CODE I$ + INT(L/8)*2
1744 LET L = L  INT(L/8)*8
1746 LET I$ = I$(2 TO )
1748 PLOT X + 4,CODE I$ + INT(L/4)*2
1750 LET L – L – INT(L/4)*4
1752 LET I$ – I$(2 TO )
1754 PLOT X + 4,CODE I$ + INT(L/2)*2
1756 LET L = L – INT(L/2)*2
1758 LET I$-I$(2 TO )
1760 PLOT X + 4,CODE I$ + L*2
1770 NEXT X
1780 SLOW
1790 PRINT  AT  21,4;H$(A + 1);" ""ENTER""  FOR  NEXT
     FRAME"
1800 LET L$ = INKEY$
1810 LET A = ABS(A – 1)
1820 IF L$ = " " THEN GOTO 1800
1830 IF INKEY$ < > " " THEN GOTO 1830
1840 IF L$ = "M" THEN RETURN
1850 FAST
1860 CLS
1880 IF  CODE  L$  >  28  AND  CODE  L$  <  64  THEN  LET
     F = (CODE L$ – 30)*60 + DATA
1890 NEXT F
1900 REM PRINT WORD ADDRESS
1910 LET F = DATA
1920 LET ADDR = 0
1930 FOR P = 0 TO 4
1940 LET F1 = 0
1950 LET F2 = 0
1960 FOR F = F TO 32512
1970 IF PEEK F = 32 + 16 + 2 THEN LET F1 = 1
1980 IF PEEK F < 32 + 16 AND F1 = 1 THEN LET F2 = 1
1990 IF PEEK F > = 32 + 16 AND F2 = 1 THEN GOTO 2010
2000 NEXT F
2010 LET ADDR = ADDR + 16**P*((PEEK F) – 32 – 16)
2020 LET F = F + 5
2030 NEXT F
2040 REM KEYBOARD ADDRESSES
2050 IF ADDR > 803 THEN GOTO 2140
2060 FOR F = F TO 32512
2070 IF PEEK F = 32 + 15 THEN LET F1 = F1 + 1
2080 IF PEEK F = 32 + 15 AND F1 > 14 THEN GOTO 1920
2090 IF PEEK F < > 32 + 15 THEN LET F1 = 0
2100 NEXT F
2110 PRINT AT 5,7;"ADDRESS NOT FOUND"
2120 SLOW
2130 GOTO1300
2140 PRINT AT 15,7:"WORD ADDRESS: ";ADDR
2150 GOTO 1190
2900 REM MENU
2910 PRINT AT 1,7;"**ZX-SPEAK**"
2920 PRINT AT 4,3;"1...DETERMINE WORD ADDRESS"
2930 PRINT AT 6,3;"2...SPEAK"
2940 PRINT AT 10,9,S$(A + 1);"MODE"
2950 LET S = CODE INKEY$ – 28
2960 LET A = ABS(A – 1)
2970 IF S <  1 OR S > 2 THEN GOTO 2940
2980 IF INKEY$ < > " "THEN GOTO 2980
2990 FAST
2998 RETURN
3000 REM****EXEC****
3010 LET MENU = 2900
3020 LET PIO = 16514
3030 LET SPEAK = 16541
3040 LET OFF = 16610
3050 LET STODATA = 16658
3060 LET DATA = 27648
3070 DIM S$(2,8)
3080 LET S$(1) = " SELECT "
3090 LET S$(2) = "[SELECT]"
3100 DIM H$(2,5)
3110 LET H$(1) = " HIT "
3120 LET H$(2) = "[HIT]"
3130 LET A = 1
3140 SLOW
3150 GOSUB MENU
3160 CLS
3170 GOSUB S*200 + 1000
3180 CLS
3190 GOTO 3140
```

TABLE V—RAM MEMORY MAP

16514	PIO Initialization	
16541	Speak	
16610	Off	
16620	PDC (H=64, L=236)	10K RAM
16648	Delay (H=65, L=5)	
16658	Sto-Data	
16690	End of REM	
26624	RAMTOP (POKE 16389,104)	1K RAM
27647	End of NYBL Storage	
27648	Bus Data Storage Begins (H=108)	5K RAM
32512	End of Data Storage (A-129)	

ment variable AS by five for each word.

When all words are stored, delete all but the first REM statement. Then write a subroutine that calls PIO at 16514. Then, after POKEing 16542 and 16543 with the location of the word to be spoken, call SPEAK at 16541. Or, if desired, you can arrange the words in the proper sequence; and, after calling SPEAK initially, call 16341 (SPEAK +3) for the next word.

Conclusion. Only the basics of using the Speak & Spell vocalizer with Sinclair and Timex computers have been discussed here. There are many things you can do with the system beyond what we've presented. For example, you can locate the addresses of individual word sounds (phonemes) contained in ROM and string them together to make words that don't exist in the ROM's vocabulary, making it possible to build an almost unlimited dictionary of words. You might trim the prefix from the word "anything" to obtain "thing" simply by locating and using the starting address of the suffix.

Another approach to obtaining a larger vocabulary is by adding more ROMs to the system. Currently, as many as 16 ROMs can be connected into the system, each individually accesssed through the address-decoded ROM chip select. Access to data output from the ROMs is available at the Speak & Spell's edge connector.

The more you use the system, the more you're likely to learn about it. As you experiment with it, you may discover many features of the Speak & Spell we haven't covered here. You may even crack the word-encoding scheme. ◊

Magnify your CALCULATOR'S DISPLAY

Add a simple multiplexing circuit to your handheld calculator's output so you can use ½-inch digital displays

By Lawrence G. Souder

DO YOUR eyes ache after spending much time with your calculator? Does Granny refuse to take advantage of the usefulness of a calculator because she can't see the digits? Did you ever want to use the calculator as a teaching aid in a math class but couldn't because the people in the back row couldn't see what came up on your display? If you answer yes to any of those questions, you will find this project a useful addition to your calculator. It is a simple circuit that provides a large, easy-to-read display. In addition to being practical, this project demonstrates a principle used in almost every electronic product with two or more seven-segment displays—multiplexing.

What is Multiplexing? Multiplexing is a form of time sharing, a technique that allows more than one signal to occupy the same conductor. It is commonly used in digital circuits, particularly seven-segment displays. Digital clocks, for example, require a separate seven-segment code for each digit. A four-digit clock would need a total of 28 (7 segments times 4 digits) separate lines to feed the digits. However, the same display in a multiplexed configuration could use the same segment code bus for all four digits, with each digit taking its turn using the bus to get its data. Separate digit enable lines tell each digit when to take its turn at the bus. When the seven-segment code for the units value of the minutes is on the segment bus, all four digits get the same code, but only the enabled digit will actually display the code on the bus. Likewise, when the code for the tens value of the minutes is on the segment bus, only the enabled tens digit will display that value. The other three digits remain dark. The cycle continues until all four digits appear to be "on" at the same time because the process of scanning is so rapid.

TI-30 CALCULATOR CHIP

Pin	Function
1	Digit 7
2	Digit 8
3	Digit 9
9	$V_{dd}(-)$
11	Segment DP
12	Segment B
13	Segment G
14	Segment D
15	Segment A
16	Segment F
17	Segment E
18	Segment C
20	$V_{ss}(+)$
23	Digit 1
24	Digit 2
25	Digit 3
26	Digit 4
27	Digit 5
28	Digit 6

Handheld calculators use this technique to feed their displays. In the case of the standard nine-digit calculator, multiplexing makes it possible to feed all nine digits with just 17 conductors (eight segment lines and nine digit enable lines). Without multiplexing, a nine-digit display would require 72 signal lines.

Multiplexing also economizes on current demands since only one digit is on (powered) at any one time. This feature is particularly advantageous for battery-powered devices.

About the Circuit. The outboard display circuit shown in Fig. 1 is essentially a copy of the multiplexed display used in most calculators. The important difference is that it uses 0.5-inch digits instead of the usual 0.15-inch digits. All like segments (A through G) of the nine displays are wired in parallel, and each segment line has its own transistor driver (*Q1* through *Q8*). Each display common-cathode lead also has its own transistor driver (*Q9* through *Q16*), the base of which is fed by a digit enable line. The base of every transistor has a series current-limiting resistor to isolate the low impedance of a forward-biased base-emitter junction from the signal line of the calculator chip. Nineteen leads in all run between the outboard display and the calcu-

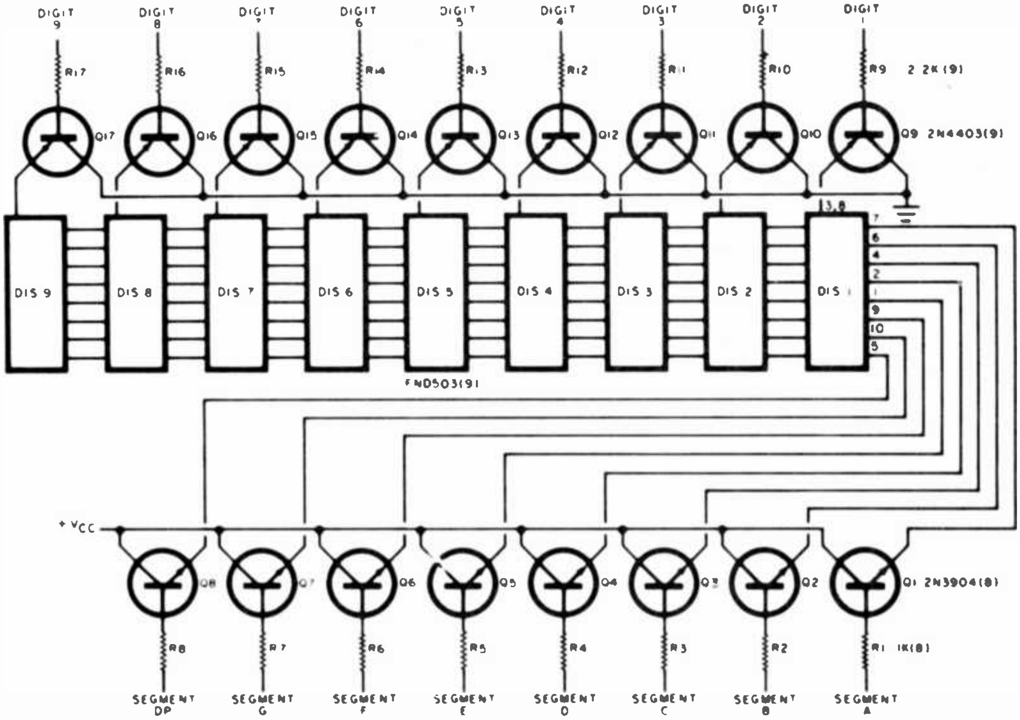

Fig. 1. Nineteen leads connect the outboard display circuit to the calculator itself.

PARTS LIST

D1 through D9—FND 503 0.5 inch, 7-segment display, common-cathode
Q1 through Q8—2N3904 transistor
Q9 through Q17—2N4403
R1 through R8—1-kΩ, ¼-W resistor
R9 through R17—2.2-kΩ, ¼-W resistor

lator: eight for the segment bus (A through G and decimal point), nine for the digit enable lines, one for V_{cc}, and one for ground.

Construction. There is nothing critical about construction. Perforated board is probably the easiest and cheapest way to go, although it does require considerable point-to-point soldering. Multi-conductor ribbon cable will make the interconnection between the display and the calculator easier and neater. Try to use cable having individually colored conductors so that some kind of color-coding scheme can be used (e.g. digit enable one = brown, digit enable two = red, and so forth).

This outboard display was designed for the Texas Instruments TI-30 calculator. The table shows which pins of the calculator chip provide the segment-and digit-enable signals. Since the calculator pc board is crowded, soldering the nineteen wires from the display must be done very carefully using fine solder and a needle-tipped soldering iron. The only additional modification required is to disconnect the digit enable lines of the TI-30's existing display. This is easily done by cutting (with a razor blade) the foil traces from each digit-enable pin of the calculator chip. Cutting them in this way will allow restoring the original display later, simply by bridging the cuts with small blobs of solder.

Adapting Other Calculators. Although the hook-up shown is for a TI-30, this display circuit is easily adapted to other calculators that use a common-cathode display. All you need to do is find out whether your calculator's display is common-cathode or common-anode (common-anode displays are not compatible with the circuit) and what pins of the calculator chip provide the various segment and digit drives. To locate these pins, remove power from the calculator and experimentally apply a low dc voltage (about 5 V) in series with a current-limiting resistor (5000 ohms or so) to various pc traces near the display until at least one segment on the display lights up. When you get two different segments to light, you will know which element is common. Follow those traces back to the chip and record the pin numbers. Eventually, you should be able to track down all digit and segment drive pins.

Operation. Once the outboard display is properly connected, use the calculator as normal. No outside power source is needed since the outboard display "steals" its power from the calculator; the power switch on the calculator will control power to the display as well. The only difference from normal operation is that, since the larger digits draw about three times more current than the original display, it may be best to use the calculator's ac adapter. ◊

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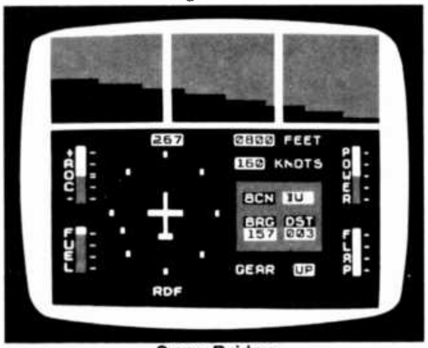

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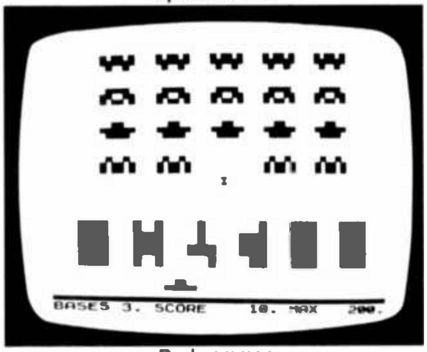

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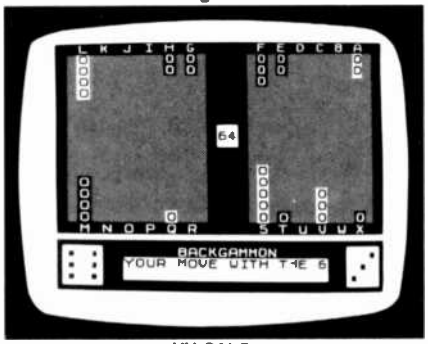

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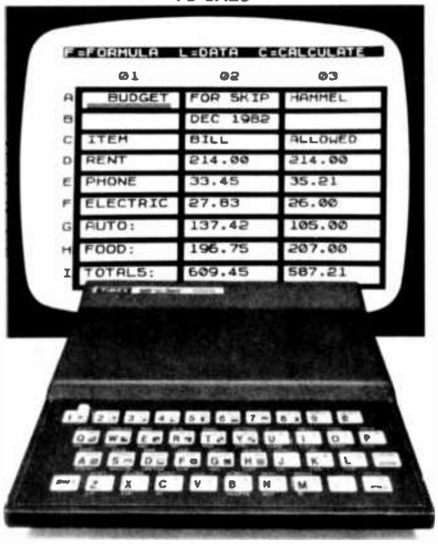

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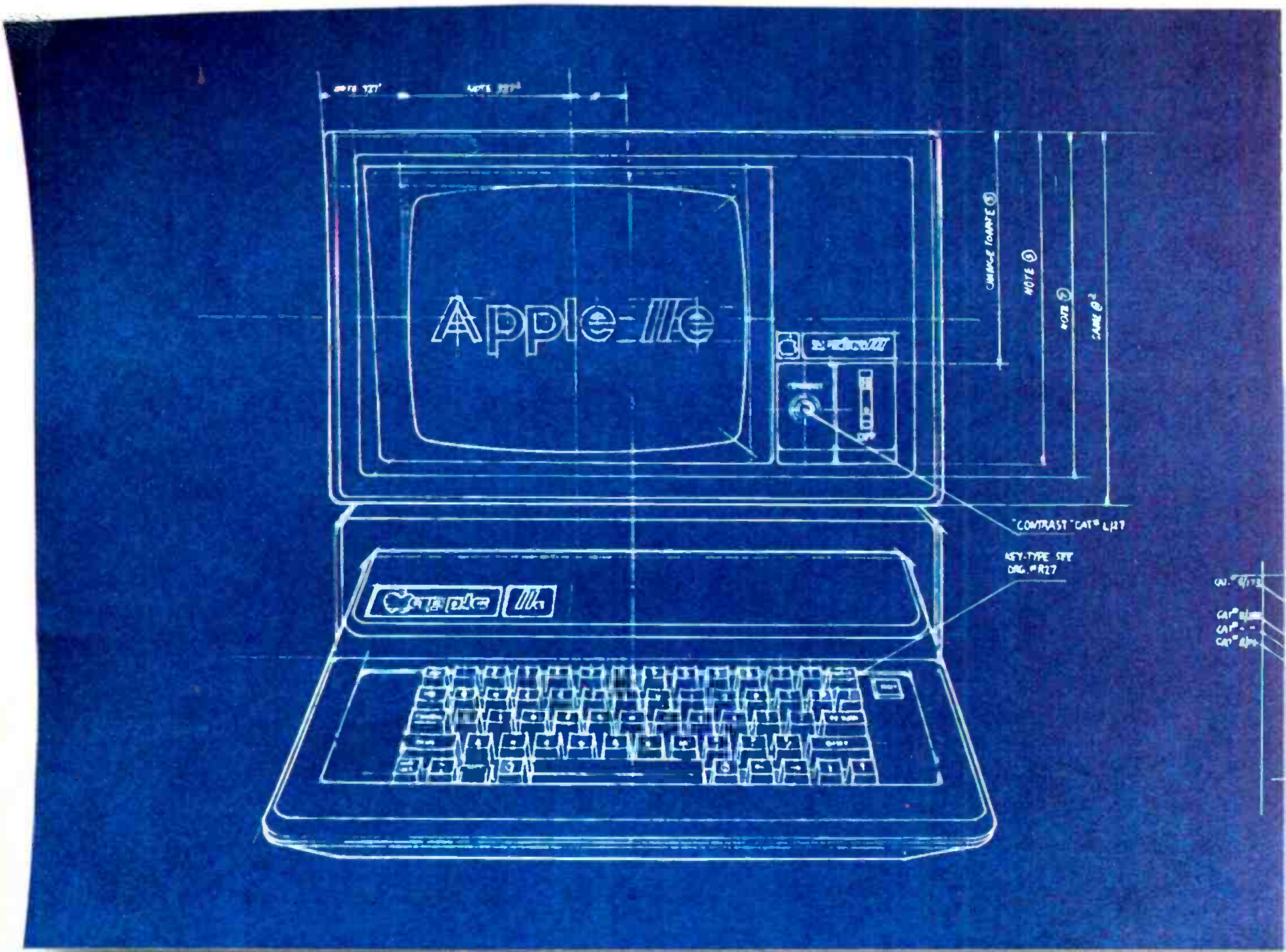

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NEW BRIEFCASE COMPUTERS

Portable microcomputers from Epson and Hewlett-Packard can double as small desktop machines with appropriate peripherals

COMBINE POWER & VERSATILITY

By Stan Veit

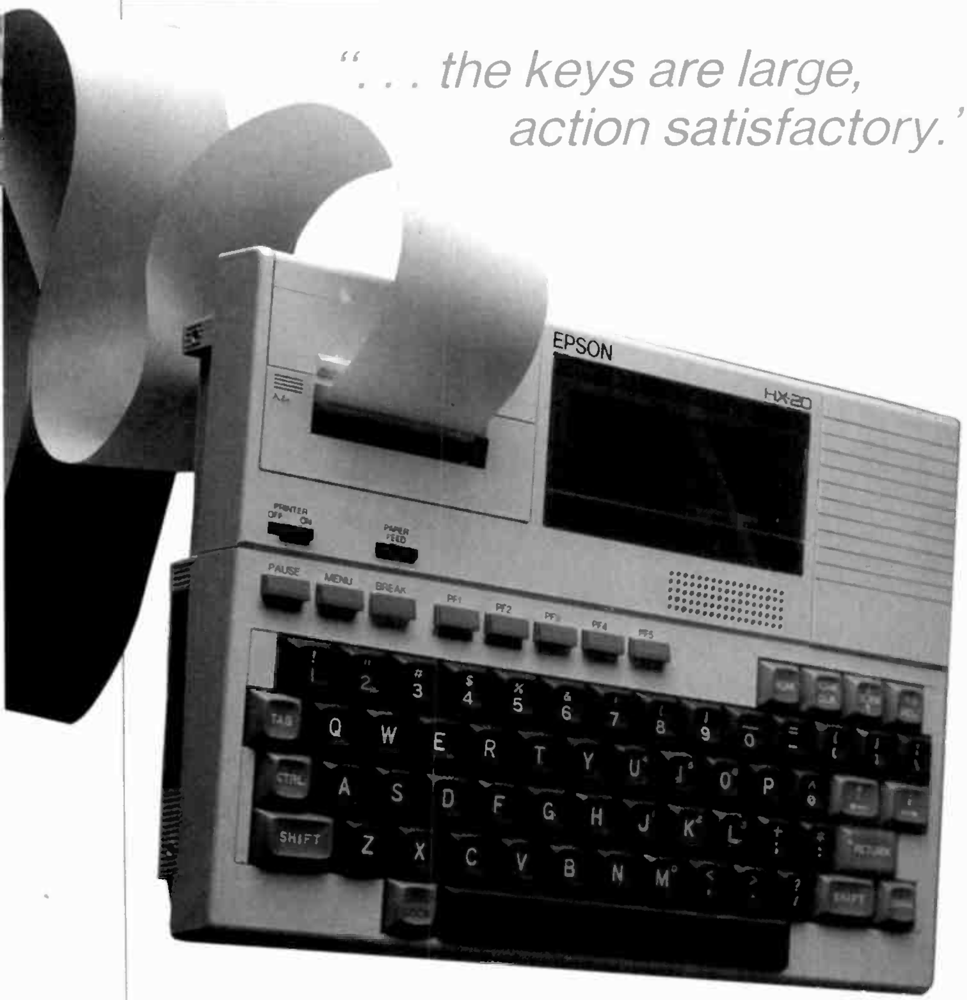
PORTABLE computers come in three sizes: pocket, suitcase, and briefcase. In the latter category are the Epson HX-20 and Hewlett-Packard HP-75C models. Though neither can be stuffed into a large pocket, they don't take up much room in a briefcase.

In a welcome evolution, these portables feature keyboards that can be used by touch-typists, overcoming a shortcoming of many pocket computers. The two portables cannot be directly compared, as each has its unique attributes. So we will discuss them in turn.

The Epson HX-20

THE NEW Epson portable computer is the larger of the two machines tested, measuring 11⅜"W × 8½"H × 1¾"D com-

". . . the keys are large, action satisfactory."



pared to the HP-75C's 10" × 5" × 1¼". But the HX-20 accounts for this most admirably by packing a microprinter and an optional micro-cassette drive or ROM program module easily into its rectangular face.

In this rather small area, the HX-20 also incorporates a full-size keyboard that's slightly on the tight side and a four-line liquid-crystal display.

The Epson HX-20 is battery-powered, and the manual goes to great length to tell you that the plug-in power unit is only a battery charger and not a power supply for the computer. It is not designed to run your HX-20 directly from ac and you are warned to use the computer only on its internal batteries, charging them when necessary. This is different from most other plug-in adapter units that run on the plug-in power supply.

There are two dual CPU chips in the HX-20—both 6301 CMOS. The main CPU accesses the RAM and ROM memories. It also controls the keyboard. The secondary CPU controls the micro-printer, the external cassette, and an internal speaker. When a plug-in cartridge is installed, it has ports for both CPUs.

The liquid-crystal display shows four lines of 32 characters and it is a window on a "virtual width" line that is up to 255 characters wide. The use of four lines is a great advantage over handheld portables with a single line display. It is also possible to use the LCD to display plotting points and other graphic features. The complexity of the graphics is limited by the size of the LCD display, but the computer can create complex graphics when it is connected to a CRT through the optional video display controller. One other feature of the Epson HX-20 that will be appreciated by users is the provision for adjustment of the display. There is a small wheel on the right side of the computer that changes the viewing angle of the display unit so the user can see it from any angle.

The keyboard is a standard QWERTY type containing the ASCII upper/lower case character set on 68 keys. There are also five special function keys across the top of the board (PF1 through PF5). These are assigned functions in printer operation and software applications, and they are also used as the operating buttons on the micro-cassette when one is installed. There are also 13 special keys on the control panel. Two are to control the printer, and three are for PAUSE, MENU and BREAK when running BASIC programs. The INS/DEL key is used to insert or delete characters during screen editing, the NUM key converts part of the keyboard into a numeric keypad for rapid mathematical operation. The HOME/CLR key controls the cursor and clears the screen. Finally, the SCRN key scrolls the display for greater visability.

The keyboard has international character sets for use in foreign languages. The selection is made by setting switches inside the computer. Character sets are labeled for use in Denmark, England, France, Germany, Italy, Spain, Sweden, and the USA.

The keyboard is a high-quality type. The keys are large, the action is positive, and the satisfactory feel is aided by small depressions. A touch typist can operate the keyboard as rapidly as any portable typewriter. In addition to the standard ASCII character set, the HX-20 has a set of 32 graphic characters. These are for such useful things as small cars, people, airplanes, music notes, graphic patterns, and lines.

The printer is a 24-column, dot-matrix impact type. It uses the full ASCII character set (upper/lower case) and has a graphic print rate of 42 lines per minute. It prints graphic characters, and also has bit-addressable graphics. It uses plain paper in 55-mm rolls and has a cartridge ribbon for easy installation. This is a very nice printer with good-quality printout—truly a "baby Epson."

When you use the computer for the first time, you must initialize the memory and the calendar clock. Once this is done, the computer will maintain the time and date information whether the computer is turned on or not.

The CMOS memory will also retain up to five programs in the computer until they are cleared. The TITLE command permits the user to make any of the stored programs part of the initial menu so that they can be directly accessed and run when selected from the menu.

The computer comes with 16K bytes of RAM memory and 32K of ROM. There is internal expansion room for 8K of ROM and external expansion provisions for 16K of RAM and 32K of ROM which must be bank-switched with the BASIC ROMs.

The Epson HX-20 uses a ROM-based form of Microsoft MBASIC. It is very much like other implementations of MBASIC except that it contains extensions for features found only on the HX-20 computer. Some of these include the clock and calendar, sound, and the cassette-based file system. This differs from the file system used with the HP-75C because it uses an audio-type cassette without the ability to drive the tape forward and backward to locate requested files. However, through the use of file indices and the location on the tape recorder digital indicator, it is possible for the user to find the requested programs on the tape.

The tape file system works either with the plug-in microcassette drive or an external cassette recorder unit. In addition to storage provided by the optional casssette file system, Epson advises it will provide an optional disk drive operating out of the high-speed serial port at 38,400 baud.

Another method of storing data inside the computer is provided by RAM files. This is an area of memory set aside to store data even when the computer power is turned off. To use this memory area, you define RAM files and then store strings and numbers in them. The size of this storage is not great; but if used to save numeric and string values, it can be very valuable for creating software systems.

Our experience with this computer shows it to be capable of running complex BASIC programs within its memory capacity. Since we did not have any of the external perhiperals, we could not test its operation as a complete system. We did use the RS232 cable to connect to a CRT terminal in order to get some idea of the operation, though the BASIC commands to open the port and send and receive data through it are somewhat complicated. We doubt if the beginning user can accomplish it. Epson advises that it will provide communications software that will be user friendly. However, the first owners of the computer will not find it easy to communicate.

The documentation supplied with the computer includes an Operations Manual that we found to be very frustrating. It goes to great lengths to be "cute" and tell the owner the basics of operation, but just when the owner is about to do something, this book stops and refers him to the Tutorial and Reference Manual. Even the Operations Manual for the Epson CX-20 Portable Acoustic Coupler does not tell you how to operate the modem with the computer.

However, the Epson HX-20 BASIC Tutorial Manual is very good. It is not only a manual for the computer, it is a thorough course in the BASIC language, the HX-20 operation, and the file system.

Conclusions. Although I could not test the HX-20 with all its peripherals, this "notebook-size" computer is an admirable package. It answers the need for a portable with a full keyboard and enough computing power to be of real use on its own. The integral printer, though only 55 mm wide, is a real boon to computer users who want to travel light and yet retain a permanent record of what they are doing on the computer. With its interface provisions, the HX-20 can function reasonably well on a desktop, too, though this should not be its prime application. It is a lot of portable computing power for $795 (without the cassette drive), but it needs applications software to reach its highest potential.

The Hewlett-Packard HP-75C

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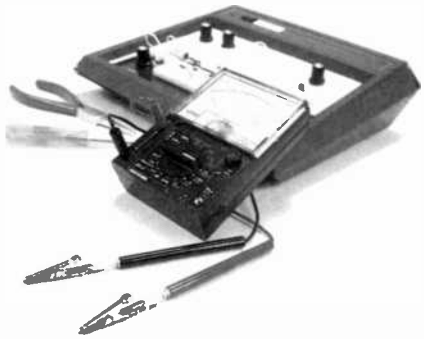

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MAIL TODAY!

The HP-75C connected to a Hewlett-Packard plotter through the HP Interface Loop.

the flexibility to perform as a desktop computer through use of many peripherals presently available and soon to be announced. Unlike handheld computers, its QWERTY keyboard can be used for touch typing, though it does not have the proper-size keys and spacing to satisfy a speed typist.

It is the only handheld computer with networking capabilities (excepting the HP-41 Calculator, which is not a full computer). The HP-75C is the master unit in the Hewlett-Packard Interface Loop (HPIL) network, a low-speed baseband type network designed to connect computers, perhiperals, and electronic test equipment.

The 26-oz HP-75C is powered by rechargeable nickel-cadmium batteries that are said to be able to operate the computer for 30 hours under maximum power-drain conditions and for three to four weeks under normal usage. It uses a CMOS CPU and RAM so that it can retain memory while turned off. The user can redefine the standard keys for special applications. In this case the redefined keys can be used with "snap-on" labels and keyboard overlays. The keys are somewhat larger than other handheld computers such as the Panasonic, which it somewhat resembles, but it is easier to type text with the HP-75C.

The HP-75C has a single-line liquid-crystal display that is a 32-character window on a 96-character line. The display is easy to read and you get used to the idea of a partial window on a line. For those who have trouble making this adjustment, there is a video adapter that can be connected to a monitor or an r-f modulator and a TV set. Of course, the use of a CRT eliminates portability of the system and the prime reason for buying a handheld computer!

The HP-75C has 16K of user RAM that can be increased to 24K by adding an 8K memory module. There are three firmware module plug-in slots that will accept 8K or 16K ROM modules. The use of these plug-in ROM modules frees the user memory for data.

The built-in operating system uses 48K bytes of the maximum 120K memory capacity, and it is ready to use when the computer is turned on. It features 169 instructions of which 147 are BASIC commands, statements, or functions. The operating system is based upon files. They consist of program files, data files, and appointment files. This is somewhat unusual for a hand-held portable computer. Most of them use simple monitor-type operating systems and cannot support disk file systems. This capability is made possible by the HP-75C using digital cassette mass storage. As a result, tape can be moved forward and backward to locate a file and access it under command of the operating system.

There is a second type of magnetic storage available with the HP-75C—a hand-pulled magnetic-card reader built into the computer. The magnetic cards are in the form of plastic strips with magnetic striping on the back. These are inserted into the built-in reader slot and pulled through by hand. Both programs and data can be stored on the cards and the operating system will both read and write to them. They have a capacity of 1.3K bytes per card; multiple cards can be used for a program. This unusual method of magnetic storage gives the computer mass storage even in a completely portable environment.

Using the HP-75C is easy. The documentation is all contained in one Owners Manual that is so good that it could be a model of its type. Every step is explained and illustrated so that no previous experience is required to learn to operate and program the computer.

The ATTEN key turns the machine off and on. Next to this are three other keys marked TIME, APPT, and EDIT which select the modes of operation. The TIME mode displays the time and calendar information including day of week, day, month, year, hour, minute, second and a.m./p.m. Setting this information in the time mode makes it available for use in all other modes of operation.

The APPT key sets the appointment mode. In this mode the user can set the day and time of an appointment, including up to 68 characters of information about the event. When the appointment time comes, an alarm sounds and an annunciator turns on in the display window. The HP-75C comes with two calendars, a year calendar and an extended (10,000-year) calendar. Using the APPT mode, a user can schedule more than 3000 different appointments! Each appointment can keep repeating itself at intervals from 1 minute to 8 years.

The EDIT mode is the main operating medium of the HP-75C. Practically all operations are performed in this mode. When the computer is turned on, or when the EDIT key is pressed, the computer is in this mode of operation. There are two prompts. First there is the BASIC prompt which is the "greater than" symbol. In BASIC, you can write programs, run them, or load and save them. There is also a program editing facility. Keys can be re-defined and part of the keyboard can be used as a numeric keypad.

HP-75 BASIC is a very powerful version of the language. It supports many of the extended features of BASIC including conditional branching (IF-THEN-ELSE), multi-statement lines, computed GOSUB, Program Timers, Arrays, Strings, User-Defined Functions, and Program Calls. There is also complete formatting capability for screen use as well as print formatting.

One does not expect to find this language strength in a portable computer. In addition the HP-75C includes a complete debugging facility with the ability to trace program execution, variables, and branches.

The HP-75C also has a file handling system that enables the user to store and access multiple programs, text memos, appointment calendars, and other blocks of information. A file is defined as an area of memory that can be identified by name and manipulated as a unit. They are collections of lines of information that have either been entered from the keyboard or from a mass data-storage medium. The computer can hold as many files as memory permits. There are six types:

1. Basic or program files.
2. Text files
3. Appointment files.
4. Keys files (special text files).
5. Language Extension files (special program files from magnetic cards, cassettes, or plug-in ROMS).
6. Logical Interchange files (files with a special format for interchanging information between the HP-75C and other computers).

Files are created from the EDIT mode when either the BASIC or TEXT prompt is selected. The system includes the capacity to edit all files in the computer.

The Hewlett-Packard Interface Loop enables the user to extend the capabilities of the HP-75C to as many as 30 external devices. This includes video interfaces, printers, plotters, tape drives, other computers with disk systems, and numerous electronic devices used for control and test purposes. It is this facility that is the best feature of the computer. It opens the whole world of control and computing to this relatively inexpensive device that is portable, powerful, and versatile.

The HP-75C can also be connected to the HP Series 80 computers by means of the HP-IL through an adapter plugged into the back of the computer. This makes it possible to use the computer as part of a desktop system and then detach it and carry it to use in a completely portable mode.

Conclusion. In our tests of the HP-75C, everything worked as specified in the excellent manuals. We did have one problem in getting the cassette storage function to work. We called Hewlett-Packard for help; but before they could get back to us, a little more reading in the manual enabled us to solve the challenge ourselves. We had not initialized the microcassette tape. We are used to disks that have to be formatted, but audio types normally do not require initialization. Once we did what the manual instructed, everything worked as it should. As usual we ran some benchmarks, which are given here in a box. The HP-75C is fast for a portable if that is your criterion, and it has the capability to solve the most complicated problems.

When it comes to price, the HP-75C costs more than twice as much as the Panasonic (Quasar, *et al.*), which can do some of the same things. However, the Hewlett-Packard is unique in some ways and thus must be considered to stand in a class of its own. For such a machine, I consider $995 a reasonable price. You could spend much more on a less powerful but larger computer, without the same utility and capability. The 8K memory modules are priced at $195, the digital cassette is $550, and the printer/plotter is $795.

If you want to use a large video screen with a monitor or TV, you can buy an adapter for $295. The HPIL converter to connect the loop to the other Hewlett-Packard Series 80 Computers is $395. Other adapters for RS232C and the Hewlett-Packard Interface Bus (HPIB) will be released early in 1983.

Software for the HP-75C will be available in large quantities according to Hewlett-Packard. The first releases are to include nine Solutions Books for investment, real estate, math, and statistics. These will have programs on magnetic cards or tapes and are scheduled to be priced at only $10 each. ◇

BENCHMARK TESTS

The benchmark test involved the generation of prime numbers from 0 to 1000; with 303 primes generated. Using the Sieve of Eratosthenes method adapted for portable computers, the times for the two computers were:

Epson HX-20: 79 seconds
Hewlett-Packard HP-75C: 59 seconds

A Broadcast-Band

By John Potter Shields

MANY shortwave receivers suffer from severe front-end overload when operated near high-power, AM-broadcast stations (50 kW or more). This problem is caused by several factors. One is insufficient front-end selectivity and another, which happens more frequently, is cross modulation due to nonlinearity of the first-stage transistor's operating characteristics. The effect of this broadcast band (BCB) overload is reduced overall receiver sensitivity and the appearance of spurious signals throughout portions of the shortwave band.

The problem of front-end overload can be corrected to some extent by placing a resistive attenuator between the antenna and receiver's input terminals. However, this will degrade overall receiver performance. A better solution is to install a series-resonant "wave trap" between the antenna and the receiver's input. This will eliminate the interfering broadcast signal without affecting receiver sensitivity in the SW bands.

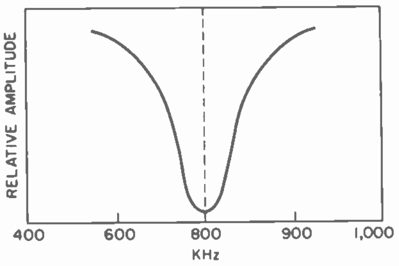


Fig. 1. Frequency characteristic of the notch filter.

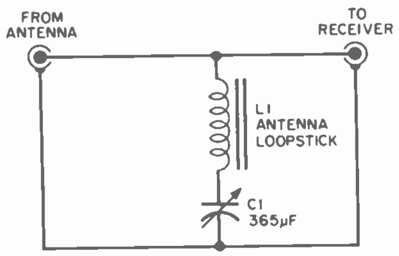


Fig. 2. Schematic diagram of the filter.

Circuit Operation. Figure 1 shows how the filter performs its task. In this example, the filter is tuned to the interfering station (800 kHz). Note that the filter's notch greatly attenuates the signal amplitude at

Notch Filter

800 kHz, while not affecting signal frequencies on either side of the notch.

Figure 2 shows the schematic diagram of the filter. It is series-resonant, tuned to the frequency of the interfering signal. A ferrite "loopstick" antenna coil is used for the inductance due to its high "Q." It provides a sharp null at the resonant frequency. Tuning is accomplished by means of a standard 365-μF variable capacitor.

Construction. You might be able to find most or all of the parts for the project in your junk box. The variable capacitor can often be salvaged from an old broadcast set.

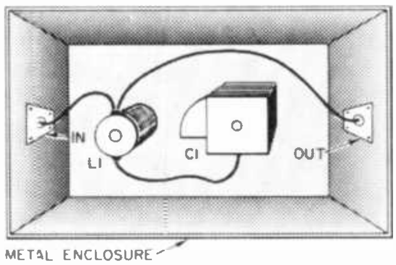


Fig. 3. Construction of the filter.

(These capacitors can be purchased from companies, such as Calectro, which have parts displays in most electronic parts stores.) You can also use a 365-μF trimmer with good results. Similarly, the loopstick antenna coil can be dug out of an old set or purchased from a source such as Calectro.

Figure 3 shows a suggested method of assembling the filter. Although SO-239 connectors are shown, you can use "RCA" type. Also, you can include the filter in your receiver if there is room.

Use. Using the BCB filter is simplicity itself. Just connect the input of the filter to the antenna and the output to the receiver's antenna terminals. A length of shielded cable should be used between the output of the filter and the receiver's antenna terminals.

With the filter connected, switch on the receiver and adjust the filter's tuning control to notch out the interfering BCB signal. ◊

COMPUTER VIDEO GAMES

Hands-on Reviews of the Latest Computer Game Software

FREE FALL

Sirius Software. Arcade game for Apple II. $34.95.

Programmer Mark Turmell has developed an eye-catching, cartoonist style as was evidenced in his earlier best-selling games of *Sneakers* and *Beer Run*. Turmell's legions of fans won't be disappointed by his latest effort—a wild, carefree romp through a never-never land of anti-gravity girders.

The girders fly across the screen. Atop some of the girders are fizzing bombs. The bouncing balls that are constantly traversing the screen can contact a bomb and set off a deadly explosion at any time. Also atop some girders are prizes. Long, deadly knitting needles shoot upward from the bottom of the screen and the floor of the display is cut by cartoon-man sized holes.

To the right of the girder display is the elevator that lifts your hapless cartoon hero to the roof over the girders, prizes, bombs and holes. Paddles, joystick, keyboard or joyport controls will allow you to control his grasping little hands so as to drop through space, grabbing girders and prizes all the way to—hopefully—vanish into a hole in the floor. Miss the hole and splat!

Higher levels of play introduce the dreaded bip-bops and the vicious and (to us, anyway) super-deadly gunners. If you like cartoon-style arcade, you'll drop everything for this one.

BATTLE FOR NORMANDY

Strategic Simulations Inc. Wargame simulation for Apple II, Atari 800, and TRS-80. $39.95.

If you've been thinking of getting into computer wargaming, this is just about the best introductory game we've seen. And, it is full of enough features so that even the old campaigner should find it interesting.

You are in charge of Operation Overlord, the D-Day landings by the Allies on the shores of France. All of the units that took part in the historical battle are represented in the game. The computer, if you lack a human opponent, will gladly become a siliconized version of Reichmarshall Rommel and attempt to throw your invasion back into the sea.

The main map that you play on is called the Tactical Map. This is gridded in a hexagonal manner to regulate the movement of the playing pieces (hi-resolution shapes on the Apple, flags on the Atari and lettered blocks on the TRS-80). But, before you even begin moving each day you must split up that day's available transport allocation between fuel, general, combat and amphibious supplies.

Finally, once you have done the logistics, the paratroopers land; the United States hits Omaha and Utah beaches and the British Expeditionary Forces swarm ashore at Gold, Juno and Sword beaches. Meanwhile, you allocate your air and naval support.

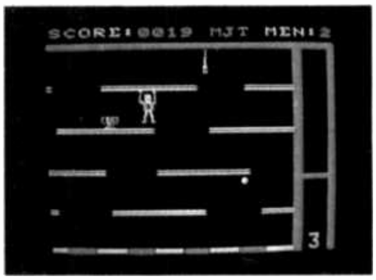
You begin to carefully but aggressively establish your beachheads by moving your depot brigades to form a supply line for your rangers, commandos, and regular combat troops of both infantry and armored divisions. As you deploy, and make ready to fight for every pixel of land, you must keep in mind many factors. The bright terrain is delineated into clear hexes, as well as bocage, swamp, river, beach and ocean—and villages and cities are depicted as well. Each terrain has an effect on both defender and offender for each combat.

While the computer does indeed keep track of figuring out the fairly complex formulas that govern the results of combat and movement—it is well for the human player also to be familiar with these as presented in the rules. While it *is* possible to play this game without knowing, for example, how combat results will affect fatigue levels—the computer or a studious human opponent would win every time.

We found the new movement system of one-key controls to be easy to learn and use. You simply move a cursor atop a unit, and then move the unit. Full on-screen details are given for each of the units you are moving to help you keep track of the myriad of variables involved in even the simplest move.

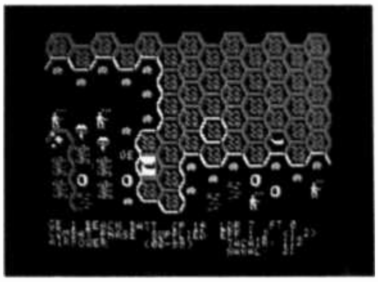
Victory conditions are much the same as they were on D-Day. The Allied player must take and occupy the Cherbourg Peninsula while also taking Caen and St. Lo. Meanwhile, the Allies must mass for a breakout through Normandy.

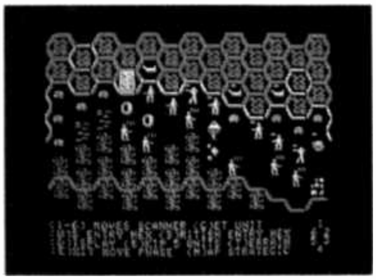
Sit down with this game on your computer and a videotape of *The Longest Day* playing on the TV in the background, and you'll be on the edge of your seat as you really get into the strategic and tactical concepts of this fine simulation. ◊



Free Fall (right)

Battle for Normandy (below)





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TIMEX COMPUTERS

Designing Subroutines For a Board Game

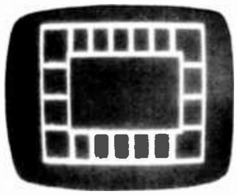
By Jim Keogh

ONCE in a while, we all get talked into playing one of those board games—usually just when we feel like doing something else. Sometimes, though a board game can be just what you need to get a small party off and running. Chances are it might be even better if you could play the game on your microcomputer. With a little programming ability, you can design your own program to play your favorite game on your computer.

Here is a subroutine that will "draw" the game board on your display screen. Subroutines for both the TRS-80 and Apple II are shown here. However, they can be modified to operate on other microcomputers.

The game board generated by these subroutines is not designed to represent any particular one. The purpose of the display is to illustrate how you can modify this subroutine to fit your own program.

The REM statements contained in these subroutines identify program statements that will display the outside of the board, the inside of the board, and the game board boxes. To modify this design, find the segment of the subroutine that you would like to change and insert the newly modified statements in that segment of the subroutine.



A sample board.

By careful study, you will be able to mold the subroutine into one of your favorite game boards. Of course to make your computerized game board complete, you will have to include other subroutines.

Remember these subroutines are just building blocks from which you can create your own board game. You should, however, find building a board game from this subroutine just enough to head you in the proper direction. ◊

APPLE II

```
1 REM CLEAR SCREEN
2 CALL -936
3 GR
4 COLOR=1
10 REM OUTSIDE EDGE OF GAME
   BOARD
20 HLIN 4,37 AT 4
30 VLIN 4,37 AT 4
40 HLIN 4,37 AT 37
50 VLIN 4,37 AT 37
60 REM INSIDE EDGE OF GAME
   BOARD
70 HLIN 9,32 AT 11
80 VLIN 11,30 AT 9
90 HLIN 9,32 AT 30
100 VLIN 11,30 AT 32
110 REM GAME BOARD BOXES
120 VLIN 4,11 AT 10
130 VLIN 4,11 AT 15
140 VLIN 4,11 AT 20
150 VLIN 4,11 AT 25
160 VLIN 4,11 AT 30
170 HLIN 4,9 AT 13
180 HLIN 4,9 AT 18
190 HLIN 4,9 AT 23
200 HLIN 4,9 AT 28
210 VLIN 31,27 AT 10
220 VLIN 31,37 AT 15
230 VLIN 31,37 AT 20
240 VLIN 31,37 AT 25
250 VLIN 31,37 AT 30
260 HLIN 32,37 AT 13
270 HLIN 32,37 AT 18
280 HLIN 32,37 AT 23
290 HLIN 32,37 AT 28
```

TRS-80

```
1 CLS
2 REM OUTSIDE EDGE OF GAME
  BOARD
10 FOR A = 15428 TO 15483
20 POKE A,176
30 NEXT A
40 FOR A = 15492 TO 16260 STEP 64
50 POKE A,149
60 NEXT A
70 FOR A = 16262 TO 16315
80 POKE A,176
90 NEXT A
100 POKE 16260,181
101 POKE 16261,176
110 FOR A = 15547 TO 16316 STEP 64
120 POKE A,170
130 NEXT A
140 POKE 16315,186
150 REM INSIDE EDGE OF GAME
    BOARD
160 FOR A = 15627 TO 16075 STEP 64
170 POKE A,170
180 NEXT A
190 FOR A = 15629 TO 15666
200 POKE A,176
210 NEXT A
211 POKE 15666,144
220 POKE 15627,160
230 POKE 15628,176
240 FOR A = 15730 to 16115 STEP 64
250 POKE A,149
260 NEXT A
280 FOR A = 16140 TO 16178
290 POKE A,131
300 NEXT A
301 POKE 16139,130
302 POKE 16178,129
310 REM GAME BOARD BOXES
320 POKE 15580,191
330 POKE 15516,191
340 POKE 15644,191
350 POKE 15587,191
360 POKE 15523,191
370 POKE 15651,191
380 POKE 15594,191
390 POKE 15530,191
400 POKE 15658,191
410 POKE 15601,191
420 POKE 15537,191
430 POKE 15665,191
440 POKE 15573,191
450 POKE 15509,191
460 POKE 15637,191
470 POKE 15566,191
480 POKE 15502,191
490 POKE 15630,191
500 FOR A = 15685 TO 15690
510 POKE A,131
520 NEXT A
530 FOR A = 15877 TO 15882
540 POKE A,131
550 NEXT A
560 FOR A = 16069 TO 16074
570 POKE A,131
580 NEXT A
590 FOR A = 15731 TO 15738
600 POKE A,131
610 NEXT A
620 FOR A = 15923 TO 15930
630 POKE A,131
640 NEXT A
650 FOR A = 16115 TO 16122
660 POKE A,131
670 NEXT A
680 POKE 16206,191
690 POKE 16270,191
700 POKE 16142,191
710 POKE 16277,191
720 POKE 16213,191
730 POKE 16149,191
740 POKE 16284,191
750 POKE 16220,191
760 POKE 16156,191
770 POKE 16291,191
780 POKE 16227,191
790 POKE 16163,191
800 POKE 16298,191
810 POKE 16234,191
820 POKE 16170,191
830 POKE 16305,191
840 POKE 16241,191
850 POKE 16177,191
860 GOTO 860
```

ROBOTIC ARMS

By Leslie Solomon, *Technical Director*

ROBOTIC arms operate under the control of a pre-programmed computer or computer-like control system. Any one of various types of end-of-arm tools can be added to create a machine capable of performing almost any number of industrial tasks such as painting, welding, or in a physically smaller version, even moving chess pieces on a board. For industrial purposes the arms are usually fixed to some form of baseplate, making them static. This type of mechanism is sometimes called a "pick-and-place" device since that is about the extent of their use.

There are three types of arm actuation—hydraulic, pneumatic, and electrical. The first two require the use of large, expensive, and

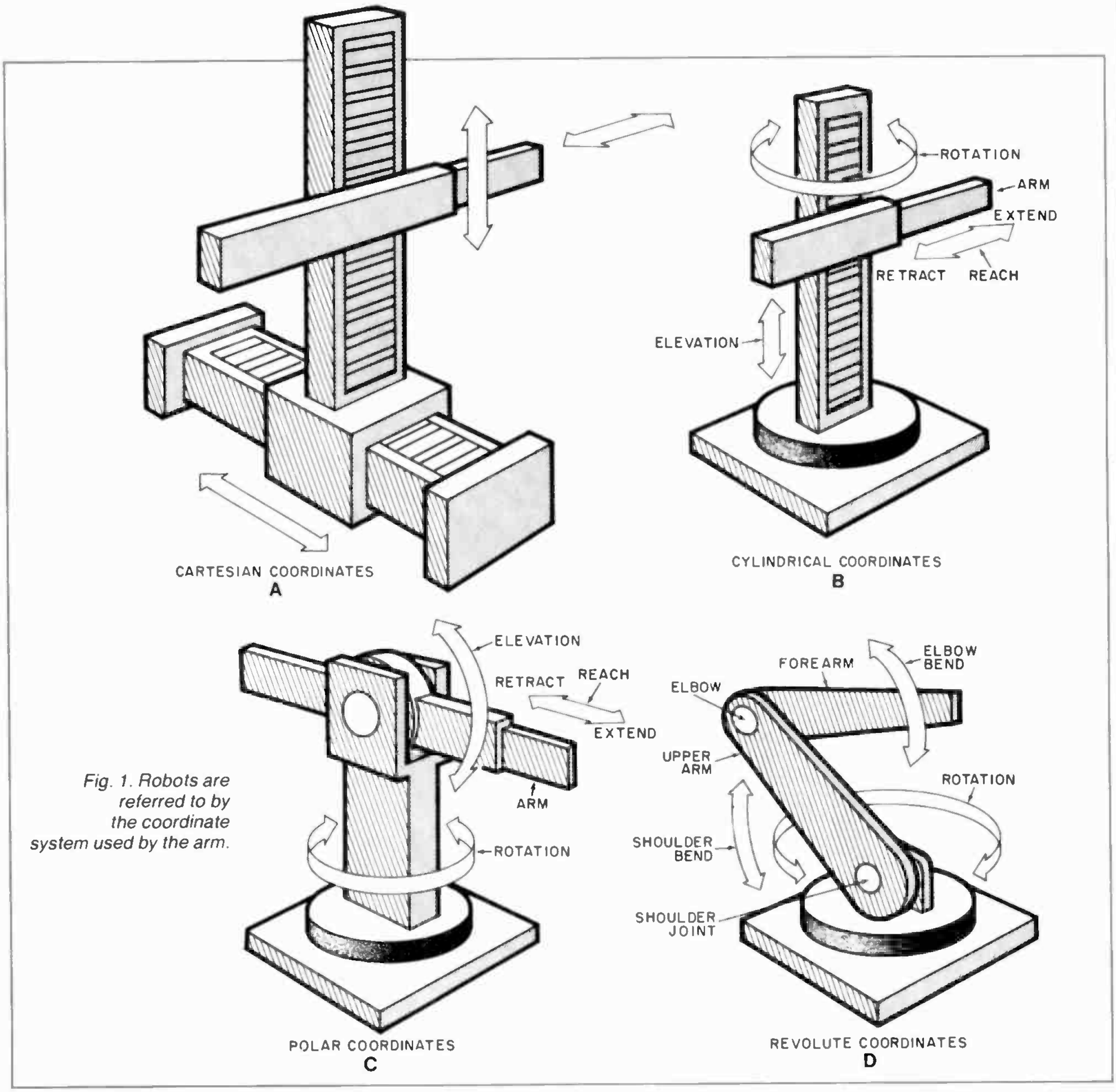


Fig. 1. Robots are referred to by the coordinate system used by the arm.

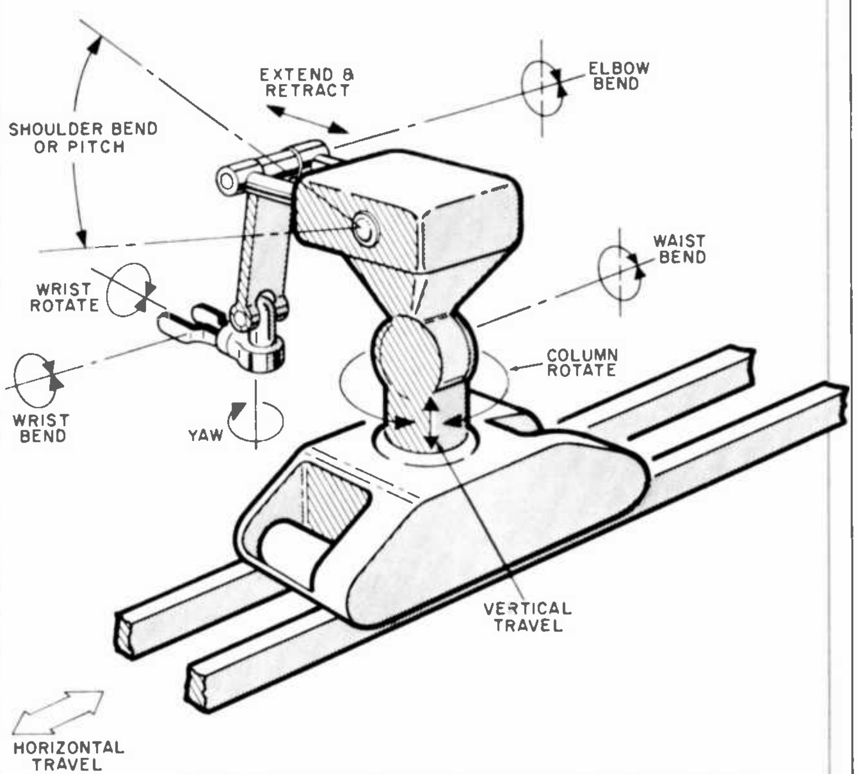


Fig. 2. This mechanism has 10 degrees of freedom, with the axes of movement resembling those of a human torso.

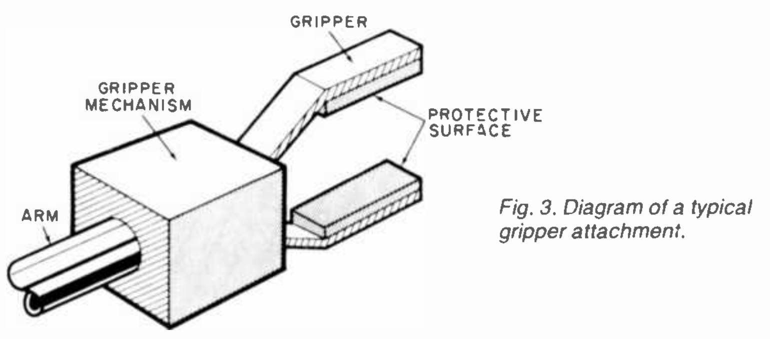


Fig. 3. Diagram of a typical gripper attachment.

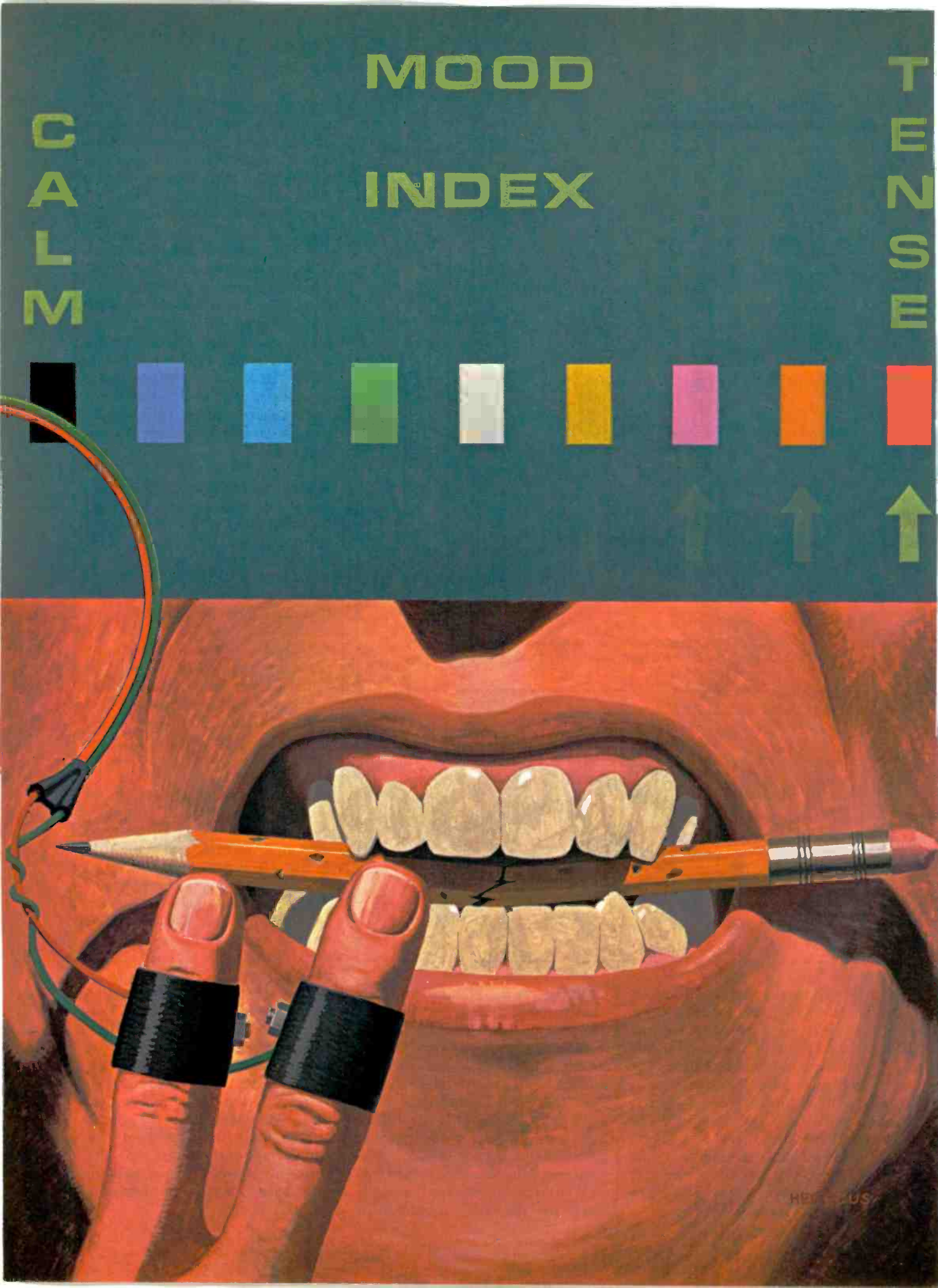
noisy pumps and compressors. Therefore they are for heavy-duty, factory-type applications where physical strength is required to manipulate large heavy objects. The electrical approach can essentially be divided into two areas—heavy-duty (factory) and mobile robots. The heavy-duty area is similarly used in a factory environment, and requires large multi-horsepower motors and heavy-duty gear trains and reduction gears.

In the low-power, electrically actuated mobile robot, movement is via fractional horse-power dc motors, which limits its "work" power to light loads. However, this approach lends itself to relatively low cost and permits operation from batteries. This frees the robot from restraints of power system cabling, allowing it to be mobile.

Some of the terms used for fixed-arm industrial robots are also applicable to "personal" robots. Such configurations refer to the coordinate system used by the arm, and include Cartesian, Cylindrical, Polar, and Revolute. These are shown in Fig. 1. The particular coordinate system used dictates the shape and size of the area, called "work envelope," in which the end of the arm and its attached manipulator (gripper, etc.) can be placed. As can be determined from Fig. 1, the Cartesian system can produce a work envelope shaped like a cube; the Cylindrical coordinate system's work area will be shaped like a thick cylinder; the Polar coordinate system produces a work space shaped like half a sphere; and the Revolute approach can almost emulate the human arm.

Degrees of Freedom. The number of intricate motions that a robot's arm can perform is determined by the number of axes it has. These are often called "degrees of freedom." A device having 10 degrees of freedom is shown in Fig. 2. Note that other than the capability of extension and retraction of the arm "shoulder," all axes resemble those of the human torso. Most industrial robots have three to five degrees of freedom to perform their specified task. Obviously, the greater the number of degrees of freedom, the more complex task the robot can perform.

In the mechanical systems shown in Fig. 1, some form of gripper or manipulator as in Fig. 3 is assumed to be attached to the end of the arm. In Fig. 1B, the manipulator can be extended, retracted, moved up or down, or rotated to any desired azimuth. Thus, the work envelope forms a cylinder. In the approach shown in Fig. 1C, the manipulator can be extended, retracted, pivoted in the vertical plane, and rotated around the base to form a half-sphere work envelope. The Revolute approach shown in Fig. 1D closely resembles the human arm. It has a base plus an "upper arm" and "forearm" that move in a vertical plane with respect to base, while the "elbow" and "shoulder joint" resemble those of the human arm. The work envelope of this approach approximates a major portion of a sphere. ◊


MOOD
INDEX
CALM
TENSE

What's Your TENSENESS LEVEL?

Connecting an interactive "Biobox" to a TRS-80 Color Computer enables you to monitor how tense you are and experiment with biofeedback techniques

By Jim Barbarello

RELAX!

If your emotions have been riding the express track all day and can't stop to heed the command above, maybe you need a Biobox in your life. The Biobox is a low-cost ($15) electronic device that detects body changes due to stress and tension. The electronic information from the Biobox is applied to a TRS-80 Color Computer and fed back to you in the form of variations in sound and color on the TV display. Through the biofeedback procedure, it is possible, with practice, to consciously control your emotional state. (*Note: Biofeedback is a subjective procedure and may not give the same results in all cases.*)

About the Circuit. One condition of the body that can be measured easily is skin resistance. When you are tense or stressful, the electrical resistance between your index and middle fingers decreases. As you relax, this resistance increases. The Biobox senses this resistance change and converts it into a voltage.

As shown in Fig. 1, the two "bioprobes" are attached to the middle and index fingers. The resultant skin resistance is represented by R_{BIO}. The two resistances, R_{BIO} and *R1*, form a voltage divider. As the skin resistance decreases, the voltage at the base of transistor *Q1* increases. This voltage is multiplied (amplified) by a factor of about −20 and applied to the computer's joystick input.

About the Program. So far, the hardware we've discussed detects changes in skin resistance and sends a binary number betweeen 0 and 63 to the Color Computer. What we need now is a program that uses this information to provide audible and visible feedback. That program is shown on page 79. It does not use any Extended BASIC functions so it can be run on any version of the Color Computer.

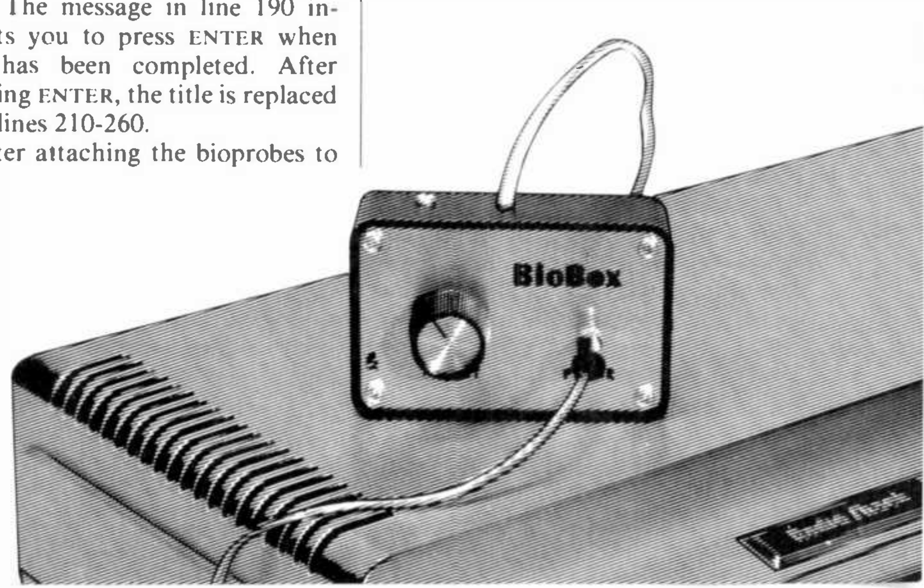
The program begins with the DATA statement of line 10. The eight numbers represent the eight different screen colors (3—blue, 6—cyan, 1—green, 5—buff, 2—yellow, 7—magenta, 8—orange, and 4—red). Using these colors, we can create a "Mood Index." If we consider buff as the middle (neutral) point, the "cooler"colors of green, cyan, and blue (also black) will indicate successive stages of calm. The "hotter" yellow, magenta, orange, and red indicate escalating tension.

When the program is run, the screen presents a title and the Mood Index. The Index is used as a gauge with an arrow as the indicator. Next, a message to attach the Biobox to the right joystick input is displayed (lines 170-180) below the title. The message in line 190 instructs you to press ENTER when this has been completed. After pressing ENTER, the title is replaced with lines 210-260.

After attaching the bioprobes to your index and middle fingers, you can begin to vary the ADJUST control on the biobox. As you do, you will note that the arrow pointer moves along the scale (see lines 270-300). When you press ENTER, execution jumps to line 310. The actual biofeedback monitoring occurs in lines 310-360.

The number corresponding to the voltage generated by the Biobox is stored in the variable M. This number is then used to determine the pitch of the audible feedback beep (line 330), the color the screen presents as a visual feedback (lines 340-350), and the repetition rate of the beep (line 360). Thus, as tension decreases, the screen's colors become "cooler," and the beeping is at a lower pitch and repetition rate. At the "ultimate" state of calmness (see line 320), sound and visual presentation cease (CLS0 produces a totally black screen).

Construction. The Biobox is relatively simple to construct. Start by assembling the circuit of Fig. 1 on a small piece of perf board or printed-



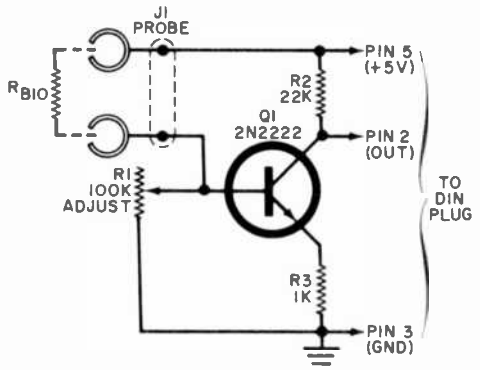


Fig. 1. Schematic of the Biobox.

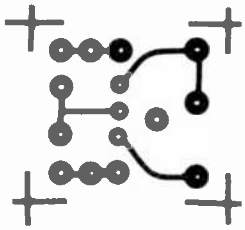


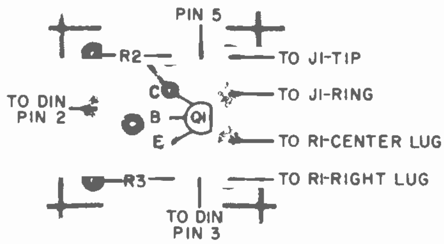
Fig. 2. Actual-size pc foil pattern.

PARTS LIST

R1—100-kilohm linear potentiometer
R2—22-kilohm, ¼-W, 5% resistor
R3—1-kilohm, ¼-W, 5% resistor
J1—3/32" subminiature phono jack
P1—6-pin male (stereo) audio DIN connector
P2—3/32" subminiature phono plug
Q1—2N2222 or 2N2222A npn silicon, general-purpose transistor
Misc.—Control knob, pc board or perf board, 1' 3-conductor wire, 4' stranded and twisted wire, 1 case (Radio Shack #270-230 or similar), self-sticking hook-and-loop fasteners (Radio Shack #64-2345 or similar) two #4-40 × ¼" machine screws, two #4-40 machine nuts, 4 flat washers, 1' #22 stranded wire, solder, etc.

Note: The following is available from J. J. Barbarello, RD #1, Box 241H, Tennent Rd., Englishtown, NJ 07726: complete kit (Item CBF) containing all listed materials and Biofeed program on cassette tape for $15. New Jersey residents, add 5% sales tax.

Fig. 3. Components and external connections to the pc board.



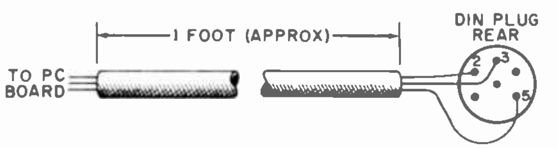


Fig. 4. Interconnect cable to go to the computer.

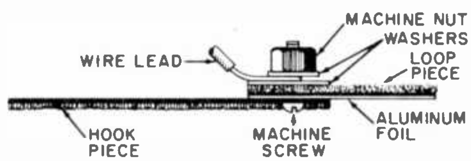


Fig. 5. Making the bioprobes.

small piece of perf board or printed-circuit board (using the foil pattern of Fig. 2). Mount *R1, R2,* and *Q1,* and connect four 3" lengths of wires to *R1* and *J1* as indicated in Fig. 3. Now prepare the Color Computer interconnect cable as shown in Fig. 4. Finally, connect the cable to the pc board as shown in Fig. 3. Mount the unit in any suitable case.

The bioprobes are simple electrical contacts with a contact area of about 1 sq in. each. In its simplest form, a probe could be a piece of aluminum foil wrapped around a finger with a jumper wire connecting it to the circuit. Our bioprobes, however, are a bit more sophisticated. Besides the foil, hook-and-loop fastener material (commonly called "Velcro") is used.

Cut two 3" × ¾" hook pieces and two 1¼" × ¾" loop pieces. On each of the four pieces, punch a ⅛"-diameter hole located ¼" from one end and centered along the width (i.e. ⅜" from either side).

Cut a 2" × 3" piece of aluminum foil. Fold it in half to form a 1" × 3" piece. Fold it in half again to form a 1" × 1½" piece. Then fold the four sides over ⅛" for a final size of ¾" × 1¼". Create another piece the same way. Now remove the paper backing from the two loop pieces, and carefully place an aluminum foil piece (with the folded edges toward the adhesive) onto each of the two loop pieces.

Using a sharp knife, cut the paper backing of the hook piece ½" from the end that has the ⅛" hole. Remove that ½" of paper backing. Take the loop piece and place it on the exposed adhesive of the hook piece so that both ⅛" holes are aligned and the aluminum foil is sandwiched in the middle. Using a sharp knife, slit the aluminum foil in the ⅛" hole so the screw passes through but makes electrical contact. Repeat this procedure with the remaining hook-and-loop piece.

To complete the bioprobes, you will need two #4-40 × ¼" machine screws, two #4-40 nuts, four small washers, a four-foot length of stranded, twisted wire and a subminiature phono jack. Place a screw through the ⅛" hole of one of the hook/loop pieces so the screw head is against the hook piece. Place a washer over the end of the screw (on the loop side). Strip ½" of insulation from one wire and wrap the wire around the end of the screw. Place another washer over the screw and secure with a nut (Fig. 5). Repeat this procedure with the other hook/loop piece. Finally, attach the subminiature phono plug to the other end of the wire. Remove the remaining paper backing and press your fingers against the adhesive. Repeat this until the adhesive is no

(Continued on page 84)

BIOFEEDBACK PROGRAM

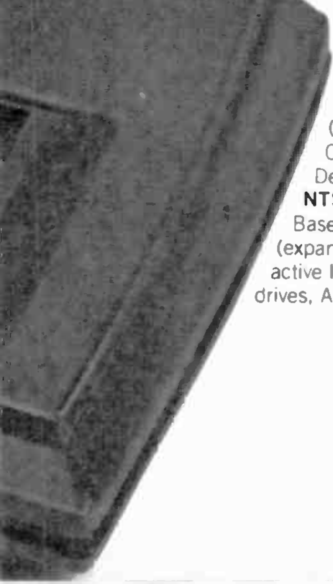
```
  1 REM**   BIOFEEDBACK PROGRAM
  2 REM**   NAME:BIOFEED
  3 REM**   #4, 21 AUGUST 1982
  4 REM**
 10 DATA3,6,1,5,2,7,8,4
 20 CLS:FOR I=1024TO1055:POKE I, 32:NEXT
 30 FOR I=1056TO1212STEP32:POKE I,32:POKE I+31, 32:NEXT
 40 FOR I=1216TO1248:POKE I, 32:NEXT:POKE 1279, 32
 50 PRINT@33, "******************************"
 60 PRINT@65, "****B I O F E E D B A C K ***";
 70 PRINT@97, "******************************"
 80 PRINT@227, "C 1982 BY J.J. BARBARELLO";
 90 FOR I=1280TO1535: POKE I, 32:NEXT
100 A$="MOOD": FOR I=1TO4:POKE1324+(I-1)*2, ASC(MID$(A$,I,1))-64:NEXT
110 A$="INDEX":FOR I=1TO5:POKE1387+ (I-1)*2,ASC(MID$(A$,I,1))-64:NEXT
120 POKE1475,128
130 FOR I=0TO21STEP3:READ CL:POKE 1478+I,127+16*CL:POKE 1476+I,45:POKE 1477+ I,45:NEXT
140 RESTORE:POKE 1347,3:POKE 1379,1:POKE 1411, 12:POKE 1443,13:POKE 1507,30
150 POKE 1339,20:POKE1371,5:POKE1403,14:POKE 1435,19:POKE1467,5
160 FOR I=1 TO 1000:NEXT:GOSUB 370
170 PRINT@133, " 'BIOBOX' CONNECTS TO ";
180 PRINT@163, "THE RIGHT JOYSTICK INPUT.";
190 PRINT@227, "PRESS <ENTER> WHEN READY.";
200 A$=INKEY$:IF A$="" THEN 200 ELSE IF ASC(A$) < > 13 THEN 200
210 GOSUB 370:PRINT@33, " PLACE THE BIOPROBES ON YOUR";
220 PRINT@65, "INDEX AND MIDDLE FINGERS. ";
230 PRINT@97, " USING THE <ADJUST> CONTROL,";
240 PRINT@129, "SET THE ARROW TO THE POSITION";
250 PRINT@161, "THAT BEST MATCHES YOUR MOOD.";
260 PRINT@225, " PRESS <ENTER> WHEN ADJUSTED.";
270 I=JOYSTK (0):M=JOYSTK(1):SO=SC:SC=8-INT((M+1)/8)
280 A$=INKEY$:IF A$=""THEN 290 ELSE IF ASC(A$)=13 THEN GOSUB 370:GOTO 310
290 IF SO< >SC THEN POKE 1507+SC*3,30:POKE 1507+SO*3,32
300 FOR I=1 TO 100:NEXT:GOTO 270
310 I=JOYSTK(0):M=JOYSTK(1)+1
320 IF M>56 THEN CLS0:GOTO 360
330 SOUND197.1-M*M/16,1
340 SC=8-INT((M+1)/8)
350 FOR I=1 TO SC:READ CL:NEXT:CLS CL:RESTORE
360 FOR I=1 TO 15*M:NEXT:GOTO 310
370 FOR I=100TO200STEP20:SOUND I,1:NEXT:RETURN
```

Simulated TV Reception

4.

3.

3. **The NTS/Heath HM-89A Microcomputer** features floppy disk storage, "smart" video terminal, two Z80 microprocessors, with 32K RAM Memory, expandable to 64K on board. 4. **The NTS/Heath GR 2001 Digital Color TV (25" diagonal)** features specialized AGC-SYNC muting, filtered color and new solid-state high voltage tripler rectifier.



1. **The NTS/Rockwell AIM 65 Dedicated Microcomputer** A Single board unit featuring on board printer and display—4K RAM (expandable). Application Functions: Central processor—Controller/Monitor—Development System. 2. **"The NTS/SYM-1 Microcomputer" 6502** Based CPU—4K bytes ROM (expandable)—1K RAM (expandable). 51 active I/O lines for versatile interfacing: disk drives, ASCII key boards, cassette tape, etc.

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...TENSENESS LEVEL (from p. 78)

longer sticky. This completes construction of the bioprobes.

Experimenting With Biofeedback. Locate a quiet area where you won't be disturbed. Relax yourself (loosen clothing, remove shoes, etc.). Sit in a position that is comfortable and provides arm/elbow support. Your hands should be clean and dry, and the room temperature should be around 70°F.

Load and run the Biofeed program. The first instructions will advise you to connect the Biobox to the right joystick connector. Do so, and then press ENTER to continue. Next, you will be advised to place one bioprobe on your index finger, and the other on your middle finger. Turn the Biobox's ADJUST control to the point where the MOOD INDEX arrow begins moving. Keep that hand with the bioprobes stationary, and move the ADJUST control so the arrow points to the INDEX position that best matches your mood. For instance, if you are moderately calm, place the arrow to midrange (the white box). When adjustment is done, press the ENTER key.

The screen will clear in a color that reflects your level of tension/calmness. A beeping will be heard, the pitch and speed of which are also an indication of your mood. Try to relax by breathing deeply, relaxing your body, etc. Note which of your efforts get best results. You may notice that the feedback indicates momentary jumps in mood. This is common, but can be minimized by keeping your hand completely motionless.

As an experiment, take a deep breath and hold it for a few seconds. You should see a calming trend. Conversely, pinch your arm, bite your lip, or otherwise cause mild pain. You should notice an increase of tension. You will find that it is easier to increase tension than it is to calm yourself. This is a normal body reaction. The body tends to tense up faster and calm down much more slowly. In fact, trying too hard to calm down will actually cause you to tense up. Learning to relax requires practice—don't become discouraged!

Some people find that visualizing a pleasant scene (such as a beach or forest) helps in reducing tension. Conversely, thinking of an unpleasant experience can raise tension. So one method of learning to control your mood is to first visualize an unpleasant experience until the feedback indicates heightened tension, and then visualize a pleasant scene in an attempt to reduce the tension.

It is interesting to note that many people who respond to a question with a deliberate lie will exhibit increased tension. Does that suggest another use for the Biobox? If you're interested in the more serious aspects of biofeedback, your physician or a person knowledgeable in the field can direct you to further sources of information. ◇

A Programmable FUNCTION GENERATOR

Produces laboratory-accuracy sine/square/triangle waveforms through crystal control

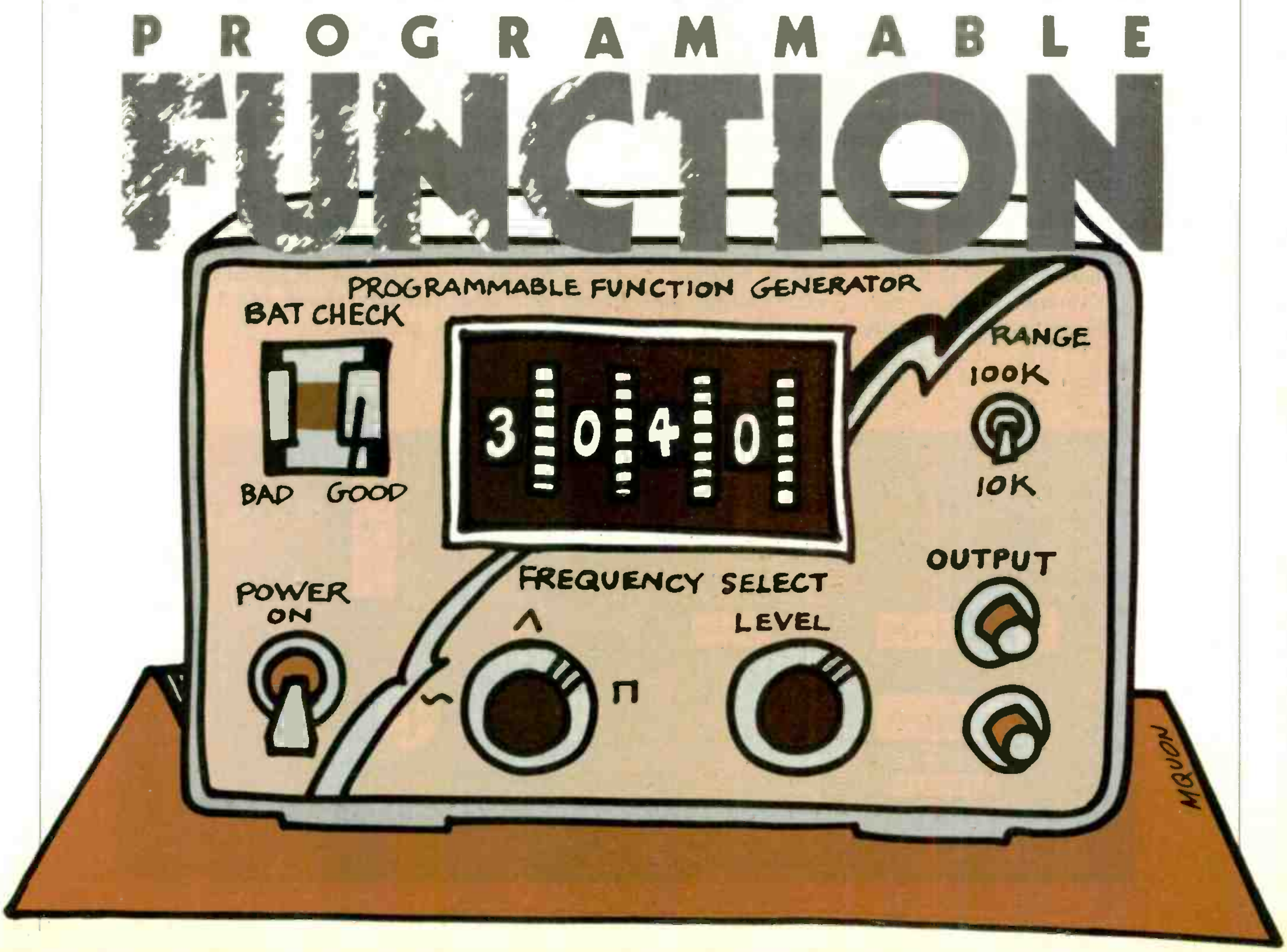
By Gary McClellan

THE UBIQUITOUS function generator is a versatile general-purpose test instrument in the tradition of the multimeter and the oscilloscope. Like these instruments, the function generator finds a host of applications in virtually every area of electronics, from audio to digital. The low-cost programmable function generator described here has few of the shortcomings of other such instruments. It also has features you'd normally expect to find in far more expensive instruments.

Thanks to crystal control, the programmable function generator's frequency range (20 to 10,000 Hz in 1-Hz steps and 200 to 100,000 Hz in 10-Hz steps) can have a calibrated accuracy of ±0.005% or better, which is true laboratory-grade quality. Even without instrument calibration, the project's basic accuracy is in the range of ±0.01%, an impressive figure by itself.

Available at the programmable function generator's output are sine, square, and triangle waveforms, all buffered to drive low-impedance loads and direct coupled to provide excellent low-frequency response. Sine-wave distortion ranges from less than 0.5% THD at all frequencies up to 10,000 Hz and to 3% beyond.

General Description. The programmable function generator is built around a single chip that has



very low sine-wave distortion characteristics. The basic circuit of the instrument, shown in Fig. 1, consists of two phase-locked loops (PLLs). (CMOS devices are used throughout to keep power requirements low.) The first PLL is a frequency synthesizer made up of *IC1*, *IC2*, and *IC3* and their associated components.

The output of oscillator/divider *IC1*, controlled by a conventional 3.58-MHz color TV crystal, goes to the phase-detector portion of *IC2*, whose output is, in turn, coupled to its companion voltage-controlled oscillator (vco). Coupling here is via a loop filter that converts the output of the phase detector into a smoothed dc voltage that controls oscillator frequency. The loop filter also stores the dc for short periods when the phase detector goes into its high-impedance state.

The vco's output drives programmable frequency divider *IC3*, which accepts BCD data from four thumbwheel switches (*S1* through *S4*). This stage divides the input frequency by the factor programmed by thumbwheel-switch selection. The divided output from *IC3* is the second input to the phase detector contained in *IC2*. Hence, the dc output of the phase detector that controls the vco's frequency is proportional to the frequency (actually phase) difference between the two inputs.

The selected vco frequency is passed to frequency divider *IC4*, a dual decade counter. To obtain 1- and 10-Hz resolution on the 10- and 100-kHz ranges, respectively, the first PLL must operate at some high frequency that can be successively divided to produce a frequency in the desired range. To accomplish this, *IC4* divides by 10 for the 100-kHz range and divides by 100 (10 × 10) for the 10-kHz range, depending on whether RANGE switch *S5* is set to LO or HIGH. The complete schematic diagram of this portion of the circuit is shown in Fig. 2.

The second PLL in the system is made up of *IC5*, *IC6*, *IC7*, *Q1*, and their associated components. This tracking-filter circuit accepts the signal selected by the RANGE switch and delivers clean sine, triangle, or square waveform signals from the logic-level signals delivered by *IC5*.

Function generator *IC6* is essentially a wide-range vco with sine, triangle, and square output waveforms. Frequency control is via VMOS power FET *Q1*, which serves as an electronically variable resistance in the negative-voltage supply to *IC6*.

One input of *IC5* is from *IC4*, through RANGE switch *S5*; the other input comes from *IC6*, whose output is buffered by one element in *IC7*. Output pulses from *IC5* (the error voltage between the selected input from *IC4* and the oscillator in *IC6*) are coupled through a loop filter that smooths the dc output to drive *Q1*. This locks the output frequency of *IC6* to the dc output of *IC5*, which in turn can be traced directly to the crystal oscillator.

Output waveforms (sine, triangle, or square) are selected with *S6*. LEVEL control *R32B* provides the means for adjusting the amplitude of the output signal. The output of *IC6*, selected with *S6*, is passed to buffer *IC8* for connection to external devices. The complete schematic diagram for this portion of the project is shown in Fig. 3, which is a continuation of the circuit shown in Fig. 2.

Since the generator requires a bipolar source of power from a pair of rechargeable 9-volt batteries, some means must be used to create a reference ground for the needed positive and negative voltages. This is accomplished with the power supply circuit made up of 12-volt regulator *IC10* and operational amplifier *IC9* in Fig. 3.

All circuitry on the project's circuit board assembly connects between the +12-volt and common (negative) lines of the power supply. Some off-board components, namely the LEVEL control and OUTPUT connectors, however, connect to *IC9*'s output ground (GND) to ensure that the signal swings symmetrically above and below reference ground.

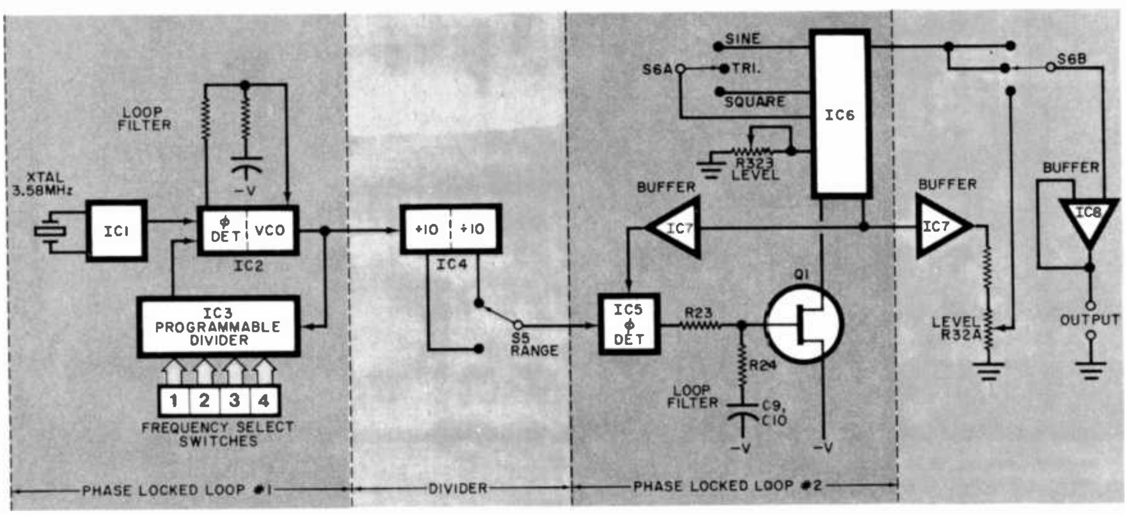


Fig. 1. The basic circuit consists of two phase-locked loops.

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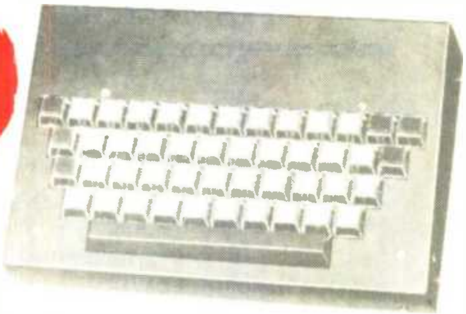

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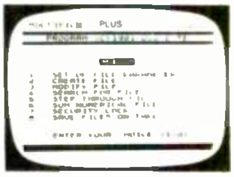

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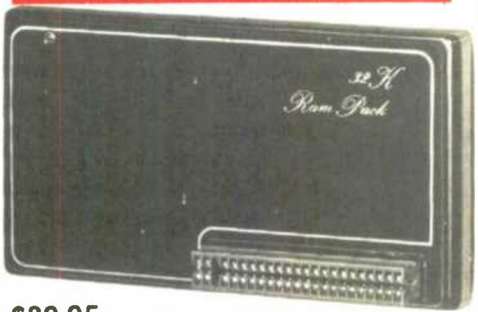

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Op amp *IC9* serves as a buffer, with resistors *R29* and *R30* forming a voltage-divider network between the +12-volt and common buses. As a result, the +V and −V are at +6 and −6 volts, referenced to GND at the output of *IC9*.

An expanded-scale voltmeter consisting of *M1*, *R33*, and zener diode *D3* monitors the condition of the battery's charge state. It's designed to cover a range of 13 to 14.5 volts across two-thirds of its scale, which indicates simple BAD/GOOD conditions.

Since *IC10* stops regulating at about a 13.8-volt input level, it's important to recharge batteries *B1* and *B2* just as or before the meter's pointer swings into the BAD area on the scale.

The meter's circuit works on the "knee" of the zener diode. When the input from *B1* and *B2* is less than 12 volts, *D3* isn't biased, resulting in no indication on *M1*. At an input of 12 volts, *D3* begins conducting and passes current through limiting resistor *R33* and the meter.

PARTS LIST

B1,B2—Rechargeable 9-volt battery
C1,C17—0.1-µF, 25-V disc capacitor
C2—33-pF disc capacitor
C3—5-to-20-pF trimmer capacitor (E.F. Johnson No. 275-0320-005 or similar)
C4,C14—10-pF disc capacitor
C5—47-pF disc capacitor
C6,C11—1-µF, 16-V tantalum capacitor (do not substitute)
C7—47-µF, 16-V upright pc electrolytic
C8—100-µF, 16-V upright pc electrolytic
C9,C10—22-µF, 16-V tantalum capacitor (do not substitute)
C12—0.0068-µF Mylar capacitor (do not substitute)
C13—100-pF disc capacitor
C15,C16—22-µF, 16-V upright pc electrolytic
D1,D2—1N4148 diode
D3—1N4742 (12-V, 1-W) zener diode
IC1—MM5369 EST oscillator/divider
IC2,IC5—CD4046 CMOS PLL
IC3—CD4059 CMOS counter
IC4—CD4518 CMOS counter
IC6—XR2206 function-generator
IC7—CD4050 CMOS hex buffer
IC8—318 operational amplifier
IC9—356 operational amplifier
IC10—7812 or 340-12T 12-V regulator
J1,J2—5-way binding post (red, black)
J3—Power connector (Switchcraft 712A)
M1—0-to-400-µA meter movement with BAD/GOOD scale
Q1—VN10KM VMOS FET
The following are ¼-W, 5% carbon-film resistors unless otherwise specified:
R1—10 megohms
R2 through R18,R23,R29,R30—100 kilohms
R19,R31—2.2 kilohms
R20,R26,R28,R33—10 kilohms
R21—500-ohm potentiometer (Jim-Pak No. 840P-500 or similar)
R22—20-kilohm potentiometer (Jim-Pak No. 840P-20 or similar)
R24—330 ohms
R25—1 kilohm
R27—100 ohms
R32—50/5-kilohm dual linear-taper pot.
R34—Approx.100 ohms
S1 through S4—Decade thumbwheel switch (Unimax No. SR-21 or similar)
S5—Spdt switch
S6—3-position, 2-pole nonshorting rotary switch
S7—Spst switch
XTAL—3.579545-MHz color TV crystal
Misc.—Printed circuit board or materials for fabricating same; quick-set epoxy cement; one 24-, five 16-, and three 8-pin IC sockets; battery holders and connectors for *B1* and *B2*; control knobs (2); plastic enclosure large enough to house circuitry; ribbon cable; 14-V plug-in battery charger; etc.

Note: The following is available from Technico Services, P.O. Box 20HC, Orangehurst, Fullerton, CA 92633: etched and drilled printed circuit board (PFG-1) for $12.00 postpaid in U.S. California residents, please add sales tax. Foreign residents, add $3.00 postage and handling for foreign orders.

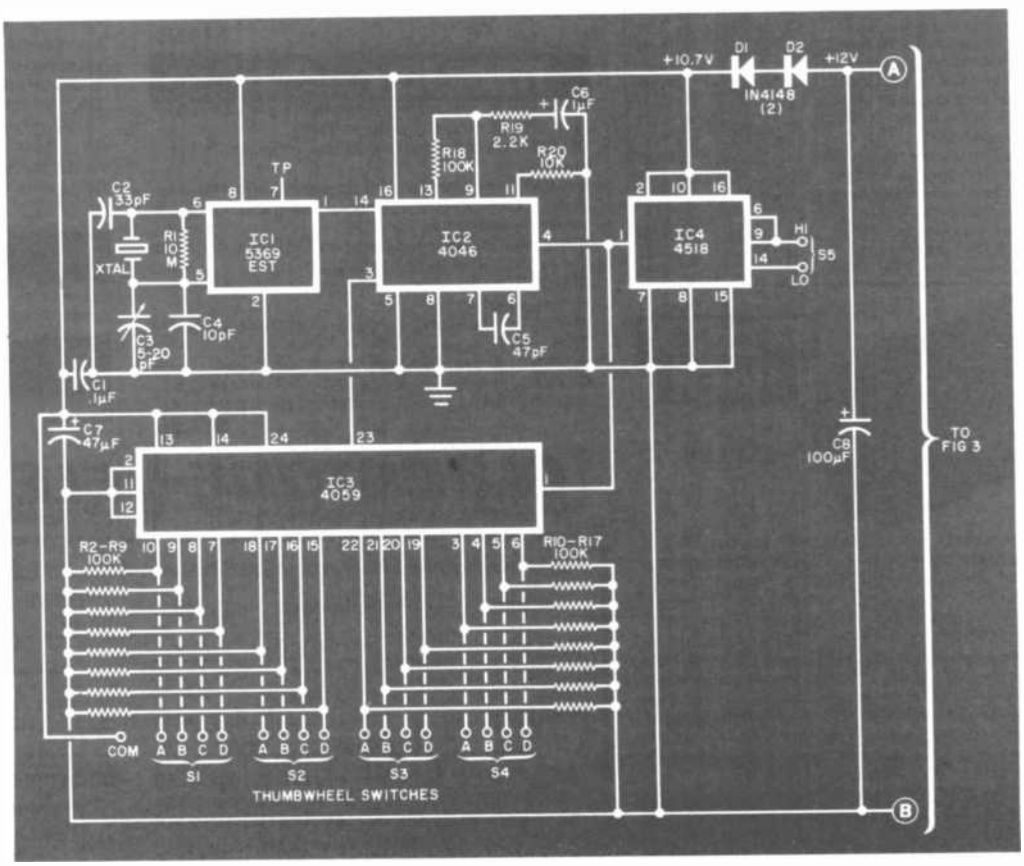
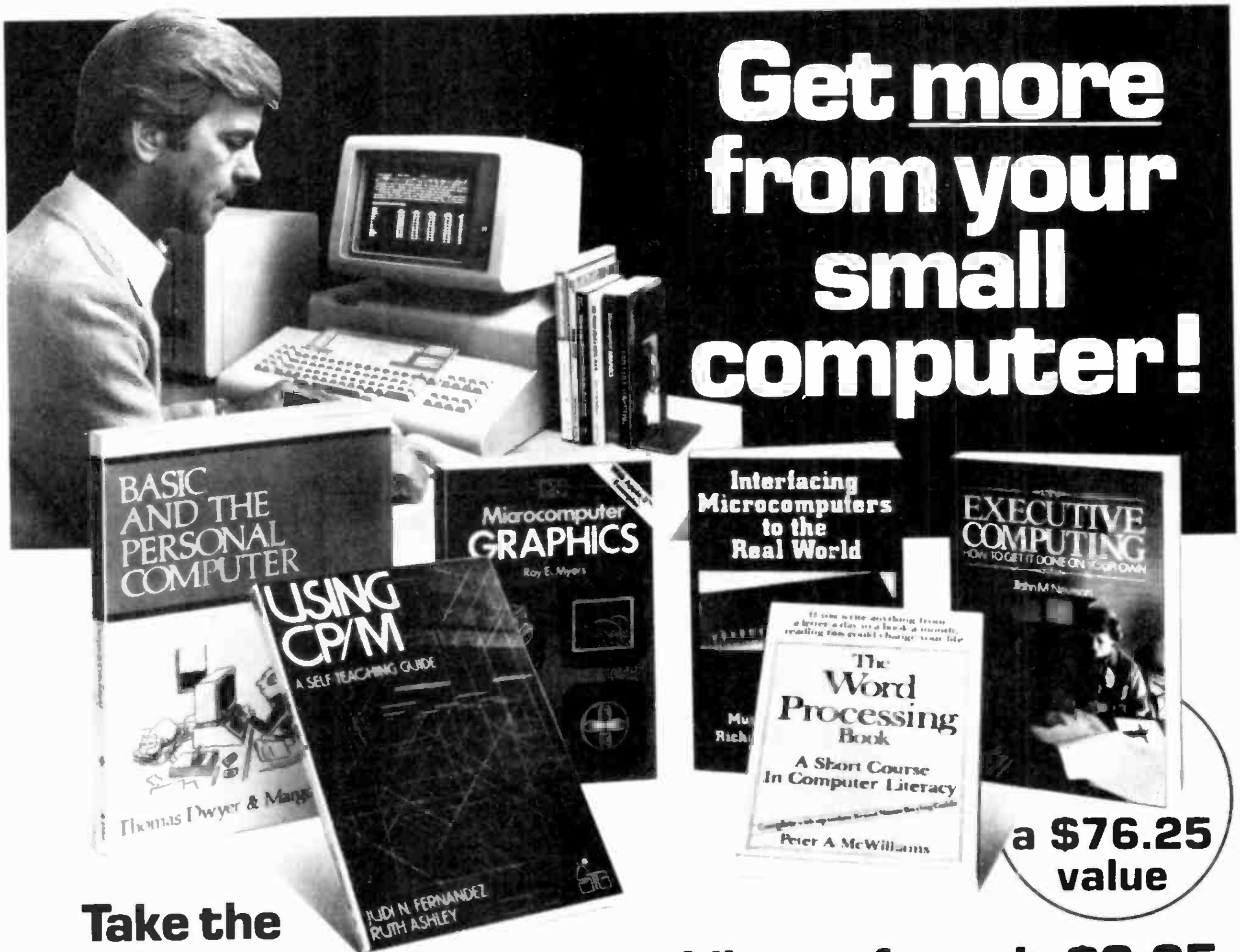


Fig. 2. The first phase-locked loop is a frequency synthesizer as shown here.



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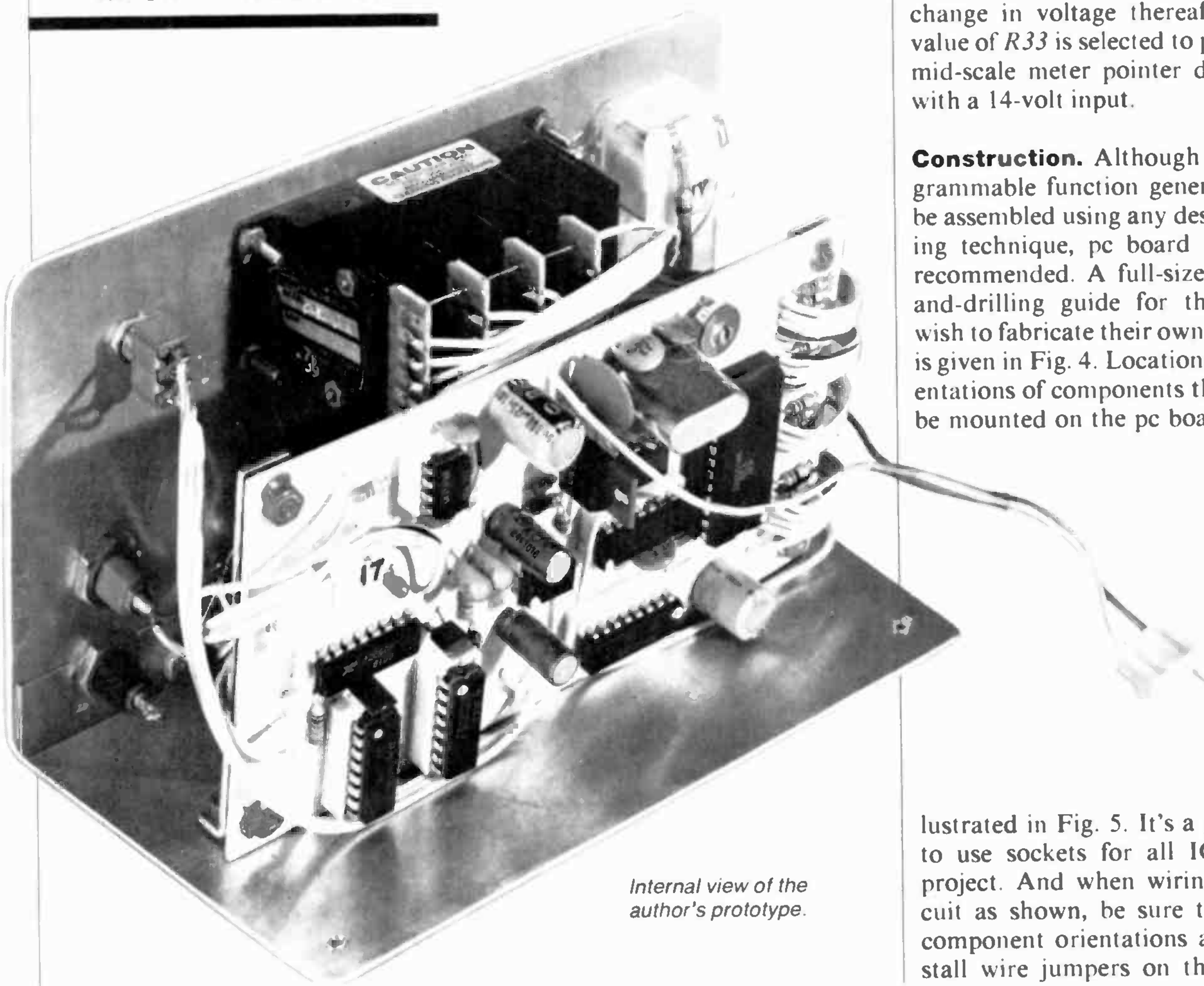


Internal view of the author's prototype.

Current rises rapidly for any small change in voltage thereafter. The value of *R33* is selected to provide a mid-scale meter pointer deflection with a 14-volt input.

Construction. Although the programmable function generator can be assembled using any desired wiring technique, pc board wiring is recommended. A full-size etching-and-drilling guide for those who wish to fabricate their own pc board is given in Fig. 4. Locations and orientations of components that are to be mounted on the pc board are illustrated in Fig. 5. It's a good idea to use sockets for all ICs in the project. And when wiring the circuit as shown, be sure to observe component orientations and to install wire jumpers on the compo-

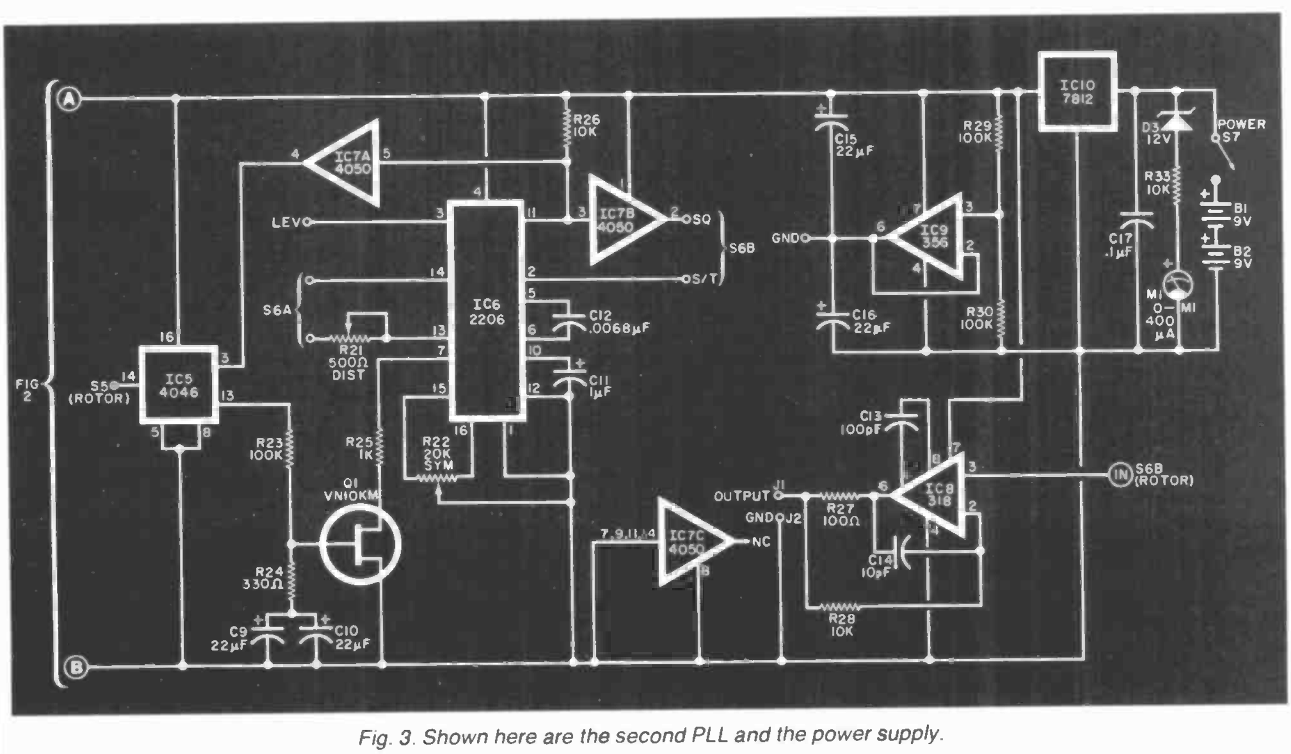


Fig. 3. Shown here are the second PLL and the power supply.

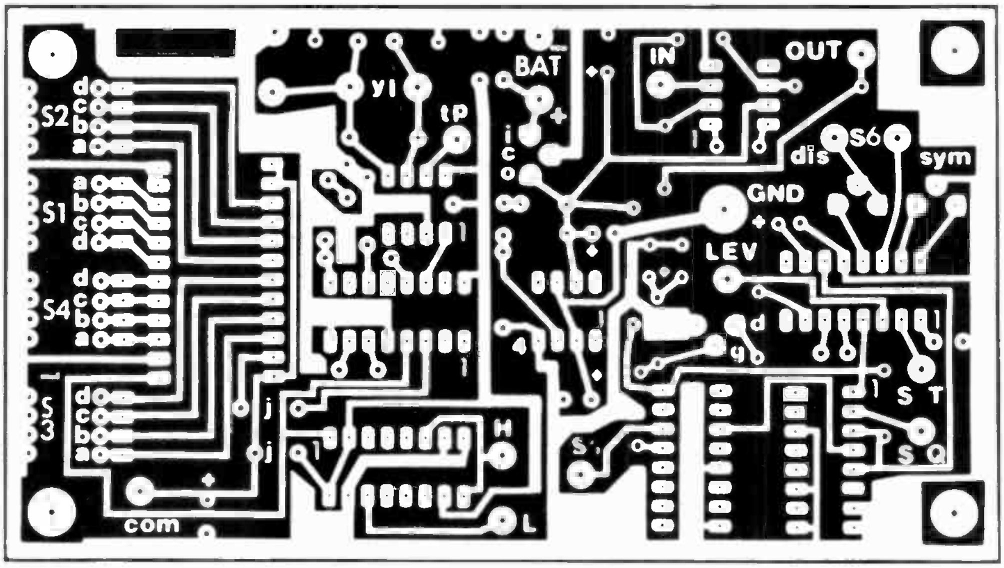


Fig. 4. Full-size etching and drilling guide for pc board.

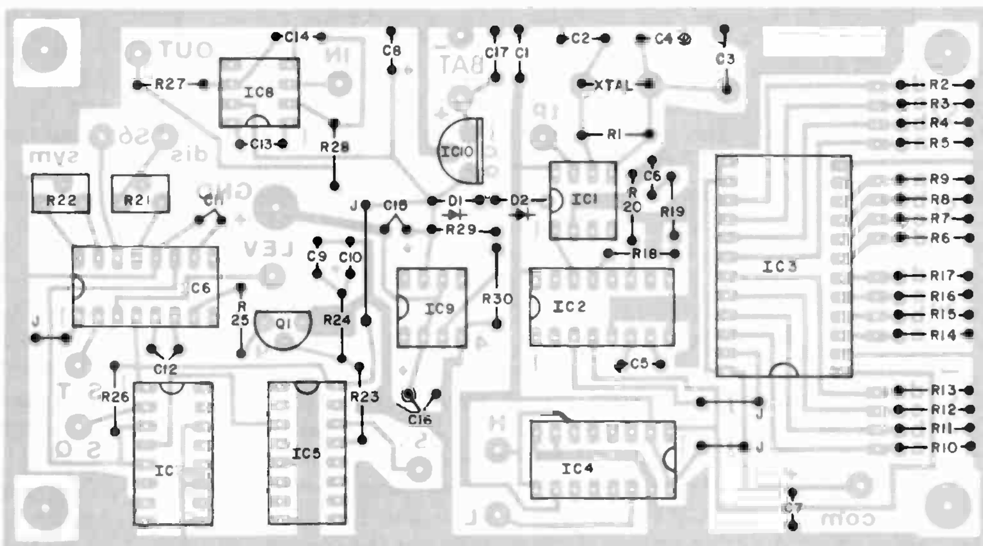


Fig. 5. Locations and orientations of the components on the pc board.

nent side of the board where indicated.

All off-the-board components must be mounted on the walls of the enclosure selected to house the project, via appropriate-size mounting holes. The exception here is with batteries *B1* and *B2*, which mount in brackets that are secured to one of the inside walls of the enclosure with quick-set epoxy cement. An ordinary 4" × 6" plastic file box makes an ideal-size enclosure for the project.

Interconnect the off-board components with the pc assembly according to the diagram shown in Fig. 6. Note the use of 4-conductor ribbon cable between thumbswitches *S1* through *S4* and the appropriate solder pads on the printed circuit board.

Upon completion of assembly, use a lettering kit to label identifiers and/or positions of the various controls, switches, connectors, and meter.

Test and Adjustment. With the function generator powered up, measure the frequency at pin 1 of *IC1* with a frequency counter. The counter's display should read 100 Hz, which is the reference signal; if it reads 60 Hz, the wrong IC is installed. Make sure that you install an MM5369-EST version in the *IC1* socket before proceeding.

Set thumbwheel switches *S1* through *S4* to 1-0-0-0 and use the frequency counter to measure the frequency at pin 4 of *IC2*, which should be 100,000 Hz. Then set *S1* through *S4* to 2-0-0-0, 4-0-0-0, and 8-0-0-0 and in each case note the frequency measured at pin 4 of *IC2*. The displayed frequencies should be 200, 400, and 800 kHz, respectively. Repeat the switch-setting sequence using 0-1-0-0, 0-2-0-0, 0-4-0-0, and 0-8-0-0 and note that the measured frequencies at pin 4 of *IC2* are 10, 20, 40, and 80 kHz, respectively. Repeat the thumbwheel settings one

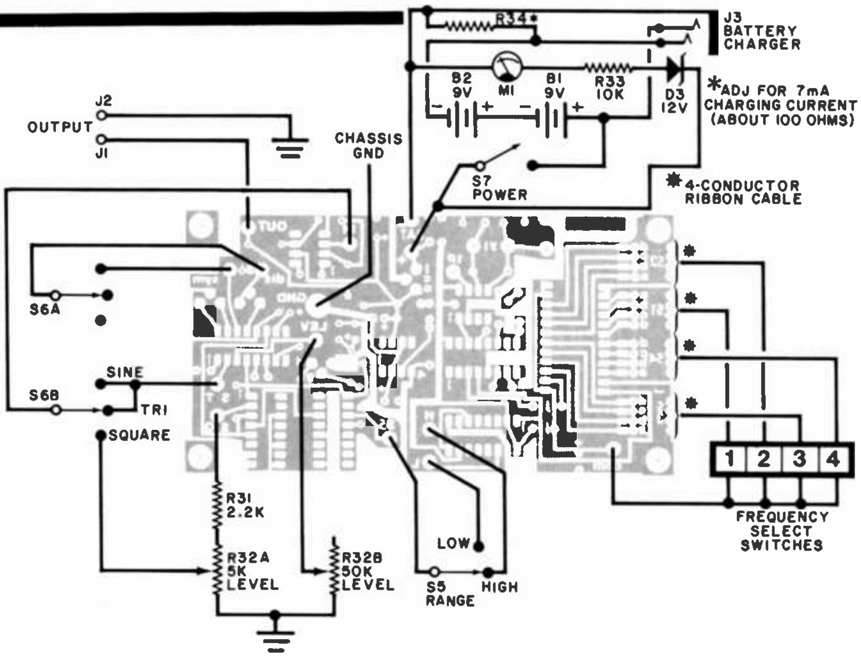


Fig. 6. Connection of off-board components to the pc assembly.

more time, using the sequences 0-0-1-0, 0-0-2-0, 0-0-4-0, and 0-0-8-0 and measure at pin 4 of *IC2* the frequencies 1, 2, 4, and 8 kHz.

Return the settings of *S1* through *S4* to 1-0-0-0 and connect the frequency counter to first pin 9 and then pin 14 of *IC4*. The counter should indicate 10,000 Hz at pin 9 and 1000 Hz at pin 14.

To check operation of *IC6*, keep the thumbswitches set to 1-0-0-0 and connect an oscilloscope's probe to pin 14. A 10-kHz signal should be displayed on the scope's CRT with the project's RANGE switch set to HI and 1 kHz with it set to LO. A square-wave signal should be present at pin 11 of *IC6* and pin 3 of *IC5*.

Once the programmable function generator has been tested, you can proceed to adjustments with an oscilloscope and accurate frequency counter. If you don't have access to these instruments, you can skip this section. Basic accuracy of the instrument, even without formal calibration procedures, will be sufficient for all but critical testing.

Begin the adjustments procedure by setting POWER switch *S7* to ON, FREQUENCY SELECT thumbwheel switches to 1-0-0-0, RANGE switch to LO, and function switch *S6* to SQUARE. Position LEVEL control *R32* to the center of its rotation.

Connect the frequency counter between TP (pin 7 of *IC7*) and GND jack *J2* on the instrument's front panel. Carefully adjust trimmer capacitor *C3* for a displayed frequency of 3,579,545 Hz. This done, disconnect the frequency counter and set it aside.

Connect the scope's probes to the function generator's OUTPUT and GND binding posts. Set the scope's vertical gain for a display of at least two graticule divisions and horizontal sweep time and sync controls for display of one full cycle, starting and ending at the ends of the graticule. Adjust trimmer potentiometer

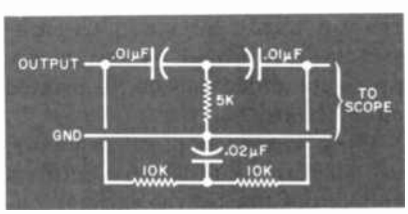


Fig. 7. Filter to be used in viewing project output on scope.

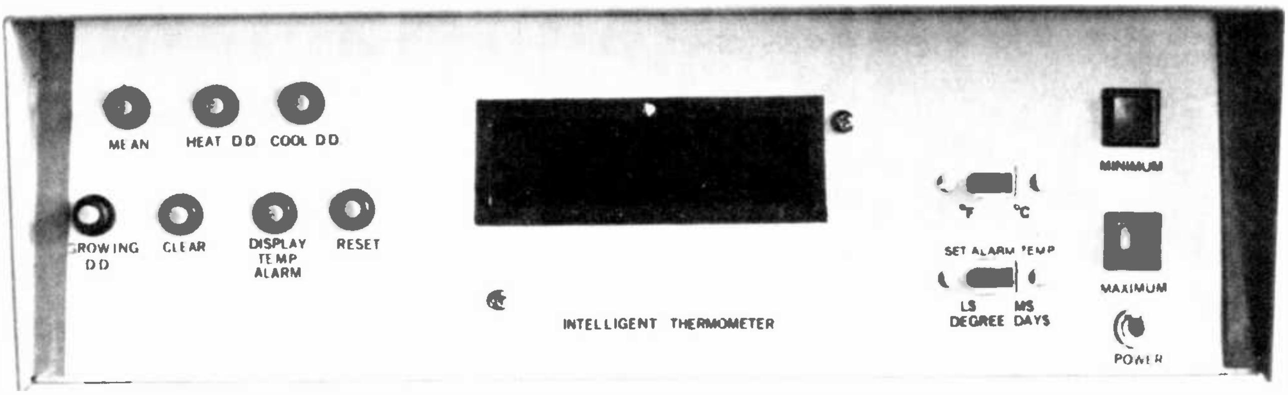
R22 until the waveform changes state at the center of the graticule, producing positive and negative signal peaks of equal size on the CRT screen.

There are three ways to adjust for minimum sine-wave distortion. One is to set the function switch to SINE and adjust trimmer potentiometer *R21* (DIST) for a clean approximation of a sinusoid waveform at the output of the function generator. Using this technique, distortion can be brought to within 3%. If the sine wave flattens during adjustment, decrease signal amplitude with the LEVEL control to restore the sinusoid shape to the monitored waveform.

An alternative approach to making the distortion adjustment requires building of the bridged-T filter shown schematically in Fig. 7. (Use 1% tolerance resistors and matched capacitors when assembling this circuit.) With this filter connected to the project's OUTPUT and GND binding posts, use an oscilloscope to observe the signal present directly at the project's output connectors (before the filter) while adjusting the LEVEL control for a 2-to-3-volt peak-to-peak signal. Then move the scope probes to the output end of the filter and adjust the scope's vertical gain for a usable display. Set the function generator's FREQUENCY SELECT switches for the lowest-amplitude display, which should be in the neighborhood of 1590 Hz with the component values specified in Fig. 7. Disregard the least-significant-digit switch (*S4*), since the units position switch generates such small changes in amplitude that they won't be discernible on the scope's CRT.

Having adjusted for minimum amplitude, adjust DIST control *R21* to minimize the displayed signal. All peaks should have equal amplitude. In the prototype, this point occurred at about a 9-mV peak-to-peak signal level.

The third and, by far, most accurate approach to minimizing distortion is with the aid of a total harmonic distortion (THD) analyzer. If you have access to such an instrument, connect it to the programmable function generator's OUTPUT and GND binding posts and set the FREQUENCY SELECT switches for a 1-kHz output. Then adjust the project's DIST control for the lowest possible measured distortion figure. This is a one-time-only adjustment; the DIST control need never be touched again unless you replace *IC1* or *IC6*. ◊



Build The Intelligent Thermometer *Part 2*

A microprocessor and a programmed EPROM are used in this sophisticated circuit to measure and analyze changes in temperatures

By Tom Fox

LAST month, we described the circuit of the Intelligent Thermometer and how it works. Here is a description of the program and instructions on construction.

EPROM Program Description. Figure 5 shows a simplified flow chart for the program.

The CPU must receive 18 identical temperature readings in a row before it can continue its program. This feature provides digital filtering, makes for a steady display, and eliminates faulty readings.

Every four minutes an internal clock causes the CPU to stop what it's doing, find the current temperature, and then proceed to the MEAN routine. Although the procedure appears simple in the flow chart in Fig. 5, it takes many instructions to calculate the different mean-temperatures and degree-days. For instance, first the hourly mean is calculated. This is done by using temperature readings taken every four minutes over a one-hour period. These temperatures are added together and divided by 15. Next, the daily mean is found by adding up 24 consecutive hourly means and dividing by 24. Finally, the mean is found by adding up the daily means and dividing by the days since the mean was last cleared.

A complete EPROM listing can be obtained free of charge by including a self-addressed stamped envelope and requesting it from the address in the Parts List.

Construction. The project should be constructed on a pc board. A double-sided board for this purpose has been designed but the foil patterns are too large to be reproduced here without reduction. Full-size copies of the foil patterns for the CPU board and the display board will be supplied with component layout diagrams when the EPROM listing is ordered from the address given in the Parts List. Note that, while the pc board is double-sided with plated-through holes, it is possible to use a one-sided board with jumpers, instead of foil, on the component side. Use wires or a cable to connect points labeled with letters on the display board to the same points on the CPU board. External elements are connected to the CPU board as shown in Fig. 6.

Battery *B1* is an optional four-cell nickel-cadmium type that has a fully charged voltage of about 5.2 V. This back-up battery will allow retention of information in its memory during a power failure. Resistor *R13* should be chosen for a proper trickle-charge rate for the battery used. As a rule of thumb this rate should be around C/50, where C is the capacity of the battery in ampere-hours. AA cells having an ampere-hour rating of about 0.5 were used in the prototype. C cells have a rating about three times as high. With AA cells you can try 470 ohms for *R13*. It is best to check *B1*'s charging rate after you have the project up and running for a day or so. Use a milliammeter placed in series with *B1*.

If you choose not to use a back-up battery, eliminate *D1, D2, R13,* and *C6* and connect pin 35 of *IC8* to the main V_{cc} (+5 V) source. You can do this on the circuit board by connecting jumper wire J to point J5 instead of point JB on the board.

Resistors *R34* through *R45* are optional. In most applications they increase the circuit's noise immunity although here their use is ques-

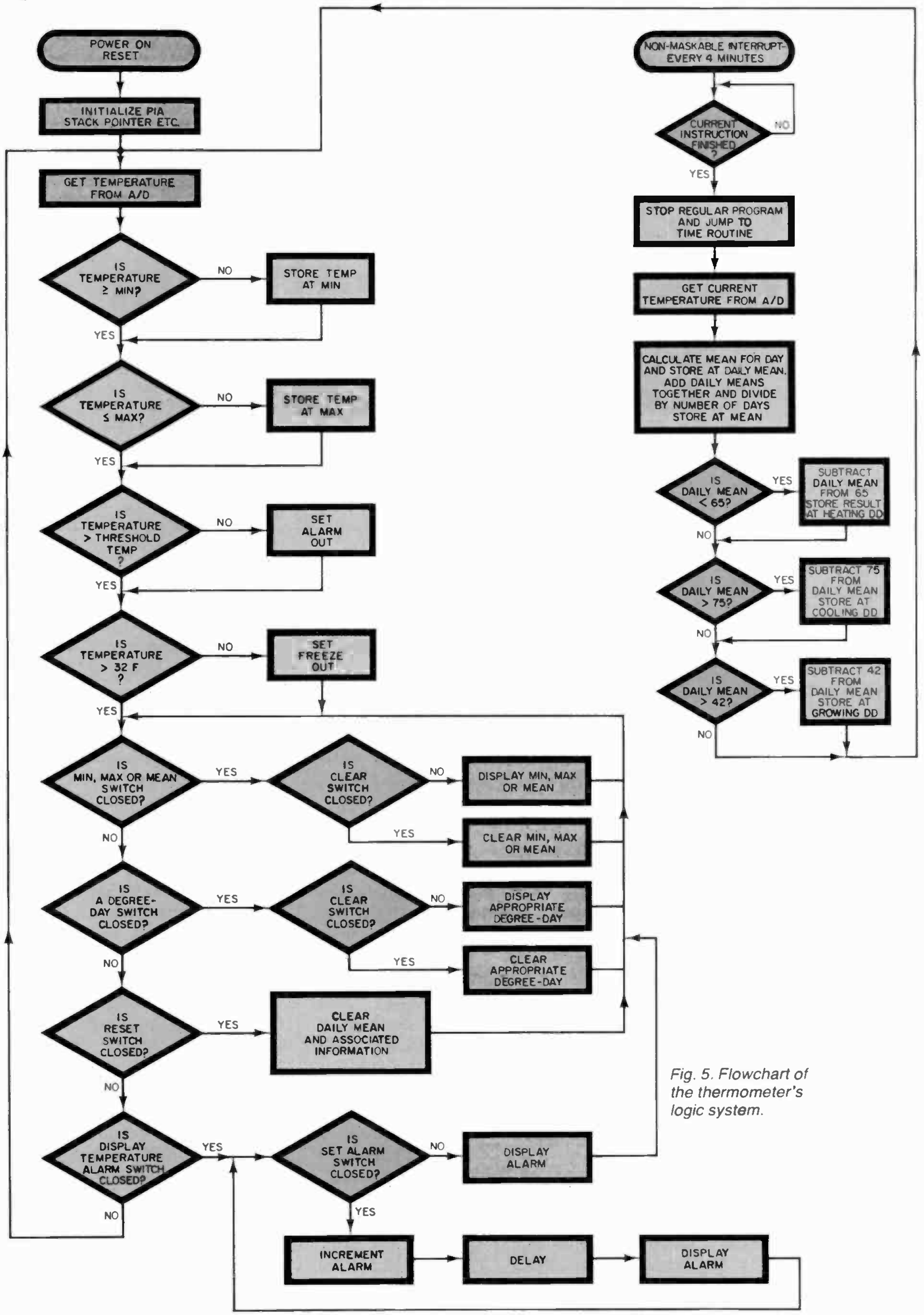


Fig. 5. Flowchart of the thermometer's logic system.

tionable. They are not shown on the pc board. If you wish, they can be easily soldered directly to the switches.

Capacitors *C7* and *C31* are needed for *IC8*'s crystal oscillator to perform properly. The 6802 is designed to be used with a 4-MHz parallel-resonant fundamental crystal.

Connect point T on the CPU circuit board to a secondary lead of the power transformer. Make sure this lead is not a ground. If you are not sure of the voltage rating of the transformer (which sometimes happens if you buy a commercial power supply) use an ac voltmeter to measure the voltage between this lead and ground. If the voltage is 6.3 V, *R7* should be about 100 kilohms. If the voltage is 12.6 V, try a 39-kilohm resistor, and if you have a 16-V transformer, a 33-kilohm resistor is close to optimum. The exact value of *R7* is not critical. Just make sure it is chosen so that the output of *IC5A* is normally high when *R9* is adjusted properly.

Notice that *R30* and *R31* are 1% precision resistors. They simplify calibration. If you wish, you can replace *R31* with a combination 22-kilohm resistor and 5-kilohm pot in series. However, this complicates calibration and can reduce long-term accuracy.

For a faster responding unit, reduce *C8* (*IC9*, pin 4) to 150 pF, but some flicker may be noticed in the display. Although they are not shown in the schematic (they *are* shown on the component layout), 0.01-μF capacitors should be connected between the supply leads (+5 V and ground) physically close to *IC5, IC10, IC13, IC17, IC18, IC20, IC22, IC24,* and *IC27.*

Figure 7 shows a typical low-cost power supply that uses a 6.3-V transformer that can be purchased from surplus electronic dealers. The transformer should be rated at least at 1.5 A. This circuit uses two voltage-doubling circuits to achieve +12 V and −5 V, in addition to the +5-V supply. Keep in mind that this is a low-cost power supply that provides the minimum power requirements. Any other power supply is suitable as long as it is well filtered, well regulated (±5%), and provides the following minimum requirements: +5 V at 500 mA, +12 V at 50 mA, and −5 V at 40 mA.

To protect the circuit against lightning and other destructive power-line surges, it is wise to connect a surge absorber to the ac line immediately after the switch and fuse. You can use Panasonic's ZNR or GE's Varistor or any other similar device. To protect the RAM from error bits, you also might want to connect an r-f filter to the line circuit. One filter that is readily available is Radio Shack's 15-1106.

Sensor Assembly. Use a 2-conductor cable, size #26 or larger, for the sensor probe assembly. If a length of several hundred feet is desired, use #22 wire.

Refer to Fig. 8 for one way of sealing and waterproofing the probe. If you use this construction, first, color code the leads so there can be no confusion. Cut off the "Adj" lead from *D9* since it will not be used. Place sleeving on the cable's wires before making connections to the sensor. After soldering (use a heat sink between the solder and sensor), spray the assembly with several coats of a plastic insulating spray. Pull up the sleeving to cover all bare wires. Spray the assembly again. When the spray is dry, use an epoxy-type putty (E-POX-E Ribbon etc.) to encase the assembly. Use your fingers and hands to form a neat appearing probe. After the epoxy sets, spray the assembly again with plastic. If you wish to paint the probe, use a white or metallic silver paint.

Preliminary Testing. If the display doesn't show some number when first turned on, don't panic! It is possible that *R9* may have to be adjusted. Slowly turn *R9* until the display appears steady. Then turn it another ⅛th of a turn in the same direction. Hold the probe in your hand. The display should show increasingly larger numbers. If everything seems to be OK so far, proceed to the Calibration section. If not, use a voltmeter or oscilliscope to measure the voltage at pin 40 of *IC8.* It should be close to 4 volts. If you cannot get pin 40's voltage up this high by adjusting *R9*, you'll have to increase *R7.* Try first increasing it by about 25%. If still no luck, increase it further.

Calibration. Use an accurate voltmeter (a DVM is preferred) to measure the voltage, with respect to ground, at pin 9 of *IC9*. Adjust *R28* so that it is exactly 2.49 V.

Note that the display shows the temperature of the probe unless one of the pushbutton switches is pressed. To measure temperatures in degrees Fahrenheit, place the "°F/°C" switch (*S10*) in the "°F" position. The "F" on the display should light. If you prefer the Celsius system, switch to "°C".

For final calibration, place the waterproof probe in the middle of a large container that has a mixture of ice and water (50% minimum ice). Stir occasionally and wait at least 10 minutes. Adjust *R26* so that 32 F or 00 C shows on the display. If you wish, you can place a drop of cement on *R26*'s wiper arm.

Operation and Use. If this sophisticated instrument is to be used to monitor the weather and local climate (its original purpose) don't

ORDERING INFORMATION

Note: The following are available from Magicland, 4380 S. Gordon, Fremont, MI 49412: complete kit of parts including pc boards, all ICs, and sensor, but not case, power supply, battery or cable, for $179.00, postpaid. Also available separately: 2708 EPROM (preprogrammed) for $25.00; ADC0801 for $8.25, LM135H for $9.50; 1% precision resistor for $1.75 each; LM324N for $1.25. On orders less than $5.00, add $1.00 for handling. Outside U.S., Canada, and Mexico, add $5.00 for shipping. Michigan residents, add 4% tax. The following are available from Danocinths Inc., PO Box 261, Westland, MI 48185: microprocessor pc board (#RW403) for $64.00; display pc board (#RW403D) for $10.85; both pc boards for $70.00; postpaid. Michigan residents, add 4% tax. The listing for programming the EPROM and the foil patterns and component layouts for the pc boards can be obtained by sending a stamped, self-addressed legal-size envelope to Dept. IT, Computers & Electronics, One Park Ave., New York, NY 10016.

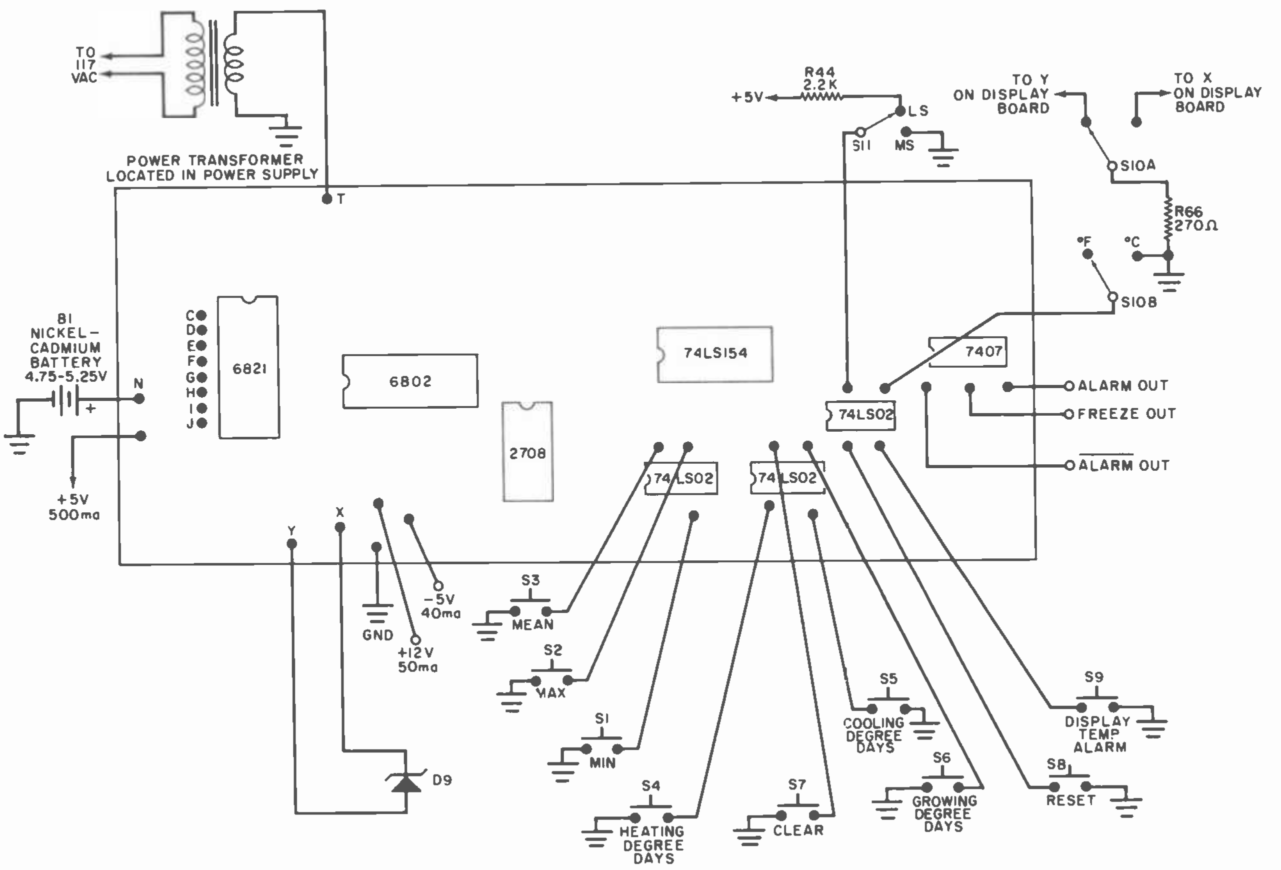


Fig. 6. External connections to the main pc board.

simply stick the probe out a window! Even a north window isn't good enough. No matter how accurate an instrument is, the readings it takes can only be correct if the probe is placed in a suitable location. The reason for this is that only *air* temperature readings are pertinent for most applications. Your primary aim in locating the probe is to avoid letting the sensor receive any infrared radiation from a source that is at a different temperature from that of the air. You may already have taken the first step by painting the probe white or metallic silver. Placing the probe at the 5-foot level in a large screened porch where it gets plenty of air circulation and is away from a heated building is close to being the ideal location for the sensor.

On the other hand, a simple shelter can be made from a wood box that has no bottom and a back consisting of a fine meshed plastic or aluminum screen. A second large roof on top of the box can be added for even better results. Paint the shelter and roof white and suspend the sensor in the middle of the box about 5 feet from ground level. Place the shelter in a location that gets plenty of air circulation and orient it so that the screened back is pointing north.

After turning the unit on, press the RESET switch (*S8*). This is necessary to clear internal registers in the memory. The RESET switch can also be used whenever you want the precise mean temperature or degree-days from a particular time. If you simply clear the MEAN memory registers (by pressing the MEAN and CLEAR switches at the same time), without pressing the RESET switch, the mean temperature shown by the display can be off a bit. Practically speaking, however, if you plan to find the mean-temperature or degree-days for a period longer than a week, it is not necessary to reset the circuit (except when you first turn it on).

To clear the minimum, maximum, mean, heating degree-days, cooling degree-days or growing degree-days memory registers, press clear switch *S7* at the same time you press the switch that pertains to the register you want cleared.

When the minimum or maximum memory registers are cleared, the present temperature is stored in the registers. When the mean register is cleared, −56°F (−49°C) is stored in the mean memory register. When any degree-day registers are cleared, 0 is stored in the respective register.

When operating any of the pushbutton switches, keep the switch depressed until the display

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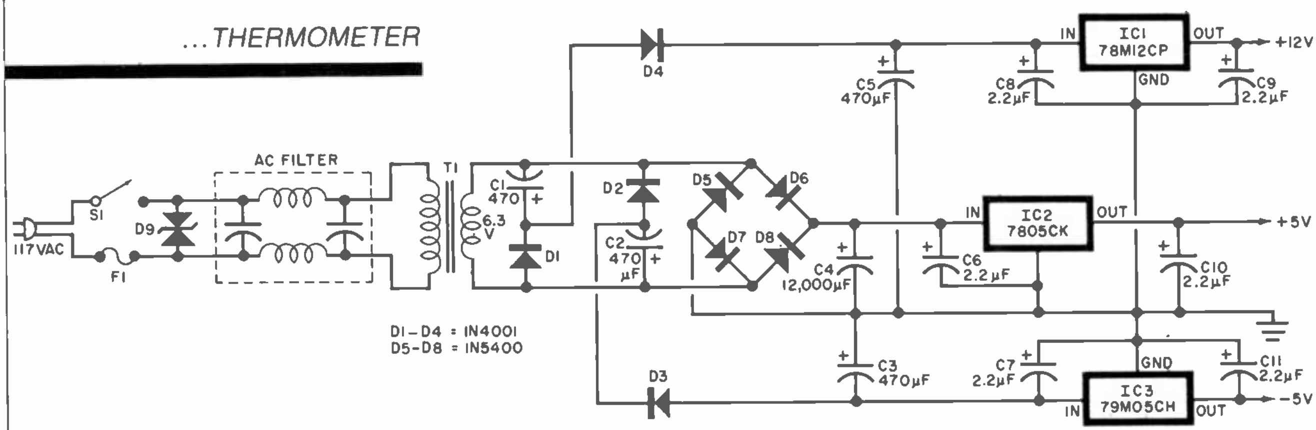


PARTS LIST (Power Supply)

C1,C5—470-μF, 25-V electrolytic
C2,C3—470-μF, 15-V electrolytic
C4—12,000-μF, 15-V electrolytic
C6 through C11—2.2-μF tantalum capacitor
D1 through D4-1N4001 diode (or similar)
D6 through D8-1N5400 diode (or similar)
D9-Varistor (Panasonic ZNR or similar)
F1—½-A slow-blow fuse
IC1—78M12CP, 12-V voltage regulator
IC2—7805CK, 5-V voltage regulator
IC3—79MO5CH, —5-V voltage regulator
S1—125-V, 3-A spst switch
T1—6.3-V, 1.5-A transformer
Misc.—AC filter (Archer 15-1106 or similar), wire, hardware, etc.

Fig. 7. Schematic for a suitable power supply.

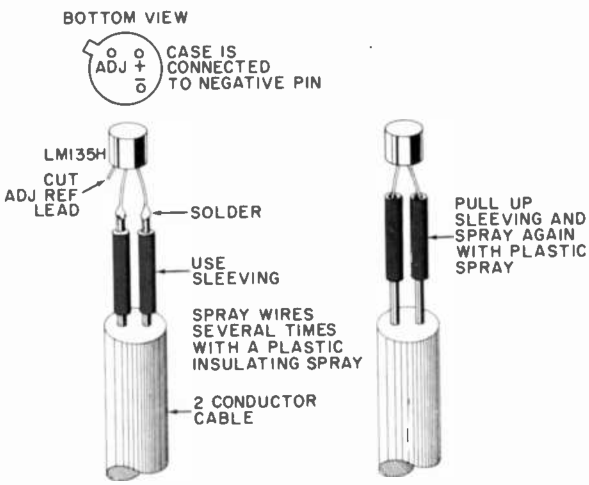


Fig. 8. How to make the sensor assembly.

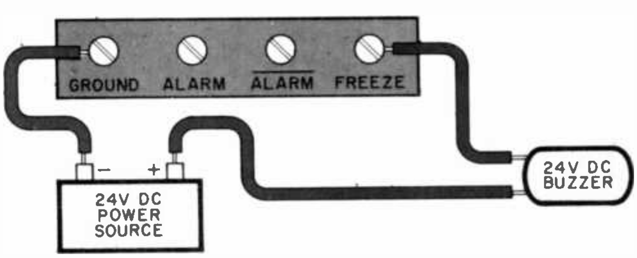


Fig. 9. Connecting to the terminals on the back panel.

changes. The CPU must receive 18 identical temperature readings in a row before continuing the program. If the temperature is exactly between two numbers (which occurs infrequently) this "digital filtering" can cause a second or so delay in switch action.

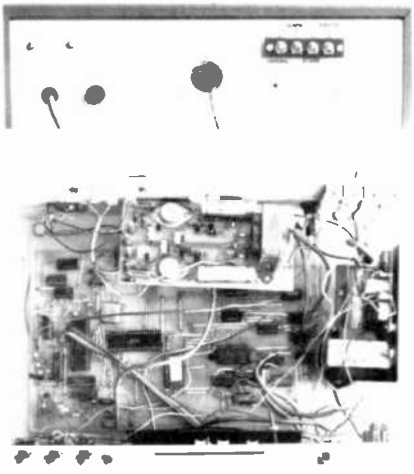
The operation of the MINIMUM and MAXIMUM switches is rather obvious. When you press either of these switches, the display shows the minimum or maximum temperature, respectively, measured since last memory clearance. When the MEAN switch is pressed, the display shows the accumulated mean temperature over a period of days (255 maximum) since the MEAN register was last cleared.

To display degree-days, place the LS/MS switch (*S11*) in the MS position. Also determine if you want Fahrenheit degree-days or Celsius degree-days and place the °F/°C switch (*S10*) in the appropriate position. (Note: Celsius degree-days are automatically rounded off to the nearest hundred and the LS display will always show 00.) When you press the particular DEGREE-DAY switch you are interested in, the display will show the number of degree-days in hundreds (e.g. 34 stands for 3400). Finally, switch the LS/MS switch to the LS position to find the units. (If the display shows 34 in the MS position and 53 in the LS position the number of degree-days is 3453.)

To display the threshold temperature stored in the alarm memory register, press the DISPLAY TEMPERATURE ALARM (DTA) switch. To change this threshold temperature, momentarily switch on the SET ALARM TEMPERATURE switch while pressing the DTA switch. Continue pressing the DTA switch until the desired temperature shows up on the display and then release it.

Up to 30 V and up to 40 mA dc can be controlled with the FREEZE and ALARM outputs (Fig. 9). The "FREEZE" output sinks current when the temperature drops to 32°F (0°C) or lower. The "ALARM" output sinks current when the temperature drops to or below the "threshold temperature" stored in the ALARM memory register. The $\overline{\text{ALARM}}$ output is complementary to the ALARM output since it responds to temperatures above the threshold.

Applications. The practical uses for this thermometer to measure the current temperature, and record the maximum and minimum temperatures over a period are obvious.



Photos of the rear and interior of the author's prototype.

The interested builder should consult library references covering heating/cooling degree days as they pertain to gas or oil heating and air conditioning, and growing/cooling degree days as they pertain to plant and crop growing.

The FREEZE output is connected to an alarm that will sound off when the measured temperature drops below freezing. The ALARM output is set to the "threshold" temperature; and, when an alarm is connected to this output, it will sound off at the preset temperature. The threshold temperature can be set (another example) to −20°F to sound an alarm that the water pipes are frozen!

By connecting the ALARM output to one relay, and the $\overline{\text{ALARM}}$ output to another relay, you can create a digital heating/cooling thermostat. It is possible to re-write the EPROM program to use the built-in clock and make a very sophisticated thermostat that is activated by time and temperature. ◇

COMPUTER HOTLINE

The C & E Staff Answers Your Questions About Computers

CP/M ANYONE

Q: *I went to a lot of trouble and expense to add CP/M to my computer. Now I find that I can not get versions of programs to run on my machine. In addition, all of the CMUG (CP/M Users Group) and SIG/M public-domain software that I thought I would be able to use does not come in my format. Is this a rip-off or just a misunderstanding on my part?—Joe Stratton, Norr Hope, PA.*

A: It is a misunderstanding of CP/M and the mechanism for distributing public-domain software. Each manufacturer who distributes CP/M for his computer writes the BIOS for his format and design; most of them are different. Software publishers sell their programs through distributors who undertake to translate the CP/M program into many different formats that they support. Lifeboat Associates, for example, has a list of CP/M formats that they support. When a customer orders a copy of a program, say, in Micropolis format, the people at Lifeboat download the programs from a "standard" 8-inch single-density disk to the Micropolis format. This is the process used to convert all CP/M sofware from one format to another. Now this doesn't happen unless the computer manufacturer makes his equipment available to the distributors and asks that his format be supported.

In the case of public-domain software, all distribution is made in 8-inch, single-density, single-sided disks. In some cases, there are also libraries of other formats such as NorthStar, Micropolis, and Apple because someone in the group went to the trouble of downloading the entire library of software. SIG/M will supply clubs with NorthStar and Micropolis versions for distribution to their members. It is up to the club to keep them up to date by getting future releases. I don't know if anyone has collections of CP/M Users Group or SIG/M software in any other formats.

When you see a new computer come on the market and it is advertised to have CP/M, do not assume that there will be CP/M software to run with it. There is no assurance that software vendors will convert their product to this new format.

AC CONTROL CIRCUIT

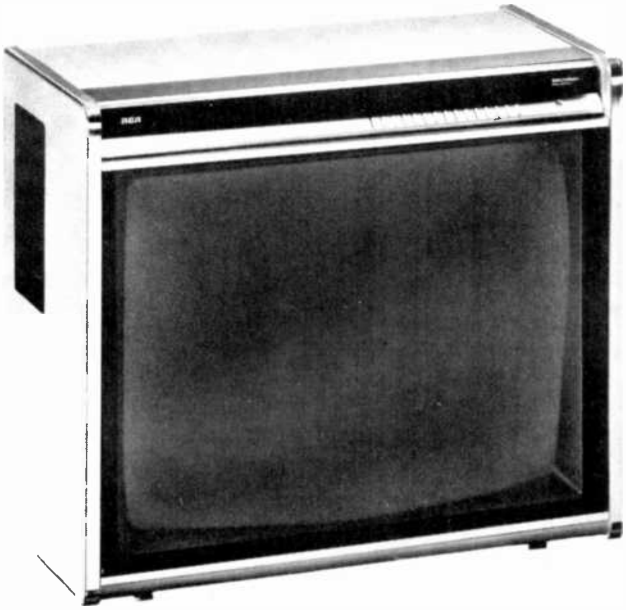
Q: *I'm interested in designing and building an ac outlet control circuit for my home that can be controlled by my Radio Shack TRS-80 Color Computer. I need help in designing the carrier-current circuit that would activate electrical outlets via the home power system.—David McNamara, Detroit, MI*

A: There are two types of devices needed to implement a computer-operated, carrier-current, electrical control system. First, there is the Interface/Controller connected to the computer. This device translates the programmed output from the computer into coded pulses. The pulses are then transmitted along the 60-Hz lines to the receivers.

The second type of device is a Receiver/Decoder and Switch that's connected to the power system at the remote location. When this unit receives its coded number, it changes the status of the switch according to the received message (from ON to OFF or vice versa).

I would not recommend that you build the Interface/Controller device. Use the one designed for your computer. Radio Shack has provided the TRS-80 Plug'n Power Controller for the Color Computer and Models I and III. It plugs directly into the cassette port and is able to access any of 16 house codes used to avoid conflict. For each house code there are 16 module codes that control individual outlets, appliances, or lights. This gives you maximum flexibility in working out the different control programs. ◊

TEST REPORT: VIDEO



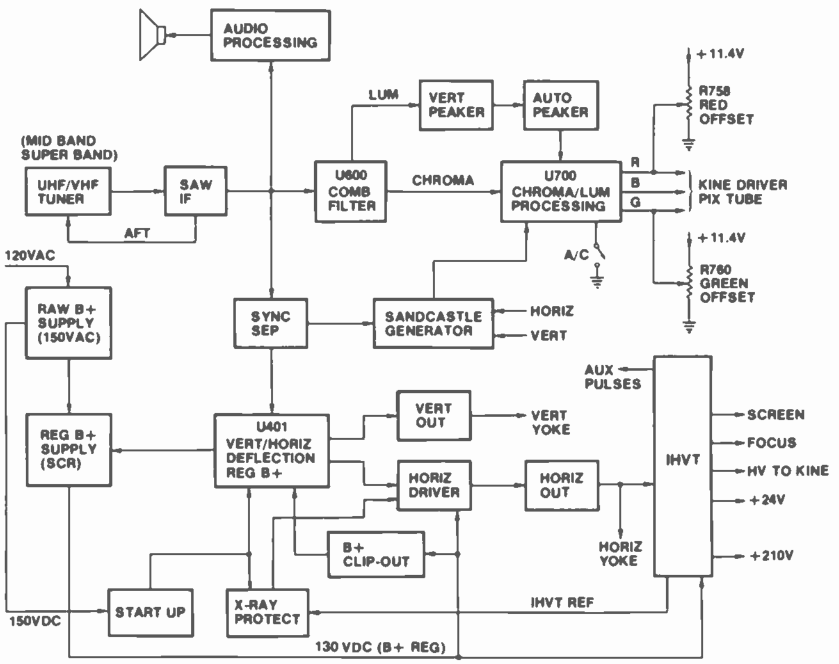
RCA Model VGM 2023S 25" Color TV Receiver

WHEN is a TV set not a TV set? When it's a Selecta-Vision Video Monitor like the new Model VGM 2023S 25" color model introduced recently by RCA. Taking a tip from a host of component TV systems that feature separate video monitors and tuners, RCA combined both in a single unit.

This is essentially a top-of-the-line RCA ColorTrack TV receiver with an extra source of picture and sound from a PW44000 circuit board added to a CTC-121 chassis. It includes an auxiliary input/output panel at the rear for easy access to video and audio monitor facilities for a VCR, video camera, video disc, computer, and external hi-fi stereo system. Its high-performance TV receiver section includes a bevy of advanced features such as a solid-state tuner that can receive 127 channels (vhf, uhf, and the cable midband, superband, and hyperband channels), comb filter and surface acoustic wave (SAW) filter circuitry, and a deluxe infrared wireless remote control. Additionally, the audio system includes a pseudo stereo synthesizer with a pair of speakers for each channel, while the monitor section has stereo output/input hi-fi signal jacks and external speaker jacks.

The "S" in the model number we tested stands for silver finish, adding $50 to a suggested retail price of $1080 (a wood-grain finish cabinet is the standard model).

General Description. One obvious attribute is the unit's cabinet size. RCA's designers have managed to wrap the cabinet so closely around the screen that only a two-inch space is left at the sides and bottom, and only three inches at the top. This results in a cabinet that is 21¾"H × 24¼"W. And, because of the short, 110° deflection, 25" CRT, the cabinet is only 18⅜" deep. Within the top three inches RCA has neatly stowed channel tuning and power and volume controls, while the rest of the customary controls are located under a hinged panel strip that runs the width of the screen. A set of built-in, high-compliance speakers (5" woofer, 2" tweeter) are located at each



Functional block diagram of the RCA 2023 TV receiver.

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side panel, internally recessed to project sound forward. The 127-channel tuning system uses frequency-synthesized circuits. An infrared (IR) remote control permits either direct channel access by dialing the channel number, sequential scanning through every channel, or scanning through preprogrammed channels only. There is also a channel-up/down, and a mute switch that instantly silences the audio. (The same channel selection can be made using the levered pushbuttons at the top of the set.)

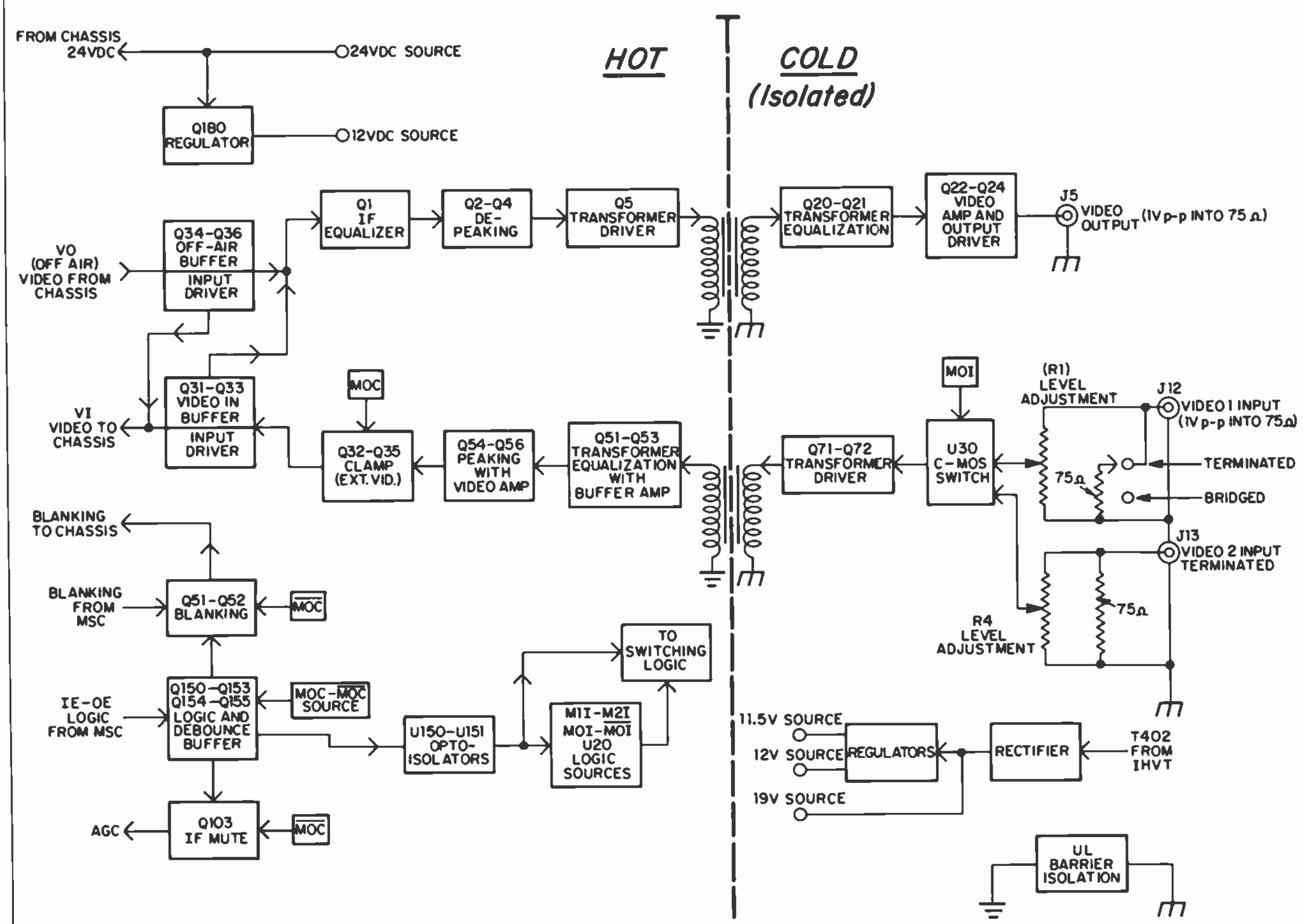
Fifteen separate RCA phono jacks, two slide switches, and two potentiometers provide the array of video and phono inputs and outputs accessible to the user on the set's rear panel. Video inputs are selected by using the channel selection on the front of the receiver or by the IR remote control. Once the two video input level controls are set, the viewer can switch from TV reception to monitoring a VCR or another source of video just by dialing "91" or "92."

The channel number and the time-of-day are superimposed on the picture whenever a channel is selected or the RECALL button is pressed. After about 6 seconds, the display disappears. Separate pushbuttons under the hinged panel at the top of the screen set the correct hours and minutes. The internal digital clock runs even when the set is turned off, but if power is interrupted, the next time display on the screen will show blank dashes, requiring resetting of the clock.

The TV broadcast channels, 2 through 83, are selected in the usual manner by their assigned numbers. To receive any of the 45 cable channels, the viewer must actuate a slide switch at the rear of the set near the antenna terminals. A simple chart is provided assigning a two-digit number to each cable channel. Both vhf and uhf 300-ohm terminals as well as a 75-ohm, coax terminal with a moveable jumper, permit connection of indoor and outdoor antennas or cable TV signals.

Though the channel selection and on-screen display features are not unusual in digital tuning TV sets, the fact that they are accomplished by only four ICs is certainly novel. Even more intriguing, however, is the actual r-f tuner circuitry. It consists of three separate, varactor-tuned, r-f amplifiers, oscillators and mixers—one covering uhf and one each covering the superband and vhf midband channels. Each r-f amplifier uses individually trimmed, multiple, resonant-circuit input and output stages as well as isolation amplifiers following the mixer. A host of separate varactor diodes assures precise tuning for each channel.

The output from the solid-state varactor tuner goes to an i-f amplifi-



Block diagram of the video section of the PW4400 monitor board.

...RCA TV

er IC, which also provides automatic gain control (agc), noise limiting, detection, and video preamplification. A surface acoustic wave filter ensures proper i-f response. The vertical-sync system operates in two different modes, depending on the setting of an internal electronic switch that senses whether or not the NTSC standard vertical sync is received. On NTSC signals the crystal-controlled horizontal sync signal is counted-down further to generate the vertical sync. If another type of vertical sync signal is detected, the count-down is disabled and a sync separator and detector are switched in. The horizontal sync system uses two phase control loops: one each for slow and fast changes—comparing the incoming horizontal sync pulses against those counted-down from the 251-kHz crystal oscillator. This system provides such solid lock-in that no external horizontal sync control is needed.

Probably the most important circuit feature is the CCD (charge coupled device) comb filter, which removes the interleaved color subcarrier from the luminance signal, and then reinstates it while maintaining the full 4-MHz luminance bandwidth. Thus, video information, i.e., picture detail carried at the higher frequency, is retained without interference from the lower-frequency chrominance sidebands. This system is not really new, but the combination of the filter with RCA's elaborate automatic color features promises unusually high video quality. The automatic color control section maintains color intensity regardless of station variations. The automatic contrast/color control (accc) maintains the balance of color, contrast, and brightness. RCA's unique automatic flesh-tone correction ensures that there are no green or purple faces, and the automatic light sensor uses a light-dependent resistor (LDR) to compensate for changes in room lighting.

When we dial 91 or 92 on the front panel or on the remote control channel selector, the RCA model VGM 2023 becomes a video monitor. There are two separate video input channels, each with its own stereo audio input capability. One channel provides an optional internal bridge circuit for both video and audio inputs. This allows us to connect, for example, a camera and microphones to the monitor, and then connect a VCR to the other side of the bridge. If the bridge on the first video input is not desired, a slide switch disconnects it. The second video input channel is not bridged. There is a level adjustment for each video input, while a set of output

TEST MEASUREMENTS
RCA MODEL 2023S 25″ COLOR TV RECEIVER

Parameter	Measurement
Sensitivity, vhf (Ch. 3):	−58 dBm
Sensitivity, uhf (Ch. 20):	−55 dBm
Noise figure, vhf (Ch. 3):	5 dB
Noise figure, uhf (Ch. 20):	9 dB
Horizontal resolution at CRT:	350 lines
Video bandwidth to CRT (−6 dB):	4.25 MHz
R-f osc. stability (Ch. 3):	0.05 MHz
(105 to 130 V ac, 2 hr.) (Ch. 20):	0.05 MHz
Agc dynamic range:	67 dB
Dc restoration:	100%
Horizontal linearity:	100% left, 100% right
Vertical linearity:	100% top, 100% bottom
Convergence:	95% at worst area
Audio frequency response:	60 to 16,000 Hz
Speaker impedance:	16 ohms (internal > 6 ohms)
Dc regulation, B+: (105 to 130 V ac)	98% at +127 V dc
High-voltage regulation: (105 to 130 V ac)	96% at +27.0 kV
Weight:	78 lb
Power rating:	110 W avg.

jacks provides access to video and audio whether in the monitor or TV broadcast mode. The audio is either in mono or stereo, and separate jacks are available for speakers.

For regular TV broadcast operation the audio is, of course, monophonic. However, the SelectaVision monitor automatically engages the Dual Dimension Sound circuitry to electronically divide and enhance the mono sound to simulate stereo. In addition, the internal stereo amplifier for this and other SelectaVision monitors can be connected to any external stereo signal source via the audio inputs on the rear panel. Similarly, if you want to hook up a stereo disc or VCR to your own hi-fi equipment, the monitor's audio output will route the sound directly to your amplifier or audio receiver, while at the same time displaying the video portion of the program on the screen or recording on another VCR. RCA's audio specifications include a frequency response of 50 to 15,000 Hz, an audio output of 1.3 V rms, audio input of 0.96 V rms, and an external speaker impedance of 6 ohms or greater. The VGM 2023 also has bass and treble controls for use with the internal amplifier.

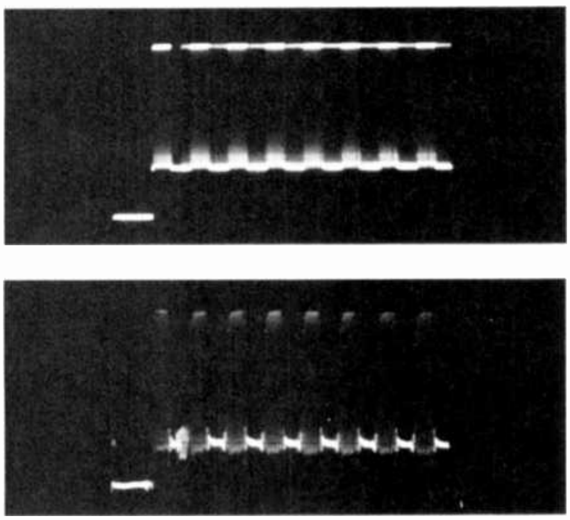
For servicing purposes, you should note that this is a "hot" chassis except for the monitor panel section's audio and video output. Thus, an isolation transformer should be used when troubleshooting circuits.

Laboratory Measurements. The r-f performance measurements of vhf and uhf sensitivity and signal-to-noise ratio are clearly the best of any TV all-in-one receiver we have reviewed in the last two years, although the tuner of the Sony Profeel component system came very close. The noise figure of 5 dB vhf and 9 dB uhf are obviously the result of the elaborate r-f amplifier circuits described. This receiver will do well even in deep fringe areas.

As soon as we saw the color pictures from our studio camera, we knew that the video bandwidth was excellent. We measured 4.25 MHz, slightly better than the Sony Profeel monitor, though the difference of 0.05 MHz would not be noticeable on any picture. As promised by RCA's literature, the CCD comb filter provided excellent bandwidth and color fidelity without any trace of 900-kHz interference. The same five observers who had previously admired the color pictures of the Sony Profeel now agreed that the RCA VGM 2023 color quality and resolution were just as good.

The remaining measurements, as indicated in the accompanying table, show excellent results that correspond almost exactly to those measured on the Sony Profeel monitor. Deflection linearity and convergence were excellent. The top of the screen has a 5% misconvergence, but this was noticeable only with a grid pattern.

User Comments. Summing up the results of our measurements, it is clear that this RCA Model VGM 2023 provides excellent performance, both as a deluxe color TV receiver and as a versatile video monitor. From a technical point of view, RCA's r-f tuning system and its CCD comb filter, combined with all the automatic color circuitry, represent a highly sucessful, advanced design. For the consumer, this RCA model represents the top-of-the-line in performance and features.



Color-bar pattern scope photos. Input on Ch. 3 at top; video output below.

If we continue the comparison with the Sony Profeel as a reference, we find that the two systems are close to equal in performance and operating features; both are excellent. There are some differences, however, that may be important.

While both systems have versatile video and audio input/output arrangements, only the Sony has the ability to accept RGB signals directly. Also, Sony's RS232 computer interface connector, for RGB and other signals, is a decided advantage for some applications. The RCA system, on the other hand, is much more compact. Its monitor and built-in tuner are smaller than Sony's 25" monitor alone. Sony's tuner is designed to be part of a modular video system, but it is a separate box and needs a cable to connect it to the monitor.

A significant difference between the RCA and the Sony, however, is cost RCA's suggested selling price for the VGM 2023 is $1080, while Sony's is $2020 for the monitor alone if one is using a VCR as a tuner. Beyond price, a buyer should take into account the potentially superior picture garnered by using RGB signals with the Sony. This becomes especially important should the monitor be used for computer alphanumeric displays. Furthermore, the Profeel is built like a monitor—coaxial cable connectors rather than pin jacks, for example—throughout.

We were favorably impressed with the Sony Profeel's performance and features, and now that we have tested RCA's VG2023, we are equally impressed and hope that other manufacturers will join in elevating TV receivers to meet the multiple needs of today's video applications. —*Walter Buchsbaum*

CIRCLE NO. 102 ON FREE INFORMATION CARD

Flash Analog/Digital Converters Come of Age

By Forrest M. Mims

TRANSFORMING a digital signal into its analog equivalent is relatively simple; it can be done with little more than a handful of resistors and an op amp. The reverse operation, analog-to-digital conversion, is more involved.

Many clever schemes have been developed for achieving analog-to-digital (A/D) conversion. Unfortunately most require a synchronized series of operations that are very slow by today's standards. Consider, for example, an A/D converter consisting of a D/A converter, clock, counter, and comparator, as shown in Fig. 1.

The counter, which is initially cleared, is incremented by the clock. Each successive count is converted to an analog voltage by the D/A converter and applied along with the incoming analog signal to the comparator. When the voltages are unequal, the counter continues to advance. When the voltages are equal, the comparator changes states and inhibits the clock. The binary output from the counter is the digital equivalent of the analog input signal.

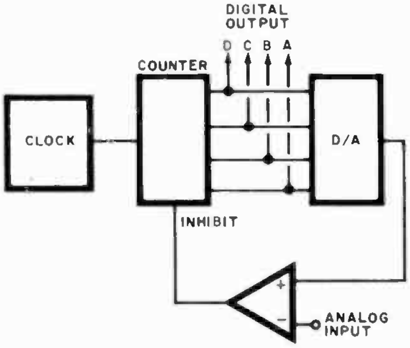


Fig. 1. Simple A/D converter.

The conversion time for this method of A/D conversion, can range from instantaneous when the input signal is 0 V to 2^n clock periods (where n is the counter's capacity in bits). Therefore, an 8-bit counter would require a minimum of 256 clock intervals for a single conversion cycle.

However, there are other sequential A/D conversion methods that are faster than the rudimentary method just described. The *successive approximation* method, for example, although more complex, achieves a conversion in only n clock periods.

Flash A/D Converters. There's a much simpler method of A/D conversion and it is achieved by means of a voltage divider, a string of comparators and an encoder, connected as shown in Fig. 2.

Each node in the divider chain provides a successively higher voltage which serves as a reference level to the noninverting input of the comparator to which it is connected. As the signal voltage is increased from zero potential, it reaches the reference level of the lowest order comparator and causes it to change states. When the signal amplitude rises to the next reference voltage level, the second comparator changes states. The comparators continue to change states to reflect the level of the incoming signal.

Since all comparators whose reference voltage is at or below the amplitude of the signal change states, a basic voltage-divider/comparator circuit can function as a LED bargraph voltage indicator. For microprocessor and other digital applications, it's necessary to incorporate a network of gates to encode the output pattern from the comparators into its respective digital word. Though this increases circuit complexity, no clock is required and the conversion time is much faster than that of other methods.

Though the operating principle of a flash converter is very simple, the number of circuit components increases rapidly with the resolution required. The number of comparators needed, for example, is $2^n - 1$ where n is the number of bits of resolution required. Therefore, a 4-bit flash A/D converter requires only 15 comparators but an 8-bit unit requires 255.

For this reason, flash A/D converters have not been developed nearly as rapidly as other types. One firm that makes microprocessor compatible flash A/D converters is TRW LSI Products (PO Box 2472, La Jolla, CA 92038).

TRW's 6-bit TDC1014J flash A/D converter accepts and digitizes a 1-volt p-p signal at sample rates of dc to 30 megasamples per second. A complete conversion requires only 33 ns! This chip is supplied in a 24-pin DIP package, with an optional evaluation board available.

One-micron fabrication technology has recently permitted TRW to surpass the performance of the TDC1014J. For example, the TDC1025EIC is a 100-mm by 160-

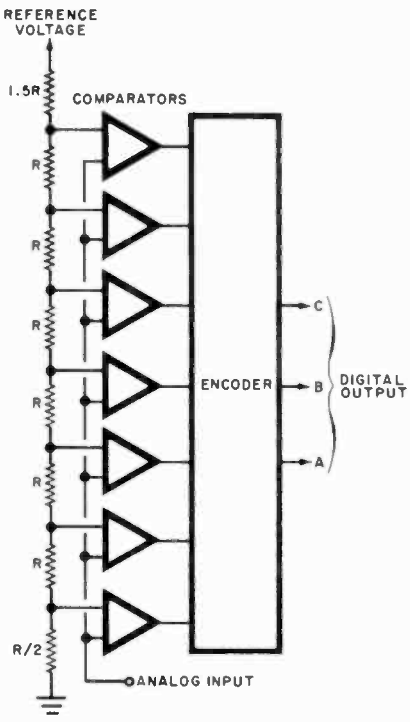


Fig. 2. A 3-bit flash A/D converter.

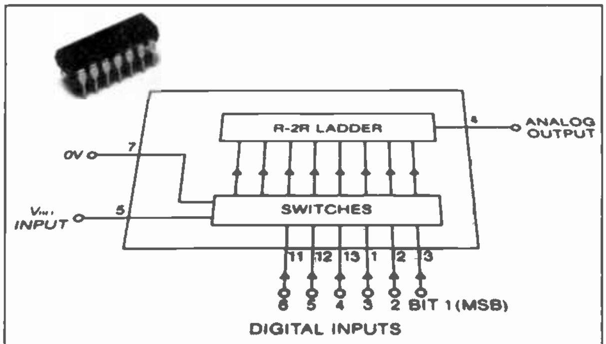


Fig. 3. Ferranti's ZN436 6-bit D/A converter operates from a 5-V supply and has 1-μs conversion speed.

mm circuit board containing an 8-bit flash A/D converter and all necessary support circuitry.

The circuit provides 75 megasamples per second. Even faster conversion speeds are provided by TRW's TDC1029J. This 6-bit flash A/D converter provides 100 megasamples per second!

The lastest flash A/D converter from TRW, the TDC1019J, provides 9 bits of resolution, the highest yet for a monolithic flash A/D converter. Operating at 20 megasamples per second, the 9-bit chip incorporates 511 comparators, a 511-to-9-bit encoder, and a 9-bit ECL-compatible latch on a *single* chip.

No other A/D conversion method available can come close to the conversion speeds provided by these flash converters. Unfortunately, however, the TRW flash converters are more expensive than slower kinds of converters. The price drawback may soon change, however, as more companies enter the flash A/D converter business.

Recently, for example, RCA (Route 202, Somerville, NJ 08876) introduced the first CMOS flash A/D converter, the CA3308. This 8-bit device operates at 15 megasamples per second and dissipates only 240 mW. Fully microprocessor compatible, the CA3308 includes an 8-bit latch with three-state outputs, plus two chip-enable inputs. Two CA3308's can be paralleled to double the conversion speed of a single chip.

Motorola (Box 20912, Phoenix, AZ 85036) and National Semiconductor (2900 Semiconductor Drive, Santa Clara, CA 95051) have also begun to make flash A/D converters. Motorola's 10315/10317 provides 7 bits of resolution at 15 megasamples per second. National makes an 8-bit chip that uses what the company calls a "half-flash" technique. Designated the ADC0820, the chip includes 32 comparators and has a maximum conversion time of 1.2 μs. While not as fast as some chips that use nonflash A/D conversion methods, it's reasonably priced. The plastic-packaged version of the chip sells for $12.95 in quantities of 100.

All these new products portend

the eventual arrival of a wide selection of very affordable flash A/D converters. This development, which cannot be far away, will usher in a new era of ultra-fast processing for such applications as speech processing and recognition, television special effects, video frequency signature recognition, and high-speed sampling and data analysis.

One application to watch for will be inexpensive, high-speed, sampling oscilloscopes that incorporate one or more flash A/D converters. While some of these instruments will resemble conventional scopes, others will take the form of hardware peripherals that convert ordinary personal computers into highly sophisticated, fully programmable oscilloscopes.

One such peripheral is already available from Northwest Instrument Systems, Inc. (PO Box 1309, Beaverton, OR 97075). It's called the Model 85 aScope™, and it's designed to interface with an Apple II™ equipped with 48K of RAM and a Disk II™ (plus DOS 3.3). While the aScope uses nonflash A/D conversion, it can provide a bandwidth of dc to 50 MHz. Flash A/D conversion would provide even higher bandwidths. The aScope sells for $995. You can receive a data sheet by calling toll free 800-547-4445.

Low Cost D/A Converter. Many different D/A converter chips are readily available, but few can match the price of Ferranti Semiconductor's new 6-bit ZN436. Featuring a 1-μs conversion time, the ZN436 is priced at only 83 cents in quantities of 1000.

As shown in Fig. 3, the ZN436 contains an R-2R ladder network and an array of bipolar switching transistors. The chip is housed in a 14-pin DIP package. For more information, contact a Ferranti distributor or write the company (87 Modular Ave., Commack, NY 11725).

A Liquid-Crystal Bar-graph Readout. Epson America, Inc. (23844 Hawthorne Blvd., Torrance, CA 90505), a major supplier of liquid-crystal displays manufactured by Japan's Shinshu Seiki Co., Ltd., has recently introduced a 100-element bar-graph and display. Designated the LD-H9003A, the display is organized as a row of 100 parallel bars, each tenth bar being slightly longer than the preceding nine. The display measures 2.75" by 0.87" and is enclosed in a glass package.

The LD-H9003A does not have conventional connection pins. Instead, connection is made to the conductive regions on the display by means of elastomer connectors similar to those used to establish electrical contact with the miniature liquid-crystal readouts used in watches. Operating over a −20° C to +80° C range, it is available for $8.10 in 100-unit quantities. ◇

Experimenting With a Low-Cost Fiber-Optic Link

By Forrest M. Mims

UNTIL now high prices have prevented many hobbyists from experimenting with fiber-optic data links. General Electric has come to the rescue, however, with a fiber-optic designer's kit that sells for only $9.95. The kit includes a near-infrared emitter and a phototransistor detector, each of which is installed in a threaded plastic receptacle. Low-cost AMP Optimate™ fiber-optic connectors can be quickly mated to the receptacles.

The General Electric kit also includes a one-meter length of DuPont Crofon™ 1040 fiber-optic cable terminated with Optimate connectors at each end and a complete set of specification sheets and application notes. You can order the kit directly from General Electric (Semiconductor Products Dept., Optoelectronics, West Genesee St., Auburn, NY 13021).

The key feature of General Electric's designer's kit is the cleverly designed threaded plastic package into which the active emitting and detecting components are installed. Figure 1 shows the package and how it interfaces with a threaded Optimate plastic connector. Figure 2 is an internal view of a package that contains an infrared emitting diode. Note the use of a reflector and lens to collect radiation emitted by the diode and direct it toward the aperture in the package, where a terminated fiber will be connected.

The Emitter. The emitter furnished with the General Electric designer's kit is designated GFOE1A1. This device is a silicon-compensated, liquid-phase, epitaxial, gallium-arsenside diode that emits near-infrared radiation peaking at about 940 nanometers. At room temperature and 30 to 50 mA forward current, the diode has a power conversion efficiency of about 4%. The conversion efficiency increases to 5 to 6% at 200 mA (pulse drive).

The diode is mounted behind a diffuse, molded-epoxy lens that provides a 1.2-mm diameter source having nearly uniform intensity across its surface. The large source size assures good optical coupling between the LED and the wide variety of different fibers to which Optimate connectors can be terminated.

At 50 mA forward current, a typical GFOE1A1 will couple more than 100 μW into a 1-mm diameter fiber. This is approximately 10% of the total power (i.e. a −20-dB loss) radiated by the chip and is comparable to the light injection efficiency of cther low to moderately priced fiber-optic links.

The silicon dopant added to the GFOE1A1 increases both power conversion efficiency and wavelength at the expense of the diode's *response time* (the sum of delay and rise times or storage and fall times). Conventional GaAs emitters, for example, have response times measured in tens of nanoseconds or even less. A GaAs:Si emitter like the GFOE1A1, however, has a response time of nearly a microsecond. This places an upper limit of about 400 kHz on the modulation bandwidth of the GFOE1A1, which, of course, is more than adequate for many kinds of telecommunications and data-transmission applications.

The Detector. One of two different detectors can be provided with the General Electric designer's kit. One is an npn phototransistor (GFOD1A1), and the other is a photodarlington transistor (GFOD1B1). Both are installed in packages identical to those used for the GFOE1A1 emitter. Since the base of a phototransistor is not often used in optoelectronic circuits, neither device is provided with an external base lead.

The spectral response of both

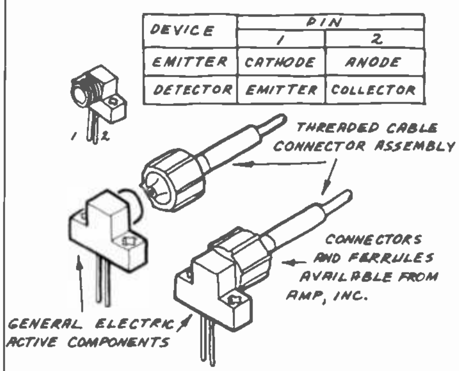


Fig. 1. Construction of GE active fiber-optic components.

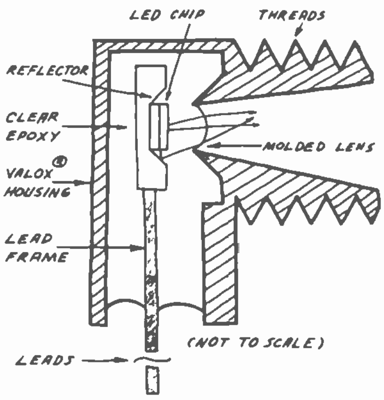


Fig. 2. Internal view of GE side-looking emitter.

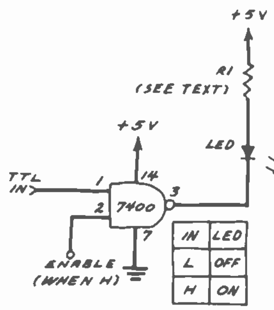


Fig. 3. Basic TTL compatible LED driver.

phototransistors peaks at about 850 nanometers. At the 940-nanometer wavelength emitted by the GFOE1A1 emitter, both phototransistors exhibit about 80% response efficiency.

When illuminated by radiation from a GFOE1A1 emitter transmitted to the phototransistor via a 1-m length of Crofon 1040 fiber, the GFOD1A1 exhibits a minimum responsivity of 70 μA per μW. The GFOD1B1 provides 1000 μA under the same conditions. The turn-on and turn-off times of the GFOD1A1 are each 3 μs when the load resistance is 0 ohm. The turn-on and turn-off times for the GFOD1B1 are, respectively, 10 and 25 μs when the load resistance is 0 ohms.

Digital Logic Application Circuits. Short fiber-optic links are ideally suited for transmitting digital data through noisy environments. The circuits that follow illustrate straightforward ways to send and receive signals through such a fiber-optic link.

TTL Emitter Driver Circuits. Figure 3 shows a basic TTL LED driver made from a single NAND gate. When the enable input is *low*, the LED is turned off irrespective of the logic level at the TTL input. When the enable input is *high*, the LED is forward-biased when the logic level input is high. When the input is low, the LED is turned off.

Series resistor *R1* limits current through the LED to a safe value. The output from a standard TTL 7400 gate can sink up to 16 mA. To drive the LED at this level means *R1* must be 312.5 ohms. (From Ohm's law, *R1* equals 5 volts divided by 16 mA.) The closest standard resistance value, 330 ohms, will provide a LED current of 15 mA.

Incidentally, the maximum current output from a LS TTL gate is only 5 mA. Therefore, you should use standard TTL in the circuit shown in Fig. 3.

In applications where higher infrared emission levels are required, more drive current can be provided by adding a transistor driver stage as shown in Fig. 4. Note that the transistor inverts the signal from the gate. Also note that since the transistor and not the gate drives the LED, a LS TTL gate can be used.

Resistor *R2* should be selected to limit the current (I) through the LED to the desired level. The combined voltage drop of *Q1* and the LED is about 2 V. Therefore, the series resistance is $(V_{cc2}-2)/I$. If V_{cc2} is 5 V and the desired current level is 50 mA, then *R2* should have a resistance of 60 ohms. Higher current levels can be achieved by increasing V_{cc2} or reducing *R2*'s resistance. It is essential, of course, that *Q1*, *R2*, and the LED emitter be rated for the selected current level.

Detector Circuits. Figure 5 shows two basic phototransistor detector circuits. In Fig. 5A, the phototransistor is normally off and the voltage across R_L is high. When the phototransistor is turned on by an incoming light pulse, the output is brought low.

While a basic phototransistor circuit is very sensitive, its response time is slowed by the RC time constant of the internal capacitance of the phototransistor and R_L. The delay induced by the load resistor is virtually eliminated by adding a common-base stage as shown in Fig. 5B. The low-resistance path provided by *Q2* greatly speeds up the charge-discharge time of *Q1*'s internal capacitance, thereby substantially improving its response time.

Figure 6 compares the response of the two basic phototransistor circuits in Fig. 5. Waveform A is the

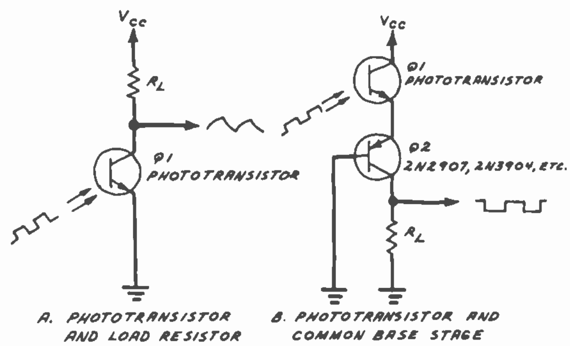


Fig. 5. Two phototransistor circuits.

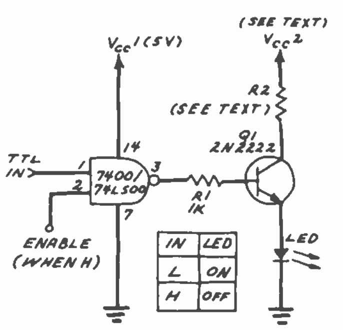


Fig. 4. TTL compatible fiber-optic LED driver with gain stage.

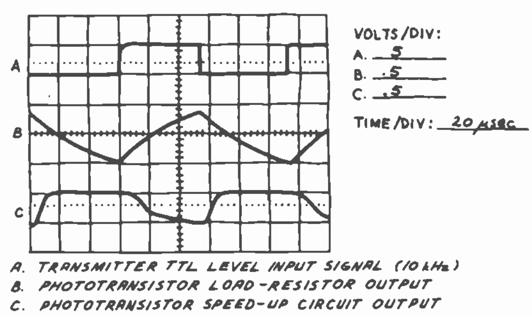


Fig. 6. Received signal waveforms for basic phototransistor detector circuits.

signal delivered to the TTL compatible LED driver shown in Fig. 4. The signal is inverted by the LED driver transistor. Waveform B is the output of a basic phototransistor load-resistor circuit (Fig. 5). Waveform C is the output of a phototransistor circuit to which a common base stage has been added.

Note the slow response of the phototransistor circuit in trace B. The rise time of the common base circuit in trace C is approximately ten times faster. Also note the phase reversal of the output from the two phototransistor circuits.

TTL Compatible Fiber-Optic Receiver. The outputs from the phototransistor circuits in Fig. 5 are not TTL compatible. To provide a fully transparent TTL fiber-optic link (one that accepts and outputs TTL level logic signals), amplification and pulse restoration is required.

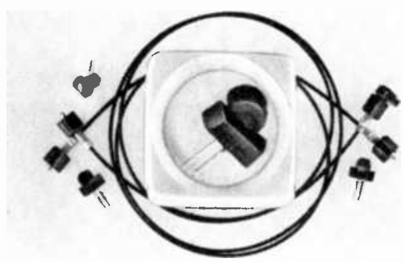
Figure 7 shows a fiber-optic receiver that provides a TTL compatible output signal. An optical signal received by *Q1* is delivered directly to the inverting input of a 741 operational amplifier. Potentiometer *R2* permits the gain of the 741 to be adjusted. The amplified signal from the 741 is coupled through *C1* into a Schmitt trigger formed by a 555 timer.

Figure 8 is a set of oscilloscope waveforms that confirms the transparent nature of this receiver. Waveform A is the TTL signal delivered to a TTL compatible LED transmitter (Fig. 4). Waveform B is the signal at the output of the 741. Waveform C is the TTL level signal at the output of the Schmitt trigger.

The 555 output is a phase-reversed image of the TTL input at the transmitter. The phase reversal can be eliminated simply by following the 555 with a TTL inverter.

The circuit in Fig. 7 requires an initial gain adjustment via *R2*. It may also be necessary to alter the transmitted signal level. Too much infrared at the phototransistor may result in failure of the phototransistor to follow the transmitted signal.

Though the phototransistor load resistor arrangement is very slow (trace B in Fig. 6), this circuit has a surprisingly fast response of about 60 kilobits per second. This performance is made possible by the Schmitt trigger stage. The oscilloscope traces in Fig. 8 were produced



GE components, Dupont cable, and AMP connectors.

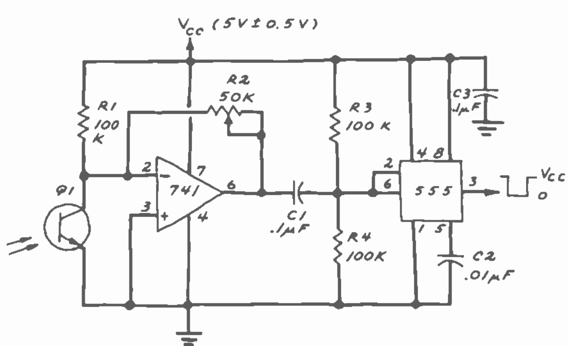


Fig. 7. Fiber-optic receiver with TTL output.

when the circuit was receiving a pulse train of 50 kilobits per second.

General-Purpose Fiber-Optic Receiver. The circuit in Fig.9 is a more versatile version of the preceding circuit. The Schmitt trigger stage has been replaced by a 555 connected as a monostable multivibrator. Optical pulses received by the phototransistor are amplified by the 741 and passed directly to the trigger input of the 555.

A negative-going pulse triggers the 555 into delivering a positive output pulse having a duration of 1.1*R3C2* seconds. With the values given in Fig. 9, the pulse duration is about 2.5 μs. This corresponds to an upper bandwidth of about 160 kHz. (Bandwidth is found by dividing 0.4 by the pulse duration.)

The circuit in Fig. 9 will provide a response greater than 100 kilobits per second. As with the circuit in Fig. 8, it is necessary to adjust the transmitted signal level and *R2* for optimum results.

Going Further. Though I used GFOE1A1 emitters and GFOD1A1 detectors in the test versions of the circuits described above, many other emitters and detectors can be used. Also, many kinds of fiber-optic cable can be used. In fact, over short distances, fiber is not required at all so long as infrared from the emitter can reach the detector.

The GFOE1A1 emitter and GFOD1A1 detector can also be used to transmit *analog* signals through a fiber-optic cable. Many suitable transmitter and receiver circuits have appeared in past installments of this column. Several of these circuits have recently been published in Chapter 2 of *The Forrest Mims Circuit Scrapbook* (McGraw-Hill, 1983). Additional circuits appear in *Engineer's Notebook II* (Radio Shack, 1982).

Finally, the GFOE1A1 emitter can also function as a detector. This means half-duplex, bidirectional transmission over a single fiber-optic cable can be achieved by placing a GFOE1A1 at each end of the link. ◇

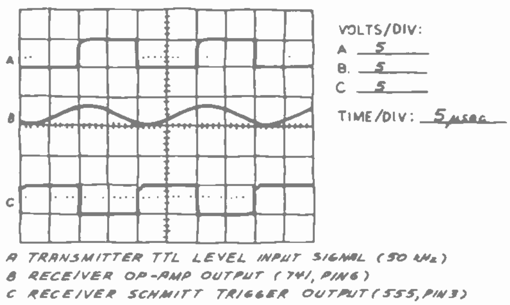


Fig. 8. Received signal waveforms for circuit in Fig. 7.

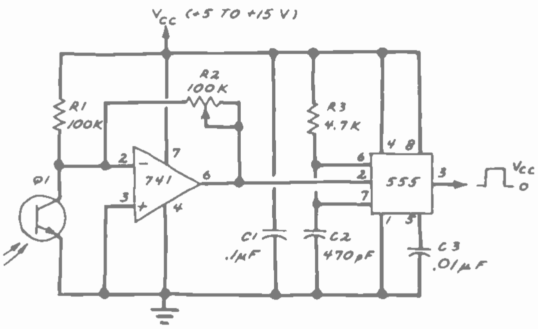


Fig. 9. Fiber-optic receiver with pulse restorer output stage.

PROJECT OF THE MONTH

A Photonic Door and Window Intrusion Alarm

By Forrest M. Mims

THE circuit in Fig. 1 is the photonic equivalent of a conventional intruder alarm that uses magnet switches to detect open doors and windows. The circuit consists of two 555 timers, the first of which is connected as a free-running oscillator that drives the LED in a slotted optoisolator (or optocoupler) at a frequency given by $1.44/(R1+R2)C1$. Resistor $R3$ limits current through the LED to a safe value.

The second 555 is connected as a monostable multivibrator that functions as a missing pulse detector. When the slot in the optoisolator is blocked, pulses from the LED do *not* reach the phototransistor in the optoisolator and the output from the one-shot is *low*.

When the slot is opened, the phototransistor receives pulses from the LED. With the first pulse, the one-shot begins its timing cycle. Its output goes *high* until the timing cycle is completed. The piezoelectric alerter is activated during this time.

The time constant of the one-shot is $R5C2$. If the time constant is adjusted so the timing cycle is *longer* than the interval between incoming pulses from the LED, the output from the one-shot will stay high and the alerter will emit a continuous alarm tone.

If, on the other hand, the timing cycle is *briefer* than the interval between pulses, the one-shot will complete its timing cycle before the next pulse from the LED arrives. This will cause the alerter to emit a pulsating warning tone.

The component values in Fig. 1 have been selected to provide the pulsating output tone because of its attention-getting impact. An added benefit is that in this mode the circuit consumes less current when the alarm is sounding.

Although I used a General Electric H20A1 slotted optoisolator, any LED-phototransistor optoisolator will work. Some of these devices, such as G.E.'s H13B1, have mounting holes. If you cannot locate one of these devices, you can make your own with a phototransistor and an infrared LED. Install the two components facing one another on a small phenolic board. Leave a gap of about 0.25" between them.

To operate this circuit as an intruder alarm, the optoisolator should be installed on the frame of the door or window to be protected. Attach an opaque projection flag such as a small aluminum L-bracket to the door or window so that it rests in the slot of the optoisolator when the door or window is closed. When the door or window is opened, the alarm will sound.

The circuit can be powered by a supply providing from 3 to 15 V. My prototype version, powered by a 9-V transistor radio battery, consumed about 8.5 mA in standby.

Going Further. An obvious simplification of the basic circuit in Fig. 1 is to replace the pair of 555 timers with a 556 dual timer. The circuit in Fig.2 is the result. Though it is functionally identical to the circuit in Fig. 1, I have included it to preclude the possibility of pin errors should you wish to try it.

Other variations are also possible. For example, the piezoelectric alerter can be replaced by a relay (Radio Shack 275-004 or similar) which, in turn, can switch on a siren or other powerful alarm signal. For silent alarms, substitute for the alerter a 270-ohm resistor in series with a red LED. The LED will flash at a rate of a few hertz when the alarm is triggered.

Still another variation is to replace the slotted optoisolator with a reflection-sensing transducer. The sensor, consisting of a LED and phototransistor facing in the same direction, can detect the presence of an object a few millimeters away. If the object is sufficiently reflective (add white tape if it is not), the alarm will sound. When the object is moved away from the sensor, the alarm will cease sounding. This operating mode can be reversed by connecting the alarm between pin 3 of the 555 and V_{CC}. This will cause the sensor to sound the alarm when a door, window or valuable object has been moved away from its detection zone.

Finally, be sure to assemble and install your alarm circuit with care, for the quality of your work will determine the reliability of the alarm. Be sure to not have exposed wires leading to the optoisolator to avoid pickup and replace the battery when necessary to prevent improper operation. ◇

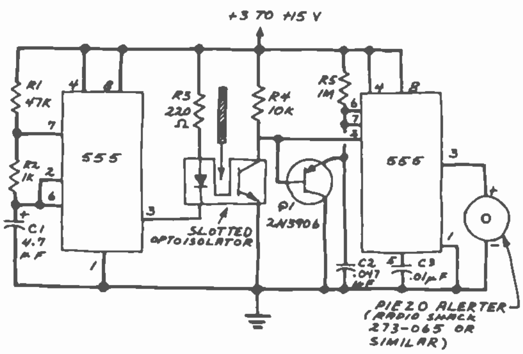


Fig. 1. Schematic of a simple photonic door and window intrusion alarm. Components shown provide a pulsating output tone.

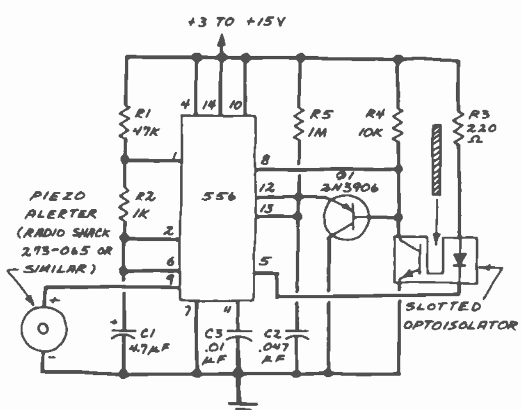


Fig. 2. In a variation of the circuit in Fig. 1, the two 555 timers are replaced by a 556 dual timer as shown here.

OPERATION ASSIST

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist. COMPUTERS & ELECTRONICS, *1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)*

Hallicrafters Model SX-28 skyrider. Need schematic and parts list. Bruce Myers, 9915 Oleander Ave., Vienna, VA 22180.

Archer project board catalog #277-109. Need board, schematic and parts list. **Cal-Tex** CT 7001 IC. Need data and schematic for 6 digital/alarm/calendar clock or complete kit. Joseph DeMaio, 84-31 110 St., Richmond Hill, NY 11418.

Collins R-388/URR receiver. Need manual and schematic. Larry Gotts, Box 44, Pleasant Mount, PA 18453.

Hallicrafters Model S20R receiver. Need schematic and alignment data. Louis A. Johnson, 2453 Coronet Way, Apt. A1, Atlanta, GA 30318.

Precision Apparatus Co., Model 915 tube tester, **RCA** Model TMV-122-B oscilloscope, **RCA** WV-500A voltohmyst and **Electronic Designs** voltmeter (circa 1940.) Need tube rolls, owner's manuals, operating manuals and schematics. Robert A. Ridings, 2370 SW, 23 Terrace, Miami, FL 33145.

B&K Model 650 tube tester. Need tube chart. Daniel Putallaz, 39 E Broadway, Apt. 307, Long Beach, NY 11561.

Raytronic Model CB-54A cathode ray tube tester, **Hickok** Model 610A sweep generator, **Friden** Model 1160 calculator and **Victor** Model 14 321 calculator. Need manuals or any information available. Jim Hudson, 1826 Elmwood Lane, Bettendorf, IA 52722.

Fisher Model 800 output transformer. Need part #T806-127 Also need operating manual for **JVC** Model V73 S.E.A. controller. Robert O. Adams, 4755-A N W. 2nd St., Delray Beach, FL 33445.

Dumont Model 224 3" oscilloscope. Need schematic. Harold Hersh, 40 Monument St., Freehold, NJ 07728.

Challenger Model CHA75 amplifier. Need output transformer. Fred McClintic, Rt. 1, Hunnewell, MO 63443.

RCA Model WV-97A VTVM. Need schematic. Robin Krisher, RD #1, Box 66, Shinglehouse, PA 16748.

Superior Instruments Co., Model 77 VTVM. Need schematic and service manual. E. Verhulst, 3837 Lexington Dr., St. Charles, MO 63301.

Teletype Model 33 keyboard/page printer. Need electronic and mechanical operating instructions and source of supply for parts. Tim Dove, 601 Riverside Drive, West Richland, WA 99352.

Teac Model A-2050 tape deck. Need head covers and service manual. Tracy Lavere, 12850 Sundance Ave., San Diego, CA 92129.

Sanders Associates Model 722-1, series #ED0170 CRT terminal. Need schematics and documentation. Kendall Stambaugh, PhD., 5009 Guide Meridian Road, Bellingham, WA 98226.

Sears Model #4132 TV. Need service manual and schematic. Kim R. Phillips, 107 Brian St., Mingo Junction, OH 43938.

Singer Model HE-8101 9" TV. Need schematic, parts list and DC power cord. **Echo Communications** 2 tube 25-40 MHz linear amplifier. Need schematic, parts list and operation manual. Lee A. Freel, 4725 Lane Ave., Jacksonville, FL 32210.

RCA Victor Model K80 radio. Need complete dial assembly or picture of dial and schematic. Bill Spaulding, 10607 32nd Dr. S.E., Everett, WA 98204.

Mostek Model 3870 and 3872 microprocessors. Need programming manual. Junioa Gentler, 118-50 229th St., Queens, NY 11411

Roberts Model 450A tape deck. Need playback head. Jimmy Hubbard, 11104 Coppermine Rd., Woodsboro, MD 21798.

Kenwood Model KX1030 cassette deck. Need wood side panels. B. Fox, Box 286, Highland Park, IL 60035.

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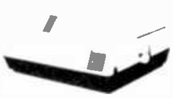

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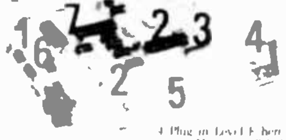

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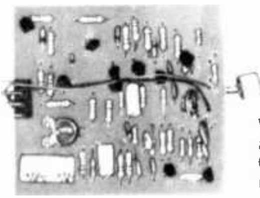

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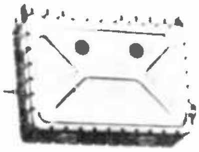

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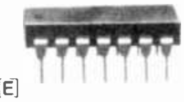

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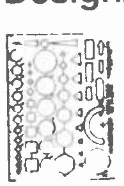

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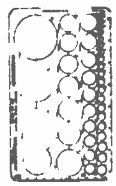

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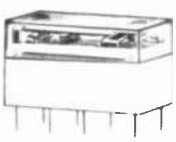

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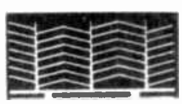

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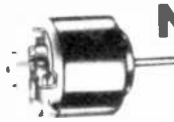

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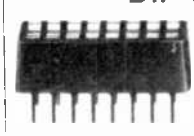

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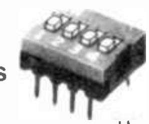

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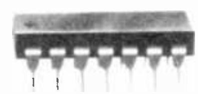

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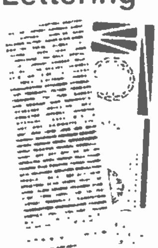

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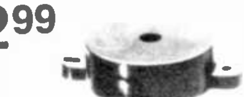

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TMS4027	4096 x 1 (250ns)	1.99
UPD411	4096 x 1 (300ns)	3.00
MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/13.95
4116-150	16384 x 1 (150ns)	8/15.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
4164-200	65536 x 1 (200ns) (5v)	6.25
4164-150	65536 x 1 (150ns) (5v)	7.25

5V = single 5 volt supply

EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
2758	1024 x 8 (450ns)(5v)	5.95
2716	2048 x 8 (450ns)(5v)	3.95
2716-1	2048 x 8 (350ns)(5v)	6.25
TMS2516	2048 x 8 (450ns)(5v)	5.50
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns)(5v)	7.95
2732	4096 x 8 (450ns)(5v)	4.95
2732-250	4096 x 8 (250ns)(5v)	12.95
2732-200	4096 x 8 (200ns)(5v)	16.95
2764	8192 x 8 (450ns)(5v)	16.95
2764-250	8192 x 8 (250ns)(5v)	18.95
2764-200	8192 x 8 (200ns)(5v)	24.95
TMS2564	8192 x 8 (450ns)(5v)	24.95
MC68764	8192 x 8 (450ns)(5v)(24 pin)	39.95

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

DISC CONTROLLERS

1771	16.95
1791	29.95
1793	38.95
1795	54.95
1797	54.95
6843	34.95
8272	39.95
UPD765	39.95
1691	18.95
2143	18.95

INTERFACE

8T26	1.69
8T28	2.49
8T95	.99
8T96	.99
8T97	.99
8T98	.99
DM8131	2.95
DP8304	2.29
DS8835	1.99
DS8836	.99

MISC.

3242	7.95
3341	4.95
MC3470	4.95
MC3480	9.00
11C90	13.95
95H90	7.95
2513-001 UP	9.95
2513-002 LOW	9.95

SOUND CHIPS

76477	3.95
76489	8.95
AY3-8910	12.95
MC3340	1.49

CRT CONTROLLERS

6845	14.95
68B45	35.95
HD46505SP	15.95
6847	12.25
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
TMS9918A	39.95
DP8350	49.95

BIT-RATE GENERATORS

MC14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
COM8116	10.95
MM5307	10.95

UARTS

AY3-1014	6.95
AY5-1013	3.95
AY3-1015	6.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
TMS6011	5.95
IM6402	7.95
IM6403	8.95
INS8250	14.95

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95

CLOCK CIRCUITS

MM5314	4.95
MM5369	3.95
MM5375	4.95
MM58167	8.95
MM58174	11.95
MSM5832	6.95

Z-80

2.5 Mhz

Z80-CPU	3.95
Z80-CTC	5.95
Z80-DART	15.25
Z80-DMA	17.50
Z80-PIO	5.75
Z80-SIO/0	18.50
Z80-SIO/1	18.50
Z80-SIO/2	18.50
Z80-SIO/9	16.95

4.0 Mhz

Z80A-CPU	6.00
Z80A-CTC	8.65
Z80A-DART	18.75
Z80A-DMA	27.50
Z80A-PIO	6.00
Z80A-SIO/0	22.50
Z80A-SIO/1	22.50
Z80A-SIO/2	22.50
Z80A-SIO/9	19.95

6.0 Mhz

Z80B-CPU	17.95
Z80B-CTC	15.50
Z80B-PIO	15.50

ZILOG

Z6132	34.95
Z8671	39.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

DATA ACQUISITION

ADC0800	15.55
ADC0804	3.49
ADC0809	4.49
ADC0817	9.95
DAC0800	4.95
DAC0806	1.95
DAC0808	2.95
DAC1020	8.25
DAC1022	5.95
MC1408L6	1.95
MC1408L8	2.95

8000

8035	5.95
8039	6.95
INS-8060	17.95
INS-8073	24.95
8080	3.95
8085	5.95
8085A-2	11.95
8086	29.95
8087	CALL
8088	39.95
8089	89.95
8155	7.95
8156	8.95
8185	29.95
8185-2	39.95
8741	39.95
8748	29.95
8755	32.00

8200

8202	29.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

FUNCTION GENERATORS

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

INTERSIL

ICL7103	9.50
ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	3.95
ICM7207A	5.59
ICM7208	15.95

6800

68000	59.95
6800	4.95
6802	7.95
6808	13.90
6809E	19.95
6809	12.95
6810	2.95
6820	4.95
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	12.25
6850	3.45
6852	5.75
6860	9.95
6862	11.95
6875	6.95
6880	2.25
6883	24.95
68047	24.95
68488	19.95
6800 1MHZ	
68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	7.95
68B21	12.95
68B45	35.95
68B50	12.95

68B00 = 2 MHZ

6500

1 MHZ

6502	5.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	8.75
6532	11.25
6545	22.50
6551	11.85
2 MHZ	
6502A	9.95
6522A	11.70
6532A	12.40
6545A	28.50
6551A	12.95
3 MHZ	
6502B	14.95

EXAR

XR 2206	3.75
XR 2207	3.85
XR 2208	3.90
XR 2211	5.25
XR 2240	3.25

9000 SERIES

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9334	2.50
9368	3.95
9401	9.95
9601	.75
9602	1.50
96S02	1.95

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74LS00

74LS00	.24	74LS86	.39	74LS169	1.75	74LS323	2.75
74LS01	.25	74LS90	.55	74LS170	1.49	74LS324	1.75
74LS02	.25	74LS91	.89	74LS173	.69	74LS352	1.29
74LS03	.25	74LS92	.55	74LS174	.55	74LS353	1.29
74LS04	.24	74LS93	.55	74LS175	.55	74LS363	1.35
74LS05	.25	74LS95	.75	74LS181	2.15	74LS364	1.95
74LS08	.28	74LS96	.89	74LS189	8.95	74LS365	.49
74LS09	.29	74LS107	.39	74LS190	.89	74LS366	.49
74LS10	.25	74LS109	.39	74LS191	.89	74LS367	.45
74LS11	.35	74LS112	.39	74LS192	.79	74LS368	.45
74LS12	.35	74LS113	.39	74LS193	.79	74LS373	.99
74LS13	.45	74LS114	.39	74LS194	.69	74LS374	.99
74LS14	.59	74LS122	.45	74LS195	.69	74LS377	1.39
74LS15	.35	74LS123	.79	74LS196	.79	74LS378	1.18
74LS20	.25	74LS124	2.90	74LS197	.79	74LS379	1.35
74LS21	.29	74LS125	.49	74LS221	.89	74LS385	1.90
74LS22	.25	74LS126	.49	74LS240	.95	74LS386	.45
74LS26	.29	74LS132	.59	74LS241	.99	74LS390	1.19
74LS27	.29	74LS133	.59	74LS242	.99	74LS393	1.19
74LS28	.35	74LS136	.39	74LS243	.99	74LS395	1.19
74LS30	.25	74LS137	.99	74LS244	.99	74LS399	1.49
74LS32	.29	74LS138	.55	74LS245	1.49	74LS424	2.95
74LS33	.55	74LS139	.55	74LS247	.75	74LS447	.37
74LS37	.35	74LS145	1.20	74LS248	.99	74LS490	1.95
74LS38	.35	74LS147	2.49	74LS249	.99	74LS624	3.99
74LS40	.25	74LS148	1.35	74LS251	.59	74LS668	1.69
74LS42	.49	74LS151	.55	74LS253	.59	74LS669	1.89
74LS47	.75	74LS153	.55	74LS257	.59	74LS670	1.49
74LS48	.75	74LS154	1.90	74LS258	.59	74LS674	9.65
74LS49	.75	74LS155	.69	74LS259	2.75	74LS682	3.20
74LS51	.25	74LS156	.69	74LS260	.59	74LS683	3.20
74LS54	.29	74LS157	.65	74LS266	.55	74LS684	3.20
74LS55	.29	74LS158	.59	74LS273	1.49	74LS685	3.20
74LS63	1.25	74LS160	.69	74LS275	3.35	74LS688	2.40
74LS73	.39	74LS161	.65	74LS279	.49	74LS689	3.20
74LS74	.35	74LS162	.69	74LS280	1.98	74LS783	24.95
74LS75	.39	74LS163	.65	74LS283	.69	81LS95	1.49
74LS76	.39	74LS164	.69	74LS290	.89	81LS96	1.49
74LS78	.49	74LS165	.95	74LS293	.89	81LS97	1.49
74LS83	.60	74LS166	1.95	74LS295	.99	81LS98	1.49
74LS85	.69	74LS168	1.75	74LS298	.89	25LS2521	2.80
						25LS2569	4.25

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.33
ST SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80
WW WIREWRAP		
16 pin ZIF	6.75	call
24 pin ZIF	9.95	call

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RS232 FEMALE RIGHT ANGLE	5.25
RS232 HOOD	1.25
S-100 ST	3.95
S-100 WW	4.95

DIP SWITCHES

4 POSITION	.85
5 POSITION	.90
6 POSITION	.90
7 POSITION	.95
8 POSITION	.95

7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	29	74174	.89
7438	29	74175	.89
7440	19	74176	.89
7442	49	74177	.75
7443	65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74186	18.50
7453	.23	74190	1.15
7454	.23	74191	1.15
7460	.23	74192	.79
7470	.35	74193	.79
7472	.29	74194	.85
7473	.34	74195	.85
7474	.33	74196	.79
7475	.45	74197	.75
7476	.35	74198	1.35
7480	.59	74199	1.35
7481	1.10	74221	1.35
7482	.95	74246	1.35
7483	.50	74247	1.25
7485	.59	74248	1.85
7486	.35	74249	1.95
7489	2.15	74251	.75
7490	.35	74259	2.25
7491	.40	74265	1.35
7492	.50	74273	1.95
7493	.35	74276	1.25
7494	.65	74279	.75
7495	.55	74283	2.00
7496	.70	74284	3.75
7497	2.75	74285	3.75
74100	1.75	74290	.95
74107	.30	74293	.75
74109	.45	74298	.85
74110	.45	74351	2.25
74111	.55	74365	.65
74116	1.55	74366	.65
74120	1.20	74367	.65
74121	.29	74368	.65
74122	.45	74376	2.20
74123	.49	74390	1.75
74125	.45	74393	1.35
74126	.45	74425	3.15
74128	.55	74426	.85
		74490	2.55

CMOS

4000	.29	4528	1.19
4001	.25	4531	.95
4002	.25	4532	1.95
4006	.89	4538	1.95
4007	.29	4539	1.95
4008	.95	4543	1.19
4009	.39	4555	.95
4010	.45	4556	.95
4011	.25	4581	1.95
4012	.25	4582	1.95
4013	.38	4584	.75
4014	.79	4585	.75
4015	.39	4702	12.95
4016	.39	74C00	.35
4017	.69	74C02	.35
4018	.79	74C04	.35
4019	.39	74C08	.35
4020	.75	74C10	.35
4021	.79	74C14	.59
4022	.79	74C20	.35
4023	.29	74C30	.35
4024	.65	74C32	.39
4025	.29	74C42	1.29
4026	1.65	74C48	1.99
4027	.45	74C73	.65
4028	.69	74C74	.65
4029	.79	74C76	.80
4030	.39	74C83	1.95
4034	1.95	74C85	1.95
4035	.85	74C86	.39
4040	.75	74C89	4.50
4041	.75	74C90	1.19
4042	.69	74C93	1.75
4043	.85	74C95	.99
4044	.79	74C107	.89
4046	.85	74C150	5.75
4047	.95	74C151	2.25
4049	.35	74C154	3.25
4050	.35	74C157	1.75
4051	.79	74C160	1.19
4053	.79	74C161	1.19
4060	.89	74C162	1.19
4066	.39	74C163	1.19
4068	.39	74C164	1.39
4069	.29	74C165	2.00
4070	.35	74C173	.79
4071	.29	74C174	1.19
4072	.29	74C175	1.19
4073	.29	74C192	1.49
4075	.29	74C193	1.49
4076	.79	74C195	1.39
4078	.29	74C200	5.75
4081	.29	74C221	1.75
4082	.29	74C373	2.45
4085	.95	74C374	2.45
4086	.95	74C901	.39
4093	.49	74C902	.85
4098	2.49	74C903	.85
4099	1.95	74C905	10.95
14409	12.95	74C906	.95
14410	12.95	74C907	1.00
14411	11.95	74C908	2.00
14412	12.95	74C909	2.75
14419	7.95	74C910	9.95
4502	.95	74C911	8.95
4503	.65	74C912	8.95
4508	1.95	74C914	1.95
4510	.85	74C915	1.19
4511	.85	74C918	2.75
4512	.85	74C920	17.95
4514	1.25	74C921	15.95
4515	1.79	74C922	4.49
4516	1.55	74C923	4.95
4518	.89	74C925	5.95
4519	.39	74C926	7.95
4520	.79	74C927	7.95
4522	1.25	74C928	7.95
4526	1.25	74C929	19.95
4527	1.95	74C930	19.95

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74S00	.32	74S163	1.95
74S02	.35	74S168	3.95
74S03	.35	74S169	3.95
74S04	.35	74S174	.95
74S05	.35	74S175	.95
74S08	.35	74S181	3.95
74S09	.40	74S182	2.95
74S10	.35	74S188	1.95
74S11	.35	74S189	6.95
74S15	.35	74S194	1.49
74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
74S30	.35	74S197	1.49
74S32	.40	74S201	6.95
74S37	.88	74S225	7.95
74S38	.85	74S240	2.20
74S40	.35	74S241	2.20
74S51	.35	74S244	2.20
74S64	.40	74S251	.95
74S65	.40	74S253	.95
74S74	.50	74S257	.95
74S85	1.99	74S258	.95
74S86	.50	74S260	.79
74S112	.50	74S274	19.95
74S113	.50	74S275	19.95
74S114	.55	74S280	1.95
74S124	2.75	74S287	1.90
74S132	1.24	74S288	1.90
74S133	.45	74S289	6.89
74S134	.50	74S301	6.95
74S135	.89	74S373	2.45
74S138	.85	74S374	2.45
74S139	.85	74S381	7.95
74S140	.55	74S387	1.95
74S151	.95	74S412	2.98
74S153	.95	74S471	4.95
74S157	.95	74S472	4.95
74S158	.95	74S474	4.95
74S161	1.95	74S482	15.25
74S162	1.95	74S570	2.95
		74S571	2.95

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FND-507 (510)	.5"	CA	.99

LED LAMPS

	1-99	100-up
Jumbo Red	.10	.09
Jumbo Green	.18	.15
Jumbo Yellow	.18	.15

LINEAR

LM301	.34	LM381	1.60	LM1310	1.49
LM301H	.79	LM382	1.60	MC1330	1.69
LM307	.45	LM383	1.95	MC1349	1.89
LM308	.69	LM384	1.95	MC1350	1.19
LM308H	1.15	LM386	.89	MC1358	1.69
LM309H	1.95	LM387	1.40	LM1414	1.59
LM309K	1.25	LM389	1.35	LM1458	.59
LM310	1.75	LM390	1.95	LM1488	.69
LM311	.64	LM392	.69	LM1489	.69
LM311H	.89	LM394H	4.60	LM1496	.85
LM312H	1.75	LM399H	5.00	LM1558H	3.10
LM317K	3.95	NE531	2.95	LM1800	2.37
LM317T	1.19	NE536	6.00	LM1812	8.25
LM318	1.49	NE555	.34	LM1815	5.20
LM318H	1.59	NE556	.65	LM1818	2.90
LM319H	1.25	NE558	1.50	LM1820	3.50
LM319	1.25	NE561	19.95	LM1830	3.50
LM320	(see 7900)	NE562	6.00	LM1871	5.49
LM322	1.65	NE564	2.95	LM1872	5.49
LM323K	4.95	LM565	.99	LM1877	3.25
LM324	.59	LM566	1.49	LM1889	1.95
LM329	.65	LM567	.89	LM1896	1.75
LM331	3.95	NE570	3.95	LM2877	2.05
LM334	1.19	NE571	2.95	LM2878	2.25
LM335	1.40	NE592	2.75	LM2900	.85
LM336	1.75	LM703	.89	LM2901	1.00
LM337K	3.95	LM709	.59	LM3900	.59
LM337T	1.95	LM710	.75	LM3905	1.25
LM338K	6.95	LM711	.79	LM3909	.98
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LM358	.69	LM741H	.40	MC4044	4.50
LM359	1.79	LM747	.69	RC4136	1.25
LM376	3.75	LM748	.59	RC4151	3.95
LM377	1.95	LM1014	1.19	LM4250	1.75
LM378	2.50	LM1303	1.95	LM4500	3.25
LM379	4.50	LM1304	1.19	LM13080	1.29
LM380	.89	LM1305	1.49	LM13600	1.49
LM380N-8	1.10	LM1307	.85	LM13700	1.49

H TO-5 CAN   T TO-220   K TO-3

VOLTAGE REGULATORS

7805T	.89	78L05	.69	7905K	1.49
7808T	.89	78L12	.69	7912K	1.49
7812T	.89	78L15	.69	7915K	1.49
7815T	.89	78H05K	9.95	7924K	1.49
7824T	.89	78H12K	9.95	79L05	.79
7805K	1.39	7905T	.99	79L12	.79
7812K	1.39	7908T	.99	79L15	.79
7815K	1.39	7912T	.99	LM323K	4.95
7824K	1.39	7915T	.99	UA78S40	1.95
		7924T	.99		

T TO-220   K TO-3   L TO-92

TRANSISTORS DIODES

PN2222	NPN SWITCH	TO-92	10/1.00	100/8.99
PN2907	PNP SWITCH	TO-92	10/1.25	100/10.99
2N2222	NPN SWITCH	TO-18	.25	50/10.99
2N2907	PNP SWITCH	TO-18	.25	50/10.99
2N3055	NPN POWER	TO-3	.79	10/6.99
3055T	NPN POWER	TO-220	.69	10/5.99
2N3904	NPN SWITCH	TO-92	10/1.00	100/8.99
2N3906	NPN SWITCH	TO-92	10/1.00	100/8.99
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IN4004	SWITCHING		10/1.00	100/8.99

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DIGI-KEY now has an expanded line of Panasonic Ceramic Disc Capacitors, including (listed after NPO banner)

NPO TYPE

For Complete Specs on Physical Size and Electrical Characteristics, consult your FREE DIGI-KEY Catalog

Part No.	Cap	Volt	Price 10	100	1,000
P4000	10 pf	500	.75	6.49	48.71
P4002	15 pf	500	.75	6.49	48.71
P4003	18 pf	500	.75	6.49	48.71
P4004	22 pf	500	.75	6.49	48.71
P4005	27 pf	500	.75	6.49	48.71
P4006	33 pf	500	.75	6.49	48.71
P4007	39 pf	500	.75	6.49	48.71
P4008	47 pf	500	.75	6.49	48.71
P4009	56 pf	500	.75	6.49	48.71
P4010	68 pf	500	.84	7.23	54.22
P4011	82 pf	500	.84	7.23	54.22
P4100	100 pf	500	.63	5.43	40.72
P4102	150 pf	500	.63	5.43	40.72
P4103	180 pf	500	.63	5.43	40.72
P4104	220 pf	500	.63	5.43	40.72
P4105	270 pf	500	.63	5.43	40.72
P4106	330 pf	500	.63	5.43	40.72
P4107	390 pf	500	.63	5.43	40.72
P4108	470 pf	500	.80	6.91	51.88
P4109	560 pf	500	.80	6.91	51.88
P4110	680 pf	500	.80	6.91	51.88
P4111	820 pf	500	.80	6.91	51.88
P4112	1000 pf	500	1.00	8.58	64.35
P4114	1500 pf	500	1.00	8.58	64.35
P4115	1800 pf	500	1.31	11.25	84.37
P4200	1000 pf	100	.58	5.01	37.57
P4202	1500 pf	100	.58	5.01	37.57
P4203	2200 pf	100	.58	5.01	37.57
P4205	3300 pf	100	.58	5.01	37.57
P4206	4700 pf	100	.58	5.01	37.57
P4209	6800 pf	100	.70	6.00	45.00
P4300	.01 uf	25	.56	4.83	36.23
P4303	.022 uf	25	.68	5.81	44.32
P4305	.033 uf	25	.82	7.08	53.10
P4307	.047 uf	25	.88	7.68	57.60
P4311	.1 uf	25	1.79	15.37	115.31

NPO NPO NPO NPO NPO NPO NPO NPO

Part No.	Cap	Volt	10	100	1,000
P4401	10 pf	500	.73	6.28	47.13
P4402	15 pf	500	.81	6.97	52.31
P4403	18 pf	500	.81	6.97	52.31
P4404	22 pf	500	.81	6.97	52.31
P4405	27 pf	500	.81	6.97	52.31
P4406	33 pf	500	1.03	8.89	66.71
P4407	39 pf	500	1.03	8.89	66.71
P4408	47 pf	500	1.37	11.80	88.53
P4409	56 pf	500	1.37	11.80	88.53
P4410	68 pf	500	1.56	13.38	100.35
P4411	82 pf	500	2.05	17.58	131.96

See The DIGI-KEY Catalog For Low OEM Prices On Disc Capacitors

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DIGI-KEY Part No.	Working Voltage (W.V.)	Cap (uF)	Prices 1	10	100
P6500	16	3300	$1.68	$12.96	$116.60
P6501		4700	2.06	15.87	142.85
P6502		6800	2.67	20.51	184.60
P6503		10000	3.35	25.80	232.90
P6504		15000	4.77	36.72	330.56
P6505	25	2200	1.72	13.26	119.40
P6506		3300	2.11	16.22	145.95
P6507		4700	2.65	20.36	183.20
P6508		6800	3.48	26.80	241.20
P6509		10000	4.49	34.58	311.20
P6510		15000	5.78	44.43	399.90
P6511	35	1000	1.43	11.00	99.10
P6512		2200	1.93	14.87	133.90
P6513		3300	2.60	20.01	180.10
P6514		4700	3.33	25.65	230.10
P6515		6800	4.28	32.93	296.40
P6516		10000	5.48	42.17	379.50
P6517	50	1000	1.75	13.46	121.10
P6518		2200	2.69	20.67	185.95
P6519		3300	3.70	28.45	256.00
P6520		4700	4.82	37.07	333.65
P6521		6800	5.87	45.12	406.10
P6522	100	470	2.02	15.53	139.75
P6523		1000	3.40	26.15	253.30
P6524		2200	5.46	41.98	377.80
P6525	200	220	2.55	19.63	176.66
P6526		330	3.52	27.07	243.60
P6527		470	4.49	34.54	310.85
P6528	250	150	2.58	19.86	178.75
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3 AMP SILICON RECTIFIER

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3A	50V	100A	1.1V

Part No.	1	10	100	1000
PR5400	.35	3.00	27.50	250.00

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1N4002	1 Amp 100 PIV	00 41	.80	7.00	60.00	540.00
1N4003	1 Amp 200 PIV	00 41	.80	7.50	64.00	576.00
1N4004	1 Amp 400 PIV	00 41	.90	7.90	68.00	612.00
1N4005	1 Amp 600 PIV	00 41	1.00	9.00	74.00	666.00
1N4006	1 Amp 800 PIV	00 41	1.00	9.00	80.00	720.00
1N4007	1 Amp 1000 PIV	00 41	1.50	12.00	100.00	900.00
1N4148	Ultra Fast Switching Diode (1N914 equiv.)	00 41	.60	5.00	32.00	276.00

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3AG SLO-BLO FUSES

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MA1026 Time-Temp Clock Module

Giant .7 Inch 4-Digit LED Display

- F° and/or C° and virtually any number of sensors
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- 12 or 24 Hour Display

Instruction included with all orders

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Part No.	Description	Price
MA1026M	MA1026 clock module only	$18.95
MA1026P	Digi-Key switch panel kit (P.C. Board, 12 switches, two LM3342 temp. sensors, two KOA32 potentiometers, instructions)	11.95
MA1026T	110 VAC transformer for MA1026M	3.95
MA1026B	Alarm buzzer for MA1026M	3.38
MA1026A	MA1026M, P, T, B	34.95

For additional sensor units, you will need:

LM3342	Temperature Sensor	1.51
K4A32	300 ohm Potentiometer	.32
502PB	Normally open SPST Switch	.56

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0.7" or 0.84" Red 4 Digit LED Display

User Programmable For:

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- 50/60 Hz line frequency
- Fixed or flashing dot (colon indicator)
- Display: hours and minutes, minute and seconds, alarm time and sleep time
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- Typical applications include clock radio timer, alarm clock, desk clock, instrument panel clock, and many more

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[illegible]

DIGI-CLOCK KIT

Part No. 5001E ONLY $17.95

[illegible]

LED's

[illegible]

Panasonic LED Numeric Displays

[illegible]

Silicon Transistors

DIGI-KEY Part No.	1	10	100	1,000
2N3055	1.44	12.00	108.00	980.00
2N3904	.20	1.79	16.25	146.25
2N3906	.20	1.79	16.25	146.25
2N4124	.21	1.93	17.50	157.50
2N4126	.22	2.01	18.25	164.25
2N4401	.21	1.93	17.50	157.50
2N4403	.21	1.93	17.50	157.50
2N4410	.30	2.70	24.38	219.38
2N5087	.24	2.20	20.00	180.00
2N5089	.24	2.20	20.00	180.00
2N5210	.27	2.48	22.50	202.50
2N6457	.54	4.88	43.88	394.88
92PU01A	[illegible]	3.42	30.88	277.88
92PU10	[illegible]	3.42	30.88	277.88
92PU45A	[illegible]	3.69	33.32	299.82
92PU51A	[illegible]	3.42	30.88	277.88
MJ2955	1.47	13.44	122.50	1102.25
MJE172	.76	6.66	60.13	541.13
MJE182	.65	5.55	46.25	416.25
MJE3439	.46	4.00	40.00	360.00
MJ1344	[illegible]	6.12	55.25	497.25
MJE370	[illegible]	8.01	72.32	650.82
MJE371	1.10	9.90	[illegible]	804.38
MJE520	.86	7.74	69.88	628.88
MJE521	.86	7.74	69.88	628.88
MJE703	1.13	10.17	91.82	826.31
MJE712	.74	6.66	60.13	541.13
MJE722	.74	6.66	60.13	541.13
MJE1800	1.01	9.09	82.07	738.57
MPF102	.56	4.95	45.00	405.00
MPS2222A	[illegible]	1.93	17.50	157.50
MPS2369A	.24	2.20	20.00	180.00
MPS2907A	.24	2.20	20.00	180.00
MPS3392	.23	2.07	18.75	169.00
MPS3393	.21	1.93	17.50	157.50
MPS3394	.24	2.20	20.00	180.00
MPS3395	.24	2.20	20.00	180.00
MPS3563	.21	1.93	17.50	157.50
MPS3646	.21	1.93	17.50	157.50
MPS3638A	.21	1.93	17.50	157.50
MPS3641	.21	1.93	17.50	157.50
MPS3643	.21	1.93	17.50	157.50
MPS918	[illegible]	1.98	17.88	160.88
MPS930	.21	1.93	17.50	157.50
MPSA13	.27	2.48	22.50	202.50
TIP112	[illegible]	8.40	70.00	630.00
TIP117	1.12	10.08	91.00	819.00
TIP120	1.17	10.73	97.50	877.50
TIP122	1.54	13.20	110.00	990.00
TIP127	1.58	13.20	110.00	990.00
TIP132	2.32	20.88	188.50	1696.50
TIP135	2.32	20.88	188.50	1696.50
TIP29C	.81	6.90	57.50	517.50
TIP30C	.81	6.90	57.50	517.50
TIP31C	[illegible]	8.40	70.00	630.00
TIP32C	1.02	8.70	72.50	652.50
TIP61C	.81	6.90	57.50	517.50
TIP62C	.81	6.91	57.50	517.50

PCB Transformers

Ratings Based on 20% Regulation

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5% Carbon Film Resistors

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S — SOCKET CONNECTOR TERMINATION

P — PCB CONNECTOR TERMINATION

X — CARD EDGE CONNECTOR TERMINATION

[illegible]

DIP Jumper Cable Assembly

Standard Assembly Styles

[illegible]

alpha wire cable tubing

Hookup Wire, Stranded, PVC Insulated

[illegible]

Hookup Wire, Solid, PVC Insulated

[illegible]

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[illegible]

Multipair Individually Foil Shielded Cable

[illegible]

Multiconductor Stranded PVC Insulated Cable

[illegible]

Twisted Pair Solid Comm. and Control Cable

[illegible]

Shrinkable Tubing, Polyolefin, Black

[illegible]

Adhesive Wall Shrinkable Tubing, Black

[illegible]

Self Encapsulating Caps, Black

[illegible]

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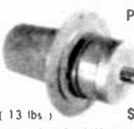

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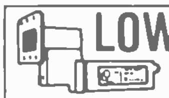

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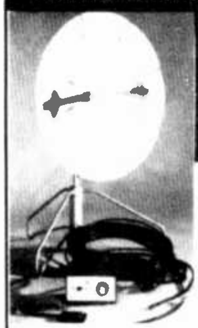

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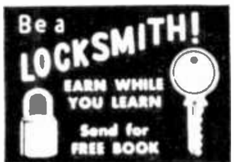

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Murfreesboro — Murfreesboro Radio & Elect.
Murfreesboro — Standard Auto Parts
Nashville — Eddie Warners Parts Co.
Nashville — Electra Dist. Co.
Oak Ridge — Mr. Radio
Oak Ridge — National Electronics
Smyrna — Delker Electronics
Tullahoma — H & H Electronics

TEXAS
Brownsville — George's Electronic Mart
Dallas — Heathkit Electronic Center
Enid — Trice Electronics
Fort Worth — Heathkit Electronic Center
Garland — Tinker Tronics
Harligen — George's Electronic Mart
Houston — Heathkit Electronic Center
Lubbock — Trice Electronics
McAllen — Carlos Franco Electronics
McAllen — George's Electronic Mart
Richardson — Martin Wholesale Electronics
Richardson — Trice Electronics
San Antonio — Appliance Equipment Co.
San Antonio — C & K Electronics
San Antonio — Heathkit Electronic Center
Waco — L & M Wholesale

UTAH
Midvale — Heathkit Electronic Center
Ogden — Cater Supply Co.
Provo — Alpine Electronic Supply
Salt Lake City — Best Distributing
Salt Lake City — Kimball Electronics
Salt Lake City — Mountain Coin Distributing
Salt Lake City — RA-ELCO Inc.

VERMONT
Burlington — Greylock Electronics
Essex Junction — I.E.S. Lafayette Radio

VIRGINIA
Alexandria — Computers Plus Inc.
Alexandria — Heathkit Electronic Center
Annandale — Arcade Electronics
Arlington — Arlington Electronic Wholesalers
Blacksburg — Scotty's Radio & TV
Charlottesville — Graves Electronics
Falls Church — Crossroad Elect. Wholesalers
Hampton — Electronic Sales Inc.
Harrisonburg — Electrical Wholesalers
Hopewell — B & G Electronics
Lynchburg — Electronic Service Co.
Norfolk — Avec Electronics
Norfolk — Cain Electronics
Norfolk — Priest Electronics
Portsmouth — Electronics Unlimited
Richmond — Avec Electronics
Roanoke — Avec Electronics
Vienna — Electronic Equipment Bank
Virginia Beach — Heathkit Electronic Center
Warrenton — Trans-Tech Co.
Woodbridge — Virginia Micro Systems

WASHINGTON
Bellevue — A.B.C. Communications
Bremerton — Electronic Supermart
Everett — A.B.C. Communications
Hoquaim — Harbor Electronics
Kennewick — C & J Electronic
Kent — Electronic Supermart
Moses Lake — Ron's Electronics
Olympia — The Electronic Shop
Pasco — Radio Shack
Pasco — Riverview Electronics
Pullman — H & O Electronics
Richland — Radio Shack
Seattle — A.B.C. Communications
Seattle — Amateur Radio Supply
Seattle — Electronic Supply Co.
Seattle — Empire Electronics
Seattle — Heathkit Electronic Center
Spokane — Don's Stereo Center (D.S.C.)
Spokane — Personal Computer
Tacoma — C & G Electronics
Tukwila — Heathkit Electronic Center
Vancouver — Heathkit Electronic Center

WEST VIRGINIA
Elkins — Williams Electronics
Fairmont — T.P.S. Electronics
Morgantown — Computer Corner
Morgantown — Electro Dist. Co.
Morgantown — State Electronics
Ripley — Radio Shack
Wheeling — Industronics

WISCONSIN
Kenosha — Chester Electronic Supply
Milwaukee — Amateur Electronic Supply
Milwaukee — Heathkit Electronic Center
Milwaukee — Olson Electronics
Milwaukee — Petted Micro Systems
Rhinelander — New-U Electronics

WYOMING
Cheyenne — Computer Concepts
Rock Springs — D.C. Electronics

FOREIGN
Guam: Agana — Marianas Electronics
Guatemala — Electronica Pan Americana
Panama — Sonitel S.A.
Panama — Tropelco S.A.
Puerto Rico: Rio Piedras — Microcomputer Store
Puerto Rico: Rio Piedras — Radio Shack
Singapore — Applied Digital Systems
West Indies: Trinidad — The Hobby Centre

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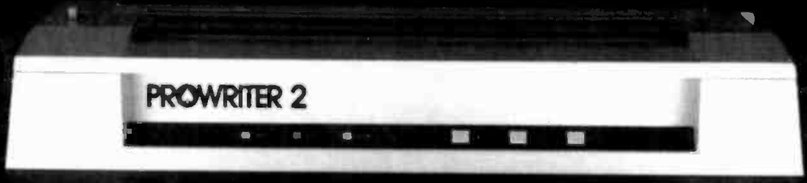

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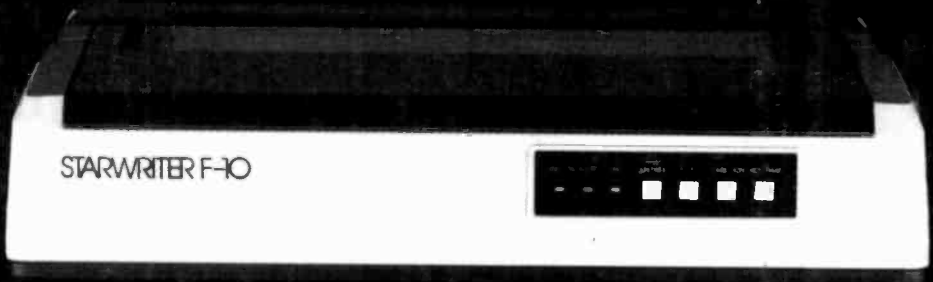

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