Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE DECEMBER 1980/ 95¢

Build a Digital Phono Stylus Timer

Comparing Electronic Games

Low-Cost Computer-Memory Expansion

New Cordless Telephones for the Home

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SPECIAL SECTION:
The Electronic World

Edison had over 1,800 patents in his name, but you can be just as inventive with an Apple.

Apple is the company with the brightest ideas in hardware and software *and* the best support — so you can be as creative with a personal computer system as Edison was with the incandescent bulb.

How Apple grows with you.

With Apple's reliable product family, the possibilities of creating your own system are endless. Have expansion capabilities of 4 or 8 accessory slots with your choice of system.

Expand memory to 64K bytes or 128K bytes. Add an A to D conversion board. Plug into time sharing, news and electronic mail services. Use an IEEE 488 bus to monitor lab instruments. Add 4 or 6 disk drives — the 5¼", 143K bytes, high-speed, low-cost drive that's the most popular on the market.

Apple speaks many languages.

Since more than 100 companies create software for Apple, you'll have the most extensive library in the personal computer world. Want to write your own programs? Apple is fluent in BASIC, Pascal, FORTRAN, PILOT and 6502 assembly language.

There's even a series of utility programs called the DOS Tool Kit that not only lets you design high-resolution graphic displays, but lets you work wonders with creative animation.

More illuminating experiences in store.

You won't want to miss all the Apple products being introduced at your computer store all the time. Don't let history pass you by. Visit your nearest Apple dealer or call **800-538-9696**. In California, **800-662-9238**. Or write: Apple Computer, 10260 Bandley Drive, Cupertino, CA 95014.

apple computer inc.

CIRCLE NO. 5 ON FREE INFORMATION CARD

These cassette deck makers have very high standards.

And this is how they set them.

With TDK SA. It's the high bias reference standard for these major cassette deck manufacturers. Which means that when they set the high bias position on their decks, there's a TDK SA inside. Since all these decks are adjusted to sound their best with TDK SA, it stands to reason yours will, too.

A lot of deck owners agree. When they listen to the more than 35 manufacturers who recommend TDK SA, they try it. When they listen to their music on TDK SA, they're convinced. They feel TDK SA's Super Avilyn formulation handles their music better than any chrome tape. And TDK SA's Super Precision Mechanism assures years of reliable performance. Each TDK SA cassette is backed by a lifetime warranty.*

You can listen to all the cassettes that might meet the high bias standard. Or you can buy the one that sets it. TDK SA.

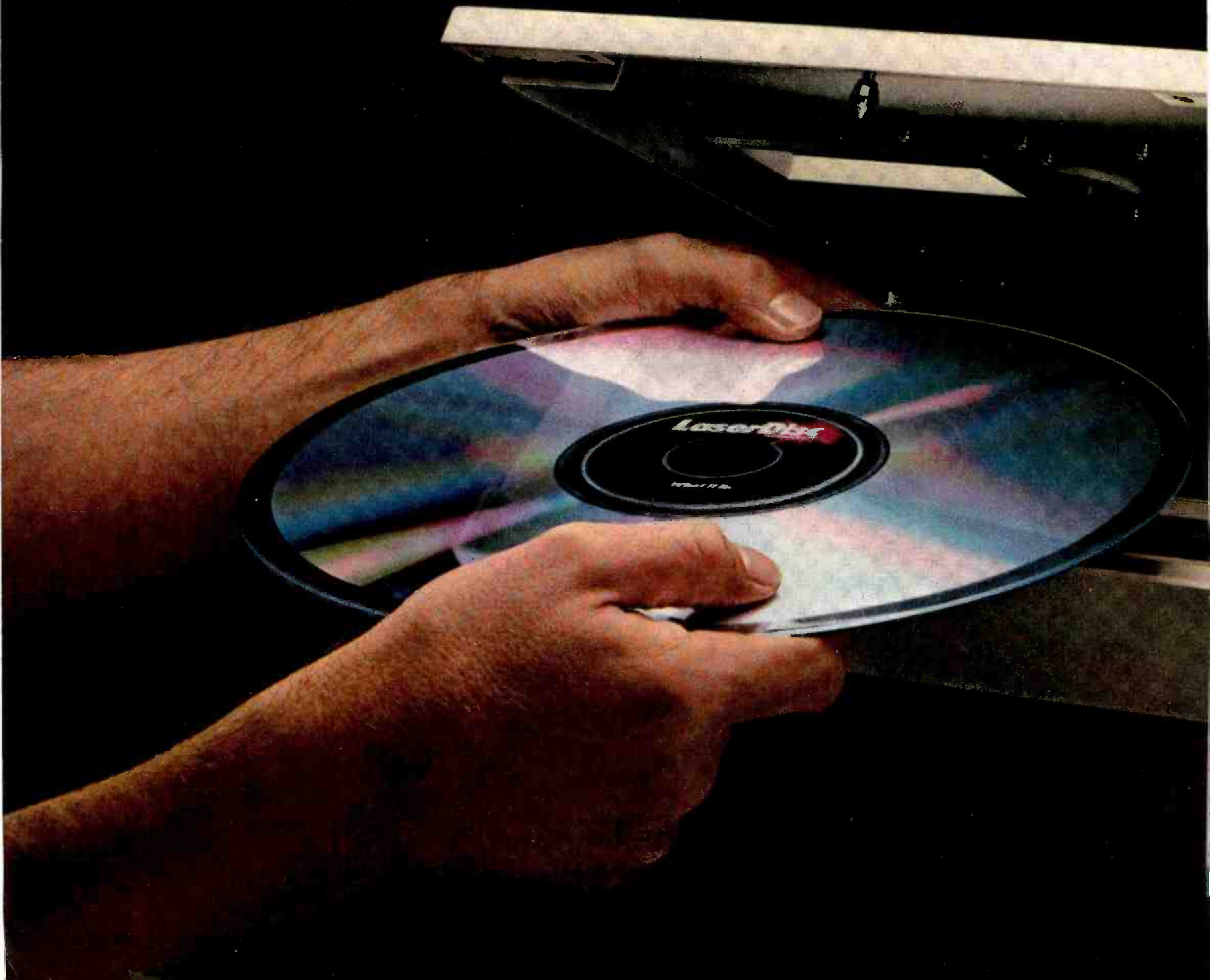
TDK
The Amazing Music Machine.

*In the unlikely event that any TDK cassette ever fails to perform due to a defect in materials or workmanship, simply return it to your local dealer or to TDK for a free replacement.

CIRCLE NO. 60 ON FREE INFORMATION CARD

Introducing Pioneer LaserDisc.

The biggest innovation in television since television.

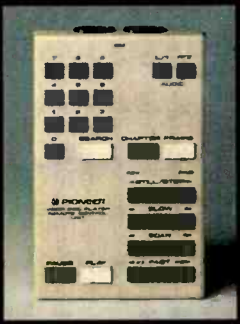


Imagine you could sit down in front of your TV set and see virtually any movie or concert you wanted to see when you wanted to see it.

Imagine you could actually see and hear concerts on your TV in stereo. The best stereo you've ever heard. Or cut to your favorite scene in a movie at will. Or study sports in slow motion, even one frame at a time. Imagine a machine that could teach your children at their own rate.

You now have just an idea of Pioneer LaserDisc. A remarkable innovation that puts both picture and sound on a record. And plays them both by means of a laser beam onto your TV and through your hi-fi. (The player hooks up to your TV with just one wire. And when it's not in use, your TV plays the way it normally plays.)

The laser picture quality is exceptional. As good as the best broadcast reception you've ever seen. And laser sound is better than the best conventional audio recordings you've ever heard. And since nothing touches the disc but a laser beam, the disc never wears out. The quality is forever.



For all it does, surprisingly, the suggested retail price of the player is only $749* (just $50 more with remote control). And you can own a disc of a great movie or concert forever for the cost of taking your family to the movies.

There are a few hundred different discs to choose from right now. And more and more are coming out every day. Someday, virtually anything that entertains anyone will be on the disc.

Nothing we say here will fully prepare you for the magic of Pioneer LaserDisc. You simply have to see it.

For a personal demonstration from the dealer nearest you call us at **800-621-5199** toll free. (In Illinois 800-972-5855.)

LaserDisc
PIONEER®

*Suggested retail price, actual price set by dealer.

DECEMBER 1980 VOLUME 18, NUMBER 6

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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Construction Articles

Equipment Reviews

Columns

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The Age of Affordable Pers

In 1978 Ohio Scientific introduced a revolutionary new low cost computer — the Superboard II. This computer provides all important personal computer features on a single board at a cost of under $300. The Superboard II received rave reviews by microcomputer experts such as:

"We can heartily recommend the Superboard II computer system for the beginner who wants to get into microcomputers with a minimum of cost. Moreover, this is a 'real' computer with full expandability."
POPULAR ELECTRONICS MARCH, 1979

"The Superboard II weighs in at $279 and provides a remarkable amount of computing for this incredible price."
KILOBAUD MICROCOMPUTING FEBRUARY, 1979

"The Superboard II and its fully dressed companion the Challenger 1P series incorporate all the fundamental necessities of a personal computer at a very attractive price. With the expansion capabilities provided, this series becomes a very formidable competitor in the home computer area."
INTERFACE AGE APRIL, 1979

"The graphics available permit some really dramatic effects and are relatively simple to program . . . The fact that the system can be easily expanded to include a floppy means that while you are starting out with a low-cost minimal system, you don't have to throw it away when you are ready to go on to more complex computer functions. At $279, Superboard II is a tough act to follow."
RADIO ELECTRONICS JUNE, 1979

"The Superboard is an excellent choice for the personal computer enthusiast on a budget."
BYTE MAY, 1979

Since the introduction of Superboard II, the cost of personal computers has actually gone up with new models by major manufacturers ranging from $1000 to well over $4000 due to the general cost of inflation and the increasing functionality included in these computers. Today Cleveland Consumer Computers is offering you the original Superboard II at its original price of just $279. In today's economy this is by far the best buy in personal computing ever!

The Superboard II can entertain your whole family with spectacular video games and cartoons, made possible by its ultra high resolution graphics and super fast BASIC. It can help you with your personal finances and budget planning, made possible by its decimal arithmetic ability and cassette data storage capabilities. It can assist you in school or industry as an ultra powerful scientific calculator, made possible by its advanced scientific math functions and built-in "immediate" mode which allows complex problem solving without programming! This computer can actually entertain your children while it educates them in topics ranging from naming the Presidents of the United States to tutoring trigonometry — all possible by its fast extended BASIC, graphics and data storage ability.

The machine can be economically expanded to assist in your business, remotely control your home, communicate with other computers and perform many other tasks via the broadest line of expansion accessories in the microcomputer industry.

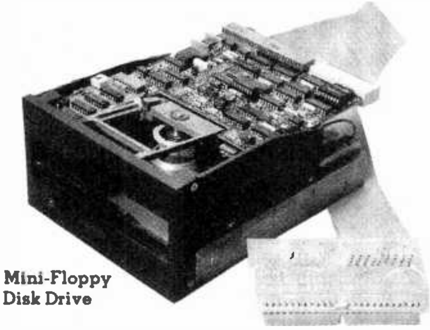
This machine is super easy to use because it communicates naturally in BASIC, an English-like programming language. So you can easily instruct it or program it to do whatever you want, but you don't have to. You don't because it comes with a complete software library on cassette including programs for each application stated above. Ohio Scientific also offers you hundreds of inexpensive programs on ready-to-run cassettes. Program it yourself or just enjoy it; the choice is yours.

The Superboard II comes fully assembled and tested. It requires +5V at 3 Amps and a video monitor or TV with RF converter to be up and running. $279.00

Standard Features:

- Uses the ultra powerful 6502 Microprocessor.
- 8K Microsoft BASIC-in-ROM. Full feature BASIC runs faster than currently available personal computers and all 8080 based business computers.
- 4K static RAM on board expandable to 8K.
- Full 53-key keyboard with upper/lower case and user programmability.
- Kansas City standard audio cassette interface for high reliability.
- Full machine code monitor and I/O utilities in ROM.

...onal Computing is Still Here.



Mini-Floppy Disk Drive

Direct access video display has 1K of dedicated memory (besides 4K user memory), features upper case, lower case, graphics and gaming characters for an effective screen resolution of up to 256 x 256 points. Normal TV's with overscan display about 24 rows of 24 characters without overscan up to 30 x 30 characters.

Optional Extras:

- Available 610 expander board features up to 24K static RAM (additional), dual mini-floppy interface, and an OSI 48 line expansion interface.
- Assembler/Editor and Extended Machine Code monitor available.
- 630 I/O Expander. RGB color and NTSC composite color outputs with up to 16 colors, Dual 8-axis joystick interface, AC remote control interface which mates with AC-12P, home security interface which mates with the AC-17P, 16-line parallel I/O interface, 16-pin I/O bus interface which allows the connection of parallel I/O lines or high speed analog I/O module, or a PROM blaster or solderless interface prototyping board, programmable sound generator and program selectable modem and high speed printer ports, and more.

Freight Policies All orders of $100 or more are shipped freight prepaid. Orders of less than $100 please add $4.00 to cover shipping costs. Ohio Residents add 5.5% Sales Tax.

Guaranteed Shipment Cleveland Consumer Computers & Components guarantees shipment of computer systems within 48 hours upon receipt of your order. **Our failure to ship within 48 hours entitles you to $35 of software, FREE.**

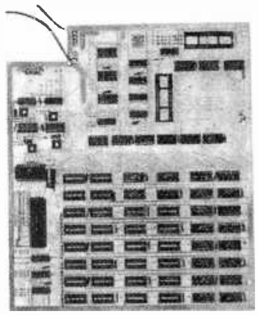
master charge VISA

Hours:
Call Monday thru Friday
8:00 AM to 5:00 PM E.D.T.

Software:

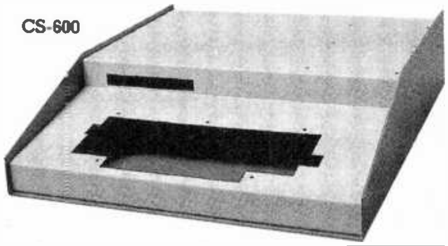
Ohio Scientific and independent suppliers offer hundreds of programs for the Superboard II, in cassette and mini-floppy form. Here is a sampling of popular Ohio Scientific programs for the Superboard II.

EDUCATIONAL PROGRAMS	SBII & C1P	Price
BASIC Tutor Series	SCE-336	$35.00
Clock Tutor	SCE-353	6.50
Continents Quiz	SCE-332	6.50
Definite Integral	SCE-326	6.50
French Drill & Tutor	SCE-339	6.50
German Tutor & Drill	SCE-342	6.50
Hangman (8K)	SCE-324	9.00
Log Tutors 1-3	SCE-344	6.50
Math Blitz	SCE-329	6.50
Math Intro	SCE-319	6.50
Mathink	SCE-337	9.00
Matrix Tutors 1-3	SCE-345	6.50
Metric Tutor & Quiz	SCE-335	6.50
Spanish Drill & Tutor	SCE-352	6.50
Spelling Quiz	SCE-333	6.50
Trig Tutor (8K) I & II	SCE-318	6.50
BUSINESS PROGRAMS		
Address Book	SCB-523	9.00
Advertisement Demo	SCB-520	6.50
Inventory Demo	SCB-518	6.50
Mailing List (8K)	SCB-524	6.50
Straight & Constant Depreciation	SCB-500	9.00
Time Calculator	SCB-525	9.00
PERSONAL PROGRAMS		
Biorhythm	SCP-716	9.00
Calorie Counter	SCP-708	6.50
Checking Account	SCP-719	9.00
Loan Finance	SCP-717	6.50
Personal Calendar	SCP-718	6.50
Savings Account	SCP-720	9.00
GAME PROGRAMS		
Baseball I	SCG-975	6.50
Black Jack	SCG-955	6.50
Civil War	SCG-977	6.50
Destroyer	SCG-951	6.50
High Noon	SCG-960	6.50
Hockey	SCG-979	6.50
Lander	SCG-925	6.50
New York Taxi	SCG-956	6.50
Poker	SCG-962	6.50
Racer	SCG-949	6.50
Space War	SCG-942	6.50
Star Trek	SCG-946	6.50
Star Wars	SCG-926	6.50
Tic-Tac-Toe	SCG-945	6.50
Tiger Tank	SCG-950	14.00



610 Board

CS-600



Hardware:

Superboard II	as specified in the advertisement.	$279
610 Board	For use with Superboard II and Challenger 1P, 8K static RAM expandable to 24K or 32K system total. Accepts up to two mini-floppy disk drives. Requires +5V @ 4.5 amps.	298
Mini-Floppy Disk Drive	Includes Ohio Scientific's PICO DOS software and connector cable. Compatible with 610 expander board. Requires +12V @ 1.5 amps and +5V @ 0.7 amps.	299
630 Board	As specified in the advertisement.	229
AC-3P	12" combination black and white TV/video monitor.	159
4KP	4K RAM chip set.	79
PS-005	5V 4.5 amp power supply for Superboard II.	35
PS-003	Mini-floppy power supply.	29
C1P Sams	C1P/Superboard II Manual.	8
OS-65D	V3.2 Disk Operating System with 9-digit extended BASIC, random access and sequential files.	49
CS-600	Metal case for Superboard II, 610 and 630 board and two power supplies.	49
CS-610	Metal case for single floppy disk drive and power supply.	49
AC-12P	Wireless AC remote control system. Includes control console, two lamp modules and two appliance modules for use with 630 board.	175
AC-17P	Home security system. Includes console, fire detector, window protection devices and door unit for use with 630 board.	249
C4P Sams	C4P Manual.	16
C3 Sams	Challenger III Manual.	40

To Order:
Or to get our free catalog **CALL 1-800-321-5805 TOLL FREE.** Charge your order to your **VISA** or **MASTER CHARGE** ACCOUNT Ohio Residents Call: (216) 464-8047. Or write, including your check or money order, to the address listed below.

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P.O. Box 46627
Cleveland, Ohio 44146

Order Form:

CLEVELAND CONSUMER COMPUTERS & COMPONENTS P.O. Box 46627 Cleveland, Ohio 44146

☐ Superboard II $279. ☐ 630 Board $229.
☐ 610 Board $298. ☐ AC-3P 12" B-W Monitor $159.
☐ Mini-Floppy Disk Drive $299. ☐ C1P Sams Manual $8.
(Attach separate sheet for other items.)

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All orders shipped insured UPS unless otherwise requested. FOB Cleveland, Ohio.

CIRCLE NO. 43 ON FREE INFORMATION CARD

Editorial

Over the Horizon

WITH 1980 ending, it's already clear that we have a lot to look forward to in electronics. Change is in the works.

Will the AM stereo fracas be resolved in '81 by the FCC, which originally accepted a proposed system and is now taking a second look? Will the EIA set standards for Teletext, Prestel or what-have-you so that we can all have access to a full home information service? Will new video cassette recorders encroach on the present market? On this score, Sony recently revealed a prototype of an all-in-one camera. And already in some retail stores is Technicolor's Funai VCR, which resembles a shoulder-strap-hanging audio recorder and uses a new-format tape that's as small as an audio cassette.

Will standard TV services be expanded, based on the recent FCC proposal to allot several new vhf channels? How will the independent telephone-instrument makers fare now that the Bell system is selling telephone equipment as well as leasing? Will the fact that a California court held that home video recording of TV programs is not covered by the copyright statute so long as it doesn't violate exclusive rights to distribute copies, perform publicly, et al, spill over into direct reception of satellite TV signals? After all, passive reception is not illegal according to the Communications Act. Or is it? Furthermore, competition from video disc machines and software will harden in 1980 as companies like Magnavox and Pioneer expand their product distribution and RCA launches its Selectavision model.

In the color TV field, look for larger screens (Sony has a 26-inch-diagonal model) and increased interest in projection TV models. And for commercial purposes, wide-screen color video from a projection system that can be adjusted electronically to Cinemascope proportions (1 to 2.35 ratio compared to the standard aspect ratio of 1.33) may well be introduced.

A boom in home computer time sharing is anticipated. Predictions are that, perhaps, 100,000 subscribers will be using the telephone lines for this purpose by the end of the year. Will the 8" disk systems push aside the minifloppies? Will memory-chip prices continue to be so cheap?

The battle for our electronics future has already begun. Expect AT&T and other biggies to play a major role in the electronic home information/entertainment area. Look, too, to the cellular mobile radiotelephone market to be commonplace down the road. And I really mean "road," since radiophones will become common fixtures in automobiles during this decade. Tokyo already has such an operational system and is expanding it to Osaka, while AT&T is still experimenting with the system in Chicago. Watch Oki of Japan and Motorola, among others, moving in on the market, especially with a portable (800-MHz) radiophone.

And, finally, if protection against computer crime and abuse isn't fought with intelligence and serious efforts, the timebomb it represents can cause disastrous results to industry, commerce, individuals, and our military posture.

Art Salsberg

Season's Greetings and Happy New Year

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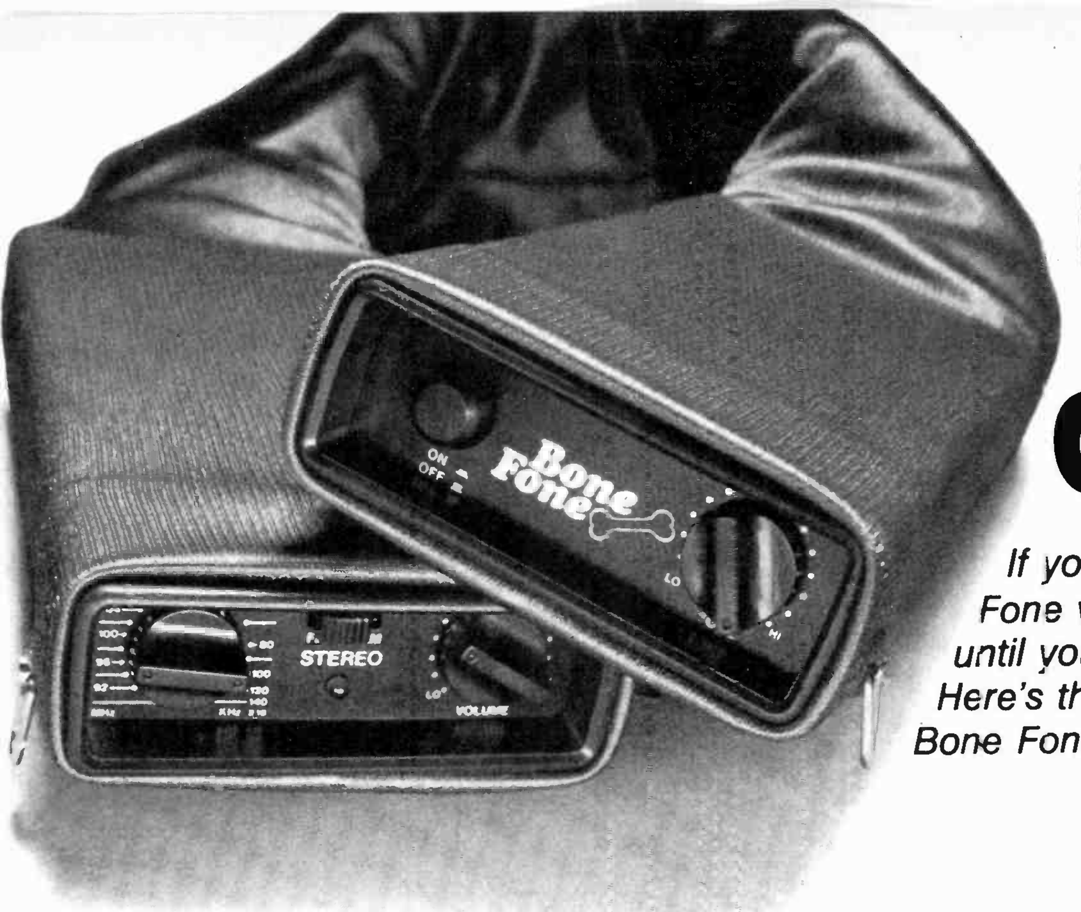

Bone Fone Clone

If you thought the Bone Fone was great, wait until you hear what's new. Here's the latest on the Bone Fone spin-offs.

It started with the Bone Fone. And this very unusual stereo system has created a whole new series of products.

The Bone Fone is an AM/FM stereo radio that drapes around your neck like a scarf. Two speakers, placed near your ears, not only provide excellent stereo separation, but vibrate slightly through your bones to give you the same sensation as standing in front of your home stereo system.

UNEXPECTED APPLICATIONS

Shortly after it was introduced, the Bone Fone became a very popular product for a variety of reasons. A lady in Helena, Montana who bought the unit for her son told us, "It's made a significant contribution to my sanity. No more rock n' roll blasting through the house, the sound goes where my son goes."

A jogger in Rowlett, Texas wrote us "Amazing separation, fantastic stereo response, helps my jogging tremendously. I wasn't really expecting this type of quality through a magazine ad at this price."

But one of the most unexpected letters came from a man in Belle Center, Ohio. "You don't have to be young and jog to enjoy Bone Fone. You see, I'm 73 years old. I just sit and listen."

LETTERS EVERYWHERE

Letters have come from mailmen, roller skaters, skiers, cyclists, motrocycle enthusiasts, hikers and even people who listen to the Bone Fone stereo while walking their dog. The Bone Fone appeals to practically every American.

The Bone Fone was designed by an engineer who wanted to listen to good stereo music without carrying heavy box radios or bulky headphones. Headphones block out all other sounds–even warnings which could be dangerous outdoors, and box radios are heavy and disturb those around you. So he invented the Bone Fone–"the stereo sound you wear around."

Weighing only 17 ounces and powered by 4AA cell batteries the Bone Fone stereo provides a sound that would be impossible to describe in an advertisement. The cliche, "you've got to hear it to believe it," certainly applies here. And for **$69.95** it's the lowest priced stereo entertainment product available.

But what about the sport enthusiast who can care less about stereo music? Or the person who wants just the news? Or simply the person that just listens to AM radio and doesn't want to spend $69.95?

The Bone Fone drapes around your neck like a scarf and has a sound that you find incredible when you first hear it.

Enter NUTS! NUTS is the AM version of the Bone Fone for sports nuts, news nuts, jogging nuts or anybody who wants a low cost Bone Fone without FM or stereo. NUTS sells for **$39.95** complete with two speakers and a strap that firmly attaches the unit to you for any physical activity.

Sitting at a football game, walking your dog, jogging–NUTS gives you a convenient way to listen to music, news and sports without paying a premium for stereo.

But the Bone Fone spinoffs don't end there. There's the Neck Fone–a device you place over your shoulders and plugs into your home stereo system. This lets you enjoy your home stereo without disturbing those around you and without the bulk of headphones. The Neck Fone sells for **$24.95**.

So there you have it. Three exciting products–Bone Fone, NUTS, and the Neck Fone–three unusual solutions designed to solve any gift-giving problem.

LOWEST-PRICED STEREO

Compare the Bone Fone price with any box radio, stereo system or even the new $200 Sony Walkman. The Bone Fone is the lowest-priced quality personal stereo system you can buy. It is also safer than headphones as it leaves you free to hear the sounds around you and keeps you in touch with the environment.

To order any of the above products, simply send your check or money order for the amount listed above plus $2.50 for postage and handling (Ill. residents add 6% sales tax) to the address below, or credit card buyers may call our toll-free number below. Each unit is backed by a 90-day limited warranty and a service-by-mail facility as close as your mailbox. Service should rarely be required as the units use solid-state components and are designed to take rugged treatment. JS&A is America's largest single source of space-age products–further assurance that your modest investment is well protected.

The Bone Fone started a small revolution. Be part of that revolution with the space-age way to listen to music, news and sports. Order a Bone Fone product at no obligation, today.

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Big Bruiser

D 804: A powerful, versatile handheld DMM with nine functions, 26 ranges, 0.1% basic dc accuracy and more. Direct temperature readings in °C with K-type thermocouples; peak hold on voltage and current functions; even an audible indicator for instant continuity and logic level detection. Available January 1981. $229.*

Series D Bench/Portables.

D 810: By means of a Fluke-built hybrid converter, this multi-purpose DMM delivers True RMS measurements of ac voltage and current with speed and precision. Also features conductance, 0.1% basic dc accuracy, an extra 10A range and diode test. $259.*

D 811: Same performance features as the D 810 with the added convenience of battery power. Rechargeable "C" size Ni-Cad batteries deliver up to 40 hours continuous operation. $299.*

Series D Accessories.

A wide range of accessories to extend the measurement capabilities of your Series D Multimeter is available, including temperature and current probes, carrying cases, deluxe test leads and thermocouples.

With Series D Multimeters so easy to find and economical to own, Fluke has made selecting the right DMM much simpler. This is your opportunity to own a Fluke.

From the world leader in DMM's. Now we've designed one for you.

CIRCLE NO. 20 ON FREE INFORMATION CARD

*suggested U.S. list price.
For technical data circle no.

FLUKE®

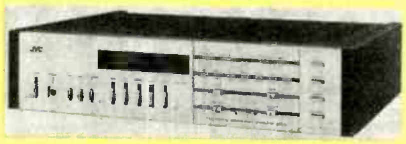
Stocking Stuffers

Home Electric Control System

Pittway Corp. has introduced its First Alert Home Command Center, a microprocessor-based system that employs existing house wiring to control remote electrical devices. The system consists of the Model HC8600 Programmable Home Command Center (with a 21-key keyboard) and three types of satellite modules: Model HC8610 lamp/dimmer module; Model HC8611 appliance module; and Model HC8612 wall switch/dimmer module. Command signals generated by the central module cause any of a number of satellite modules to turn an electrical appliance plugged into it on or off. Appliances can be programmed to turn on or off at any time of the day or week. Dimming of lamps can be controlled to a preselected level. The central module includes a digital clock, keypad, ambient-light display compensation, and a 9-volt battery backup system that prevents loss of information stored in the module's memory. It also notifies the user if a command cannot be executed because of appliance failure or some other reason.

CIRCLE NO. 88 ON FREE INFORMATION CARD

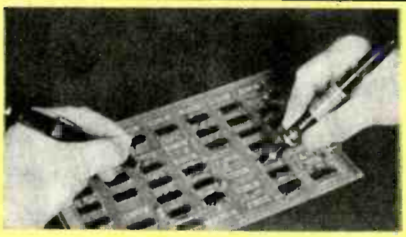
JVC Digital AM/FM Stereo Receiver



Digitally synthesized tuning and digital frequency display are featured in JVC's new Model R-S55 AM/FM-stereo receiver. Three tuning modes are offered: stepwise through the FM and AM bands, scanning to locate stations whose signals are strong enough for superior fidelity, and instant recall of any preprogrammed stations—seven AM and seven FM. A phase-locked loop is used in the FM-stereo decoder, and direct coupling is used throughout the amplifier. Specifications: Amplifier—40 W minimum continuous output power into 8 ohms from 20 to 20,000 Hz at no more than 0.03% THD (0.003% average at 1 kHz into 8 ohms); 88 dB A-weighted S/N; 20 to 20,000 Hz ±0.5 dB frequency response through phono input. FM tuner—12.1 dBf (1.: μV) sensitivity; 0.3% average distortion; 68 dB stereo S/N; 45 dB stereo separation; 65 dB alternate-channel selectivity. $399.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Logic Probe and Pulser



The PRB-1 Digital Logic Probe from OK Machine and Tool Corp. detects pulses as short as 10 ns and has a response to 50 MHz. It also has automatic pulse stretching to 50 ns, and is fully compatible with RTL, DTL, TTL, MOS, CMOS, and microprocessor logic families. Input impedance is 120KΩ and overvoltage protection is 200 V. $36.95. The PLS-1 Logic Pulser can superimpose a dynamic pulse train (20 pps) or a single pulse into the circuit node under test. Each pulse is either high- or low-going at 2 μs width. Pulse polarity is automatic. $48.95.

CIRCLE NO. 91 ON FREE INFORMATION CARD

Low-Cost Sinclair Computer

The new $199.95 Model ZX80 compact micro from Sinclair Research Ltd. measures only 9" × 7" × 2" and weighs 12 oz. All it needs is a TV receiver and cassette recorder to get you up and running. Program entry is via an alphanumeric touch-sensitive keyboard that features single-stroke key word entry. A single ROM contains the BASIC interpreter, character set, operating system, and monitor, and there is 1K byte of RAM. Every statement line is automatically checked for syntax before use in a program. The black-and-white on-screen display consists of 24 lines of 32 characters each, and 24 graphic symbols are available. Graphics and alphanumerics can be displayed in reverse video. Comes with a 130-page instruction manual.

CIRCLE NO. 92 ON FREE INFORMATION CARD

Deluxe Yamaha Turntable

The deluxe Model PX-2 single-play turntable from Yamaha features microprocessor control, tangent-error-reducing linear tracking tonearm system, and a newly designed Optimum Mass tonearm. The tonearm is said to dramatically reduce resonance in the audio range and increase the tracking ability of the cartridge. Tonearm resonance is tuned to 12 Hz, below human hearing and above the frequencies of record warps. Height of the tonearm is adjustable. In addition, the drive/control system uses a crystal-referenced phase-locked-loop servo and coreless motor. Its controls are outside the dust-cover area for convenient access. Specifications: 0.15% or less tracking error; 80 dB S/N; less than 0.01% wow and flutter. $900.

CIRCLE NO. 93 ON FREE INFORMATION CARD

License-Free Transmitter Kit

Palomar Engineers has introduced a new transmitter in kit form that operates on the license-free 1750-meter (160 to 190 kHz) experimenters' band. The main transmitter assembly contains active r-f circuits, power supply, and a control panel. An antenna tuner assembly mounts remotely at the base of the antenna. (FCC regulations limit total antenna length—including that of any transmission line used—to 15 meters.) Rated input power to the final active stage of the transmitter is one watt, the maximum allowed by FCC regulations. Difficult assembly and wiring steps, including the winding of Litz-wire inductors, are performed at the factory. Wiring the kit is said to take approximately one hour. Palomar Engineers designed the transmitter for CW op-

THE 12 MELODY ALARM. THE FARTHEST A WATCH HAS EVER GONE TO ORGANIZE YOUR LIFE.

Now there's a timekeeper that makes even the fanciest alarm watches seem ordinary.

It not only replaces one alarm with 12—but provides you with real melodies, not beeps or buzzes.

And this sweet sounding genius by Casio, available through The Sharper Image, is only $69.

7 days. 7 symphonies.

This unusual electronic watch/stopwatch features 12 computer synthesized melodies—every one engineered to help you cope with the busiest personal schedule.

Every day of the week you'll have at your disposal a different symphonic daily alarm, to bring attention to important daily events—any minute you choose.

For example, you can wake up to *American Patrol* on Monday, keep Thursday appointments with the help of a French folk song, and organize your Sundays around a Schubert masterpiece. Easily presetting every alarm with the press of a button.

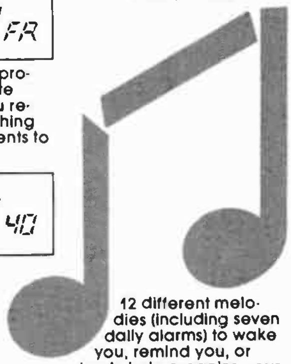
If you wish, this orchestral wonder can also measure every hour with a 2 tone chime. Even tell you it's lunchtime the way London's Big Ben would—by playing *Westminster Chimes* at 12 noon.

By the way, every note is a faithful reconstruction of a true musical pitch, and enriched with vibrato. Then visually reproduced right on the face—thanks to a moving 11-note musical display (and of course, any or all of the melodies can be programmed for total silence).

Set it months in advance—a visual and audible reminder of a birthday to remember.

Two additional programmable date alarms help you remember everything from appointments to anniversaries.

A fiercely talented stopwatch, countdown timer and 12/24 hour changeover button round out Casio's exceptional timekeeping features.



12 different melodies (including seven daily alarms) to wake you, remind you, or simply help organize your calendar. Each note is clearly heard through the front mounted speaker.

Reminders for the future.

Daily wake-up/appointment alarms are only a small part of this instrument's one-of-a-kind organizing talents.

Imagine a timepiece that reminds you of important dates—as they approach—with the help of two preprogrammable date alarms: *The Maine Fight Song* or *Wedding March* (incidentally, that latter melody sees to it you remember your anniversary *before* someone special has to remind you).

You'll also get advance notice of birthdays with a melodic rendering of Happy Birthday (like the date alarms, it comes on every hour, and each time you check the date). And all these tunes can be preset up to a year in advance.

If you like, this extraordinary minstrel will even play *Jingle Bells* every Christmas—automatically.

Want to show off Casio's musical magic without waiting for an alarm? Any of its dozen melodies can be instantly brought to life with the touch of a button. And silenced with the touch of another.

Count up.
Count down.
Count anything.

In addition to helping you organize your days, this gifted chronograph boasts some equally exceptional timekeeping traits.

Press one button, for example, and its continuous hour/minute/second readout turns into a day/date calendar display with auto end of month adjustment.

Press another, you get one of the most complete stopwatch capabilities we've ever seen. Featuring up to 1 hour of 1/10 second timing, laps, 1–2 finishes, 1 minute interval beeping and a "pip" signal to confirm starts and stops.

You can also set in motion a 1 second to 59.59 minute countdown timer—ideal for tallying cooking time, the minutes on your parking meter, or anything you like. Upon reaching zero, the timer alerts you with ten seconds of chimes. Then measures overtime—automatically (to 59.59 minutes).

This Casio wizard even lets you choose between 12 or 24 hour time. Recording both formats with ±15 second-a-month accuracy. And displaying them in large, easy to read liquid crystal digits (there's also a handy panel light, for night viewing).

We introduce it. We guarantee it.

When we first heard that the engineers at Casio were on the brink of perfecting a 12 alarm musical chronograph, we had hopes of being among the first to offer it.

And now that's a reality.

Because this $69 maestro is already available through The Sharper Image. And to be assured earliest delivery, please order yours now. As always, we guarantee your satisfaction; if not delighted with your new Casio, return it within two weeks for a full and courteous refund. Battery included. One year manufacturer's warranty also included.

Call now for a no-risk recital—your first step in getting organized.

ORDER TOLL FREE.

Please order product #244. Credit card holders may use our toll free number below. Or send check for $69 plus $2.50 delivery, and $4.48 sales tax in California. Please mention this magazine.

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Stocking Stuffers (Continued)

eration, but reports that it can easily be amplitude-modulated. Operating frequency is determined by a plug-in quartz crystal (not supplied). $145.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Satellite TV Receiver

International Crystal Manufacturing Co. announces the availability of its Model TV-4300 microwave receiver. It tunes 24 channels used for satellite TV downlinks in the 3.7-to-4.2-GHz band, according to the manufacturer, and includes a low-noise amplifier (LNA), a tuner with afc, control circuits, and a power cable. All output levels are said to be compatible with video-monitor and video-recorder inputs, with dual audio outputs at standard frequencies of 6.2 and 6.8 MHz. Options include alternate audio-output frequencies, selectable audio outputs, stereo audio outputs, and remote tuning control. $995.00

CIRCLE NO. 95 ON FREE INFORMATION CARD

Improved Discwasher Record-Care System

The D4 System, consisting of a reformulated record-cleaning fluid and a redesigned fabric in the familiar walnut handle, is the successor to Discwasher's D3 System. The D4 fluid has been designed to prevent damaging stabilizers in the high-grade vinyl used in record discs. It is said to be temperature stable and to offer enhanced micro-dust suspension. The pad itself is composed of softer fibers. Bonded with better slant stability, the fibers are claimed to attract and hold micro-dust even when dry. When used with the D4 fluid, the pad dries the disc faster and more completely than its D3 predecessor. $16.50.

CIRCLE NO. 96 ON FREE INFORMATION CARD

Createavision Projection TV Kit

VSR Sales Corp. offers two projection TV kits—the Creatavision IV, which has a four-foot diagonal screen, and the Creatavision V, whose screen measures five feet diagonally. Both models are designed to project the image developed by a 13-inch television receiver (not supplied), but the manufacturer claims that they are compatible with some 12- and 15-inch receivers as well. Polarity of the horizontal and vertical deflection-yoke windings of the receiver to be used must be reversed since the system employs reflected front projection. Both models employ one projection tube (f/1.3 Fresnel lens) and curved screens. Construction consists of assembling the walnut-grain cabinet, placing the receiver inside the cabinet, and mounting the curved screen on top of the cabinet. Cabinet size is 32"W × 20"D × 54"H (4-ft. screen). Model IV, $499; Model V, $599.

CIRCLE NO. 97 ON FREE INFORMATION CARD

TX-80 Printer Graphics

The GRAFTRAX from Epson America, Inc., is a high-resolution, bit-plot graphics add-on for the Epson TX-80 dot-matrix printer. Using a PROM, the system timing is arranged so that each seven-bit word causes the head to print at one dot position for a total of 480 dots per line. The length of a line feed is software definable in 255 steps of 0.007" each. Form-feed recognition is implemented with form lengths adjustable from one to 255 lines. The skip-over perf function allows size of print field to be adjusted from one line to a full page. Other GRAFTRAX features include an Apple screen dump routine and its source code. $99.

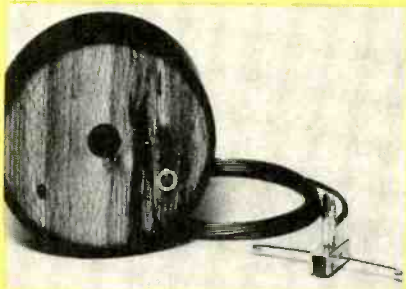
CIRCLE NO. 98 ON FREE INFORMATION CARD

Frequency-Counter Kits

Heath has introduced two new digital frequency-counter kits. The IM-2400 hand-held counter operates from 50 Hz to 512 MHz. It features a 7-digit 3/8" LED display, a 10-MHz crystal-controlled time-base and a 10-ppm temperature stability. A sensitivity of 10 mV is claimed. Size is only 15/8"H × 33/8"W × 83/8"L. $139.95. The IM-2410 Portable Frequency Counter operates between 10 Hz and 225 MHz with a 10-ppm temperature stability. This unit features an 8-digit display and comes in a durable metal cabinet with RFI shielding. A pivoting stand and locking swing-down bail place the display at a convenient viewing angle. $119.95. Options include the PS-2404 Eliminator/Charger for the IM-2400 and the SMA-2400-1 Swiveling Telescopic Antenna.

CIRCLE NO. 90 ON FREE INFORMATION CARD

Thermal Monitor for Wood Stoves



The Fire Fly® by Vine Valley Research is a solid-state thermal monitor that is said to detect build-up of excessive temperature in the stovepipe of a wood stove. It is intended to warn the user that fuel consumption has become excessive because the stove's damper has been left open too long. A remote thermal sensor attached to the stovepipe and connected to a control unit by a six-foot cable triggers the control unit when it detects a temperature of 500°F. A LED and an audible alert indicate excessive temperature. Operating power is from a nine-volt battery. $29.95.

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TALKING TIME

Now a breakthrough in Speech Technology gives Time A Voice.

A miniature marvel of microcomputer speech and timekeeping technology. It measures only 4½ x 7/8 x 2 3/8.

Rapidly emerging electronic progress in solid state speech synthesis brings micro computer generated speech to timekeeping.

In the fall of 1978, Texas Instruments engineers developed "Speak and Spell"™, an electronic spelling aid with speech generated entirely by a tiny electronic micro computer chip. In 1979, talking language translators were introduced.

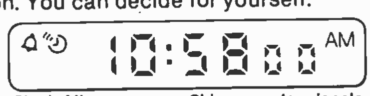
Today, most semi conductor houses around the world have major research efforts in solid state speech synthesis. In the next few years many new speech products will reach the marketplace. Now there is Talking Time. One of the first to be introduced, it may be the most useful and unique.

No Recorder—No Pull String

Like R2D2 in Star Wars, Talking Time seems to spring to life when speech synthesis and quartz timekeeping technologies come together. There are no recorders or talking doll pull strings in Talking Time, only solid state electronics. Electronics that are on the leading edge of both technologies. The forerunner of things to come. Here's how it works.

Micro Computer Brain to Slight Japanese Accent

Humans produce speech in much the same way that Talking Time does. Our brain sends nerve impulses to our jaw and chest, for our mouth to move and our lungs to push air across our voice box. Talking Times' single microprocessor chip sends electrical impulses digitized into speech patterns to an audio loud speaker. The loud speaker vibrates and out comes a clear voice that says "Attention please, it's now six o'five, please hurry"—with a slight Japanese accent. Talking Time is made by Sharp Electronics, a leading electronics company in Japan. So finely processed is the speech synthesis that you will swear it seems to speak with a slight Japanese accent. Texas Instruments Speech products are said to have a Texas drawl. Perhaps it's our imagination. You can decide for yourself.



Single Microprocessor Chip generates signals that both speak with slight Japanese accent, and time with quartz accuracy.

No Heart Failure with this Alarm

An effective alarm with a snooze feature that reminds you any minute of a 24 hour day. First a chime to get your attention, then, "It's now six o'clock," followed by a rousing melody over Talking Time's loud speaker. After a 5 minute snooze, Talking Time warns you, "Attention please, it's now six o'five, please hurry." It warns you again after 10 minutes, loud enough to wake even a sound sleeper, but pleasant enough not to give you heart failure.

Desk Top Reminder

Talking Time is ideal as a personal reminder. A perfect gift for that busy executive who is engrossed in work and forgets the time. In the **Time Announcement Mode** you're reminded automatically, every 30 minutes by, "It's now two-thirty p.m." If you want more reminders, choose the **Elapsed Time Mode.** Select 1, 5 or 30 minute intervals. Talking Time will announce each interval with "Five minutes elapsed, then "ten minutes elapsed," etc. No more missed meetings or appointments—Talking Time is Here!

Jogging Companion

Talking Time is small enough to be a handheld or pocket jogging companion. In the **Stopwatch Mode,** it's a stopwatch with one second precision and automatic as well as manual operation. In manual it announces the elapsed time at the push of a button for 10 full hours. When in automatic, it announces the elapsed time automatically every 10 seconds. During your entire run, Talking Time keeps you informed. You never have to break stride to look at your watch. Comes with a hand strap so it's easy to carry.

Interval Timer to Space Work or Fun

Talking Time is great for a periodic check against how much time has elapsed on a given task. Speed up or slow down as necessary. Production supervisors, doctors, and engineers, anyone with critical time measured functions to perform, find it useful. Pilots can use it to call out elapsed time every 10 seconds while they shoot approaches. Talking Time has both performance and functions unheard of even one year ago. The voice adds usefulness, which we think you'll agree, can only be described as Revolutionary.

Superb Chronometer That Can Keep Its Mouth Shut

Talking Time is a great chronometer in its own right. Its famous quartz accuracy is unsurpassed by chronometers costing $200 or more, but with half the functions. It has a large easy-to-read liquid crystal display (LCD) with 8 digits. A welcome relief for anyone who has poor eyesight. With Talking Time you hear as well as see the time. If you want silence, however, just tell it to keep its mouth shut. It won't let out a peep. You can still use it for its unsurpassed timekeeping accuracy.

Talking Time is easy to set in all modes, since it talks to you as you go along. You can keep track of what you're setting and how to do it. It may not be foolproof, but it's close.

Talking Time is worth its price as a superb clock alone. Its uses seem endless. It may add a whole new dimension to time. But don't take our word for it. Find out for yourself!

30 Day No-Risk Trial

To prove to you that Talking Time is everything we say, we offer it for 30 days at no risk. If during 30 days from receipt, you are unhappy with Talking Time for any reason, return it for a prompt refund of your purchase price. What have you got to lose?

One Full Year Warranty

Talking Time is all solid state. It should give you years of trouble free operation. If, in the unlikely event, anything should go wrong, it is warranted for one full year by Sharp Electronics. Talking Time comes complete with 2 AA batteries and handstrap. Under normal use, batteries should last for one year or longer.

To Order

Just fill in the order form and send it along with check or money order to our address. For even faster service credit card customers can call our Toll Free number listed below. Order yours today!

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___Yes, send me Talking Time with a 30 day no-risk return at $89.95 plus $3.00 delivery.

___SAVE $10.00 Send me two Talking Times at $84.95 ea. plus $2.00 ea. delivery.

___SAVE $30.00 Send me three Talking Times at $79.95 ea. plus $1.50 ea. delivery

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CIRCLE NO. 39 ON FREE INFORMATION CARD

Stocking Stuffers (Continued)

Address: Vine Valley Research, 1220 East Lake Rd., Middlesex, NY 14507.

Vhf/Uhf Beam Antenna

The Scanner Beam by Grove Enterprises is a seven-element log-periodic dipole array intended primarily for vhf/uhf public-service-band monitoring applications. Grove Enterprises reports that the antenna can also be used for transmission and reception of signals in the 144-, 220-, and 420-MHz amateur bands. Rated gain in the high vhf and the uhf bands is approximately 8 dB over a half-wave dipole; front-to-back ratio, 15 dB; and average VSWR, 1.92:1. On the low vhf band, the antenna is said to function as a dipole. When the Scanner Beam is mounted in the vertical plane, it is vertically polarized and, on the low vhf band, offers omnidirectional response. A supplied offset mount permits the installation of the Scanner Beam at other than right angles to the mast for satellite reception. Construction materials include aluminum tubing, ABS Cycolac insulators, and a four-foot enamel-painted boom. Included is a 4:1 balun transformer which permits direct connection to a 50- or 75-ohm coaxial transmission line. $39.95 plus $4 shipping and handling charge. Address: Grove Enterprises, Inc., Rte. 1, Box 156B, Brasstown, NC 28902.

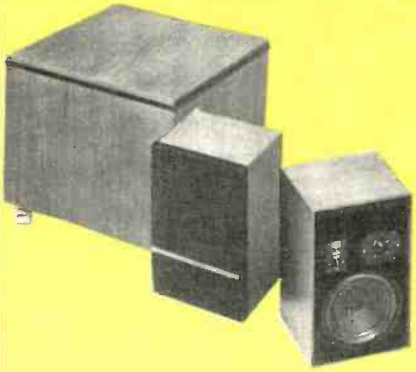
Fidelity Electronics Chess Printer

The Challenger Printer by Fidelity Electronics, Ltd. is an accessory designed for use with the company's Chess Challenger electronic game. The Challenger Printer records black and white commands on 2¼" wide thermal paper. It can also show current board positions by printing a graphic display of black and white pieces in their actual locations. The Challenger Printer is connected to the Chess Challenger by means of a cable and a jack mounted on the back of the Chess Challenger. It derives operating power from a wall-mount transformer (supplied).

CIRCLE NO. 100 ON FREE INFORMATION CARD

ADC Subwoofer & Satellite Speaker System

ADC's Model B300 subwoofer is designed to respond to audio signals in the 27-to-

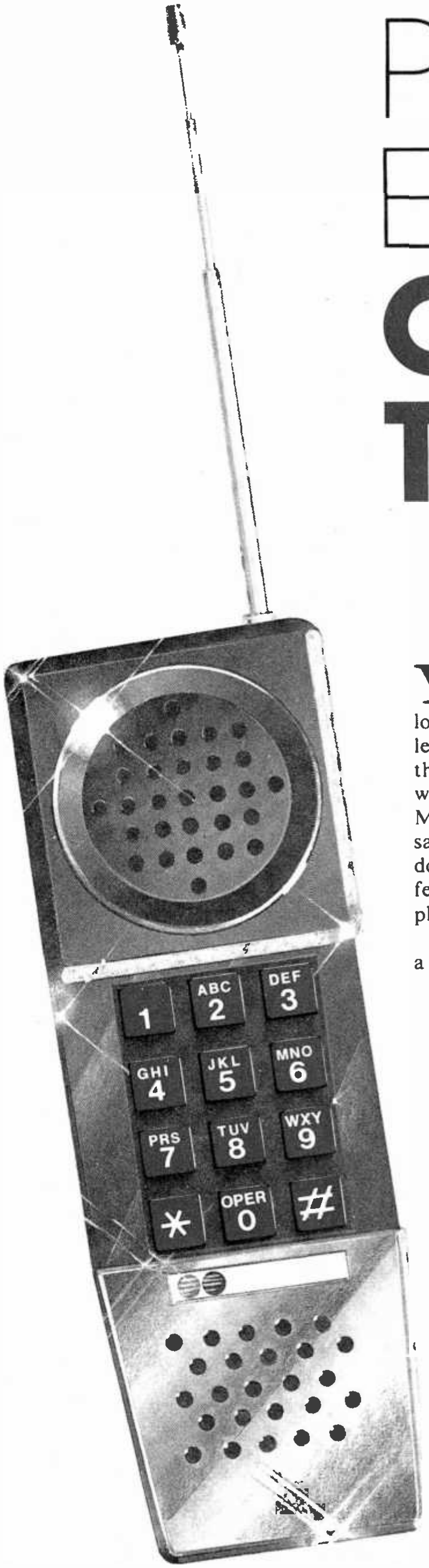


200-Hz range, while the B410 full-range satellite's rated frequency response is 65 Hz to 17 kHz ± 1.5 dB. The subwoofer's 12" acoustic-suspension driver has its own 120-watt power amplifier built into the cabinet. The B410s can be used as satellites for the B300 or as independent two-way acoustic-suspension systems. They can handle from 10 to 250 watts of input power and cross over at 1.2 kHz. $599 for B300; $185 each for B410.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Popular Electronics
DECEMBER 1980

PE EXAMINES CORDLESS TELEPHONES



BY JULES GILDER

YOU don't have to be tethered to a telephone's umbilical cord any longer, thanks to the new breed of cordless phones on the market. You can take the wireless phones indoors and outdoors without plugging them into anything. Moreover, these modern telephones will save you money in the long run since you don't pay Ma Bell an instrument rental fee and you can eliminate an extension phone or two.

The market, supported by more than a half-dozen major manufacturers, offers a wide variety of consumer-type cordless phones that range from less than $70 to about $650. Models currently being marketed have different features and functions, allowing you to choose a system to suit your particular needs and pocketbook.

Let's explore the current crop of cordless phones by discussing a number of models from different manufacturers to give you some idea of what these handy instruments can do and how much they cost. In our discussions of each model,

we'll give you the results of tests we performed under actual-use conditions in a typical home environment. But first, let's get an overview of how cordless phones work.

General Information. A minimum cordless telephone system consists of a fixed-location base station that connects to both the ac line and standard telephone line, plus a battery-powered portable remote phone. More elaborate systems can contain more than one remote and some of them may even have multiple base stations.

Most cordless phones have about the same operating range, averaging 300 to 400 feet. The frequencies most often used today are 1.7 and 49 MHz, which determine maximum range attainable. (Actual range is basically a function of the 1.7-MHz signal from the base station to the remote.) Since two frequencies are generally used and are substantially separated from each other, it is possible for both parties in a cordless-phone conversation to listen and talk simultaneously, using a "duplex" operating technique.

Some less expensive cordless phones employ a "simplex" technique that limits conversations to only one-way communication at a time. With a simplex system, you can either talk or listen, but you can't do both at the same time. Simplex systems employ only one frequency, usually 49 MHz, to transmit from remote to base station, and vice-versa.

For higher-quality sound and greater resistance to noise, frequency modulation (FM) is preferred for the transmission medium. A less expensive way to go is amplitude modulation (AM), but this medium is more susceptible to noise. Needless to say, in more expensive cordless-phone systems, FM is commonly used for the transmission medium.

The 1.7-MHz carrier (in the case of a simplex system, the 49-MHz carrier) is coupled to and radiated from the ac power-line wiring. With the ac wiring serving as the antenna, reception quality at the remote end, and operating range, can vary greatly, depending on which outlet is used.

It is important that you know what type of wiring is used in your location. According to cordless-phone manufacturers, if your wiring is shielded, operating range can be severely restricted. But manufacturers are quick to point out that this situation can be easily remedied by connecting the base station to the electrical system by a fully extended 25-foot extension cord to provide the needed exposure for properly radiating the transmitted signal.

Another serious problem with using the ac wiring as an antenna is the systems' susceptibility to electrical noise. The cordless phones we tested were designed to ignore conventional electrical noise but not noise generated by improperly designed light dimmers and other devices that generate a broad spectrum of electrical noise.

Building construction is also said to affect operating range, with aluminum and steel siding causing noticeable deterioration in range. Height of the base station above ground is another range-determining factor. In general, the greater the height, the greater the operating range.

Contrary to appearances, when a base station's signal is picked up by a remote, the telescoping antenna in the latter is not used. Instead, a built-in loopstick antenna, like those used in portable AM radios, is used. This is why most cordless phones receive paging calls and phone rings when their whip antennas are collapsed. Use of the loopstick antenna also means that, for receiving, the remote is sensitive to orientation (signal polarization), a fact borne out in our tests.

Most cordless phones come with only four or five channels from which to choose. This means that there is always the possibility that two or more people in a given area will have phones on the same frequency and, thus, be able to access each others' phone lines. The worst-case condition occurs when all phones in the area are purchased from the same manufacturer. When the phones are from different manufacturers, the problem is considerably reduced

CORDLESS TELEPHONE SAMPLER

Manufacturer	Model	Price ($)	Simplex/ duplex	Range Act. (claimed) (ft)	Modulation	Frequency Trans./Rec. (MHz)	Operating mode	Acc. jack	Redial number	Intercom capability
Mura Corp.	MP-50/51	70.00	Simplex	(400)	AM	49/49	Ans. only	No	N/A	No
" "	MP-100/101	89.95	Simplex	250(400)	AM	49/49	Ans. only	Yes	N/A	Yes
" "	MP-300/301	150.00	Simplex	(400)	AM	49/49	Orig./Ans.	Yes	Yes	Yes
Dynascan	CP-15S	149.95	Duplex	(300)	FM	1.7/49	Ans. only	—	N/A	—
"	CP-100S	239.95	Duplex	(300)	FM	1.7/49	Orig./Ans.	Yes	Yes	Limited
"	CP-200S	239.95	Duplex	440(300)	FM	1.7/49	Orig./Ans.	Yes	Yes	Limited
Universal	TEL-3000	249.95	Duplex	440(300)	FM	1.7/49	Orig./Ans.	Yes	Yes	Limited
Radio Shack	ET-300	199.95	Duplex	440(300)	FM	1.7/49	Orig./Ans.	Yes	Yes	Limited
" "	ET-310	119.95	Duplex	(300)	FM	1.7/49	Ans. only	Yes	Yes	Limited
Pathcom Inc.	8400	129.95	Simplex	—	—	1.7/49	Orig./Ans.	—	N/A	—
" "	8501/8511	194.90	Duplex	(300)	FM	1.7/49	Orig./Ans.	—	N/A	—
" "	8502/8510	349.95	Duplex	390(300)	FM	1.7/49	Orig./Ans.	Yes	No	Limited
" "	8504/8512	399.95	Duplex	(300)	FM	1.7/49	Orig./Ans.	Yes	Yes	Yes
Electra Co.	FF-500	269.95	Duplex	(300)	FM	1.7/49	Orig./Ans.	Yes	No	Limited
" "	FF-1500	299.95	Duplex	440(300)	FM	1.7/49	Orig./Ans.	Yes	No	Limited
" "	FF-3000	349.95	Duplex	440(300)	FM	1.7/49	Orig./Ans.	Yes	Yes	Limited
Fracom/Rovafone	Rovette	299.95	Duplex	(300)	FM	1.7/49	Orig./Ans.	Yes	—	—
" "	600-RDS	399.95	Duplex	(300)	FM	1.7/49	Orig./Ans.	—	—	—
" "	600-TTs	439.95	Duplex	(300)	FM	1.7/49	Orig./Ans.	—	—	—
" "	2500/B	649.95	Duplex	925(1700)	FM	27/49	Orig./Ans.	No	Yes	Limited

because many manufacturers build in guard frequencies that are used to modulate the 49-MHz carrier that also must be identical for one owner's remote to access another's base station. This appears to work well. As an example, our tests of eight cordless phones from different manufacturers revealed that none was able to use another's base, although some were able to page another remote. As a side issue, we did note serious interference, especially during dialing, when two remotes were operated simultaneously near each other.

As the number of cordless phones in use grows, manufacturers are looking toward technical and legislative means for solving the growing interference problem. On the technical side, they're working with microprocessors. For example, last January, APF Electronics announced a 32-channel microprocessor-based cordless phone that would have greatly alleviated the privacy/interference problem. In this design, the user would have been able to select his own personal code for each channel to insure privacy and protect against unauthorized listening. Though the APF phone never made it to the commercial market, other manufacturers plan to produce similar systems.

On the legislative side, some manufacturers are appealing to the FCC for allocation of parts of the 27-MHz band, while others want the 220-MHz band for cordless-phone use. If the FCC gives the nod to either band, the advantages would be two-fold. First, there would be a lot more channels available, ensuring greater privacy. Secondly, the operating range of cordless telephones could be greatly extended.

Our Test Setup. Since operating range is perhaps the most important characteristic one looks for in a cordless phone, we placed emphasis on this point during our tests. All eight models were tested with their base stations on the second floor rear of a two-story house.

Several different ac outlets were tried before we located the optimum electrical wiring circuit to use for transmission, which led us to this location. Through trial and error, we learned that outlet selection was far from a trivial matter. From one outlet to another, we noted that transmission range varied by as much as 50%.

Our test location presented worst-case conditions because the house has shielded electrical wiring and is aluminum sided. Furthermore, the locale, an ordinary residential area with mostly brick structures, always had one or more buildings between base station and remote. We used a 25-foot extension cord to connect the base station to the ac line, as recommended, but we needn't have bothered. Tests revealed that each phone system operated the same whether or not the extension cord was used. Nor did the aluminum siding appear to influence range since the results were the same with the extension cord deployed inside the house and with it hung out a window.

Units Tested. In all, we tested eight models of currently available cordless telephone systems from seven different manufacturers. Models selected for this survey represent the entire spectrum of cordless phones that receive or transmit away from the base unit. Here are our observations.

● *Mura MP-100/101.* Among the least expensive cordless phones on the market are those offered by Mura Corp., which has a series of three different Muraphone models that range in price from less than $70 to about $150. We selected the midpriced Model MP-100/101 remote/base system, which lists for about $100 but is routinely sold for $89.95, for evaluation.

Some sacrifices were made in achieving the low price for the MP-100/101 (and other models in the Muraphone line), the most notable being its simplex design. Every time you want to speak into the remote, you must hold down a button, and when you wish to listen, you must release the button. Using Muraphones, therefore, is more akin to operating a CB transceiver than it is to using a telephone.

By going simplex, Mura has made the design of the phone much simpler, of course, because it permits both remote and base to work on the same 49-MHz transmit frequency. Mura claims that operating remote and base on the same 49-MHz frequency makes it possible to get better overall range than with other cordless phones that use the two-frequency scheme.

Range for the MP-100/101 is rated at 400 feet or more, up to "thousands of feet" with ideal clear line-of-sight conditions. In our experience, the 400-foot figure is more realistic in cities and towns, but even 400 feet is optimistic, considering that the maximum distance we obtained was 250 feet.

Another shortcoming of the MP-100/101 is its answer-only capability, which prevents a user from originating a call from his remote. However, if all you need is a receiving instrument so that you don't have to run to answer the phone, the Muraphone can be a good inexpensive choice, assuming you don't mind the inconvenience of simplex operation and somewhat restricted range.

With the base station connected to a telephone line (a modular plug is supplied), it will broadcast a beep tone when it senses an incoming call. While the remote's antenna need not be extended to receive this signal, the remote's power must be turned on and volume control must be adjusted to allow you to hear the beep and respond to the call. To answer the call, you must fully extend the remote's antenna, naturally,

Muraphone MP-100/101

then press and hold the PUSH-TO-TALK button as long as you wish to talk.

Because this system uses simplex operation, when you finish speaking, you must inform your caller that he can now talk. Then immediately release the PUSH-TO-TALK button so you can hear your caller. At the end of the call, you must push the LINE RELEASE button to disconnect the phone line. When the battery gets weak, or in the event you go beyond usable range, the LINE RELEASE button won't work. Fear not, though, because a built-in timer in the base station takes over and automatically disconnects the line after 2 minutes, even if your caller is still on the line.

The Muraphone also offers intercom and page/call-intercept/call-transfer modes of operation. For either to function properly, it is necessary that a regular telephone be connected to the Muraphone through the accessory jack on the rear of the base station.

Intercom is a useful feature that allows the base station and remote to be used independently of the phone system. Unique to Mura products, intercom isn't found in even the most expensive cordless phones. (Some are claimed to have intercom capability, but the function is totally dependent upon local telephone-company equipment design, which may or may not make it possible to allow operation in the intercom mode.)

To get into the intercom mode, the INTERCOM button must be held down on the base station to activate the beeper in the remote and disconnect the base station and telephone connected to it from the telephone system. Telephone calls can be made or received from other telephone extensions any time the intercom is being used. To restore the Muraphone to normal operation, the INTERCOM button must be released and LINE RELEASE button must be pressed.

There is no capability for the remote to call the base station in the intercom mode, a feature that would make the system much more flexible and useful. (Mura isn't the only manufacturer to ignore this feature; none of the other available units had this capability.) An annoyance with the intercom mode is that the INTERCOM button must be held down for the entire time this mode is being used. Mura deliberately designed-in the hold-down requirement to prevent the system from accidentally being left in the intercom mode, but it is annoying nevertheless.

Call intercept/transfer adds to the system's utility. When a call comes in, it can be screened at the base station before being passed on to the person with the remote unit. The base-station operator can query the person at the remote end, via the intercom mode, and pass on the call only if the person at the remote desires it. While the query is being conducted, the caller is put on hold and cannot overhear the intercom conversation. This very nice feature is another that isn't available with the other more expensive systems we tested.

Mura has two other models of the Muraphone: the MP-50/51 (less than $70) and the MP-300/301 (less than $150). The MP-50/51 has just a receive-only mode and uses a nonrechargeable battery instead of the rechargeable batteries supplied in other Muraphones. The top-of-the-line Model MP-300/301 is a full-function system with the capability to originate as well as receive calls.

Cobra CP-200S and Universal "Tote & Talk"

● *Cobra CP-200S & Universal TEL-3000.* Since these two systems are electrically identical, as revealed by comparing their schematics, they performed identically. Our overall impression is that both systems are quite good. Tested for maximum range, both yielded excellent communication from as far away as 400 feet (rated 300 feet). Full duplex operation is standard, offering telephone-quality communication.

Both systems are designed to be telephone-like in appearance, with their "dials" (pushbutton Touch-Tone® type keypads) in the handsets. These phones are designed to be used with any telephone line, whether or not it has pushbutton capability.

A digit memory in these phones serves two purposes. First, it allows you to key in telephone numbers as fast as you can enter them and makes them available to the dialing circuitry as needed. Secondly, the number, which can contain up to 17 digits, is retained in memory for as long as the power switch on the remote isn't turned off. So, if a number is busy when you dial it, you can try again a few minutes later simply by pressing the * key, which automatically redials the number without requiring you to enter it again digit by digit.

Fused ac power supplies and three-prong grounded-plug line cords are common to both systems. Rechargeable batteries are built in, with the chargers located in the handset cradles. Placing the handsets in their cradles on the base station automatically recharges the batteries. A fully charged battery is rated to give 12 to 15 hours of operating time.

Cordless phones, in general, are sensitive to local electrical noise, but these two systems were somewhat more susceptible than the rest. In particular, the dialing circuits are sensitive to noise generated by digital signals from other equipment, such as from a home microcomputer or calculator.

Base-to-remote paging capability is built-in. Pressing the CALL button lets the remote user know that a call is for him. It is possible to simulate intercom by having the base-station operator lift his phone and dial any number but zero.

This eliminates the dial tone and allows the remote to be called by pressing the CALL button. There are, however, two problems associated with this approach. One is that your telephone is tied up and appears to be busy for as long as you're on "intercom." The second and more serious problem is that, depending on the equipment in your local telephone office, a disrupting tone will appear on the line after 30 seconds to 2 minutes.

Since they're electrically identical, these systems require that you look for other things that make them different when it comes to deciding which to buy. Actual selling price is one. Universal's "Tote & Talk" has a suggested retail price of $249.95, Cobra's CP-200S is $239.95. Another area in which the two systems are different is in the manual supplied with the system. Cobra's is a 16-page booklet that contains clearly labeled drawings and photos and easy-to-follow setup and use instructions. The "Tote & Talk's" manual is an 11" × 17" sheet, printed on both sides and folded in four, containing several unlabeled photographs.

● *Pathcom 8502/8510.* Only Pathcom's Model 8502/8510 "Ez Phone" remote had true telephone styling and could easily be mistaken for a Ma Bell instrument. The base station doesn't have a grounded power cord or external fuse. Ez Phone's rated range is 300 feet, which was easily exceeded in our tests. In fact, we measured it to be 390 feet.

Much thought has apparently been given to security in the Ez Phone, which comes with a choice of five different channels, reducing the probability that two people in a given area who buy from the same manufacturer will have units operating on the same frequency. A transmitter lockout system that shuts off the transmitter to any unauthorized calls once the handset is placed in the base station's cradle is another security feature. When this is done, a SECURE light comes on to inform you that no one can access your phone line. If you have more than one handset and want to be able to call on one unit while another is being charged in the base station, the secure function can be overridden by pressing the SECURE button on the base station.

One of the nice features of the Ez Phone is that base stations and remotes can be bought separately. This allows you to have one base station with several remotes, or several base stations with a single remote, etc., to cover a larger area. This model does not have a memory-redial system, so if you wish to redial a number, you have to key it in again.

Price of an 8502/8510 remote/base system is $349.95. For $50 more, you can get the 8504/8512, which does include automatic-redial as well as intercom functions, the latter permitting a remote to call a base, and vice versa, independent of the telephone line. All Ez Phones offer full duplex and answer/originate operation.

Pathcom's two economy systems are the Model 8501/8511 full duplex answer-only and Model 8400 simplex push-to-talk systems that sell for $194.90 and $129.95, respectively.

Radio Shack ET-300 "DuoFone"

● *Radio Shack ET-300.* The Model ET-300 "DuoFone" from Radio Shack is electrically identical to the Universal Tote & Talk and Cobra CP-200S. Only the packaging is different. DuoFone's remote is housed in a case configured like a walkie-talkie.

Because of its walkie-talkie design, the remote's speaker output isn't as concentrated and, as a result, sacrifices some privacy. In all else, everything said about the Tote & Talk and CP-200S, including the 440-foot range, applies to the Radio Shack ET-300, which is priced at $199.95. The company also offers an incoming-call version, ET-310, for $119.95. In addition, Radio Shack recently introduced a standard pushbutton telephone that has a cordless handset with a claimed 50-ft range ($99.95). Calls are thus made or received at the base unit, and one can walk away with the handset, which is shaped like a more traditional phone.

Pathcom 8502 "Ez Phone"

Electra Freedom Phone FF-1500

● *Freedom Phones FF-1500 & FF-3000.* We tested two of the three Freedom Phones from Electra: Models FF-1500 and FF-3000, which the company rates as having ranges of 300 feet and "up to 600 feet," respectively. (The low-end model FF-500 also has a specified range of 300 feet.) A look at the schematics reveals that both systems are identical for the base stations, but there's a small difference for the remotes. The FF-1500 employs an MK-5098N, the FF-3000 an MK-5099N integrated circuit. The latter is commonly used by other manufacturers and is in the Radio Shack, Cobra, and Tote & Talk remotes. Aside from this, the transmitter and receiver in both cases are identical. The company informs us that the reason for the greater range for the FF-3000 is that all these units are precisely tuned and peaked for maximum possible performance. We also learned that if you happen to get an FF-1500 or FF-500 with components that just by chance result in optimum performance, you'll get the same range as with the FF-3000, which may account for the fact that we obtained the same 440-foot range from both the FF-1500 and FF-3000 in our tests.

The FF-1500 doesn't have an automatic redial feature, while the FF-3000 does. A two-position switch is used to control volume in the FF-3000, but there is no means for controlling volume on the FF-1500. Finally, the FF-3000 is a little more compact, and has a belt clip, carrying case, and interchangeable telescoping whip and flexible rubber-covered antennas.

Suggested retail prices for the FF-1500 and FF-3000 are $299.95 and $349.95, respectively. An economy-end FF-500 is $269.95.

● *Rova/Pro 2500/B.* This cordless phone, from Fracom/Rovafone is the most expensive cordless phone we tested and, to our knowledge, ranks as the most expensive on the market. Although at $649.95, it costs almost twice the price of the next most expensive phone, the Rova/Pro 2500/B offers more than twice the range. In our tests, the range was 925 feet (claimed 1/3 mile or 1760 feet).

Rova/Pro's full duplex remote is much bulkier and heavier than any of the other remotes tested, perhaps to provide features the others don't. It contains a 27-MHz receiver (instead of the 1.7-MHz receiver found in most other systems). Use of the 27- and 49-MHz bands makes it possible to obtain greater range. However, no cordless phone that uses 27 MHz can be manufactured or imported into the U.S. as of December 31, 1980. But the 2500/B can still be sold until December 31, 1981 and can legally be used until the end of 1986.

The Rova/Pro saves wear and tear on the talk switch by allowing you to hang up simply by pressing the # key. On most other cordless phones, you must set a slide switch to OFF to hang up. And for security purposes, the 2500/B requires use of a security code to access the base station.

There are a few disturbing things about the 2500/B, the most annoying being a wait of as long as six seconds between the time the phone is placed in the talk mode and the time you hear the dial tone. One isn't accustomed to waiting for something that occurs instantaneously when you pick up an ordinary

Rova/Pro 2500/B

telephone. Also, there is no volume control on the remote. Furthermore, the normal volume is so high that it may not be comfortable to place the remote against your ear to listen.

Unlike other cordless phones, the 2500/B doesn't recharge its remote's battery in the cradle of the base station. Instead, a separate charger, similar to those used with portable calculators, is used. The base station also uses a small charger-like module to obtain its power from the ac line.

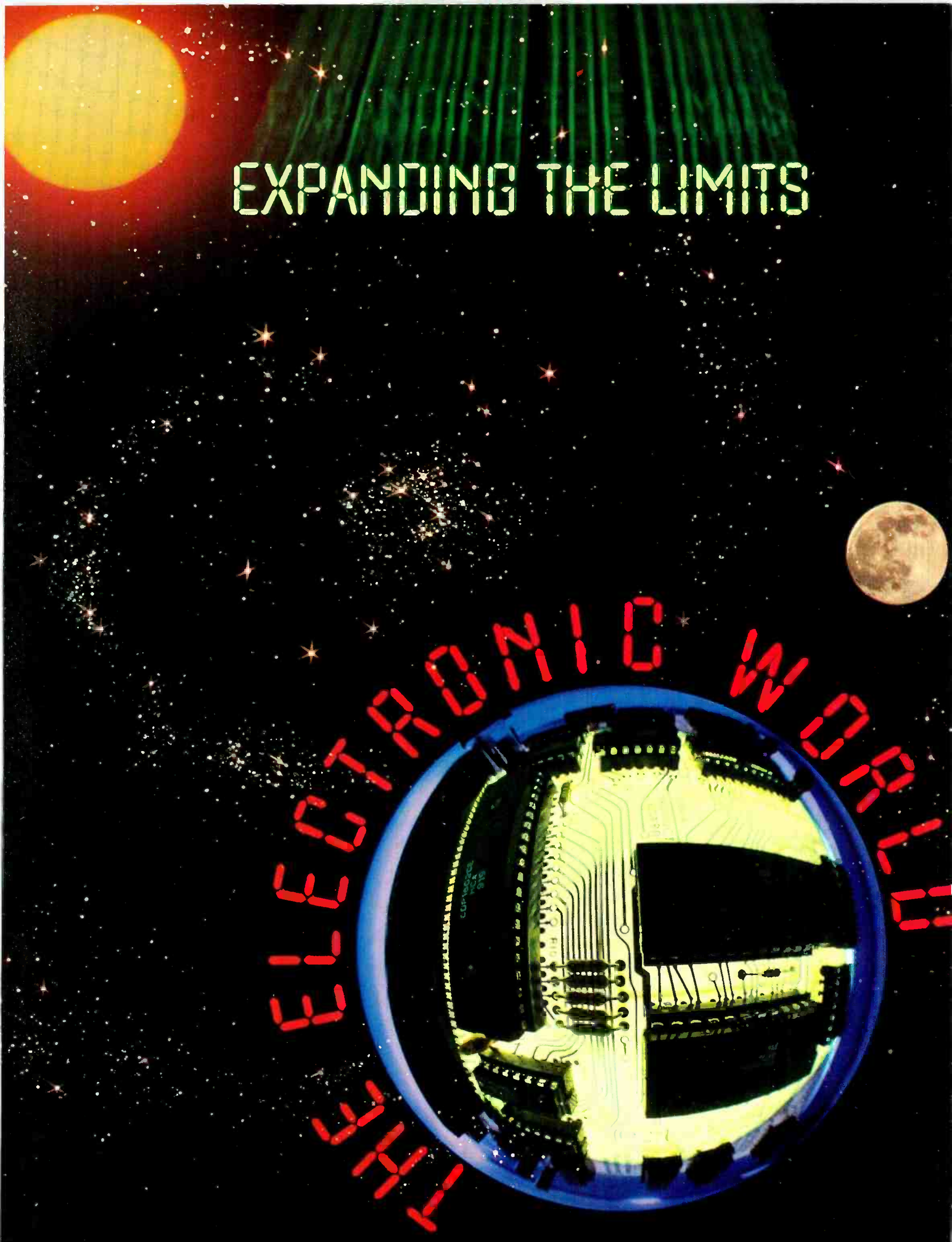
If you have two different telephone lines and wish to use the 2500/B on either one, you can obtain a two-line adapter for $72. For businesses that have multi-line telephones, Fracom has an accessory that allows the 2500/B to be used on any of five lines. It costs $124.95 and includes additional base-station circuitry, cables, 50-pin connector, and a switch-signalling control unit.

The Bottom Line. As a general comment, every system we tested and used for several weeks deserves a passing grade for range, at least in residential situations. While we at first found the simplex units a little cumbersome to use, we quickly learned to accommodate ourselves to the push-to-talk/release-to-listen procedure required, much as CBers have. Duplex operation is preferable, naturally, since people often interrupt a conversation.

Though cordless phones are certainly a boon to users, they do not quite match the fidelity exhibited by line-attached telephones. So expect some noise under certain conditions—perhaps when near a TV set or a noisy fluorescent fixture, and so on. Just orient your position a little and the interference will likely be eliminated. Phones with ear- and mouthpiece in a more or less flat plane are slightly less desirable than those that more closely resemble the familiar standard phone.

Bear in mind, again, that once you buy a cordless-phone system, you don't have to pay a monthly service fee for equipment rental. Install additional wiring yourself and you won't have to pay extra either, owing to recent changes in Federal Communications Commission rulings.

Your local telephone company must be notified when you install your own phone instruments, you should know. The cordless telephones examined here have been registered; just call off the model and make, the registration number and the ringer equivalent number (which indicates how much current is drawn) stamped on the phone when giving the phone company notice about what you're doing. ◇



Produced by Cathie Judge; FotoTeam/USA Inc. □ Concept and photographs by Don Carroll □ Designed by Jane Ronayne

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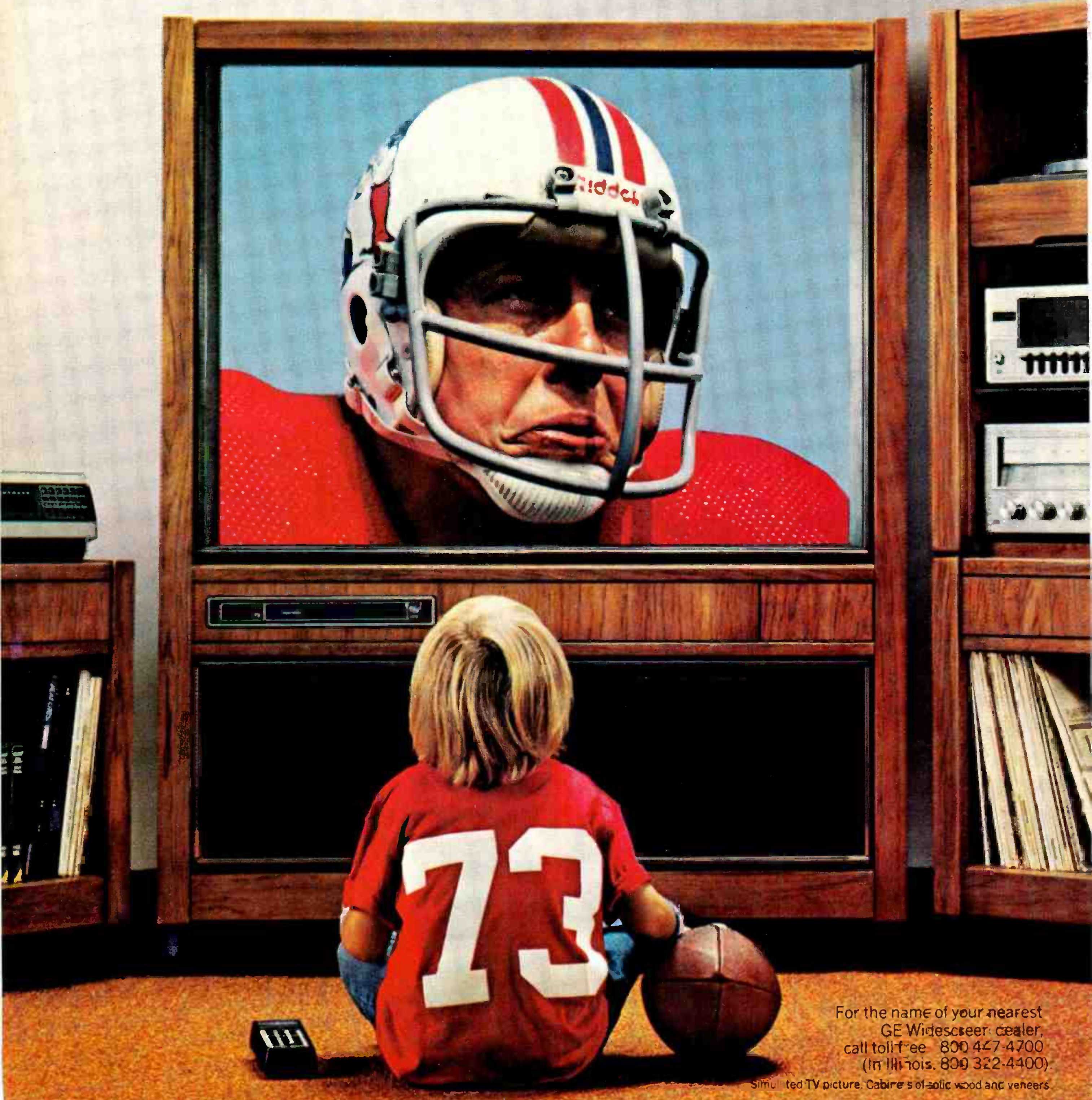

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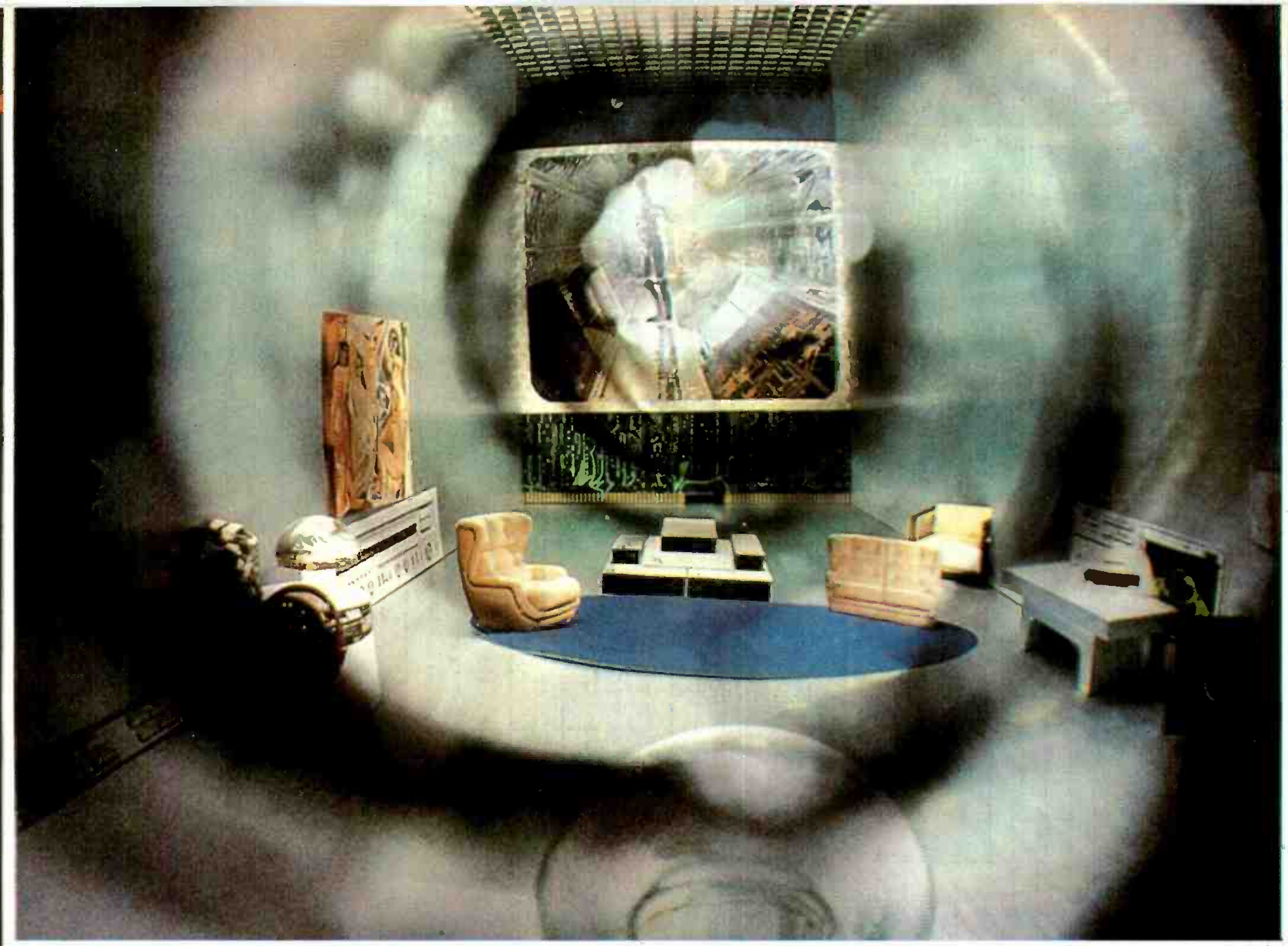


Moving into the '80's . . . Unleashing a decade that promises to see intelligent, electronic systems transform everyday life—breaking barriers, expanding the limits, extending the range of human communication and enjoyment. Change, built on the foundations of the past twenty years, is coming—most notably in video . . . audio . . . computers . . . satellites. The integral parts of the new Electronic World.

VIDEO

Television—the progenitor of video—changed the world as did no other electronic concept. We relax by it, learn from it, dress by its code of commercials. It can make vivid our weaknesses and amplify our strengths. It can unite. It can divide. It has become the eyes of nations, capturing millions of minds in a single instant of time.

Profound words indeed for a media that began in 1945 when "Uncle Miltie" came live, in black-and-white, from DuMont TV into our living rooms. 15 years later, color came on the scene, and with it began an era of remarkable change for the TV receiver. Receivers are no longer designed around discrete components. Now micro-circuits have condensed the electronics to a size that makes "pocket" TV viable. It can go with us everywhere— even to ball games, somehow lending credence to the action we see on the field!

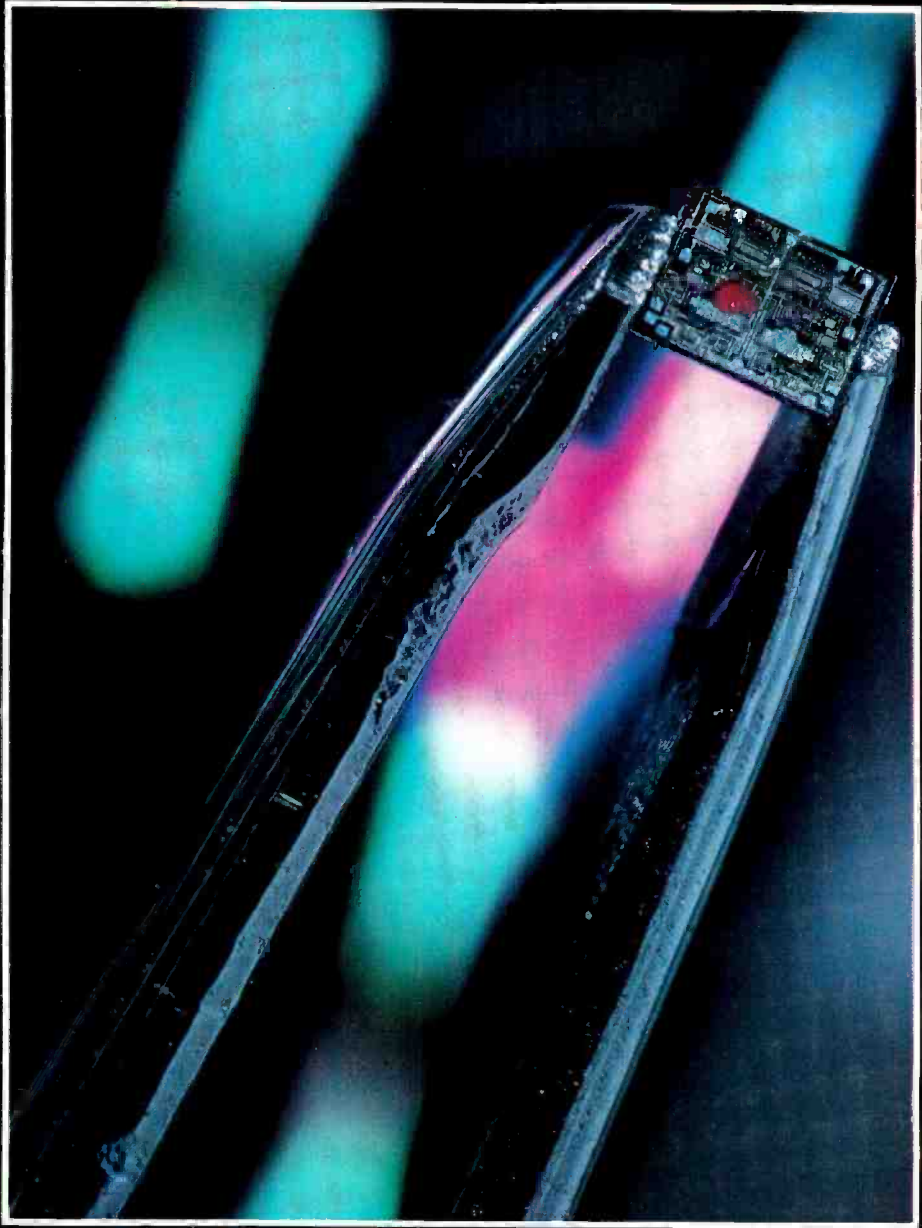
New circuits have also been designed to improve performance. Comb filters increase the bandwidth of a receiver to provide greater picture resolution. Blades of grass look like individual blades of grass—not patches of green. Other circuits automatically set picture quality. VIR systems precisely set colors to the correct tint. Varactor tuning guarantees fine-channel tuning at the push of a button. Audio reproduction has also been improved through better amplifiers and speakers. And high-fidelity sound is there for the taking, thanks to the relatively new full-frequency audio transmission on networks.

Picture tube design has improved picture quality and increased picture size. More recent and more exciting—A remarkable technology of high-light-output tubes is evolving for indirect viewing, commonly called projection TV.

This year, many television manufacturers are offering

The TV screen in a modern home entertainment center will utilize an extensive range of video sources.

"... the video cassette recorder, used as a 'time-shift' machine . . could eventually change the broadcast T.V. industry, making prime time as obsolete as Uncle Miltie."



projection TV with four- to six-foot screens. The philosophy behind these new systems is entirely different and many are not called TV's at all—they are the integral part of our new "home entertainment centers."

An extensive range of entertainment and educational video sources are available to use on our TV screens which (conventional or projection) are merely outlets, as speakers are to a hi-fi system. The modern entertainment center will include a video cassette recorder which can be used as a "time shift" machine, allowing shows to be taped and played back at your convenience—a happening that could eventually change the broadcast TV industry, making prime time as obsolete as Uncle Miltie.

Now, first-run movies are available on pre-recorded video cassettes, and by using the VCR with a portable video camera, "home movies" can be acted, recorded and played back instantly, right on your TV screen.

The newest piece of hardware that makes use of the screen is the video disc, now becoming available nation-wide. This looks like a conventional audio LP, but it contains both audio and video information. Pre-recorded movies, concerts and plays with stereo sound are suddenly alive in your viewing room. Because of the relatively low cost of each disc, instructional shows (How to Play Tennis, Golf, etc.) become practical. It's even possible that the entire Sears' catalog could come to you as a disc with one frame showing merchandise, another pricing, another its uses!

And, there are the video games. Hundreds of game cartridges convert your TV screen to a playing field, road-way, or game board. In addition, cartridges include teaching aids on a variety of subjects for children and adults.

Indirect home programming is growing, too. Over-the-air pay TV provides movies, sports, and other video extras to subscribers owning decoder boxes. Cable companies bring us dozens of additional TV channels with special movie and sports programming. You can even buy your own backyard ground station (prices start at $5000) to intercept a smorg-

The technology of I.C. chips made possible the reduction of bulk and expense in electronic equipment.

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Simulated TV picture. Simulated wood cabinet.

Video Review magazine tests a lot of sophisticated video products.

They get to see virtually every make and type of color TV receiver.

Which makes their selection of Magnavox as their standard TV receiver pretty impressive.

"We thought the Magnavox picture quality and resolution were superb."

"Ever since *Video Review* began testing products," says the magazine, "we've been looking for a top quality, 19-inch TV set that might serve as a standard of reference for all of the other products we test...video cameras, video cassette recorders, video cassettes.

"We thought the Magnavox picture quality and resolution were superb, and that off-the-air sensitivity was also extremely good.

"Major VHF channels were received with uniformly accurate color fidelity. This receiver produced superior color pictures even when using its own indoor VHF and UHF antennas."

"The special tuning features and remote control capabilities of the Magnavox receiver are awesome."

"The tuning system is purely electronic and totally digital," they continue. "There is a fine tune switch and a memory lock button. If any channel is received mistuned, the user simply fine tunes up or down in frequency by holding the button, and when perfect tuning has been achieved, the button is released and the memory lock button is depressed once.

"Nearby is Magnavox's Videomatic feature. Depressing this button activates the electronic eye for automatic brightness adjustment, color adjustment circuits and automatic fine tune."

"...unusually good for any receiver."

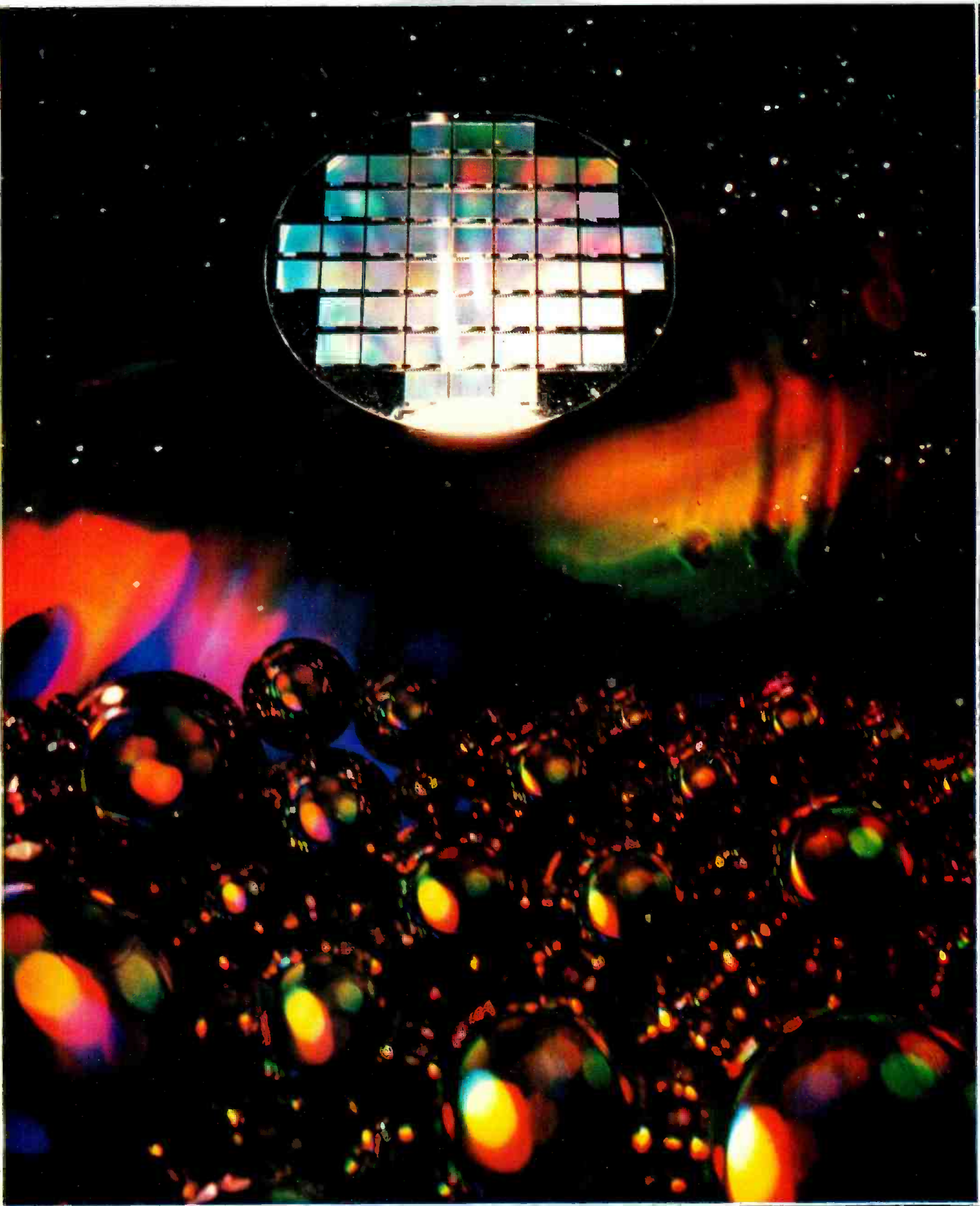
Overall, *Video Review* rated the Magnavox 9.5 or better (out of a possible 10.0) on Video Quality, Reception Sensitivity, Color Fidelity, and Video Resolution and Fidelity. As they put it, "...unusually good for any receiver."

We can only add that once you see a Magnavox color TV at your Magnavox dealer, we think you'll agree.

For Magnavox color TV specifications, write Magnavox Consumer Electronics Company, Dept. 700, P.O. Box 6950, Knoxville, Tennessee 37914.

MAGNAVOX

The brightest ideas in the world are here to play.



asbord of programming directly from an overhead satellite!

What's at the outer limits? Information systems, such as Teletext and Viewdata, could convert your screen to show everything from classified ads to local weather maps. Some systems are interactive—by watching the screen and operating a small keyboard, you could answer questions, play games, or even vote—right from the TV screen.

There's more to come. Successful 3-D tests have already been completed in Australia, and prototype flat-screen, hang-on-the-wall TV has been demonstrated by Japanese and American manufacturers. Holographic transmission gear is in the labs. Actors will no longer be confined to the screen, but will be projected, in three dimensions, into your living room.

The Home Entertainment Center is on its way!

New-generation magnetic bubbles from Bell Labs promise higher speed, greater memory capacity.

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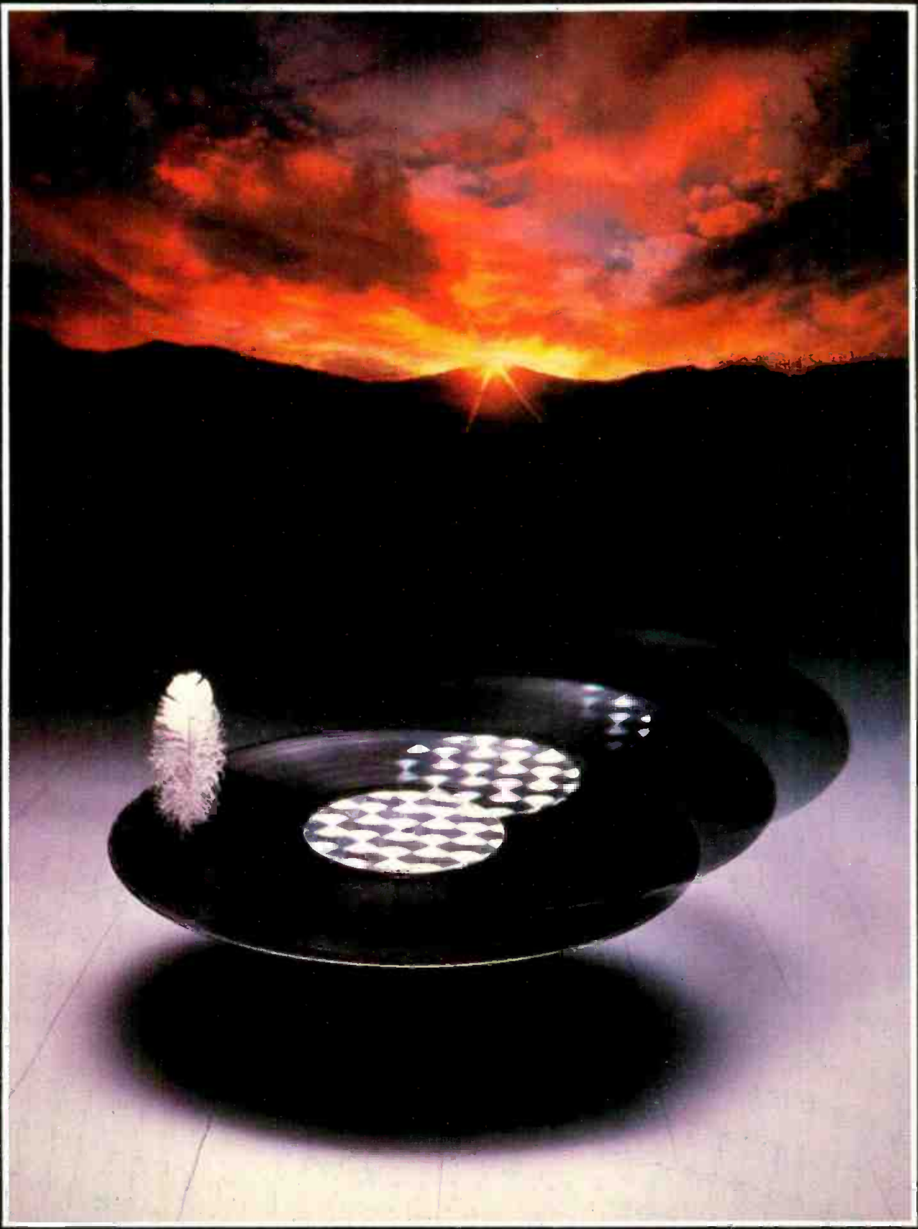


"Ultra-lightweight cartridges flawlessly track record grooves over a wide dynamic range with a minimum of distortion."

AUDIO

Clear, crisp undistorted music came from the demo speakers at the far end of a Manhattan hotel suite.

"Remember," said a spokesman for the 3M Company, "you're not listening to recorded music. You are hearing sounds "created" on a piece of recording tape" by digital pulses.

It was the first public demonstration of commercial digital recording—a quantum leap . . . the biggest news since Edison first recorded sounds on a wax cylinder!

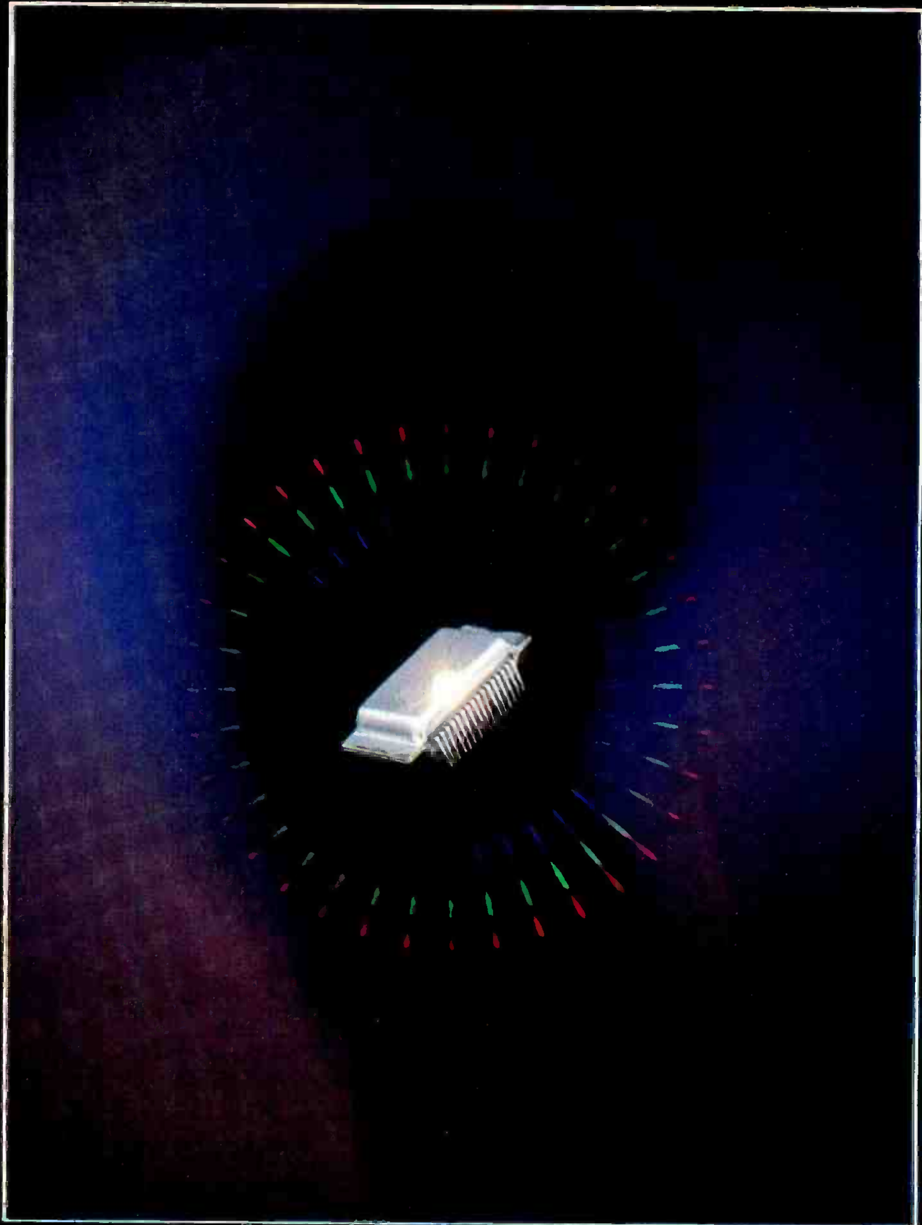
Digital sound begins in the recording studio, where audio mixers, compressors, expanders, and special-effects electronics tailor the live performance to a precise sound even before it's recorded. Master recorders save this sound as digital pieces of information on magnetic tape. The playback—dubbed to discs and tape—precisely matches the original. The result? Consumer copies of performances with optimum reproduction quality.

Throughout the years, each component in a high-fidelity system has been re-designed to take on the challenge of creating realistic audio reproduction in your home. New breeds of motors supply mechanical movement at precision speeds without adding electrical or mechanical noise. Ultra-lightweight cartridges flawlessly track record grooves over a wide dynamic range with a minimum of distortion. Electro-mechanical arms move the cartridge across the record surface in ways that eliminate the slight skew and tracking errors found in earlier conventional arms. Cassette tape formulations have been developed to increase frequency response and dynamic range while decreasing noise and hiss. High-bias heads handle the currents necessary to use new metal tape formulations.

Whether you are listening to records, tapes or a tuner, the extracted audio signal may have been processed

State-of-the-art electro-mechanical arms move across the record surface eliminating the tracking errors found in earlier arms.

"The newest equalizers contain a microprocessor (a tiny digital computer on a chip) which automatically balances your system in seconds."



before it even enters your amplifier. Noise-reduction systems encode and increase signal levels far above inherent noise levels; compressors squeeze minimum and maximum gain levels together for less distortion while recording expanders do the opposite, pulling a signal apart to offer a larger dynamic range.

Amplifiers have progressed to the point where differences in specifications become meaningless to the human ear. Both high- and low-frequency response is well out of audible range, and distortion levels are virtually undetectable. "Front-end" components increase sensitivity dramatically with little increase in noise. Output circuitry allows power levels to reach an optimum level.

Speakers, the final crucial link to our ears, have undergone radical changes, too. Inside, new materials--from fibers to metals—move air more efficiently for higher sound level, better frequency response, and lower distortion. Equalizers have given speakers electronic help by helping balance a system despite room acoustical problems. The newest equalizers contain a micro-processor (a tiny digital computer on a chip) which automatically balances your system in seconds. Slowly, the "digital" circle from recording studio to home system—is becoming complete!

Exciting innovations wait in a future where records and tapes will be composed of digital bits of information that are processed--not played--through your system. (A digital record format, played by a tracking laser beam is already a reality)! Specifications may become a thing of the analog past. Distortion is not part of the digital information, so it simply doesn't exist on playback.

With digital systems, the future of audio is full of extended possibilities—for example, you may buy an opera tape and program the key in which you'd like it sung at your system . . . or, you may "swap" recordings over the phone with a friend—the re-assembled digital data will create another exact replica at the other end!

Bell Laboratories' 30,000-element micro-processor—a computer on a chip with varied tele-communication applications.

Lux Tuner/Amplifiers

R-3055—55 watts per channel, minimum RMS into 8 ohms, both channels driven from 20–20,000 Hz with no more than 0.05% Total Harmonic Distortion.

Sound thinking is... DUO-βETA and intelligent tuning.

Sound is all we think of. Exquisite sound, rich and full from top to bottom. With the kind of sophistication that simplifies, so everything about Lux/Tuner/Amplifiers is functional... designed for a purpose.

Great sound starts with super-stable, DC amplification for low inherent distortion, high dynamic range and wide bandwidth. Then, with Lux's exclusive duo-Beta circuitry, distortion is taken below audibility...almost unmeasurable.

R-3030—30 watts per channel, minimum RMS into 8 ohms, both channels driven from 20–20,000 Hz with no more than 0.05% Total Harmonic Distortion.

We've eliminated the flat amp stage which reduces phase distortion even further, and designed the tone controls into the power amplifier section. Finally, a subsonic filter removes the last traces of audible rumble and other low frequency noise.

Superior sound also depends on pinpoint center tuning. Lux's intelligent tuning systems find—and hold—that elusive center. Mistuning is a thing of the past.

Lux's new, Flash Tuning System* is an array of LEDs which point the direction to tune, automatically changing into a signal strength indicator at the exact center tuning point.

R-3045—45 watts per channel, minimum RMS into 8 ohms, both channels driven from 20–20,000 Hz with no more than 0.05% Total Harmonic Distortion.

Another system, Closed Loop Locked (CLL) Acculock, provides an electro-mechanical lock at the exact center tuning point. You can do it blindfolded. The Acculock system includes variable sensitivity and a lock defeat for every tuning circumstance.

Lux's Tuner/Amplifiers: R-3030, R-3045 and R-3055 incorporate duo-Beta circuitry and Flash Tuning. R-3055 includes CLL Acculock as well. Both the R-3045 and R-3055 have provision for MC cartridge, with variable input impedance and equalizer gain...automatically.

Every Lux Tuner/Amplifier is built with a host of features...the expected and the exclusive. But the definitive test is performance. Superb sound, simply achieved. Listen at your Lux dealer. Lux Tuner/Amplifiers ...better because they're built with sound thinking.

*Patent Pending

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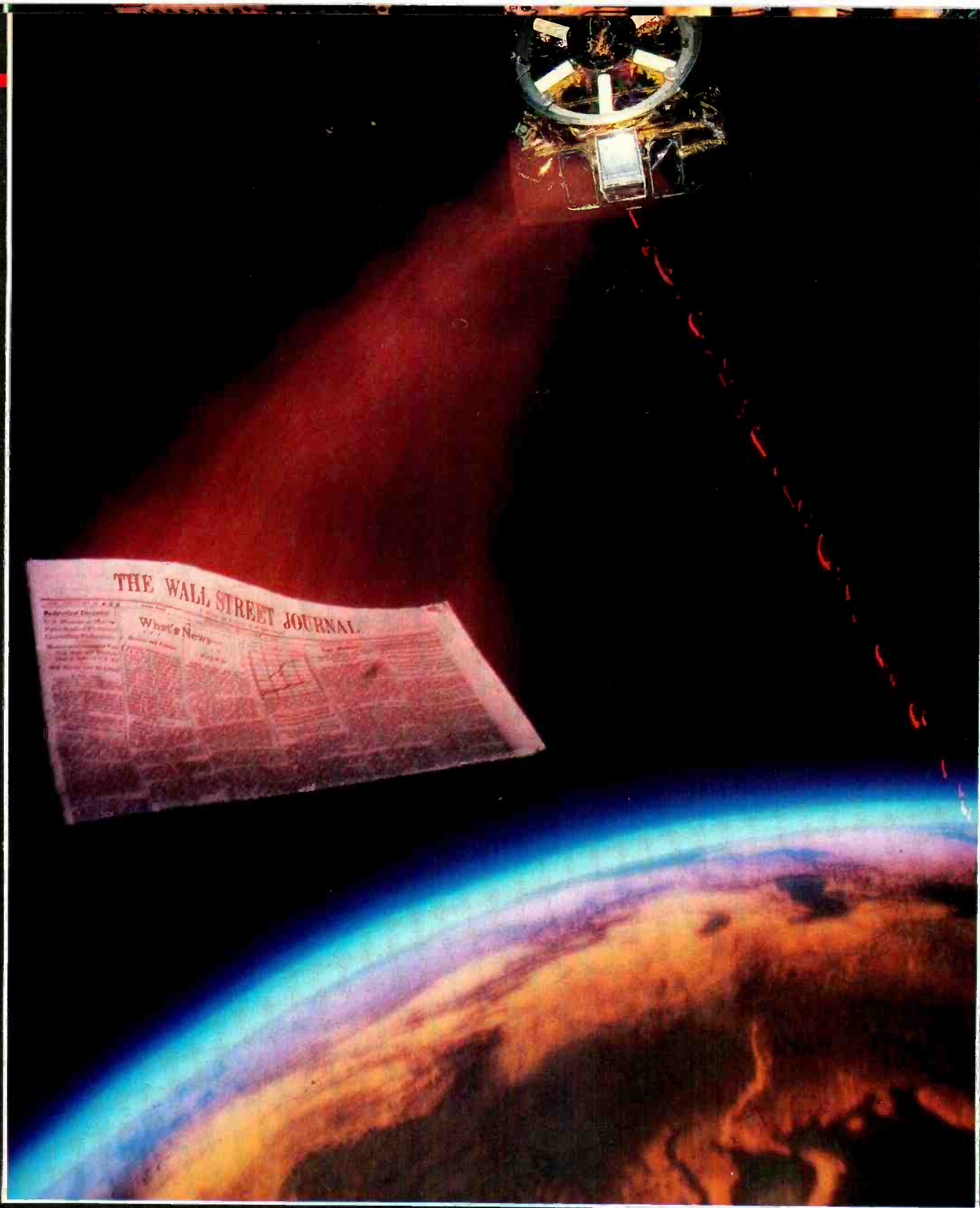
CIRCLE NO. 35 ON FREE INFORMATION CARD



and retrieve data—phone numbers, addresses, etc.

Computers also work in tandem with external devices. They control printers to make a permanent paper record of what's seen on a TV screen. In micro-seconds, disk-drive systems save and retrieve thousands of pieces of data for the computer to use. Speech processing systems let you give the machine audible commands; synthesizers allow it to talk back—in its own voice—or compose its own music. Remote control devices even permit a computer to operate the lights and appliances in your home.

By controlling a modem (modulator/demodulator) a computer can communicate with other computers over a standard phone line. The potential is mind-boggling!

Now, there are a number of such computer services available for use. Dial one of them, attach your computer to the

The Wall Street Journal hastens story text between typesetter and printer via satellite.

THE FIRST HIGH GRADE VIDEOTAPE.

Video cassette recorders have changed a lot in the last few years. New features like six-hour recording, slow motion and freeze frame have added a great deal to home recording.

But there's one drawback. To utilize these new features, you must operate your cassette recorder at a slower speed. And this places increased pressure on the videotape, which can cause the magnetic oxide particles on the tape's surface to loosen and eventually fall off. Once this starts to happen, a loss of picture quality isn't far behind.

At Maxell, we've always been aware that a video cassette recorder can only be as good as the tape that goes in it. So while all the video cassette recorder manufacturers were busy improving their recorders, we were busy improving our videotape.

The result is Maxell Epitaxial HG, the first high grade VHS videocassette. In technical terms, there are several significant differences between our high grade and regular videotape.

For one thing, our oxide particles are smaller and more densely packed on the tape surface. Which is why we have a better frequency response and signal-to-noise ratio, especially at the slower recording speeds.

And, because of our unique binding process and calendering system, the oxide particles on Maxell HG stay put. This drastically reduces friction and video recorder head wear. So not only will you get better picture quality, but you'll be able to enjoy it a lot longer.

All in all, no other home videotape can deliver better color resolution, sharper images or cleaner sound than Maxell HG.

So if you own a VHS recorder, please remember one thing. If you want high grade picture quality, you need a high grade tape.

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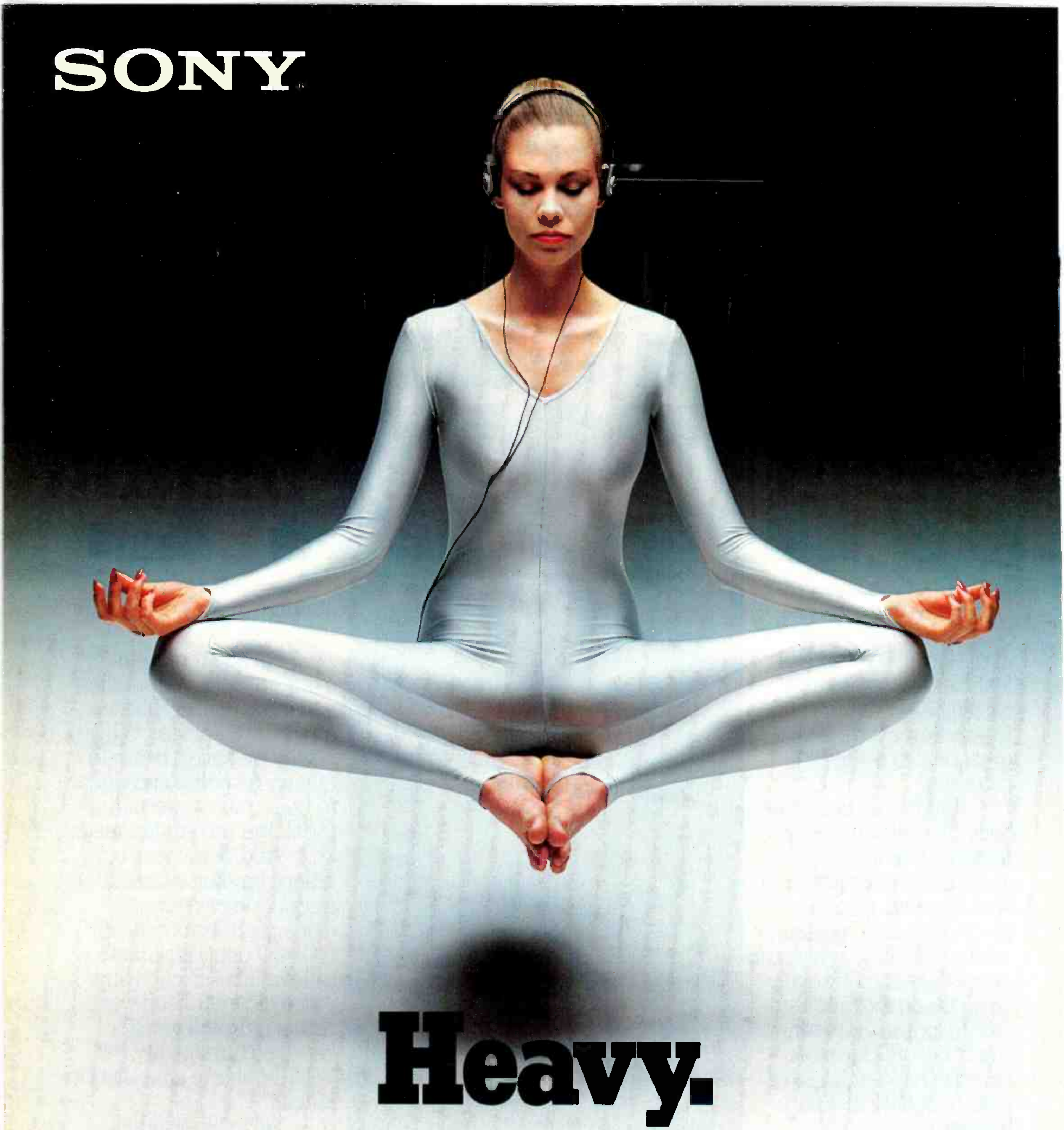

Heavy.

Introducing another Sony only. The MDR series open-air headphones. The smallest, lightest stereo headphones available today. Or tomorrow.

With our lightest at 40 grams, you will barely know you're wearing them. Yet the sound is dynamite.

Through a remarkable new audio breakthrough, our engineers have succeeded in reducing big-headphone technology down to the size of your listening channels.

The MDR series headphones' airy spaciousness delivers absolute clarity through an ultra-small driver unit that produces more than three times the energy of conventional circuits. And a new high-compliance diaphragm accurately reproduces the 20 to 20,000Hz bandwidth and improves low-range response.

That means you can listen to the heaviest of music for hours. Lightly. And know that you're hearing every nuance of the original recording from deep bass to the highest treble.

Listen to our new MDR series headphones. They're light. And heavy.

STEREO HEADPHONES
MDR

CIRCLE NO. 57 ON FREE INFORMATION CARD

"Satellites . . . giant switchboards in the sky, silently accepting and sorting radio frequencies from one direction and sending them off in another."

phone with a modem, and you'll be in touch with thousands of programs and data banks. Get national and international airline schedules, make vacation reservations, order gifts, read the latest news over AP and UPI wire services, or send correspondence over electronic mail channels. It's easy to see how home computers will change the way we live!

Shopping could become unnecessary, as could money and credit cards. Newspapers and magazines may be delivered electronically with immediate updates as they occur. We may no longer have to travel to work . . . and the postal department may never get another letter to lose!

Sound improbable that a "machine" could cause such massive changes? In five years, some experts predict, one out of every four homes will have a computer terminal or control unit that will modify living habits for the better. Implementing a host of commercial developments--bubble memories, fiber optics, et al--will make the shape of tomorrow's world feasible.

SATELLITES

In 1957, the world was to learn of a new page in science. A sphere, no larger than a basketball, had been put into orbit. Its message to radio listeners? A simple "beep" that sounded once a second indicating it was alive. Its message to visionaries? Vast, dependable, worldwide communications in less than a decade.

By 1965, the US had launched the Early Bird, a satellite capable of relaying 240 phone calls or one TV broadcast, the first of over 30 such communications satellites (comsats) now fixed over the earth.

Since then, satellites have become a standard link in all our conventional communications. Make a phone call from state to state, and the odds are your voice will have traveled some 45,000 miles through a satellite before reaching your party's ear. For television, "live via satellite" has meant instant and simultaneous viewing for millions of people throughout the world. Satellites such as Comstar handle some 18,000 phone calls and dozens of TV channels at one time. They're giant switchboards in the sky, silently accepting and sorting radio frequencies from one direction and sending them off in another.

What of the unconventional? For that, satellites both aid communications, and sometimes create a totally new form of media. At the push of a button, NASA meetings can include members from all over the country. Each participant sits in his own teleconferencing room, able to see and hear all others via satellite.

In addition to visual and audible human communication, satellites can have a tremendous effect on machine communication. Smart machines—from computers to photo copiers—are no longer restricted to the relatively low data rates imposed by phone lines. Data, which take hours to send over a phone line, will move in literal seconds through a satellite network. In addition to being faster, it can be cheaper, and is fast becoming practical.

Electronic mail can be sent from the desk of one company executive to another anywhere in the country in seconds. The "writing" is done on CRT screens linked to the company central computer. Depending upon the urgency, it is sent instantly or held in storage to be batched with others for a mass "mailing."

For news services such as AP and UPI, speed is essential. Both have satellite capability for instant text distribution and the Wall Street Journal hastens story text between typesetter and printer via satellite.

Satellite communication also has many direct effects on us. Home Box Office supplies TV viewers with first-run movies on home television sets. The distribution network? Satellite. The "Superstations" have turned the heads of more than one commercial TV network executive. Overnight, small TV stations, through access to satellite distribution, become major rivals to established networks. Ted Turner, owner of the first Superstation out of Atlanta, estimates some 2.5 million people are now tuned in to his system--and expects three times that many by the middle of 1981.

TV-via-satellite can offer a more personal touch as it did during the Republican convention in Detroit. While networks carried the events of national interest, reporters from three independent news affiliates were beaming individual state views to local stations over a Westar satellite.

In the near future, this personal touch may prove to be a twist of technological fate. Since the beginning, satellite communication has been thought of in global concepts—thousands of miles of space brought into mirror view by electronic servants. Even the technology of today's sophisticated craft support that use. Relatively low levels of energy beam earthward in a scattered array to be picked up by giant signal-gathering dishes which re-focus the energy into sophisticated electronics for practical use.

But looking to the future . . . it seems that satellite communication may give us a closer, more personal view of our immediate concerns. Two areas of technology make that possible: superior receiving electronics packages have greatly reduced the size of the antenna needed to capture signals. (A 10-foot diameter dish can be used in lieu of the 100-foot requirement established earlier.) Add to this the dramatic drop in cost for state-of-the-art components, and the result is a do-it-yourself backyard ground station. The cost? $5000 and up . . . and it's available from a catalog!

Tests have been successfully completed using super high-frequency, high-powered satellites. Canada, the U.S. and Japan have a joint venture in CTS, a communications satellite capable of broadcasting directly to your TV set. The antenna? A desk-top dish that measures just under two feet across. The down-link necessary fits in your hand and is planned to cost under $500! □

Educator, Entertainer, Accountant.

Your Challenger Personal Computer.

Through the miracle of modern technology, a complete computer as powerful as the multimillion dollar room-sized computers of a few years ago can be put in a package the size of a typewriter and sells for as little as a color television set!

Through its years of microcomputer experience, Ohio Scientific has effectively channeled this tremendous computer power into a "friendly" computer with hundreds of personal uses, via a huge software library of programs for a broad range of personal, home, educational and business use.

This available software allows you to use and enjoy your computer without becoming an expert. The Challenger, however, is a powerful, general purpose computer which can be programmed in several languages by those who choose to.

Here are just a few of the popular uses of an Ohio Scientific Challenger Computer:

Education

The personal computer is the ultimate educational aid because it can entertain while it educates. Software available ranges from enhancing your children's basic math, reading and spelling ability, through tutoring high school and college subjects, to teaching the fundamentals of computers and computer programming.

Entertainment

Many of the Challenger's games educate while they entertain, from cartoons for preschoolers to games which sharpen mathematical and logical abilities. But, entertainment doesn't stop here. The Challenger's graphics capabilities and fast operation allow it to display action games with much more detail than the best video games, providing spectacular action in games such as Invaders, Space Wars, Tiger Tank and more! All popular sports such as golf, baseball and bowling are available as simulated computer games as well as many conventional games such as chess where the computer plays the role of a formidable opponent.

Accounting

Your Challenger computer can keep track of your checkbook, savings account, loans, expenses, monitor your calorie intake and your biorythms.

If you are involved in a business, you can use it to do word processing; accounting, inventory control, order processing, customer lists, client records, mailing labels and planning.

And more:

This may seem like a lot of uses, but it's only the tip of the iceberg for a general purpose computer. For example, your Challenger can be expanded to control lights and appliances, manage your energy usage and monitor for fire and break-ins. Furthermore, it can communicate with you, with other computers and the new personal computer information services over the telephone.

In fact, the uses of general purpose, personalized computers are expanding daily as more and more people discover the tremendous capabilities of these new technological wonders.

Ohio Scientific offers you four personalized computer systems starting at just $479.

For a free catalog and the name of the dealer nearest you, call 1-800-321-6850 toll free.

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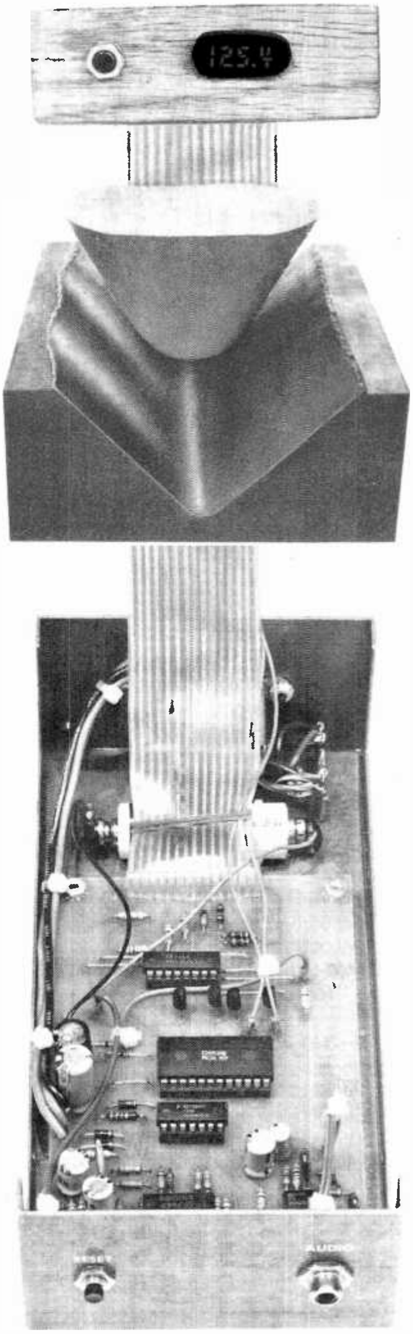
HOW MANY HOURS ARE ON YOUR PHONO STYLUS?



BY DENNIS BOHN

ALMOST every hi-fi phono stylus is made from the hardest substance known to man—diamond. Even a diamond stylus, however, will become appreciably worn after a given number of hours of use. Keeping track of the number of playing hours a stylus has accumulated—and thus indirectly the degree to which it has become worn—is important for two reasons. Using a worn phono stylus dramatically reduces playback fidelity and can cause catastrophic, permanent physical damage to the grooves of a vinyl recording.

Presented here is a simple, inexpensive project that logs the number of hours a stylus has been used. This information is displayed at the push of a button on a four-digit, seven-segment LED readout to the nearest tenth of an hour. The low construction cost of this project—$50 or less—makes it an ideal solution to the problem of monitoring stylus use. With it, you will eliminate both the risk of using the same stylus too long and the needless expense of replacing it too soon.

About the Project. One principal design goal was to produce a circuit that would provide as accurate a count of actual stylus *playing time* as possible. This immediately ruled out the use of any scheme involving the sensing of the amount of time that the turntable was simply on. What was required was a method of determining the amount of time that the cartridge would actually be generating an audio output for subsequent processing by the phono preamp. This is the approach that was taken in the project described here.

The project is shown schematically in Fig. 1. Because there is no easy access to the output of the phono-preamp stage (apart from the fact that most equipment warrantees would be voided by any such tampering), the stylus timer begins with its own RIAA phono preamplifier. The audio output of one of the cartridge's channels is tapped at the stereo system's phono-preamp input by means of a Y connector/adapter and a short patch cord. Sensing the input signal of only one audio channel was deemed sufficient for the accuracy required. It is highly unlikely that long periods of time will exist in which there is a total absence of signal in one channel of a typical stereo disc.

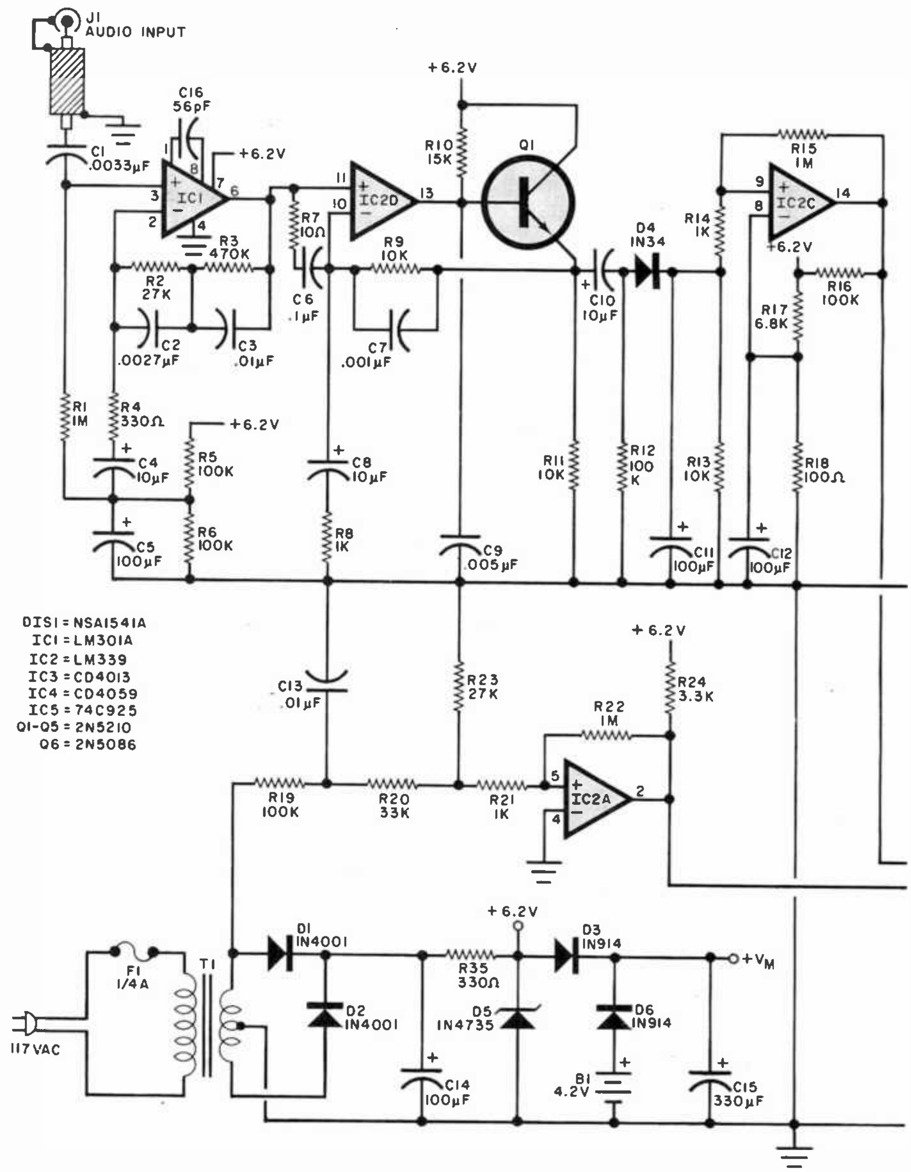
The output of the phono cartridge is applied to AUDIO INPUT jack *J1*. One megohm of resistance (*R1*) and 20 pF or less of parasitic shunt capacitance comprise the input impedance of the project. This means that there is no additional, significant loading of the cartridge. Therefore, the stylus timer's input network does not appreciably alter the loading and hence sonic performance of the phono cartridge.

Operational amplifier *IC1* boosts the level of the input signal and, with the help of *R2*, *R3*, *C2* and *C3*, provides RIAA playback equalization. Because the op amp is powered by a single-ended supply, dc level-shifting of the input signal (performed by *C5*, *R5* and *R6*) and capacitive input coupling (furnished by *C1*) are required. Output signals from *IC1* are directly coupled to the noninverting input of *IC2D*, which is one-fourth of an LM339 quad comparator. This stage is operated in linear fashion as an op amp with transistor *Q1* inside the overall feedback loop. Resistors *R10* and *R11* determine the bias of *Q1*. Resistor *R7* and capacitors *C6*, *C7* and *C9* furnish frequency compensation to ensure stability.

The 20 dB of gain provided by *IC2D* and the 40 dB of gain supplied by *IC1* (at 1 kHz) boost the input signal to the level required by the half-wave rectifying and averaging network *D4*, *C11*, and *R13*. The amplified input signal is converted into a positive dc voltage appearing across capacitor *C11*, which charges rapidly and discharges slowly through *R13*.

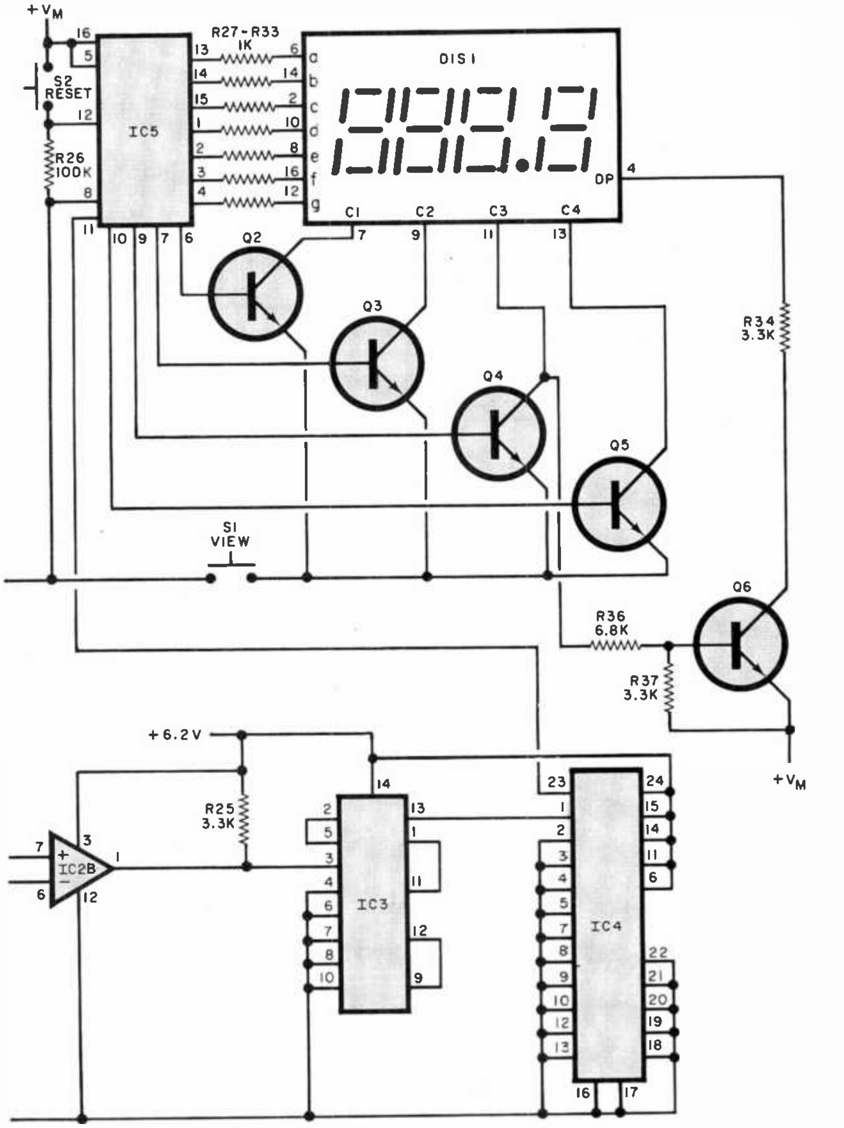
Comparator *IC2C* accepts the dc voltage appearing across *C11* and compares it with the reference of approximately 100 mV generated by *R17*, *R18* and *C12*. Resistors *R14* and *R15* provide hysteresis to stabilize the comparator. The output of this comparator is applied to the noninverting input of comparator *IC2B*, while the inverting input receives a shaped timebase signal derived from the ac power line. Transformer *T1* supplies a low-voltage 60-Hz sine wave to low-pass filter *R19C13*, whose output is attenuated by voltage divider *R20R23*. The attenuated sine wave, converted into a square wave with a dc offset by *IC2A*, is applied to the inverting input of comparator *IC2B*.

This comparator passes timebase pulses when audio from the cartridge drives the output of *IC2C* high. Timebase pulses then reach the CLOCK input of the first section of dual D flip-flop *IC3*. The mismatch between pull-up re-



PARTS LIST

B1—4.2-V mercury battery (Mallory TR-133 or equivalent)
C1—0.0033-μF Mylar capacitor
C2—0.0027-μF Mylar capacitor
C3—0.01-μF Mylar capacitor
C4, C8, C10—10-μF, 6.3-V tantalum capacitor
C5, C11, C12—100-μF, 10-V, radial-lead electrolytic
C6—0.1-μF disc ceramic capacitor
C7—0.001-μF Mylar capacitor
C9—0.005-μF disc ceramic capacitor
C13—0.01-μF disc ceramic capacitor
C14—100-μF, 35-V, radial-lead electrolytic
C15—330-μF, 6.3-V tantalum capacitor (see text)
C16—56-pF disc ceramic capacitor
D1, D2—1N4001 rectifier
D3, D6—1N914 signal diode
D4—1N34 germanium signal diode
D5—1N4735 6.2-V zener diode
DIS1—Four-digit, common-cathode LED display (NSA1541A or equivalent)
IC1—LM301A operational amplifier
IC2—LM339 quad comparator
IC3—CD4013 dual D flip-flop
IC4—CD4059 programmable divide-by-N counter
IC5—MM74C925 four-decade counter with multiplexed four-digit, seven-segment output drivers
J1—Insulated phono jack
Q1 through Q5—2N5210 or equivalent npn silicon transistor
Q6—2N5086 or equivalent pnp silicon transistor
The following, unless otherwise specified, are ¼-watt, 10% tolerance, fixed carbon-composition resistors.
R1, R15, R22—1 MΩ
R2, R23—27 kΩ
R3—470 kΩ
R4—330 Ω
R5, R6, R12, R16, R19, R26—100 kΩ
R7—10 Ω
R8, R14, R21, R27 through R33—1 kΩ
R9, R11, R13—10 kΩ
R10—15 kΩ
R17, R36—6.8 kΩ
R18—100 Ω
R20—33 kΩ
R24, R25, R34, R36, R37—3.3 kΩ
R35—330 Ω, ½ W



S1, S2—Normally open, momentary-contact pushbutton switch
T1—24-volt center-tapped, 40-mA step-down transformer
Misc.—Printed circuit board, IC sockets or Molex Soldercons, battery holder, fuse holder, suitable enclosure, Y phono-connector/adapter, shielded cable, phono plugs, hookup wire, line cord and strain relief, suitable hardware, solder, etc.

Note—The following is available from TOLECO Systems, Box 401, Kingston, WA 98346: kit of parts consisting of all required integrated circuits, common-cathode LED display, and etched, drilled and plated glass-epoxy printed-circuit board, No. ST-1, for $29.95, plus $2.00 postage and handling in U.S., $4.00, foreign. Also available separately is the etched, drilled and plated glass-epoxy printed-circuit board, No. ST-2, for $8.95, postpaid in U.S. Washington state residents, add 5.3% sales tax. No COD or foreign-currency orders. The project as designed is suitable for use only in those areas whose power-line frequency is 60 Hz.

Fig. 1. The audio input is obtained from one channel of the cartridge output to the phone preamp. It is then amplified and rectified and compared to a reference to create timed pulses and drive the digital display.

sistors *R16* and *R24* holds the output of *IC2B* low in the absence of a signal from the cartridge.

The timebase signal from *IC2B* passes to dual D flip-flop *IC3*, which functions as a divide-by-4 counter. A 15-Hz pulse train appears at the Q output of the second flip-flop in *IC3* (pin 13) when *IC2B* allows the clock signal to pass. This pulse train is applied to the input of *IC4*, which is programmed to divide the input frequency by 5400. The resulting output pulse train has a period of 6 minutes or 0.1 hour and appears at pin 23 of *IC4* to clock four-decade counter *IC5*.

This chip contains not only counting stages but also seven-segment decoders and multiplexed display drivers. The outputs of *IC5* drive not only the seven segment lines of *DIS1* but transistors *Q2* through *Q6* as well. The latter drive the digit and decimal-point cathode lines of the display. Their emitters are connected together and to one side of pushbutton VIEW switch *S1*, the other side of which is grounded. No current flows through the LED display until the VIEW switch is closed. The elapsed stylus playing time is indicated in hundreds, tens, units, and tenths of an hour up to 999.9 hours. When 999.9 hours have been tallied, counter *IC5* resets to 000.0. The user can manually clear the counter by closing RESET pushbutton switch *S2*. Resistor *R26* is the pull-down component for switch *S2*.

A simple single-ended, full-wave supply satisfies the project's power requirements. There is no power on/off switch; line power should be applied continuously so that the information stored in *IC5* is not lost. One simple way to do this is to plug its line cord into the audio preamplifier's or receiver's unswitched power socket. Mercury battery *B1* and steering diodes *D3* and *D6* ensure that the count stored in *IC5* is not lost during power failures and during times when it is necessary to unplug the timer from the power line. Current drain of *IC5* is low, making battery life at least as long as that of the stylus. It is good practice to replace the battery each time the stylus is replaced. Capacitor *C15* is optional and supplies power when both ac and battery power are lost.

Construction. The high impedances and gains of the early stages of the signal-processing chain make the use of a carefully designed printed-circuit board almost a necessity. An etching and drilling guide and component layout are shown in Fig. 2. To keep construction cost low, a single-sided pc board using several jumper wires was used. As long as the jumpers are as short as possible and are installed neatly, they need not be insulated.

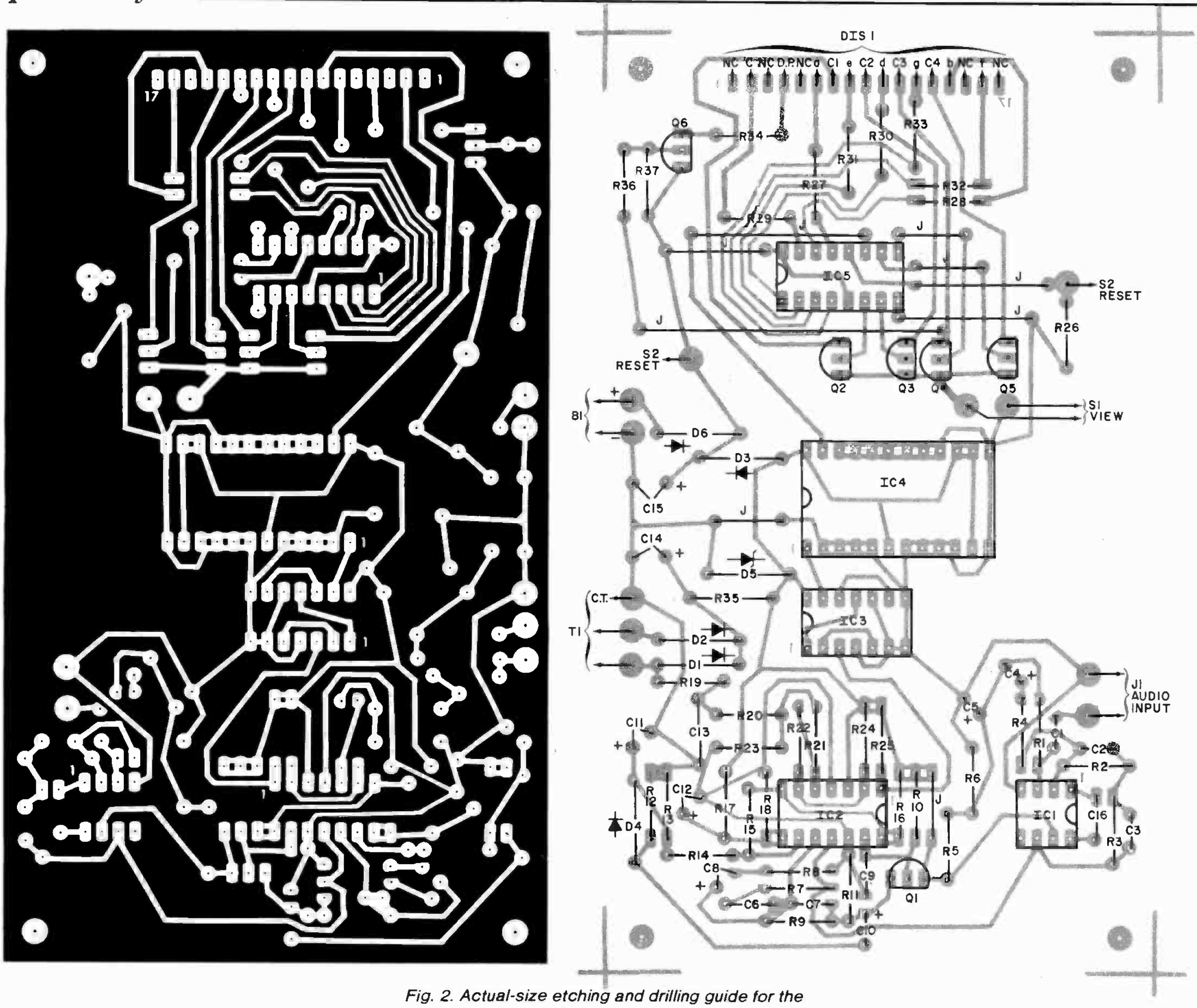


Fig. 2. Actual-size etching and drilling guide for the printed circuit board is above left, component layout at right.

After the jumpers are in place, install the resistors, and then the diodes—in the correct polarity. Molex Soldercons or IC sockets should be mounted on the board after the diodes, and then the capacitors should be installed. (The polarities of electrolytic capacitors must be observed.) Finally, the transistors should be installed. Using a small-tipped, low-wattage soldering iron and small-diameter (No. 22 AWG or similar), 60/40 rosin-core solder, make all necessary connections.

When all pc components have been mounted on the board, use suitable lengths of shielded cable and hook-up wire to connect the appropriate foil pads to those components that are not mounted on the board. Connect the shield of the cable running between input jack *J1* and the input foil pads at both ends. However, use an insulated phono jack to prevent a ground loop from arising. A suitable length of multiconductor ribbon cable can be used between the pc board and the display.

The author's prototype is housed in an aluminum utility box that encloses everything except the LED display and the VIEW switch. These were mounted on a small piece of oak and interconnected with the boxed section by a length of multiconductor ribbon cable. This arrangement permitted the placement of the utility box behind the audio preamplifier and the attachment of the oak display board to the rear of the turntable. The RESET switch was mounted *inside* the enclosure to prevent accidental switch closure and loss of count.

The display used by the author is a four-digit calculator-type readout selected for small size and low current demand. However, almost any type of LED display can be used, so long as it is of common-cathode design and is compatible with multiplexing. Discrete-digit LED readouts can be used in this application if all pins corresponding to the same display segment (a, b, c, etc.) are connected together to the appropriate outputs of *IC5*. Any available display color is acceptable. However, the use of a LED readout other than the one specified might require a change in value of current-limiting resistors *R27* through *R33*. Increasing the resistances will result in diminished display current and brightness. Decreasing them will cause more current to flow and more light to be radiated by the display segments. The output drivers of *IC5* can source a maximum of 30 mA, so the lower limit of resistance for *R27* through *R33* is approximately 100 ohms.

Transformer *T1* as specified is a 24-volt center-tapped component with a rated secondary current of 40 mA. The author's prototype has an actual current demand of approximately 32 mA in either the STANDBY (*S1* open) or VIEW (*S1* closed) mode. In the latter, the flow of display current causes a decrease in current flow through zener diode *D5*. This is why the overall current demand remains constant whether the readout is glowing or not. If a display requiring more current is used, *T1* will have to be a component that can deliver more secondary current.

In any event, to minimize hum pickup and possible false time counts, the transformer should be positioned as far away from the input stage as possible. Its leads should be routed along the opposite side of the pc board from the input cable or, even better, at the opposite side of the board and at right angles to the input cable.

Installation and Use. For initial checkout, plug the line cord into an ac power socket and depress the VIEW pushbutton switch. The display should read 000.0. If it indicates some other number, momentarily close the RESET switch and verify that the display returns to 000.0 when the VIEW switch is closed again.

Next, position the project near your turntable and preamplifier in such a way that the LED display can easily be seen. Make sure that the audio system is turned off. Then disconnect one of the signal cables running from the turntable to the PHONO input jacks of the system's preamplifier. Either the right- or left-channel output of the turntable can be used. Connect a suitable Y adapter to the unoccupied preamplifier PHONO input jack and plug the floating output cable from the turntable into one of the adapter's two phono jacks. Finally, connect one end of a patch cord to the remaining Y-adapter phono jack, and the other end of the patch cord to the project's audio input jack (*J1*).

Turn the stereo system on and play a record for slightly more than six minutes, verifying that the display reads 000.1 hour when the VIEW switch is closed. If it does, return the tonearm to its rest position and unplug the project's line cord from the power socket. Wait a few minutes and reconnect the project to the ac power source. Depress the VIEW pushbutton switch once more. A readout of 000.1 hour on the LED display confirms that the battery-powered memory-backup circuit is working.

Finally, apply ac power t the stylus timer and to the audio system. Place the preamplifier's mode selector switch in its PHONO position, leaving the tonearm in its rest position. At the end of an hour, depress the VIEW pushbutton switch. If the display still reads an elapsed time of 000.1 hour, the project is not falsely counting the 60-Hz power-line frequency. If a false count is indicated, reroute any ac line cords passing near the project's audio input jack. Also, check the audio cable's shield and the connections between the shield and the phono jacks. Grounding the metal enclosure to the audio system ground at one point only will also help keep 60-Hz ac out of the high-gain stages of the timer. Repeat the test procedure to ensure that the false-count problem has been solved.

Knowing the playing time of the stylus to the nearest hour or even ten hours is sufficient for replacement purposes. Contact the manufacturer of your cartridge for his recommended stylus-replacement interval. If this information is not available, check spherical styli after about 200 hours, elliptical styli after 500 hours, and Shibata and similar types after 900 hours. Use a stylus-replacement microscope for making visual inspections. If in doubt about replacement, consult a dealer. ◇

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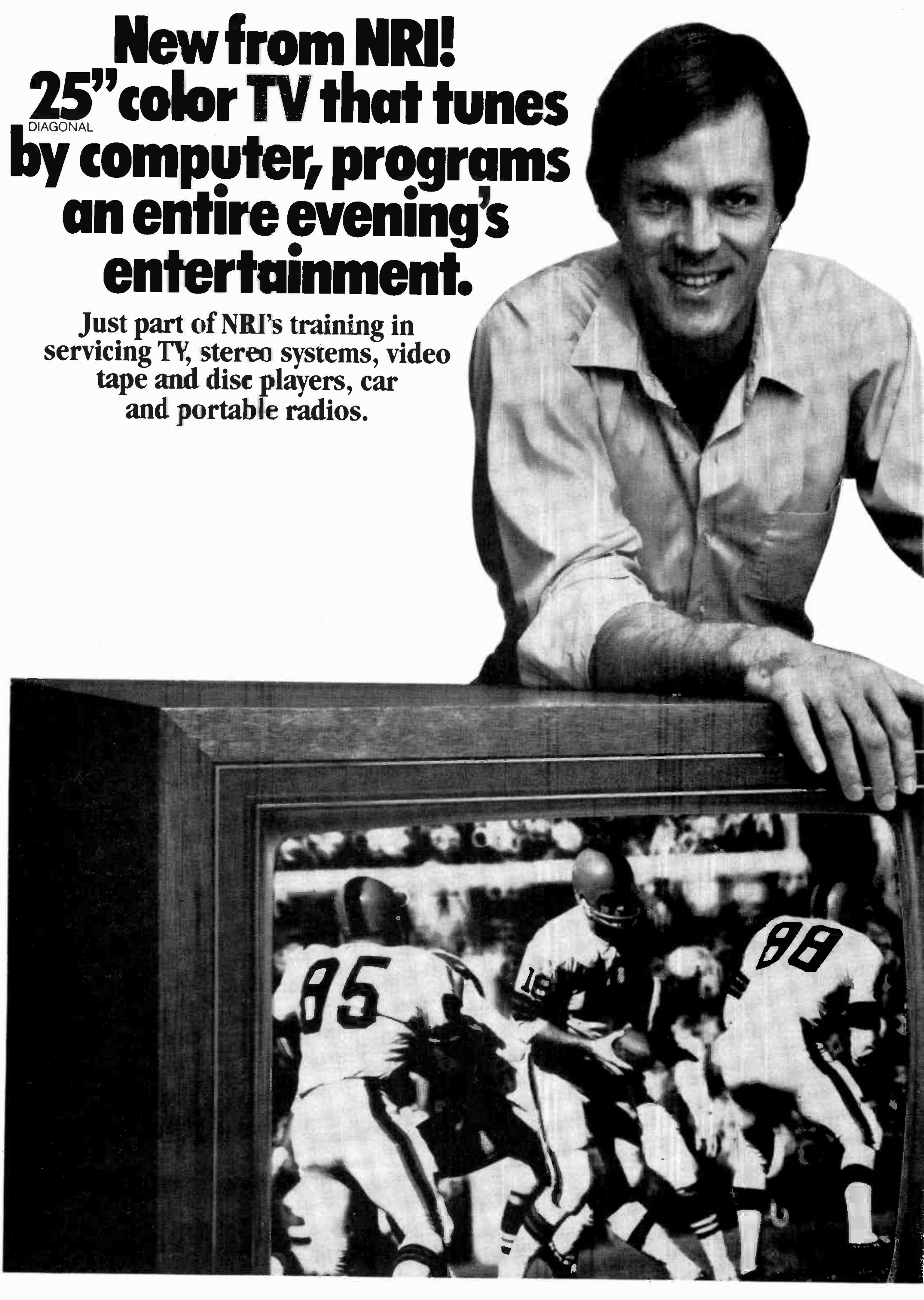

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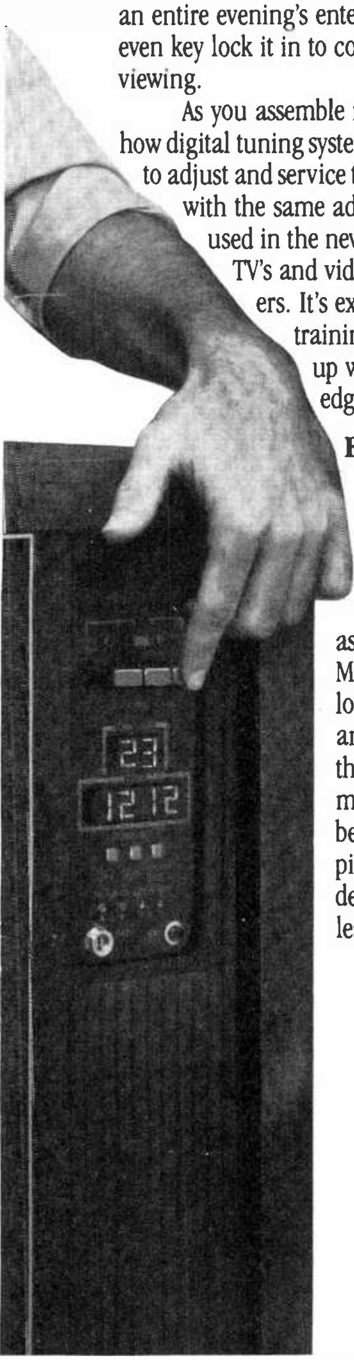

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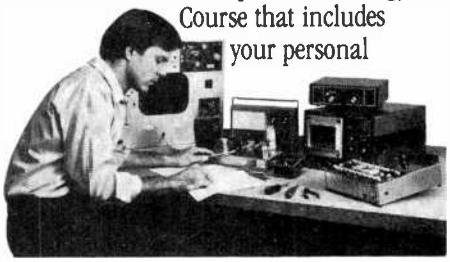

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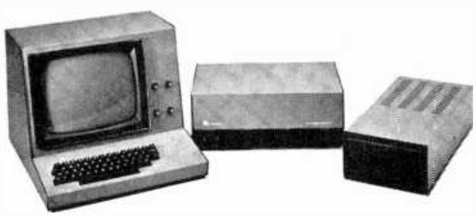
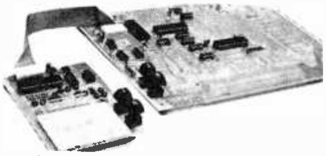
System Monitor (Hex Keypad/Display Version): Tape load with labeling . . . tape dump with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point . . . go to execution address. Level "A" in this version makes a perfect controller for industrial applications, and is programmed using the Netronics Hex Keypad/Display. It is low cost, perfect for beginners.



Full 8" disk system for less than the price of a mini (shown with Netronics Explorer/85 computer and new terminal). System features floppy drive from Control Data Corp., world's largest maker of memory storage systems (not a hobby brand!)



Level "A" With Hex Keypad/Display.

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Calculator type keypad with 24 system-defined and 16 user-defined keys. Six digit calculator-type display, that displays full address plus data as well as register and status information.

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LEVEL "C" SPECIFICATIONS

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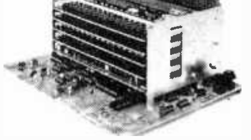

Explorer/85 With Level "C" Card Cage.

LEVEL "D" SPECIFICATIONS

Level "D" provides 4k of RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from 0000 to EFFF in 4k blocks.

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PLUG-BOARD SYSTEM FOR ADDING 16K OF DYNAMIC RAM WITH A 4K BONUS

BY ADOLPH A. MANGIERI

AN INEXPENSIVE EXPANSION OF TRS-80 MEMORY

A MICROCOMPUTER with 4K of RAM (random access memory) can perform reasonably well, but its small memory locks it out of using much sophisticated software. In most systems, memory can be expanded by installing memory chip sets or plug-in memory boards. However, in the particular case of the Radio Shack TRS-80, installation of a RAM chip set leaves 16K inside the machine and 4K of removed RAM unused. Actually, this can be a bonus if you build the memory board and expansion interface described in this article.

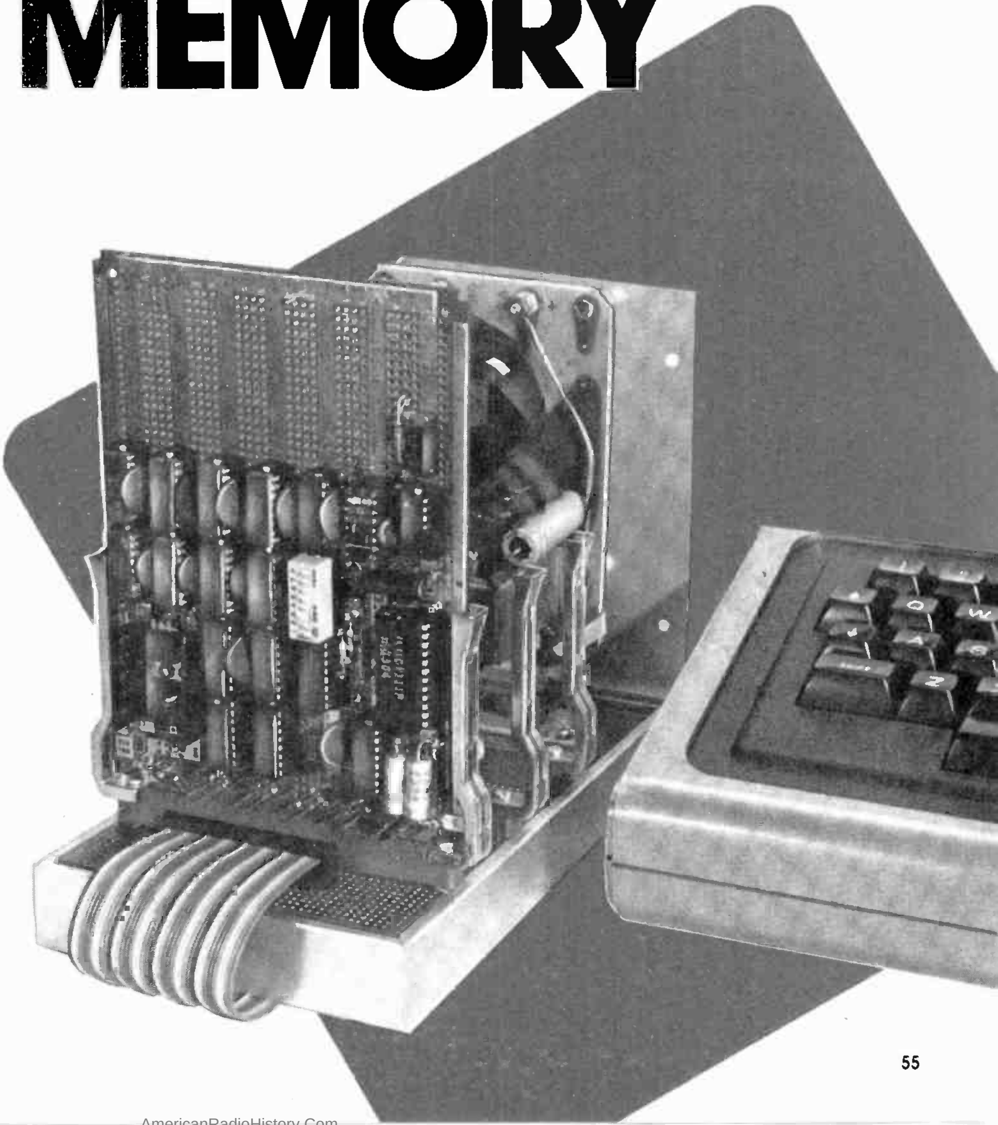
The modification detailed here provides a total of 20K of RAM and a plug-board system that allows experiments with I/O ports. The memory board features a universal address decoder that allows placing the RAM on any 4K boundary. If you program in machine language using the TRS-80 TBUG monitor, you can switch the memory block to the remote end of memory where the small utility program really belongs. Also, the board is easily converted to accept 16K RAMs if desired.

The simplicity of memory upgrade from 4K to 16K is the direct result of the use of 16-pin RAM chips. These multiplexed-address input dynamic RAMs are in wide application because of their low cost and power consumption. The latest additions to this family of devices provide up to 64K bytes with eight memory chips.

Memory Basics. The Z80 microprocessor distinguishes memory access machine cycles by concurrently issuing a 16-bit memory address and memory request ($\overline{MREQ}$), along with either a read ($\overline{RD}$) or write ($\overline{WR}$) pulse. These and other control signals operate the memory blocks of a computer. A typical memory chip includes address input, write, chip-select (or chip-enable), and data input and output lines.

Computer memory consists of a number of memory blocks arranged in sequence. A memory block may consist of one 1K × 8 read-only memory (ROM), two 1K × 4 RAMs, or eight 16K × 1 RAMs, to name a few of the possible configurations. Whatever the chip size, the storage elements of the device are arranged in a matrix. For example, the storage matrix of the 4027 (4K × 1) chip consists of 64 rows by 64 columns, yielding 4096 bits. A memory element within the matrix is selected by matrix row and column decoders. For a 4K × 1 memory chip, the address decode range is from 000 (zero) to FFF hexadecimal or 4096 decimal.

To allow stacking memory blocks end-to-end, an external memory address decoder is required. The address decoder continuously scans the higher-order computer address lines and exclusively



selects one memory block at a time, depending on the address from the CPU.

The block and timing diagram shown in Fig. 1 illustrates the operational arrangement of a 4027 4K multiplexed dynamic memory. The 4027 accepts 12 address line bits (A0 through A11) in two groups through multiplexer switches consisting of six single-pole double-throw semiconductor switches controlled by the MUX (multiplexer control) pulse. The chip data-out and data-in lines are buffered by three-state gate G3, which is controlled by gate G2 and by data-in buffer G4. The input to the address decoder consists of high-order address lines A12 through A15.

Prior to appearance of the $\overline{\text{RAS}}$, (row address select) pulse, the address decoder is disabled and its output is high. Since gate G2 is inactive at this time, gate G3 is also off. In addition, chip select line $\overline{\text{CS}}$ is high, with memory de-

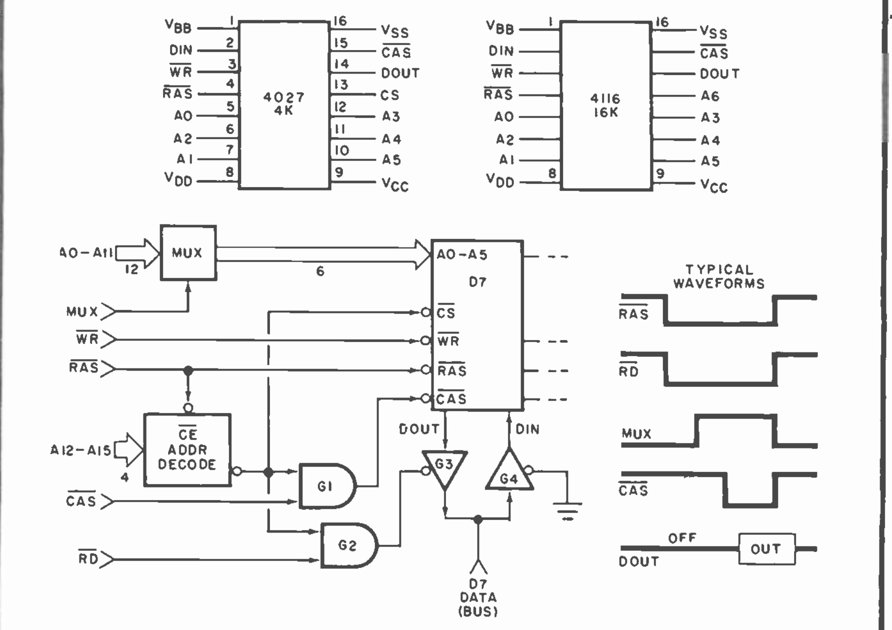
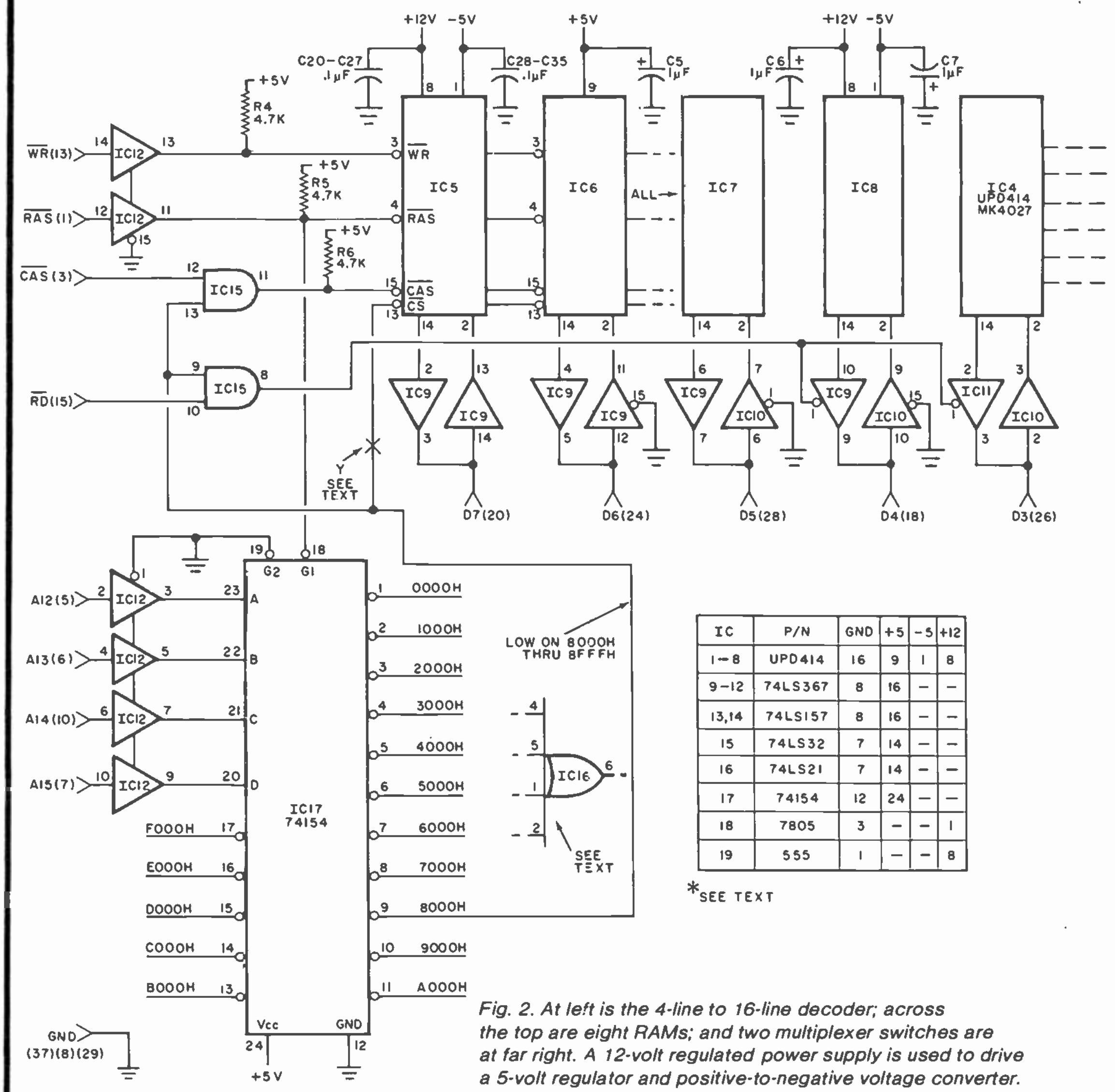


Fig. 1. RAM block diagram and timing waveforms.



IC	P/N	GND	+5	-5	+12
1–8	UPD414	16	9	1	8
9–12	74LS367	8	16	—	—
13,14	74LS157	8	16	—	—
15	74LS32	7	14	—	—
16	74LS21	7	14	—	—
17	74154	12	24	—	—
18	7805	3	—	—	1
19	555	1	—	—	8

*SEE TEXT

Fig. 2. At left is the 4-line to 16-line decoder; across the top are eight RAMs; and two multiplexer switches are at far right. A 12-volt regulated power supply is used to drive a 5-volt regulator and positive-to-negative voltage converter.

selected, gate G1 inactive, and the chip data-out line off. The MUX pulse is low and allows bits A0 through A5 to pass through the MUX switch to the chip's address input pins. On a memory read $\overline{\text{RD}}$ machine cycle, the CPU places a 16-bit address on the system bus, along with $\overline{\text{MREQ}}$ and $\overline{\text{RD}}$ pulses. (Incidentally, $\overline{\text{RAS}}$ is simply a renaming of the $\overline{\text{MREQ}}$ CPU pulse.) When $\overline{\text{RAS}}$ appears, the address decoder is enabled and its decoded output goes low, enabling memory. Also, one input pin of G1 and G2 goes low, allowing read pulse $\overline{\text{RD}}$ to pass through G2 and turn on G3, but the chip is not yet ready to output data. The $\overline{\text{RAS}}$ pulse also strobes bits A0 through A5 into the chip address latches for temporary storage. The MUX pulse next appears and "throws" the multiplexer switches allowing address bits A6 through A11 to pass. Shortly thereafter, the $\overline{\text{CAS}}$ (column address strobe) pulse appears and strobes the second group of address bits into the chip.

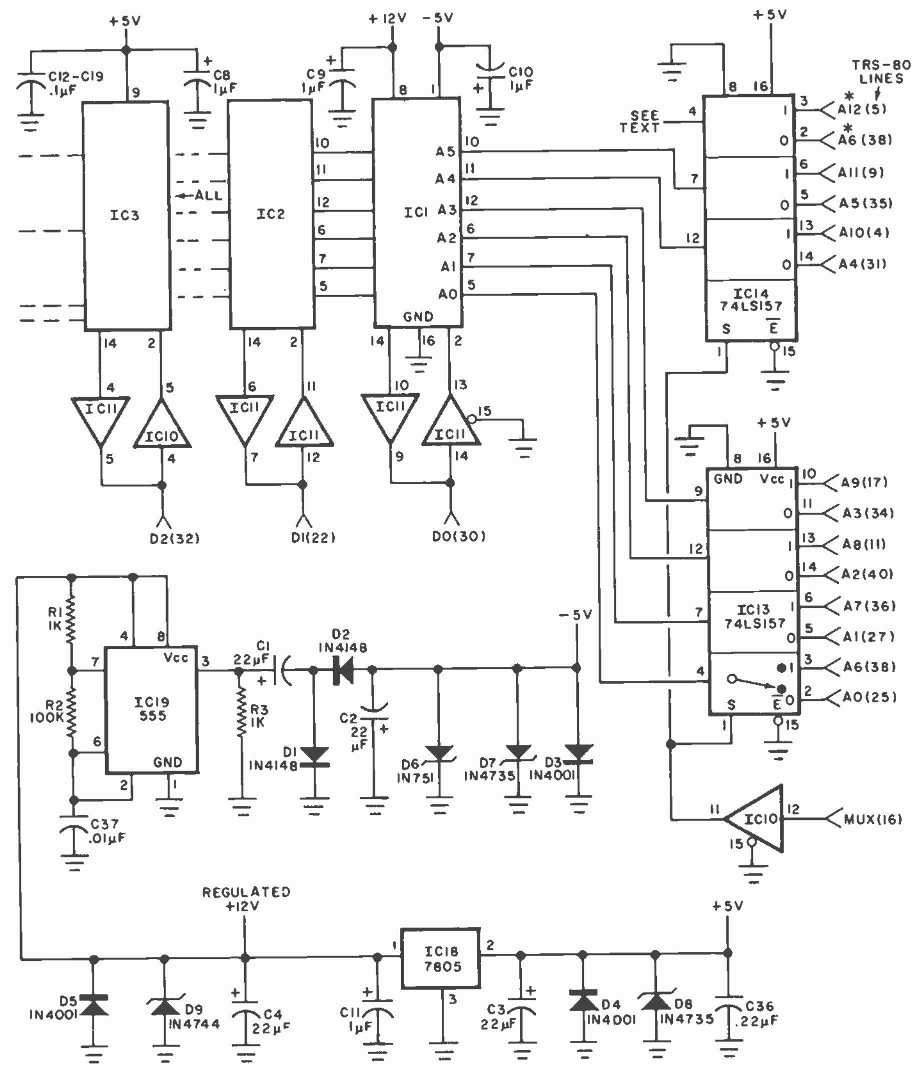
With the full address now entered, the matrix row and column address decoders decode the address and select the stored data cell. At this point, the chip data-out line becomes active and passes the data bit to the system bus through G3. The $\overline{\text{RAS}}$ pulse goes high with chip deselection, and G3 cuts off.

Action is similar on a memory write cycle. Write pulse $\overline{\text{WR}}$ appears, G3 is off throughout the cycle, and data enters the chip through G4. MUX and $\overline{\text{CAS}}$ pulses are not supplied by the CPU; rather, they are developed by other circuit logic and properly synchronized with CPU $\overline{\text{MREQ}}$ pulse. This logic is already present in the TRS-80, and MUX and $\overline{\text{CAS}}$ pulses are on the system's bus in this and most other Z80-based systems utilizing multiplexed-address input dynamic RAMs.

For the 4116 16K version, 14 address line bits are multiplexed to the chip. To make room for two additional address line bits, pin 13 of the 4116 is used to enter bits A6 and A12, sacrificing the chip-select line. Address bits A0 and A13 enter pin 5. Then, to account for the missing chip-select line, the 4116's logic senses the proper sequence and timing of the $\overline{\text{RAS}}$, MUX, and $\overline{\text{CAS}}$ pulses before enabling the chip.

Memory Refresh. All memory locations of the dynamic RAM must be refreshed within a 2-ms interval to avoid loss of data. This occurs on any memory cycle of a running program. It can be accomplished via software, but this reduces processing speed. Memory refresh, therefore, is best accomplished by hardware.

Refresh circuits are essentially counters that generate sequential addresses



PARTS LIST

C1 through C4—22-µF, 20-V electrolytic
C5 through C11—1.0µF, 35-V tantalum electrolytic
C12 through C35—0.1-µF, 15-V disc capacitor
C36—0.22-µF, 15-V disc capacitor
C37—0.01-µF, 15-V 10% disc or polystyrene
D1,D2—1N4148 switching diode
D3,D4, D5—1N4001 rectifier diode
D6—1N751 5.1-V zener diode
D7,D8—1N4735 6.2-V zener diode
D9—1N4744 15-V zener diode
IC1 through IC8—UPD414 (MK4027)* 4K or UPD416 (MK4116)** 16K RAM
IC9 through IC12—74LS367 three-state hex buffer
IC13,IC14—74LS157 quad 2-input multiplexer
IC15—74LS32 quad 2-input OR gate
IC16—74LS21 dual 2-input AND gate
IC17—74154 4-to-16 line decoder
IC18—7805 5-V, 1-A voltage regulator
IC19—555 timer
R1,R3—1-kΩ, ¼-W 10% resistor
R2—100-kΩ, ¼-W 10% resistor
R4,R5,R6—4.7-kΩ, ¼-W 10% resistor
*Use similar 4K RAMs on removal from TRS-80.
**Use JAMECO TRS-16K kit for TRS-80 16K upgrade and for 4K to 16K board upgrade. See text.
Misc.—IC sockets; wrap posts; 20/40 card edge connector; ribbon cable; plug board; card guides; chassis; card receptacles; heat sink; 12-volt power supply (JAMECO JE210 or similar); perforated board; hookup wire; etc:

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7407	2/1.19	74121	.69
7408	2/.89	74123	.99
7410	2/.85	74150	1.95
7414	.99	74154	1.95
7417	2/1.10	74157	.99
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7447	1.19	74164	1.59
7474	.69	74174	1.59
7475	.79	74175	1.49
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7485	1.19	74193	1.19
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74LS14	1.09	74LS157	1.49
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74LS32	.69	74LS174	1.79
74LS38	.69	74LS175	1.79
74LS42	1.49	74LS192	1.89
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74LS73	.79	74LS244	2.49
74LS74	.79	74LS245	3.49
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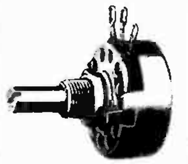
74LS85	1.95	74LS374	2.49
74LS90	1.09	81LS97	2.49

POTENTIOMETERS



2 Watt @ 70°C
7/8" Slotted Shaft
Linear Taper

1K 5K 10K
25K 50K 100K
1 Meg

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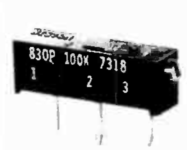
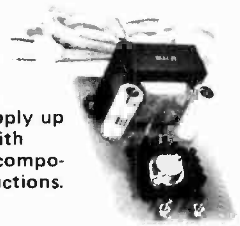


3/4 Watt @ 70°C
15 Turn Pot.
Linear Taper

100Ω 500Ω 1K
5K 10K 50K
100K 500K 1Meg

830P . . $1.79

REGULATED POWER SUPPLY KIT



Uses LM309K. Heat Sink provided. PC board construction. Provides a solid 1 amp @ 5 volts. Can supply up to ±5V, ±9V and ±12V with JE205 Adapter. Includes components, hardware and instructions. 3½"x5"x2"H

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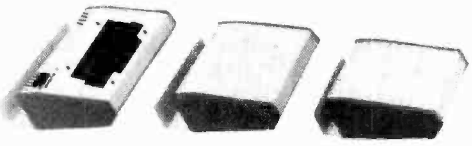
28 pin LP	.82	16 p. plug/cover	1.39
36 pin LP	.99	24 p. plug/cover	1.95
40 pin LP	1.19	+ molex p./sockets	

DESK TOP ENCLOSURES



DTE-8 (Pictured)	$31.95
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IN4733	2/.69	2N4403	2/.79
IN4734	2/.69	2N5129	2/.69
IN4735	2/.69	2N5139	2/.69
IN4742	2/.69	2N5210	2/.79
IN4744	2/.69	2N5951	2/1.29

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4001	.69	4040	1.95
4002	.69	4044	1.39
4006	1.95	4046	2.49
4009	.89	4047	2.75
4010	.85	4049	.89
4011	.69	4050	.89
4013	.85	4051	1.95
4016	.85	4066	1.19
4017	1.49	4069	.79
4018	1.49	4070	.79
4020	2.19	4071	.79
4023	.49	4081	.69
4024	1.29	4093	1.19
4027	.89	4511	1.95

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Dipped Tantalum		ELECTROLYTIC	
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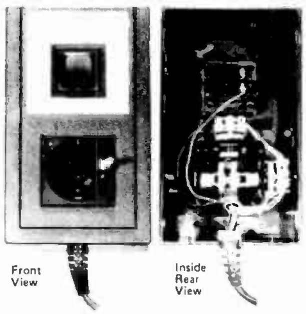
.47mfd @ 35V	2/.89	4.7mfd @ 50V	2/.59
1mfd @ 35V	2/.89	10mfd @ 50V	2/.69
2.2mfd @ 25V	2/1.09	22mfd @ 50V	2/.79
3.3mfd @ 25V	2/1.19	47mfd @ 50V	2/.89
4.7mfd @ 25V	2/1.39	100mfd @ 50V	.59
10mfd @ 25V	1.19	220mfd @ 50V	.69
33mfd @ 25V	3.95	1000mfd @ 25V	1.19
		2200mfd @ 16V	1.39
100V MYLAR		**50V CERAMIC**	
.001-.01mfd	4/.79	10pf-.022mfd	4/.59
.022mfd	4/.89	.047mfd	4/.69
.047mfd	4/.99	.1mfd	4/.79
.1mfd	4/1.19		
.22mfd	4/1.29		

VIDEO CONTROLLER



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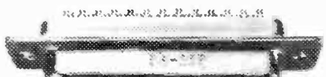
CONNECTORS



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2708	8K EPROM	10.95
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LM308N	1.19	LM380N	1.49
LM309K	2.25	LM384N	2.49
LM310N	2.69	LM555N	.69
LM311N	1.49	LM556N	1.49
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LM319N	2.95	LM567N	1.79
LM320K-5	2.25	LM723N	.79
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1

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that are applied to the chips. For dynamic memory devices, it is necessary only to apply all possible row address combinations to the chip to refresh all memory locations. This $\overline{RAS}$-only refresh is achieved in less time, and since the MUX and $\overline{CAS}$ pulses are absent, the chip is not enabled.

The Z80 CPU includes built-in refresh circuits for $\overline{RAS}$-only refresh of the chips, this refresh occurring in the latter part of the opcode instruction fetch cycle, which is a special memory access period. Furthermore, refresh occurs while the CPU is decoding the fetched instruction, effecting hidden refresh. (For complete details, refer to the Zilog Z80 Technical Reference Manual and device specification sheets.)

Circuit Operation. Referring to Fig. 2, address decoder *IC17* is a 4-line to 16-line decoder that senses address lines A12 through A15. All decoder output lines at pins 1 through 11 and 13 through 17 are at a high logic level until $\overline{RAS}$ appears and enables the decoder through strobe line G1 at pin 18. At this time, one of the 16 output lines goes low exclusively, depending on the value of the four address input bits.

Assume that the CPU issues hexadecimal address 8000, the next address following the end of the TRS-80's resident 16K of memory. Address decoder *IC17* "sees" 8 (binary 1000) at inputs D, C, B, and A in that order. The 8000 output at pin 9 goes low and remains low through address 8FFF. On the next higher address (9000), pin 10 goes low exclusively and remains low through address 9FFF, and so forth.

Notice that, in each step, the low-order address lines run through the range of 000 through FFF (4096 addresses). Hence, the decoder can exclusively select any one of 16 4K memory blocks over the total possible 64K of memory space. However, on-chip address decoders of a selected memory block decode only the address range of 000 through FFF while depending on the external address decoder to establish block location in memory space.

Multiplexer switches *IC13* and *IC14* are controlled by the MUX pulse through the S control lines of the devices. Referring to the symbolic spst switch shown on *IC13*, all "switches" are in position 0, with MUX resting low to allow address bits A0 through A5 to pass to the RAMs. When MUX goes high, all switches move to position 1 to pass bits A6 through A11 to the chips. The multiplexers also buffer the address lines.

The memory circuit is powered by a regulated 12-volt source that in turn, powers 5-volt regulator *IC18*. Supplying a small bias current to the RAMs, the −5-volt source is obtained from a charge-pump circuit formed from *IC19*, a 555 timer that delivers a square wave to the charge-pump circuit connected to pin 3. Regulation of the charge pump's −5-volt dc output is provided by *D6*, while *D3, D4*, and *D5* provide reverse voltage protection and *D7, D8*, and *D9* give some over-voltage protection.

RAM Kit Installation. We used a modified version of the TRS-80 disassembly instructions that are included in the computer's Technical Reference Manual to access the 4K RAMs. The procedure is as follows: With bottom screws removed and computer in its normal operating position, remove the top to reveal the keyboard. Next, hinge the keyboard to a vertical position, taking care to avoid strain on the short ribbon cable, and remove the five rubber spacers to free the main board. Lower the keyboard to the table top and rest it on its keytops. In a similar manner, hinge the main board outward and place it on the inverted keyboard. Reverse the procedure to reassemble.

We used the Jameco TRS-16K RAM kit which contains eight UPD416 (MK4116) high-speed RAMs and instructions for installation. Since the chips are easily damaged by static electricity, we recommend that you connect an earth ground wire to the main board circuit, and connect yourself to earth ground through a 250,000-ohm resistor and a wire running to a metallic wristwatch strap. *Stay clear of ac lines and equipment!* Use a dot of fast-drying white paint to mark the pin-1 position of each DIP shunt and 4K RAM socket location.

Remove the somewhat fragile DIP shunts, and replace with substitutes, such as 16-pin DIP headers, jumper wired according to instructions supplied. The DIP shunts and RAMs extract with difficulty, so go easy. As you remove each RAM, push it into black conductive foam plastic. Then install the 16K RAMs, being sure to orient them properly in their sockets.

If you don't have a similar system, you can assemble the plug-board system shown in Fig. 3 as follows: Install three Vector No. R644-3 44-contact receptacles on 4½" × 6" perforated board drilled as required. Bolt Vector No. BR27D card guides and receptacles to the board and slide the Wire-Wrapped assembly into the 51X-1 aluminum frame. The memory board operates off a regulated 12-volt power supply, which can be mounted on a vertical plate bolted to the frame as shown. (If you aren't planning to use a plug-board system at this time, assemble the circuit on a Vector No. 8802 Circbord that has etched buses on one side of the board, and slide the board horizontally into the aluminum frame.)

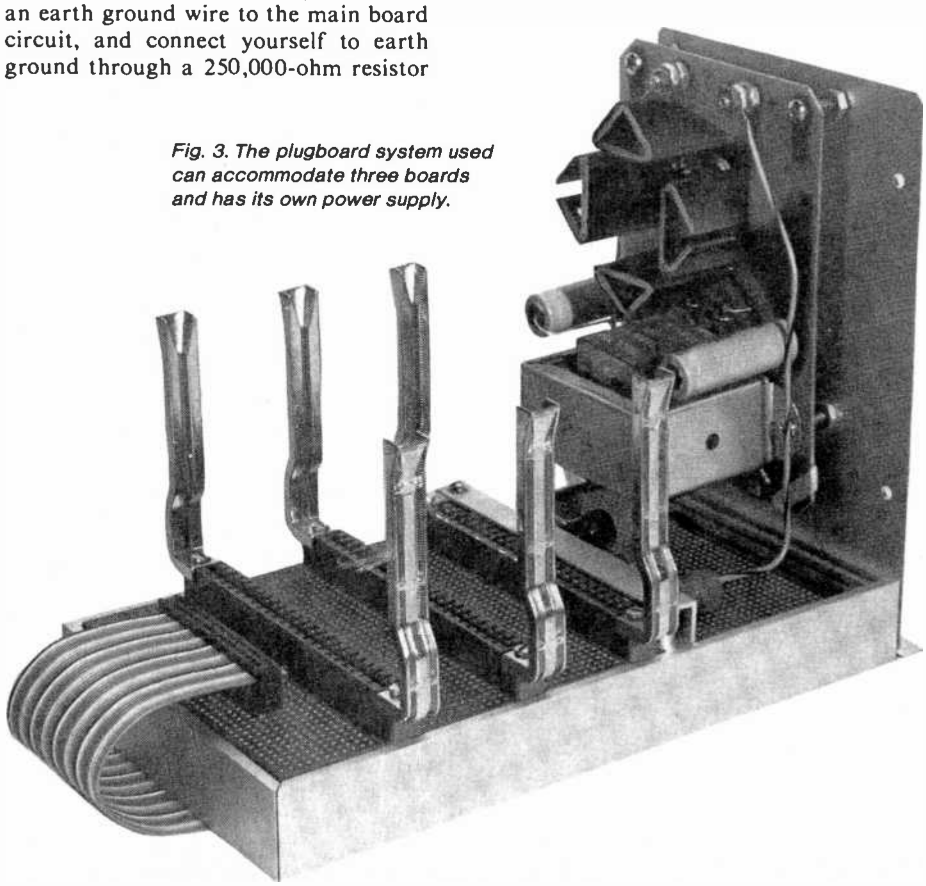


Fig. 3. The plugboard system used can accommodate three boards and has its own power supply.

CKMEM PROGRAM

ADDR	CODE	MNEMONIC	REMARK
4400	21 18 44	LD HL, 4418H	; INITIALIZE POINTER
4403	0E 01	LD C, 01H	; TEST PATTERN BUFFER
4405	71	LD (HL), C	; WRITE PATTERN IN LOC.
4406	06 08	LD B, 08H	; SET LOOP COUNT TO EIGHT
4408	CB 06	RLC, (HL)	; ROTATE LEFT CIR. IN MEM
440A	CB 01	RLC, C	; AND IN REGISTER C
440C	79	LD A,C	; GET TEST PATTERN AND
440D	BE	CP (HL)	; COMPARE
440E	20 05	JRNZ, 5	; EXIT ON MEM ERROR
4410	10 F6	DJNZ, −10	; ELSE LOOP TILL DONE
4412	23	INC HL	; POINT TO NEXT MEM LOC.
4413	18 F0	JR, −16	; LOOP TO CONTINUE TEST
4415	CD 91 40	CALL, 4091H	; STOP IN TBUG

Use only a short ribbon cable to interconnect the computer and expansion system. Connect a 6" length of 40-conductor ribbon cable to a TRS-80 card edge connector. For reduced crosstalk, overlay one side of the cable with aluminum foil. Then connect bare wire pigtails to the connector's ground lugs and tape the pigtails to the foil. Omit any connection to TRS-80 5-volt line 39.

If you prefer a disconnect at the plugboard system, cut a preassembled 40-conductor female IDC ribbon cable to length and solder to the edge connector. Install two rows of No. T46-5-9 wrap posts into the perforated board with pin faces in square alignment to accept the female IDC plug.

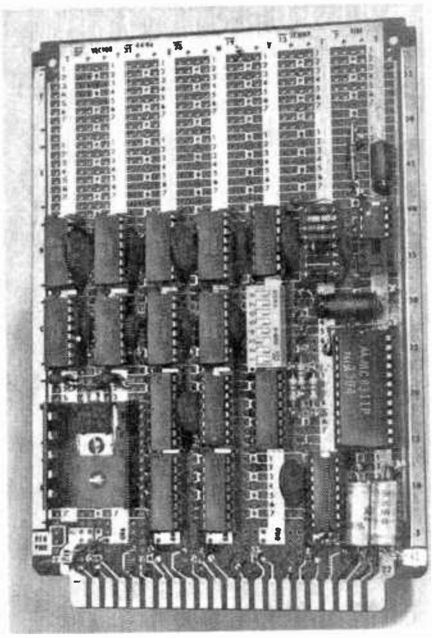
The plug board shown is a Vector No. 4494 44-contact board with etched ground and supply planes on opposite sides. Assign the +12-volt supply to one of the spare bus lines. Install the sockets for the multiplexer and buffer ICs in the first two socket tiers near the card fingers and install the RAM sockets in the third and fourth socket tiers. This leaves ample room for another bank of eight memory devices. Do *not* install the ICs in their sockets until told to do so!

Charge-pump components can be installed on a DIP header and plugged into a single socket as shown. Install small bypass capacitors with minimum lead lengths. (In the prototype, some bypass capacitors were connected directly to socket-wrap posts.) The board is preferably chain-wrapped using the Vector No. P180 Slit-N-Wrap or similar tool. To keep crosstalk low, avoid bundling the wires.

When 20K of RAM isn't enough, you can easily install 16K RAMs on the expansion board to obtain a total of 32K of memory. To do this, first break the wire at point Y (see Fig. 2) to RAM pin line 13. Remove address line A6 from pin 3 of *IC13* and connect address line A13 to pin 3 of *IC13*. Wire lines A6 and A12 to *IC14* as shown, and connect pin 4 of *IC14* to RAM pin line 13. Remove the connection from pin 9 of *IC17* and wire it to pin 6 of *IC16*. Assuming there is 16K of RAM inside the TRS-80, connect the four input pins of active-low OR gate *IC16* to pins 9, 10, 11, and 13 of *IC17* in any order.

After checking your wiring for errors and shorts, install *only IC19*, apply power, and check that the proper supply voltages appear at the appropriate socket pins. Disconnect power. Then install the remaining ICs, taking precautions with the MOS RAMs.

Checkout. You can check the 16K of RAM installed in the TRS-80 by running the "Function and RAM test" programs listed in the TRS-80 User's Manual. Running time is about 12 minutes. Next, with the power disconnected from both the TRS-80 and expansion module, connect the two together. Power-up first energizing the expansion system and then the computer. On typing the command PRINT MEMORY, 19,967 should appear on-screen. If not, deenergize the TRS-80 for 10 seconds and try again. If



The memory expansion system mounted on a 4494 plug board. There is room for eight additional RAMS if desired.

the computer still won't function properly, power down and check for bus line shorts. (If the program prints out RAM error immediately, look for wiring errors.) If the test program runs well into the test but stops at random times, the most likely cause is noise or crosstalk. A short ribbon cable, low-impedance ground and supply lines, and adequate bypassing are required.

Users of the TRS-80 TBUG machine-language monitor have the option of placing the 4K of RAM at the far end of memory. This obviates the need to revise machine language programs located at the far end of memory when you add more memory. A DIP switch can be used to select either pin 9 or pin 17 of *IC17*, allowing instant movement of the 4K block to the far end of memory. On powering up when using memory beginning at F000 always energize the TRS-80 first. Typing PRINT MEMORY should now yield 15,871 on-screen.

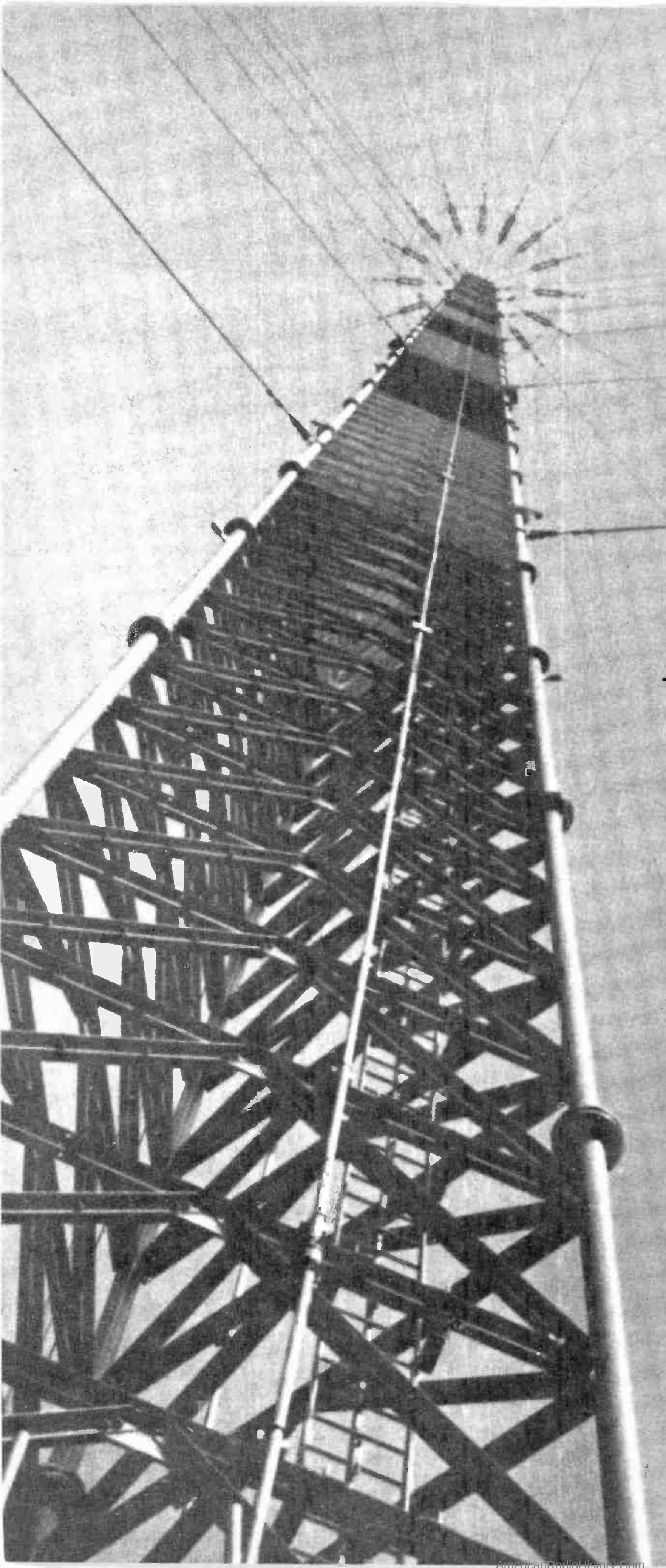
With any use of the RESET button, always type in PRINT MEMORY. For rapid memory checks and troubleshooting, use machine language program check memory CKMEM, which runs through 20K of memory in 5 seconds. You may wish to acquire the TBUG monitor for high-speed memory tests if for no other reason than to run CKMEM.

Check Memory Program. The CKMEM program given in the table writes a test pattern of a single 1 bit into a memory location and reads back the stored pattern for a comparison test. Rotated left circularly, this 1 bit is used to check all bit positions. Whenever a mismatch or RAM error is encountered, the program exits to TBUG monitor control and register pair HL holds the address at mismatch.

Entered as listed in Level I machines, the CKMEM program begins testing at address 4418 as shown in the first instruction. No changes are required to relocate the program in memory, apart from starting address initialization. The program can be used to fill memory with 0s by changing the second instruction to 0E 00. To check 4K of RAM at the remote end of memory, change the first instruction to 21 00 F0.

Program CKMEM may miss certain address-line wiring errors of the RAM board that are caught by the TRS-80 RAM test program. Either program will catch bad chips. Program CKMEM and TBUG monitor commands simplify isolation of a bad RAM, but don't be too quick to condemn a chip until it is proven defective by direct substitution. Once the whole system is up and running, you are ready to broaden your programming horizons with a system that has enough RAM to run sophisticated software. ◇

BY LAWRENCE R. LAFLER



A Low-Cost Emergency Broadcast System Monitor

Add-on circuit monitors the output of a broadcast receiver and sounds an alarm when an EBS warning signal is received

THE National Weather Service and the Civil Defense Agency, in conjunction with local broadcasters and other authorities, maintain an emergency warning system to alert the public in case of impending natural disaster or national defense emergency. This system consists of a network of AM and FM radio stations that will interrupt their normal programs to broadcast an emergency bulletin immediately after an official severe weather or Civil Defense warning is issued. You have probably heard tests of this emergency broadcast system (EBS) on local radio stations. During such tests, and in the event of an actual alert, participating stations broadcast a special two-tone signal used to activate warning devices at other radio stations and at regional Civil Defense offices.

For less than $25.00, you can build a circuit that will respond to the EBS alerting signal. This project receives signals from the earphone jack of a standard broadcast receiver and, in response

A superb frequency counter is frequently not counted-just because it doesn't have a high price-tag.

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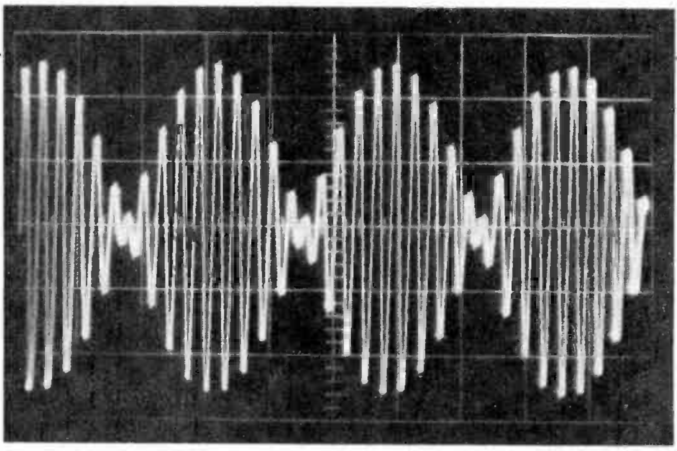


Fig. 1. Oscilloscope photo of the alert signal of the Emergency Broadcast System. It consists of two tones at 853 Hz and 960 Hz broadcast for 22.5 seconds.

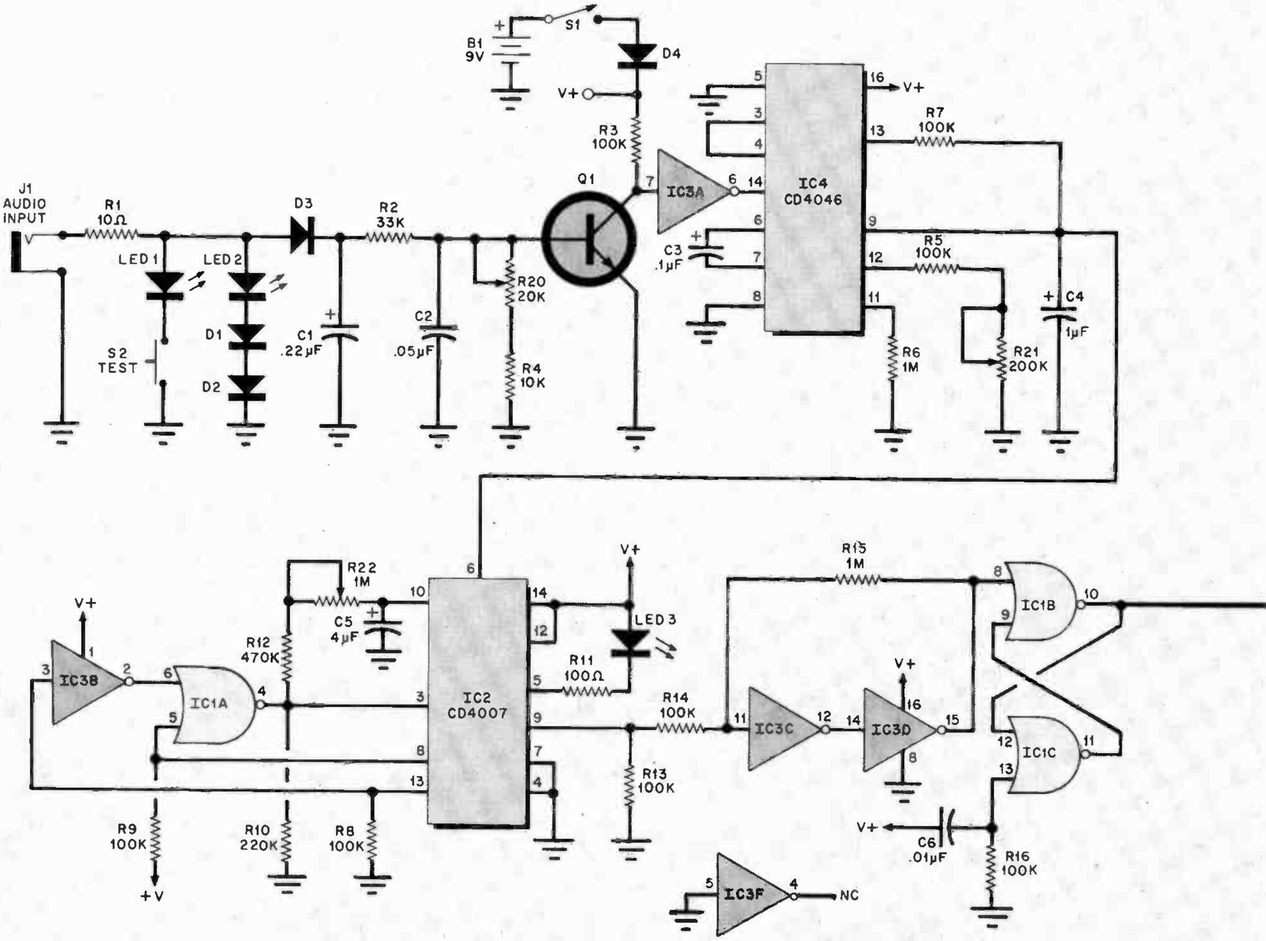
to the special EBS tones, actuates a Sonalert or similar audible alarm or a relay. For around-the-clock protection, the EBS Monitor and the radio to which it is connected can be left activated continuously. If an emergency occurs, the alarm could save your life.

How it Works. The EBS alert signal consists of simultaneous tones at 853 Hz and 960 Hz broadcast for 22.5 seconds. This unlikely combination of frequencies and its long duration make it easy to distinguish the warning signal from speech and music. (Its waveform is shown in Fig. 1.)

Commercial EBS alerting devices employ a separate tone decoder for each of the two audio frequencies and a time-delay circuit that triggers an alarm only when the two frequencies are present for 15 seconds or more. This is an expensive approach requiring a large battery power source. To minimize cost and battery drain without sacrificing performance, this project employs a single CMOS phase-locked loop (PLL) to detect the presence of both frequencies. Three other CMOS integrated circuits perform most of the remaining functions. The circuit, which is shown schematically in Fig. 2, is such an energy miser that it will operate in its listening mode for more than one year on a single 9-volt transistor battery.

The one PLL is able to detect the two discrete audio tones by responding to the 107-Hz difference between their two frequencies. This 107-Hz difference tone can be separated from the rest of the alert signal by rectifying and filtering the signal. Diode *D3*, capacitors *C1* and *C2*, resistors *R2* and *R4*, and potentiometer *R20* perform this function.

Transistor *Q1* amplifies the 107-Hz difference signal and, with the help of inverter *IC3A*, converts it to a square wave that is then applied to the input (pin 14) of *IC4*, the phase-locked loop. The loop acts as a frequency-to-voltage converter that can be programmed to respond to a narrow band of frequencies called the *lock range*. Over this lock range, the output (pin 9) of the phase-locked loop will be a voltage that increases as the frequency of the input signal increases. For an input frequency



outside of the lock range, the PLL output voltage will approach either 0 or 9 volts, depending on whether the input frequency is above or below the lock range. Capacitors *C3* and *C4*, together with resistors *R5*, *R6*, and *R7*, and potentiometer *R21* limit the lock range of the PLL to between 100 and 115 Hz. When a 107-Hz signal is applied to the input of the PLL, its output voltage will be approximately 4.5 volts. This output voltage level can, therefore, be interpreted as an indication that a 107-Hz input frequency is present.

At this point in the circuit, a network is needed that will have a logic 1 output when its input is approximately 4.5 volts, and a logic 0 output when its input is either greater than or less than 4.5 volts. Integrated MOSFETs contained in *IC2* together with inverter *IC3B* and NOR gate *IC1A* form such a network. Thus, the presence of the EBS alert signal causes the output of *IC1A* (pin 4) to go high. However, difference frequencies close to 107 Hz that are occasionally contained in voice, music and noise can also cause the output of *IC1A* to momentarily go high. False alarms due to these normal audio components can be avoided by requiring that the output of *IC1A* be high for at least 15 seconds before the circuit triggers alarm.

This delay is obtained by having the output of *IC1A* charge capacitor *C5* through resistors *R12* and *R22* before the logic level is passed to the next portion of the circuit. As *C5* charges, the voltage at pin 9 of *IC2* increases. Eventually it reaches the level required to switch from logic 0 to logic 1 the output of the Schmitt trigger made up of inverters *IC3C* and *IC3D* and resistors *R14* and *R15*. The output (pin 15) of the Schmitt trigger is connected to the input of the alarm trigger flip-flop consisting of NOR gates *IC1B* and *IC1C*. When the output of the Schmitt trigger switches to logic 1, the output of the alarm trigger flip-flop (pin 10) switches from logic 1 to logic 0. Once this happens, the output of the flip-flop will remain low even if the output of the Schmitt trigger returns to logic 0.

The logic 0 appearing at the output of the flip-flop activates the oscillator made up of NOR gate *IC1D* and inverter *IC3E*. This oscillator generates a square wave that alternately turns *Q2* on and off, activating alarm *A1*.

The circuit contains a few other components whose functions should be noted. Capacitor *C6* and resistor *R16* generate a positive pulse which resets the alarm trigger flip-flop each time power switch *S1* is closed. This assures that the alarm will be silent when power is applied to the circuit. Light-emitting diodes *LED1* and *LED2* indicate when the audio output of the broadcast receiver that drives the circuit is at the proper level. The receiver's output should be adjusted so that, when TEST switch *S2* is closed, *LED1* flickers on and off but *LED2* remains dark. If volume is too low, neither LED will flicker. If volume is too high, both LEDs will flicker. Diode *LED3* is used to indicate when a 107-Hz signal is being detected. It glows whenever the output of NOR gate *IC1A* is at logic 1. Diode *D4* prevents damage to the circuit that would otherwise occur if the battery leads were to become inadvertently reversed.

Construction. The EBS Monitor is most easily assembled using a printed circuit board. The full-size etching and drilling guide for a suitable printed circuit board is shown in Fig. 3. Its corresponding parts placement guide appears in Fig. 4. Mount the integrated circuits using sockets or Molex Soldercons rath-

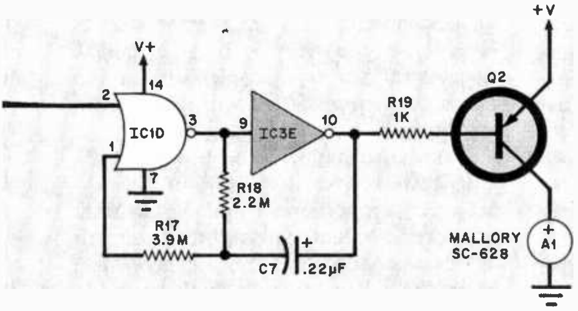


Fig. 2. The circuit in the project uses a CMOS phase-locked loop to detect the presence of the alert signal. The CMOS components cause little battery drain so that the monitor can be in use constantly.

PARTS LIST

A1—Solid-state audible warning device (Mallory SC-628 Sonalert or similar)
B1—9-volt transistor battery
C1,C7—0.22-µF, 15-volt tantalum capacitor
C2—0.05-µF, Mylar capacitor
C3—0.1-µF, 15-volt tantalum capacitor
C4—1-µF, 15-volt axial-lead aluminum electrolytic capacitor
C5—4-µF, 15-volt axial-lead aluminum electrolytic capacitor
C6—0.01-µF disc ceramic capacitor
D1 through D4—1N4001
IC1—CD4001 quad 2-input NOR gate
IC2—CD4007 dual complementary pair plus inverter
IC3—CD4009 hex inverter
IC4—CD4046 phase-locked loop
J1—Miniature phone jack
LED1—Green light-emitting diode
LED2—Red light-emitting diode
LED3—Yellow light-emitting diode
Q1—2N3904 npn silicon transistor
Q2—2N4402 pnp silicon transistor
The following are ¼-watt, 5% tolerance carbon-composition fixed resistors unless otherwise specified.
R1—10 Ω
R2—33 kΩ
R3, R5, R7, R8, R9, R13, R14, R16—100 kΩ
R4—10 kΩ
R6, R15—1 MΩ
R10—220 kΩ
R11—100 Ω
R12—470 kΩ
R17—3.9 MΩ
R18—2.2 MΩ
R19—1 kΩ
R20—20-kΩ, linear-taper, pc-mount trimmer potentiometer
R21—200-kΩ, linear-taper, pc-mount trimmer potentiometer
R22—1-MΩ, linear-taper, pc-mount trimmer potentiometer
S1—Spst switch
S2—Normally open, momentary-contact pushbutton switch
Misc.—Printed circuit board, suitable enclosure, IC sockets or Molex Soldercons, battery retainer and connecting clip, hookup wire, two-conductor cable, miniature phone plugs, hardware, etc.

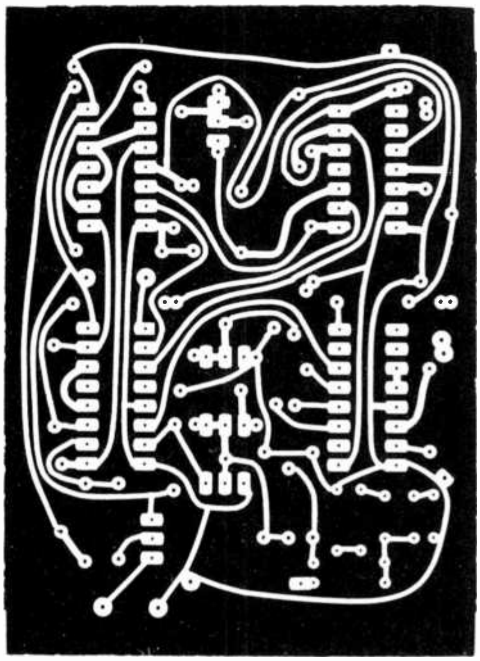
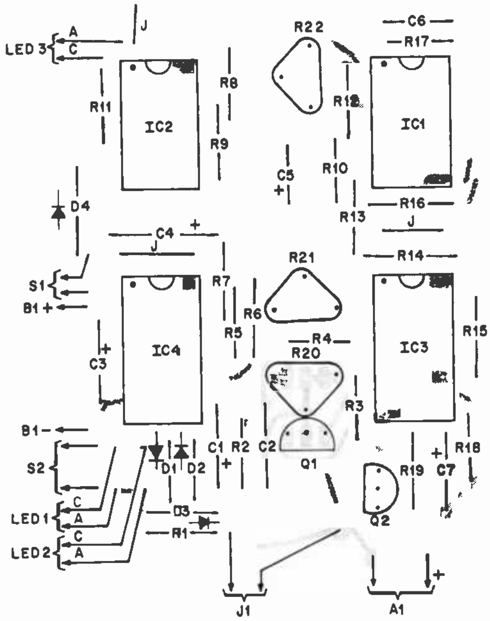


Fig. 3. Actual-size etching and drilling guide for a suitable printed circuit board.

Fig. 4. Component layout for the monitor's printed circuit board is shown below.



er than soldering them directly to the board. This makes replacement of defective ICs infinitely easier and eliminates the possibility of damaging them during soldering. Be sure to observe polarities and pin basings when you mount the diodes, transistors, LEDs, ICs, and electrolytic capacitors.

The LEDs should be mounted off the board so that they can project through the front panel of the enclosure that is employed to house the project. The switches should also be mounted on the front panel. Connect the LEDs and switches to the pc board using flexible hookup wire. Input jack *J1* should be mounted on the rear of the enclosure and connected to the board using two-conductor cable. Fasten a retaining clip for the 9-volt battery to the enclosure and connect suitably long leads from the appropriate foil pads to a 9-volt battery clip. Then install the battery and snap the connecting clip in place. Finally, prepare a two-conductor patch cord of convenient length terminated with miniature phone plugs at each end.

Alignment. There are only three adjustments that must be made before the EBS Monitor is ready for service. Potentiometer *R20* must be adjusted so that, when the audio output of the broadcast receiver is at the proper level and the EBS signal is present, a 107-Hz square wave will be applied to the input of the PLL. Potentiometer *R21* must be adjusted so that the lock range of the PLL is centered around 107 Hz. Third, potentiometer *R22* needs to be set so that, once *LED3* begins to glow, there will be a 12- to 18-second delay before the alarm sounds. The easiest way to make these adjustments is to first make a recording of the EBS alert signal when a local radio station is conducting an EBS test. Use a high-quality cassette or open-reel tape recorder that has an earphone or line-level output jack. After you have recorded the two-tone signal, patch the output of the recorder to the project's input jack and proceed as follows.

First, connect a voltmeter between pin 14 of *IC4* and the circuit ground. Then close switch *S1* and play back the EBS alert signal. (Rewind and repeat this step as necessary so that the tone is present during all of the remaining steps.) Hold switch *S2* closed and adjust the recorder's output level until *LED1* glows but *LED2* remains dark. Vary potentiometer *R20* until the voltmeter reads 3 to 5 volts dc. Vary potentiometer *R21* until *LED3* glows most or all of the time that the tone is present. Vary potentiometer *R22* until the delay between the application of the tone and the activation of the audible alarm is between 12 and 18 seconds. The delay can be reduced by moving the wiper of *R22* toward capacitor *C5* as viewed from the top of the board.

Use. Your EBS monitor is ready for service. Apply power to both the project and the broadcast receiver with which it will be used. Tune in a local radio station that participates in the Emergency Broadcast Service, has a strong signal in your area, and broadcasts 24 hours a day. If possible, choose an FM station, because static interference during an electrical storm will be less severe and the operation of the Monitor will be more reliable.

Patch the output of the receiver to input jack *J1* and, if necessary, adjust the output level so that *LED1* flickers in step with the demodulated signal when *S2* is depressed but that *LED2* remains dark. When the project is operating in its listening mode, *LED3* should flicker on occasionally. As long as it flashes brightly, the battery is in good condition. As the battery becomes weaker and needs replacing, *LED3* will diminish in brightness.

Take advantage of the broadcaster's EBS tests to check the circuit periodically for proper operation. These tests are never conducted at night, so you will not be disturbed by false alarms if you leave the project in its listening mode while you sleep. When the alarm sounds, remove power from the project and disconnect the patch cord from the output jack of your broadcast receiver. You will then be able to hear the emergency message that follows. ◇

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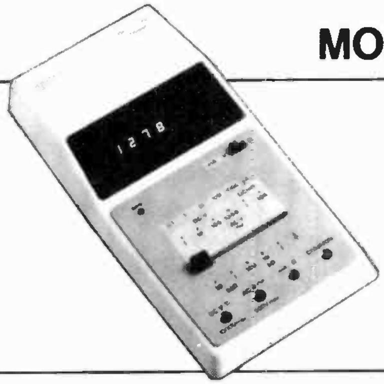

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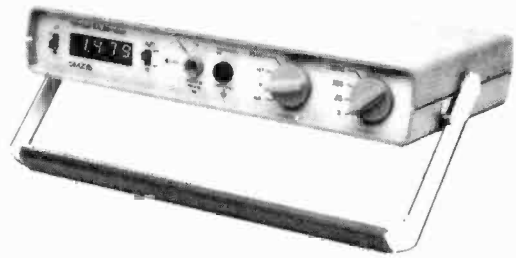

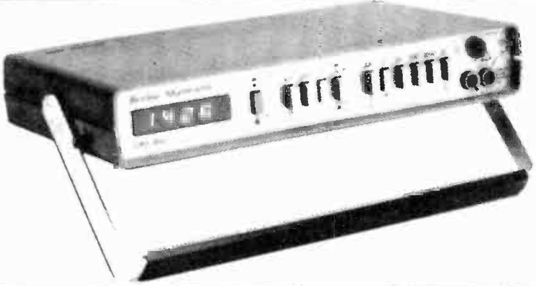

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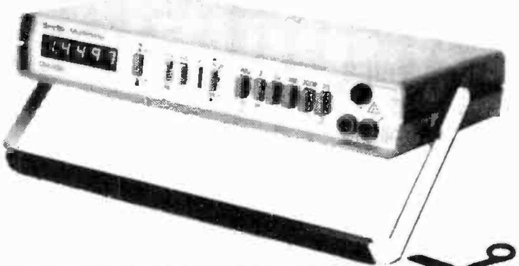

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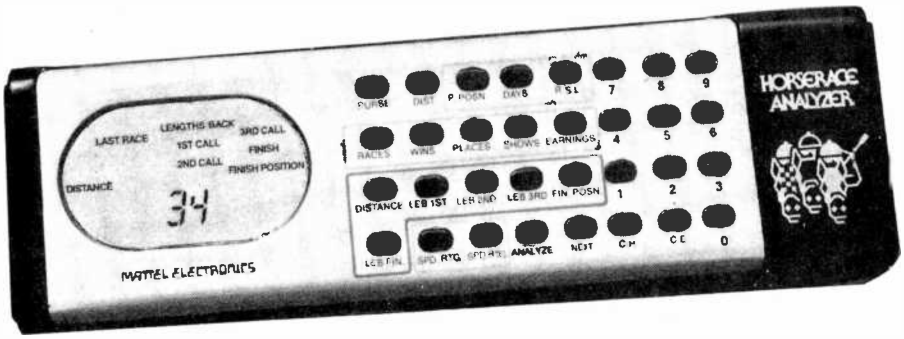

Mattel Horserace Analyzer

TABLE IX—MULTIFUNCTION GAMES

Game	Description
IDEAL Maniac	Four games: (1) react to the end of the tune, (2) guess the number of notes in a tune, (3) recall the original light pattern, (4) estimate the length of a tune.
LOGIX T.E.A.M.M.A.T.E.	Program cards provide a broad range of games including tic-tac-toe, doodling, battlefield, etc.
MEGO Fabulous Fred	Ten games: (1) organ, (2) compose a song, (3) what's that tune, (4) repeat the tune, (5) guess the number, (6) space attack, (7) sub hunt, (8) tag, (9) baseball, and (10) roulette.
PARKER BROTHERS Merlin	Six games: (1) tic-tac-toe against the computer, (2) compose a tune, (3) repeat a sequence of notes, (4) blackjack 13, (5) recall a coded sequence to create a savoie of flashing lights, (6) determine correct numbers and their order.
Split Second	Eight games (five basic games): three different mazes, two space attacks, auto cross, stomp, and speedball.
WADDINGTONS Wizard	Four games: (1) defend your corner against an attacking light, (2) repeat musical notes, (3) compose a tune, (4) find your way out of an invisible maze.
Game Machine 2	Five games including blackjack and code hunter.

IN Part 2, we started comparing some of the games, setting up an Evaluation System by which they could be rated. These comparisons are continued here, starting with Multifunction Games and ending with a detailed description of the latest video games.

One of the first **Multifunction Games** (Table IX) was Parker Brothers' "Merlin" which was originally planned as tic-tac-toe and was expanded to six games.

All eight games provided by Parker Brothers' "Split Second" are battles against time. In the three different maze games, the player moves a ball around obstacles into a goal. Hitting a wall with the ball loses precious time, and in all "Split Second" games, each split-second lost counts.

Remember the clashes between the Colonial Warriers and the Cylons? You can be Starbuck or Apollo when you play "Split Second's Space Attack." The game is the closest hand-held equivalent to the radar representations of the Colonial Vipers in the original Battlestar Galactica television episodes. When an enemy ship is positioned on the screen over the target sights, it can be destroyed by a laser blast. The explosion fills the display.

In "Split Second's Auto Cross," a car is driven through a 16-obstacle course in as short a time as possible. In "Stomp," 20 targets must be hit as fast as possible. A moving ball is boxed in by four moving lines in "Speedball"—again in a race against time. Each game must be completed in 99.9 seconds; winners and losers are greeted with appropriate little jingles. *(Continued on page 70)*

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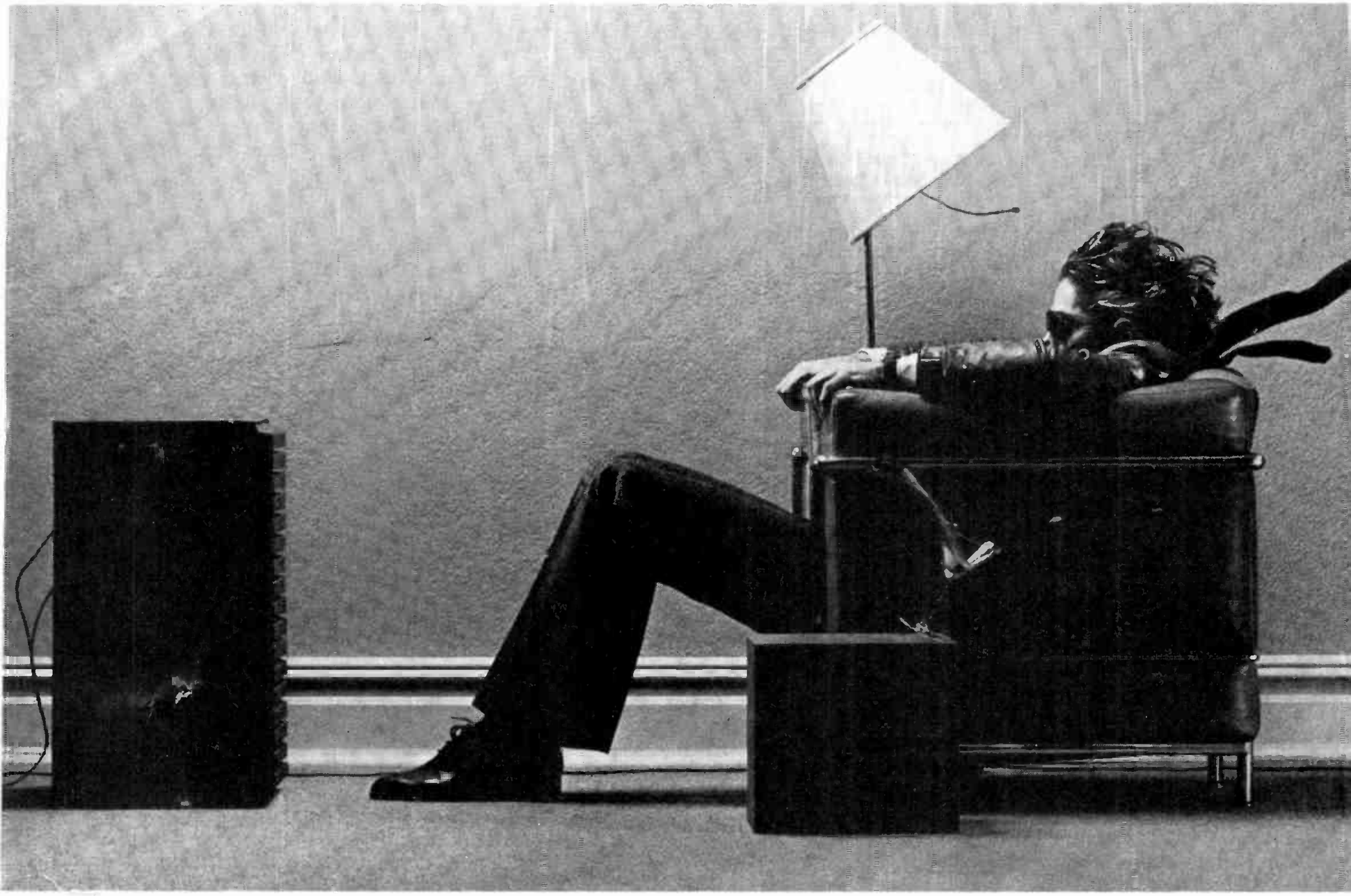

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TABLE X—ARCADE-TYPE GAMES

Game	Description
ATARI Super Breakout	Bricks are knocked out of a wall when struck by a ball; ball eventually "Breaks out."
ENTEX Blast It	Lines eliminated when hit by ball.
IDEAL Flash	Bean bags are tossed at eight-color display board. Five game variations.
PARKER BROTHERS Wildfire	Surprisingly realistic hand-held version of arcade electronic pinball machine.
TIGER Rocket Pinball	Less sophisticated than Wildfire but fun.
VANITY FAIR Starburst	Electronic pinball machine.

TABLE XI—FOR SMALL CHILDREN

BANDAI	Baseball, Basketball, Football, Incredible Hulk, Amazing Spiderman
TIGER	Safari/Darts, Football/Sea Chase, Space Invader/Gone Fishing

Arcade-Type Games (Table X). "Flash" might better be classified as a party group-participation game than an arcade game. Players toss bean bags, dart style, at the panels of a board. Lights are turned off and on; sounds are produced and scores are displayed.

Electronic Games For Small Children (Table XI) look like the real thing but require little if any skill. Some only require the player to press the start button to play the game.

Word and Number Educational Games (Table XII) abound in electronic interpretations of nonelectronic counterparts. You can get quizzed on just about anything at almost any level. Coleco's "Quiz Wiz" will test your knowledge of Sherlock Holmes or how aerosols work. Mattel's "Brain Baffler" will challenge your ability to unscramble a word as its letters change at the rate of three per second. You can even try your hand at an electronic rack of "Scrabble" called "Lexor," made by Selchow & Righter.

Sports (Table XIII). Most handheld electronic football games have been based on Mattel's "Football," designed in 1977. Mattel's original game pits two players, taking turns, against a computer defense (unlike video cartridge football games, where the players directly oppose each other).

The object of this type of football game is to move your ball carrier, represented by a bright LED light through would-be tacklers, depicted by dimmer LED lights. The original Mattel didn't have provision for passing, a deficiency eliminated in Mattel "Football 2," which also introduced other refinements to the game.

In the original Mattel "Football" (and competitive products that followed it), play starts on the 20-yard line; however, Mattel's "Football 2" begins the action with a kickoff. The ball carrier can reverse his field in Mattel's "Football 2" to avoid tacklers, a maneuver not possible in "Football" and many other competitive versions of it. The time to play is continuously displayed in "Foot-

TABLE XII—WORD & NUMBER EDUCATIONAL GAMES

Game	Description
COLECO Electronic Learning Machine	Spelling and word games, math problems and general knowledge questions.
Lil Genius	Right answer lights green LED; wrong reply turns on red LED and buzzer.
Quiz Wiz	Cartridges cover sports, movies, energy, trivia, etc. Wrong answer produces a raspberry.
FONAS Kiddy Computer	Poses over 6500 math problems. If two machines are hooked together, the first person to answer correctly, wins.
MATTEL Brain Baffler	Eight spelling and word strategy games including two-player competitive games.
MILTON BRADLEY Omni Entertainment System	Cartridges present questions on movies, sports, music, television, trivia, etc.
SELCHOW & RIGHTER Sensor	Electronic version of Scrabble, made by same company. Player can be matched against opponent or computer.
Lexor	Object of game is to form as many words as possible from seven letters.
TEXAS INSTRUMENTS Mr. Challenger	Letter and word games. Players compete against each other or the computer.
Little Professor	Generates over 16,000 basic problems in addition, subtraction, multiplication and division.
Speak & Spell	Tests players on more than 200 frequently misspelled words. Speaks words and letters.
Speak & Read	Sequel to Speak & Spell.
Speak & Math	Math version of Speak & Spell.

Coleco Head-to-Head Baseball

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Another reason for all the commotion is that the PMC-80 uses the same, easy to learn, LEVEL II BASIC language that the TRS-80 uses! What does this mean? It means that the PMC-80 can run all the 1000's of programs that have been written for the TRS-80 Level II, 16K computer! Some of the programs available include: Flight simulation, World Champion Chess program, Scores of educational and business programs. Word processing programs and hundreds of other games and simulations.

The PMC-80 is expandable!

Your PMC-80 is ready to grow with your needs. Using a special cable, available from Simutek for $35.00, it may be connected to Radio Shack's Expansion interface, to give you up to 48,000 characters of memory, up to 4 disk drives, addition of a telephone communication system, Voice Synthesizer, various printers, a real time clock, as well as plotters and other neat interfaces! As your skills with the PMC-80 improve, you're sure to want some of the ADD-ON's described above. (And these are just a few!)

Save Money! Use your own television!

The PMC-80 has a built in RF MODULATOR so you can use your black and white or color TV for a VIDEO MONITOR! A simple hook-up to your television's antenna connector, makes channel 3 your computer's video channel.

Special Introductory Offer: 25 Free Programs

SIMUTEK, a leading innovator in Home Computer Software, is making a SPECTACULAR INTRODUCTORY OFFER

Comparison Chart

Features	PMC-80	TRS-80
Microsoft's Fantastic Level II Basic	Yes	Yes
Full 128 x 48 Graphics	Yes	Yes
16,000 characters memory	Yes	Yes
Tape recorder for storing or retrieving programs	Yes	Yes
Use your own TV (Save $$)	Yes	No
Expandable to 48,000 characters of in computer memory	Yes	Yes
Use TRS-80 expansion interface	Yes	Yes
Expandable to 4 floppy disk drives (over 100,000 characters of storage on each one!)	Yes	Yes
Telephone Communications available: connect to large computers/electronic mail etc.	Yes	Yes
1000's of reacy made programs avallble for "educational" and "scientific" applications?	Yes	Yes
Printers available	Yes	Yes
High Speed Z80 CPU	Yes	Yes
Interface available for controlling lights and appliances in home	Yes	Yes
Retail Price	**$645.00**	**$849.00**

to people that ORDER the PMC-80 NOW. With each purchase, we will give 25 FREE HOME COMPUTER PROGRAMS! Some of these include: Home Amortization tables program, Loan payment programs, Depreciation rate program, Interest table program, Annuity and Investment calculation programs as well as these great animated games: GRAPHIC-TREK 2000: Command the Enterprise!, INVASION WORG.. Stop the invading marauders from space before they take over earth! You command Earth's forces of androids, space fighters, laser guns etc., against the enemy's robots, saucers, proton destroyers, etc!, STAR WARS: Fly your space fighter into the Death Star to destroy it! But watch out, Darth Vader doesn't like you!, SPACE TARGET: A fantastic animated arcade game of skill and daring!, SAUCERS: Can you win win the coveted Medal of Honor?

Here's what you get:

The PMC-80 microcomputer with 16,000 characters of "In Computer Memory", Microsoft's Level II Basic (in 12K ROM), a cassette player for storing or retrieving programs or data (cassette player is built into the computer!), an RF Modulator for connecting the PMC-80 to your television set, 25 FREE programs so you start using your computer immediately, complete instruction manual, learning manual and owners manual so you can begin writing your own programs right away!

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ball 2"; in most games, a button must be pressed to check the remaining time. "Football 2" also has an easy-to-use control panel with separate pass and kick buttons (Coleco's "Electronic Quarterback" requires moving a shift lever before touching a kick/pass button) and four speed options (most games have two).

Despite its age, Mattel's "Football" scores highly when compared with Coleco's "Electronic Quarterback" and Mattel's "Football 2." Weaknesses of "Electronic Quarterback" include difficulty in distinguishing the ball carrier from other players, awkward spacing of carrier direction buttons, and poor sound effects.

All three games ("Football," "Football 2," and "Electronic Quarterback") received strong ratings as shown in Table XIV.

Recently, hand-held game manufacturers have been increasing their emphasis on graphics. Pictorial representations of players have been replacing the

TABLE XIII— ELECTRONIC SPORTS GAMES

Football	
BAMBINO	Super Star Football
BANDAI	Electronic Football
COLECO	Electronic Quarterback
COLECO	Head-to Head Football
ENTEX	Color Football 4
EPIC	Electronic Football
FONAS	Two-Player Football/ Tennis
KENNER	Live Action Football
MATTEL	Football
MATTEL	Football II
WADDINGTONS	Sports Center*
Baseball	
BANDAI	Miracle Baseball
BANDAI	Super Baseball
COLECO	Head-to-Head Baseball
ENTEX	Baseball 3
EPIC	Digit-Com Baseball
FONAS	2-Player Baseball
LJN	Stadium Baseball
MATTEL	Baseball
TIGER	Electronic Baseball
Basketball	
BAMBINO	Basketball
COLECO	Head-to-Head Basketball
ENTEX	Electronic Basketball
MATTEL	Basketball
MATTEL	Basketball II
Soccer/ Hockey	
BAMBINO	Soccer
BAMBINO	Ice Hockey
COLECO	Head-to-Head Soccer
COLECO	Head-to-Head Hockey
ENTEX	Soccer
MATTEL	Soccer
MATTEL	Soccer II
MATTEL	Hockey
WADDINGTONS	Soccer 2
WADDINGTONS	Hockey 2
Boxing	
BAMBINO	Boxing
Golf	**(Not available)**
Bowling	
CADACO	Foto Electronic Bowling
VANITY FAIR	Computer Bowling
MARX	Electronic Bowling
Skiing	**(Not available)**
Horse Racing	
BAMBINO	Horse Race
MATTEL	Horse Race Analyzer
Tennis	
ENTEX	Electronic Tennis
Pool	
PARKER BRO.	Bankshot

*Includes football, baseball and tennis.

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LED "lines" of earlier games. In both Bambino's "Football" and Kenner's "Live Action Football," body movement is simulated on the display.

The same body-movement techniques are employed in other sports games; Bambino uses them with great success in boxing and soccer.

Coleco's "Head-to-Head Baseball" deserves special mention. Cleverly and attractively designed, it neglects few aspects of baseball, the play-by-play action includes sound effects, stealing, bunting, double plays, hit-and-run and tagging up after a fly ball.

One nice touch is the displaying of the hitter's batting average as he comes up and the posting of game statistics on the scoreboard. However, "Head-to-Head Baseball" and all hand-held baseball games rely too heavily on "announced" computer-generated decisions (single, double play, home run, etc.). Until this deficiency is dealt with, players who have tried video cartridge versions of baseball will find the hand-held baseball products dull by comparison and much less challenging.

If you can live with the idea of a cue stick formed by a row of lights, you'll find "Bank Shot" a real challenge. Parker Brothers' electronic pool game simulates straight pool and poison pool (eight ball). Balls are also represented

TABLE XIV—COMPARING HANDHELD FOOTBALL GAMES

No.	Consideration	Coleco Electronic Quarterback	Mattel Football	Mattel Football 2
1	Interest retention	25	25	25
2	Player skill required	15	15	18
3	Design creativity	18	17	20
4	Competitiveness	15	14	15
5	Display realism/ packaging/controls	10	11	12
6	Time needed to learn the game	8	8	8
7	Computer as opponent	9	9	10
8	Sound effects	5	8	9
9	Game variation random generation	N/A	N/A	N/A
10	Overall execution	12	13	15
	Total Points	117	120	132
	Max. Possible Points	140	140	140
	Score	84	86	94

TABLE XV—MISCELLANEOUS GAMES & TOYS

Game	Description
BAMBINO	
Safari	Cage as many jungle animals as possible.
Police Car Chase	Police car pursues gangsters.
CASTLE	
Name That Tune	Simulates the TV show.
COLECO	
Zodiac Astrology Computer	Chart your horoscope.
Zap	Two-player contest in reflex action.
FISHER PRICE	
Baby Soft Sounds	Doll talks when moved.
GAF	
Melody Madness	Musical version of Concentration.
LJN	
Electronic Concentration	A game of matching numbers.
Impulse	A test of instant reaction.
Lickin' From Chicken	Version of Tic Tac Toe.
LAKESIDE	
Strobe	Tests reflexes against light and sound.
MILTON BRADLEY	
Milton	Phrase completion game.
Microvision	Cartridges plug into hand-held console.
PEDIGREE	
Quickfire	Beam of light knocks out targets.
PLAYSKOOL	
Alphie	Robot with simple matching games.

by lights (the brightest one being the cue ball).

The cue stick can be controlled for soft or hard shots and backspin. The cushions can be used as in real pool and combination shots are possible. A miscalculation can cause a scratch (sinking the cue ball by mistake). The game begins by breaking the rack of balls as in real pool. Pressing a button reveals the score at any time during a game.

Mattel's "Horserace Analyzer" isn't a game; its an aid for rating horses at the racetrack. Information from the Daily Racing Form is entered in a fixed sequence and the machine provides ratings for the best four horses in the race.

Miscellaneous (Table XV) includes games not easily classified elsewhere. They range from "Melody Madness," the most musical of all games on the marketplace to "Baby Soft Sounds," the first of a new generation of talking dolls.

"Baby Soft Sounds" has no switches or controls. Movement and position trigger its electronic circuitry which randomly generates 16 different words and sounds. The circuitry was designed in a joint engineering effort by Fisher Price and Siltronics, a Canadian electronics company. The October cover of PE showed a wafer of speech synthesis chips made for the doll by Precision Monolithics, Inc., a leading supplier of military and space integrated circuits. Each wafer contains hundreds of chips. Siltronics dices the wafer to produce chips for the Fisher-Price doll. By buying wafers and slicing them instead of buying individual chips, Fisher-Price was able to use high-reliability PMI chips at minimum cost.

"Melody Madness," a musical version of concentration, will play long, short or very brief tunes, at the player's choice; the player has seven seconds to match the tune by pushing one of 24 buttons. A correct selection triggers a display of lights and a congratulatory signal; an error is greeted by a raspberry. Creative players can also use "Melody Madness" to write their own tunes; these tunes however cannot replace the 24 tunes stored in the machine's memory bank.

"Baby Soft Sounds," "Melody Madness" and other products listed in the miscellaneous category reveal some of the new directions being taken in games and toys thanks to semiconductor chips. The games in this and other categories reveal that hand-held games are very much in a transitionary period; a year from now, today's sensations could well be obsolete. ◊

Next month:
Video cassette games.

Solid-State Developments

By Forrest M. Mims

The Laser at Twenty

THE LASER is no longer a teenager! It seems hard to believe, but it was two decades ago that Theodore Maiman, then at Hughes Aircraft, assembled the world's first working laser by inserting a polished ruby rod inside a helical, xenon strobe lamp. Maiman's achievement made Hughes Aircraft the victor of a race in which several other major research laboratories were competing. Bell Laboratories, which built the first gas laser early in 1961, was one notable contestant. Bell Labs had worked to be first, because one of its scientists, Arthur Schawlow, and one of its consultants, Charles Townes, were then credited with having first proposed the laser. That achievement, however, might also be relegated to second place. In 1977, the U.S. Patent and Trademark Office issued a controversial, landmark laser patent (Patent No. 4,053,845) to inventor Gordon Gould.

Gould, who had described his laser ideas and even coined the word "laser" in a 1957 notebook, disclosed his laser concepts to the Patent Office in 1959. For technical and other reasons too complex to describe in this column, he was denied a patent.

Gould pursued his quest until he was granted his landmark patent covering optically pumped lasers. Ruby lasers, for example, are usually optically pumped by an external light source such as a xenon strobe tube. Recently, Gould was granted a second patent covering various laser applications. At least one additional laser patent will probably be issued to this inventor.

Gould's laser patents have thrown the laser industry into an uproar. As you can readily imagine, laser companies and users alike are hardly enthusiastic about having to pay royalties on an invention whose principal patents were thought to have expired previously.

We will be hearing a lot more about Gordon Gould's laser patents in coming years as the various contenders fight out their disputes in court. In the meantime, there can be no controversy whatever that, at 20, the laser has matured into an important tool of modern industry that offers countless applications in research, education, industry and the military.

Laser Light. Ordinary light is a blend of components having many different wavelengths which are out of phase with one another (even with components of the same wavelength) and which diffuse into space in many directions. Laser light is much more organized. For example, the light from most lasers is highly *monochromatic*. This means that the emitted light consists of a single wavelength or very narrow band of wavelengths. Also, the waves emitted by most lasers are all in phase with each other. Finally, the light from many lasers is highly directional. The resulting narrow beam means laser light can be incredibly intense.

How intense? The filament of an incandescent lamp would have to be heated to the impossibly high temperature of 10,000,000,000,000,000 degrees Centigrade, filtered to a single wavelength, and concentrated with lenses to equal the beam produced by a small helium-neon laser only a tenth as powerful as a small flashlight!

In 1977, I wrote a book entitled *Lasers: The Incredible Light Machines* (David McKay Co., Inc.) in which I related an experience which helps one appreciate the incredible intensity of laser light. I will repeat that description now for your benefit.

"A few summers ago, a group of students and I placed a small helium-neon gas laser atop an office building in Albuquerque, New Mexico, and pointed the laser's bright red beam at the parking lot of the Sandia Mountain tramway some 20 kilometers (12.5 miles) away. We then drove to the tramway and looked back at the scintillating lights of Albuquerque. At first we saw no sign of the laser. But as we walked down a slight slope, we gasped in awe as the dazzling red beam of the laser suddenly came into view. Though the beam contained only three-thousandths of a watt of optical power, it easily outshone every light in Albuquerque, even the flashing beacon from the city airport!"

The key to the laser's brilliance, of course, was its narrow beam. After having travelled 20 kilometers, the beam had widened to approximately the size of a drive-in movie screen. Therefore, walking ten or fifteen paces from the center of the beam made the brilliant starburst of red laser light disappear completely from Albuquerque's skyline.

Kinds of Lasers. Many different solids, liquids, and gases have been successfully stimulated to exhibit laser action. The brilliant red, green, blue and yellow beams you can see at laser light shows, for example, are produced by various kinds of gas lasers. Most of the laser target designators and rangefinders used by the armed forces employ a crystalline rod of ruby or neodymium-doped YAG (Yttrium Aluminum Garnet) to produce, respectively, bright red or invisible infrared pulses.

No doubt, you've read about the highly classified military lasers which can burn holes through steel plates and even shoot down fast-moving, airborne target

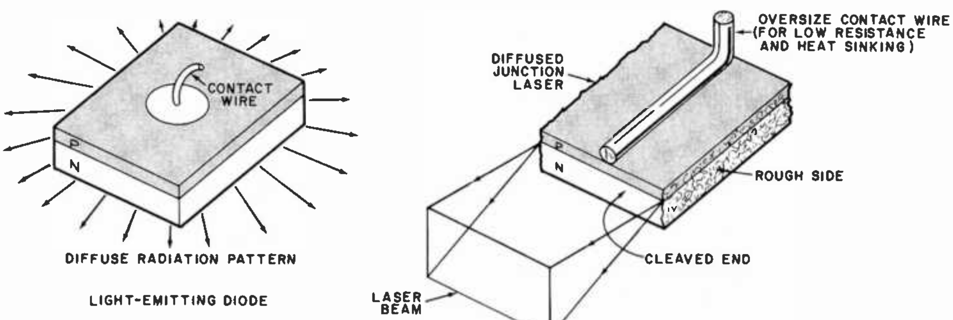


Fig. 1. Comparison of the physical structures of a light-emitting diode (left) and a simple diffused-junction laser.

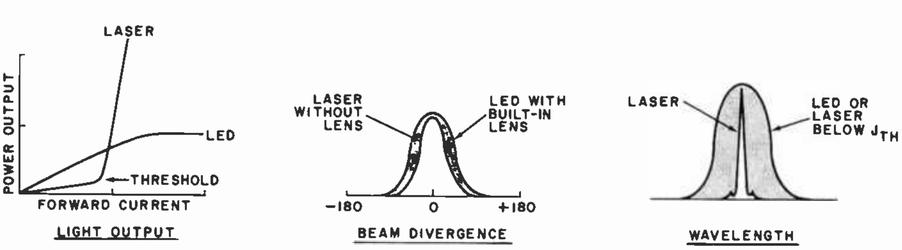


Fig. 2. Comparing the chief operating characteristics of light-emitting diodes and junction lasers.

drones. These lasers employ highly reactive chemical mixtures, combustion or high-voltage discharges to achieve power levels of from hundreds to, in some cases, hundreds of thousands of watts!

Ruby, YAG, glass, plastic and other solid laser materials certainly qualify as "solid state," but the only laser which is a totally self-contained, solid-state device is the semiconductor injection laser. Because this column is about *solid-state* developments, let's find out more about injection lasers.

Semiconductor Lasers. Several types of semiconductor lasers have been invented. One you might not have read about is the cadmium sulfide laser. This laser is made from a thin crystal of the same chemical compound used to make CdS photoresistors. If the CdS crystal is "pumped" by a focused electron beam or light from another laser, it will emit a fan-shaped beam of green light.

To date, perhaps the most important type of semiconductor laser is the injection laser. These devices are actually members of the light-emitting diode family. The first injection lasers were made from chips of n-type gallium arsenide (GaAs) into which a thin layer of p-type dopant had been diffused. Two facing ends of the chip were cleaved to produce smooth, mirror-like facets. The remaining two sides were intentionally roughened during the process of sawing a bar of GaAs into individual laser-diode chips.

When cooled to the temperature of liquid nitrogen and biased with a dc voltage, both ends of these laser chips would emit beams of continuous radiation having a wavelength of about 850 nm. At room temperature, these early lasers could be operated for only brief pulses lasting less than 200 nanoseconds each. This required the development of various kinds of high-speed, miniaturized pulse-driving circuits. To make matters worse, these early lasers had *very* limited lifetimes.

Today's semiconductor lasers are much more reliable than those comparatively primitive, diffused-junction devices. Before finding out more about these modern devices, let's explore some of the differences between semiconductor lasers and LEDs.

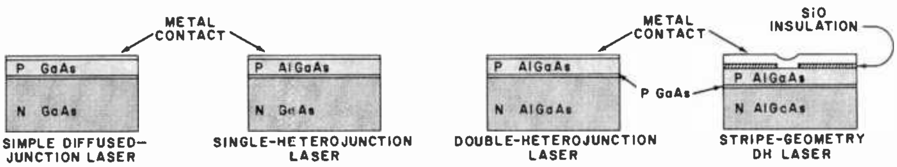


Fig. 3. Simplified cross sections of the four most important kinds of injection lasers.

LEDs vs. Lasers. Injection lasers, as we have observed, are actually members of the light-emitting diode family. When the current injected into a diode laser is below a critical point called the *threshold* (denoted symbolically as J_{th} or I_{th}), the diode behaves exactly like a LED. The chip emits a relatively broad spectrum of wavelengths in a very wide radiation pattern.

Above the threshold, the light from the laser narrows into a distinct beam which emerges from both end facets unless one is coated with a gold reflective film. Also, the wavelengths of the emitted radiation become confined to a very narrow region of the spectrum.

Figure 1 compares the physical structure of a very simple diffused junction laser with a LED made from a semiconductor wafer of the same type. The ways in which the devices operate are compared in Fig. 2.

Heterojunction Lasers. The key to the development of high-performance, long-lived lasers was the introduction of the *heterojunction*, a junction of two dissimilar semiconductors such as gallium arsenide (GaAs) and aluminum gallium arsenide (AlGaAs). This permits the light-emitting pn junction region to be sandwiched between two or more semiconductor layers that confine the generation and emergence of the emitted light to the junction region. The result is a laser with a much lower threshold and higher efficiency.

The confinement of light between two heterojunctions occurs when the refractive index of the semiconductor in which the pn junction is formed (typically GaAs) is *higher* than that of the semiconductor bordering the pn junction. This causes the heterojunctions to appear as mirrors to light waves travelling between them. The same phenomenon, which is called *wave guiding*, causes light to propagate through the core of a plastic or glass fiber when the core is clad with plastic or glass having a lower index of refraction than the material forming the outer surface of the fibers.

There are many different kinds of heterojunction lasers, the two most important of which are *single-heterojunction* (SH) and *double-heterojunction* (DH) lasers. It's *very* important to understand the differences between these two classes of diode lasers.

The Single-Heterojunction Laser. This type of laser has a heterojunction on only one side of the pn junction. A typical SH laser will emit a full watt of optical power for every mil (0.001 inch) of junction width. The smallest SH lasers are 3 mils wide and emit three to four watts at 10 amperes of forward current. Their threshold current is typically 4 amperes.

Although an SH laser is several times more efficient than a diffused-junction laser, an SH laser cannot be operated continuously at room temperature. In-

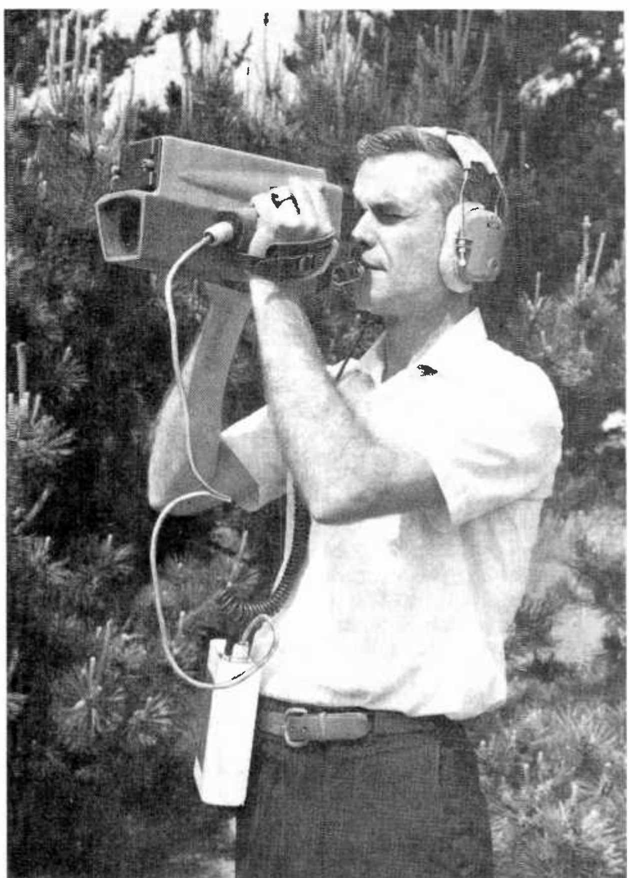


Fig. 4. A long-range laser communicator made by American Laser Systems.

stead, a high-current pulse generator which delivers fast-rise-time pulses lasting no more than 200 nanoseconds must be used to drive such a laser diode.

The Double-Heterojunction Laser. Most kinds of DH lasers, and there are far too many to describe here, can operate continuously at room temperature. That's because the heterojunctions on either side of the light-emitting pn junction efficiently confine the light to an ultra-thin region along the junction.

Many DH lasers are *stripe-geometry* devices. This simply means that all but a narrow stripe of one electrode is insulated from the upper surface of the laser. As a result, the current flow through the pn junction is confined to a thin stripe between the two end mirrors.

The very high current density present in the active region of a stripe-geometry DH laser produces a very low "lasing" threshold and operating current. Some such lasers will generate several milliwatts of laser light at forward currents of less than 100 milliamperes. Figure 3 compares the kinds of injection lasers.

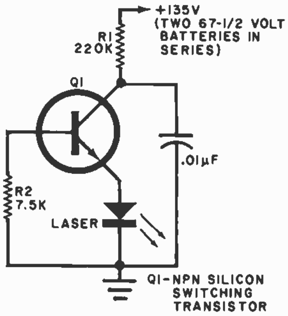


Fig. 5. Simple pulse driving circuit for injection laser.

Injection-Laser Applications. SH lasers are noted for their high output power—as much as 50 watts per pulse. Therefore, they are ideal for long-distance, pulse-modulated communications and rangefinding through the atmosphere. Figure 4 shows a sophisticated laser communicator made by American Laser Systems of Goleta, CA.

Experimenters can buy SH lasers for less than $10 from some of the parts dealers who advertise in POPULAR ELECTRONICS. Many different SH lasers are available from Laser Diode Laboratories (1130 Somerset St., New Brunswick, NJ 08901) and RCA (Solid State Division, Electro Optics and Devices, Lancaster, PA 17604). Prices of diodes sold by the last two sources range from approximately $15 to $50 or more. Both companies publish excellent data sheets and brochures describing their laser products.

SH lasers require much more operating current than DH lasers and nonlasing LEDs. They must be powered by drivers which deliver fast-rise-time, short-duration current pulses. Typically, an SCR, a four-layer diode, an avalanche transistor or a VFET is used to gate current or to discharge a capacitor through an SH laser. Because of the combined voltage drops of the switching device and the laser, the supply voltage that must be employed so that the required current will flow will range from approximately 25 to several hundred volts, depending upon the parameters of the switching device and the laser.

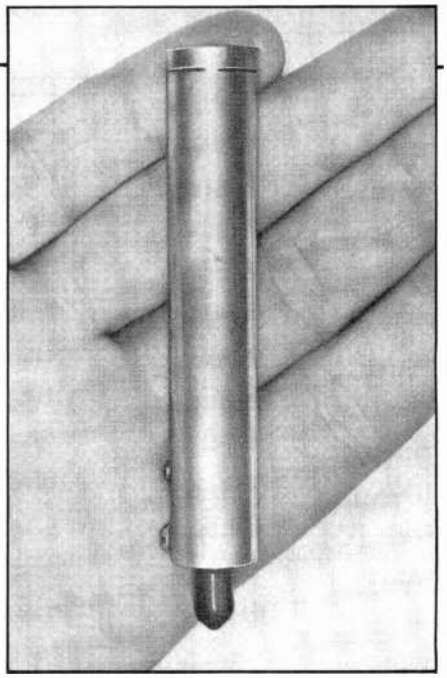


Fig. 6. A battery-driven miniaturized single-heterojunction laser transmitter.

The apparent complex demands placed on SH-laser drivers can be deceptive. As you can see by looking at the schematic diagram in Fig. 5, a driver can be *very* simple. I described in detail in the October 1971 issue of this magazine (pp. 46-49) a circuit very similar to this one. The September 1977 "Experimenter's Corner" also contained a similar avalanche-transistor laser driver.

Figure 6 shows a miniaturized SH-laser system that is smaller than a penlight. This tiny laser is powered by a sin-

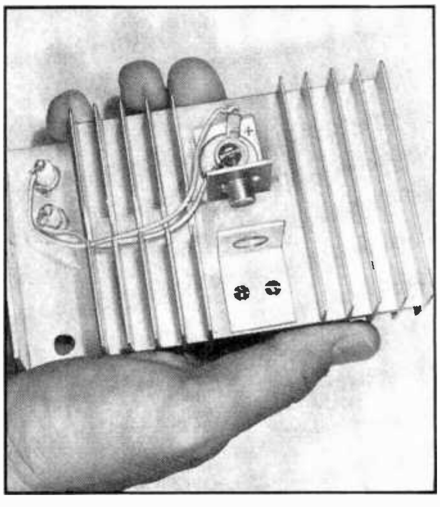


Fig. 7. A DH laser with collimating lens installed on an oversize heat sink.

gle, 1.3-volt, mercury "button cell." A miniature dc-to-dc converter charges a capacitor to 30 volts. The charge is then dumped through an SH laser by a four-layer diode. A lens collimates the laser light into a pencil-thin beam. I originally built this laser intending to publish it as a Project of the Month, but have postponed the article because the four-layer diode is no longer available in small quantities.

DH lasers are ideally suited for communications through optical fibers. They will probably also find use in laser printing systems and video-disc readouts. Because a DH laser can operate continuously at room temperature, powering one would at first glance seem a simple matter of connecting the diode to a few batteries and a current-limiting resistor. Unforunately, things are more complicated. The operating current for a DH laser is greatly influenced by temperature. A change of even a few degrees can change a laser's threshold enough either to halt the lasing process or to destroy the laser! A DH laser must therefore be maintained at a constant temperature. Otherwise, its forward current must be temperature-compensated by a thermal-tracking network.

Figure 7 shows a DH laser purchased from Laser Diode Laboratories installed on an oversize, finned heat sink. A small lens in front of the laser collimates its relatively broad beam into a very narrow pencil of near-infrared radiation. I assembled this DH laser system for experiments in long-range amplitude-modulated voice communications.

The laser that appears in Fig. 7 is biased by a 6-volt battery in series with a wirewound, current-limiting potentiometer. Current through the laser is carefully monitored by means of a digital voltmeter and a low-value, current-sense resistor. The beam from the laser can be modulated by a flexible mirror against which the user directs his voice.

Further Reading. Many hundreds of technical papers have been published about semiconductor lasers. A very good introductory article is "Light-Wave Communications" by W. S. Boyle (*Scientific American*, August 1977, pp. 40-49). The best book I've seen is *Semiconductor Lasers and Heterojunction LEDs*, by Dr. Henry Kressel and J. K. Butler (Academic Press, 1977). Ralph Campbell and I wrote an early book called *Semiconductor Diode Lasers* (Howard W. Sams & Co., 1972). Though out of print, this book contains many useful circuits and ideas.

You will be able to find all of these publications and many more at most university libraries. For the latest developments, check journals like *Applied Optics*, *Applied Physics Letters* and *Proceedings of the IEEE*. Also, read *Laser Focus* magazine each month. Keep one important thing in mind, however—if you assemble injection laser projects, be *sure* to follow the manufacturer's safety precautions. ◇

Experimenter's Corner

By Forrest M. Mims

Experimenting with a Light Pen—I

AMONG the most interesting data-entry devices for computers and remote terminals are those that are sensitive to light. The most sophisticated optical data-entry devices are solid-state television cameras. When such a camera is used with a computer having a large complement of RAM storage capacity, complex operations such as pattern recognition, equipment monitoring, and area surveillance can be performed easily.

Television cameras provide perhaps the ultimate in optical data entry, but their cost (as well as that of the necessary interface circuit) varies from high to exorbitant. Two much more common—and cheaper—optical data-entry devices are *light wands* and *pens*. Television cameras contain many hundreds or thousands of resolution elements, but most light wands and pens incorporate a single-element light detector such as a photodiode or a phototransistor.

It's important at the outset to understand the differences between light wands and pens. Light wands are designed to detect the presence or absence of contrasting marks such as bars of ink printed on paper or plastic. Therefore, light wands usually include built-in light sources to illuminate the marks. They also include precisely focused optics that assist the detector and the light source in their work.

Light pens, on the other hand, are designed to detect a point of light on the screen of a video display such as a cathode ray tube. Simple light pens do not include an internal light source because most video displays are light emitters.

Fig. 1. Hewlett-Packard's bar code-reading Optical Wand plug into an HP-41C calculator.

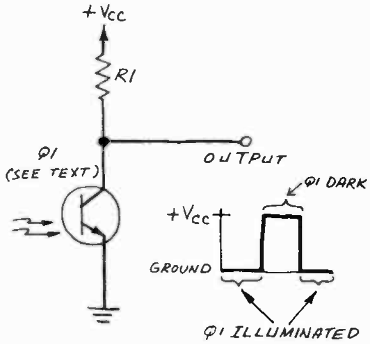
However, some pens designed for use with high-resolution displays include a pinpoint light source so that the operator will know precisely where the pen is pointed.

Applications. The light wand is a one-way data entry device. You've probably seen sleek-looking wands attached by flexible cables to some late-model cash registers. A sales clerk can record a purchase merely by sweeping the wand past the bar code printed on the label or package of many different products. Some wands can even read the printed information on a price tag!

Because light wands can be used by unskilled operators and provide faster and more reliable data entry than keyboards, their use is rapidly expanding. They are currently being used in portable inventory monitoring systems in some department stores and supermarkets. They are also used in some libraries to read information from bar-coded identity cards and books.

Figure 1 is a photograph of a light wand made by Hewlett-Packard. The wand's cable plugs into the company's HP-41C programmable calculator and allows bar-coded programs to be quickly loaded into the calculator. If you've ever spent ten or more tedious minutes loading a long program into a calculator, you can readily appreciate the convenience and speed provided by such a wand.

Fig. 2. A basic phototransistor light-detection circuit. Any standard npn phototransistor can be used.



Light-Pen Applications. Light pens are simpler and therefore physically slimmer than light wands.

How the light pen allows information to be "drawn" on the screen of a CRT is not immediately obvious—at least it wasn't to me when, as a high school student, I viewed a film which showed computer operators using light pens!

Actually, the light pen's principle of operation is remarkably simple. In a typical CRT/light-pen system, for example, the entire screen is repeatedly scanned by a tightly focused electron beam. This produces a fast-moving dot of light too dim to be seen by the human eye but easily detectable by a phototransistor or photodiode.

The computer knows the precise location of the moving dot at any given instant. Therefore, if a light pen is connected to an input port, the computer knows exactly where the light pen is pointed. Depending upon the computer's software, this permits the operator to select specific data to be displayed on a CRT for any desired purpose, and to "write" information, including complex graphics, onto the screen and into the computer's memory.

A Homemade Light Pen. A light pen is very easy to make. Both photodiodes and phototransistors make suitable sensors. The former are faster but the latter are more sensitive.

The basic phototransistor light-detection circuit in Fig. 2 illustrates how a straightforward detector responds to a light pulse. Any standard npn phototransistor such as the FPT-100 can be used for *Q1*. When *Q1* is dark, its collector-to-emitter resistance is much higher than *R1*. The output voltage of the circuit therefore rises very close to $+V_{CC}$. When photons strike the device's light-sensitive region, *Q1* becomes forward-biased and its collector-to-emitter resistance falls far below that of *R1*. The circuit's output voltage thereupon approaches ground potential. Summing up, the output of the circuit is normally a high voltage. When light strikes phototransistor *Q1*, the output voltage is low.

This basic circuit can be used in some light-pen applications. A much better circuit, however, is shown in Fig. 3. An operational amplifier is used without a feedback resistor to provide the highest possible gain. The gain is so high that the op amp functions as a comparator whose output switches from +5 volts to ground when the voltage applied to its noninverting input falls below the reference voltage provided by *R2*. This occurs when *Q1* is illuminated.

When *Q1* is dark, the voltage at the noninverting input of the op amp rises above the reference voltage. The comparator output then swings from ground potential to +5 volts. Potentiometer *R2* can be adjusted to alter the light level at which the comparator switches. Those readers who have experience with op amps are probably wondering about the function of potentiometer *R3*. In a working version of this circuit lacking *R3*, the output voltage when *Q1* is illuminated can be greater than 1 volt. This exceeds the maximum allowable TTL logic 0 level of about 0.85 volt. Therefore, if TTL logic is to be controlled by the circuit shown in Fig. 4, it is necessary to adjust *R3* to pull the output down a few tenths of a volt.

Incidentally, the basic phototransistor circuit shown in Fig.

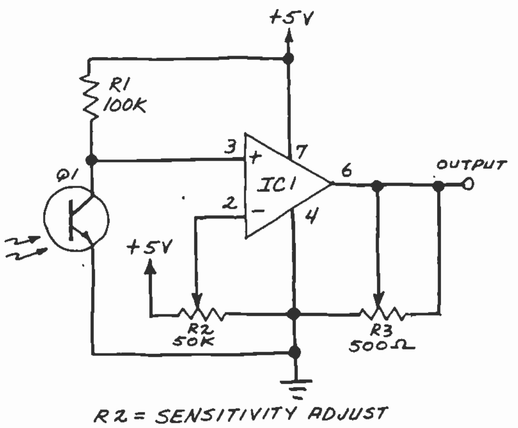


Fig. 3. An expansion of the circuit in Fig. 2. using an operational amplifier for higher gain.

2 will directly drive TTL logic without the need for a pull-down resistor. However, it is less sensitive than the circuit that appears in Fig. 3.

Light-Pen Data-Entry Circuit. It's relativitely easy to design a data-entry circuit controlled by a homemade light pen. Figure 4 is the block diagram of one such circuit I've designed.

The operation of the circuit is straightforward. The clock supplies a stream of pulses to a programmable 4-bit counter. The counter's binary output is decoded by a 1-of-16 decoder which sequentially illuminates each of sixteen LEDs.

When the light pen is dark, the LEDs are scanned at a rate determined by the clock frequency. When the light pen is brought near any of the LEDs, nothing happens until that LED glows during the scan sequence. The output from the comparator then changes state and causes the counter to be loaded with whatever data is present at its data inputs. Because these data inputs are connected to their respective outputs, the current count is loaded into the counter. This freezes the counter even though the clock continues to supply pulses to it. The address of the selected LED then appears on the 4-bit bus.

Incidentally, the usual way to block clock pulses is to insert a gate between the clock output and the counter input. The method employed here eliminates the need for such a gate.

Figure 5 is the schematic diagram of my prototype data-entry circuit. A 555 timer operating in the astable mode (*IC3*) serves as the circuit's clock. The clock frequency, and hence the LED scan rate, can be adjusted by means of potentiometer *R5*. You can also increase the value of *C1* to slow the scan rate.

Counter *IC4* is a 74193 programmable up-down counter. Note how the programming data inputs are tied to their respective outputs. The 1-of-16 decoder (*IC2*) is a 74154. The anodes of the 16 LEDs connected to the decoder outputs are all tied to a single current-limiting resistor because only one LED is illuminated at any given instant.

The light pen circuit appears above the LED array. Note that the output of operational amplifier *IC1* is connected to the LOAD input of counter *IC4*.

You can assemble a working version of this circuit on a solderless breadboard in less than an hour. The selection of devices for use as *IC1* and *Q1* is not critical. Any general-purpose op amp such as a μA741 is suitable, and any standard npn phototransistor such as the FPT-100 can be used. The phototransistor should be connected to the circuit by means of clip leads. Power can be provided by a +5-volt supply or you can use a 6-volt battery if you first connect the cathode of a 1N4001 diode to those points in the circuit marked +5 volts and the anode to the battery's positive terminal.

When you apply power to the circuit, the LEDs will either flash off and on in rapid sequence or all the LEDs will appear to glow dimly. If the latter occurs, the clock frequency is so great that the LEDs switch on and off faster than your eyes can respond. For initial tests, adjust *R5* to achieve this latter condition.

Before attempting to use the circuit, you must trim the light-pen circuit. A trial-and-error approach will eventually produce useful results, but a much better approach is to temporarily disconnect the grounded lug of potentiometer *R3* from ground and connect a voltmeter between the output of the op amp and ground. Illuminate *Q1* with a flashlight and adjust *R2* until the output voltage of the op amp falls to its lowest value, which was approximately 1.2 volts in the prototype circuit. Don't turn the rotor of *R2* beyond this point once you have found it.

When you remove light from *Q1*, the output voltage of the op amp should immediately increase several volts. (It reached 3.4 volts in the prototype.) The light pen is now adjusted for maximum sensitivity. Indeed, it is probably so sensitive that ordinary room lighting will be able to switch the comparator. Therefore, you should wrap a cylinder of black electrical tape one-half inch in diameter around *Q1* to block ambient light. Heat-shrinkable tubing can also be used for this purpose.

Next, reconnect the lug of potentiometer *R3* to ground and again illuminate *Q1* with a flashlight. Adjust the rotor of *R3* until the LEDs stop scanning and only a single LED remains on. The light-pen circuit is now trimmed and ready for use.

Test the circuit by bringing the aperture of *Q1* close to any of the LEDs in the array. Depending upon the scan frequency, the selected LED should immediately or very quickly glow brightly and all the remaining LEDs will darken. The binary

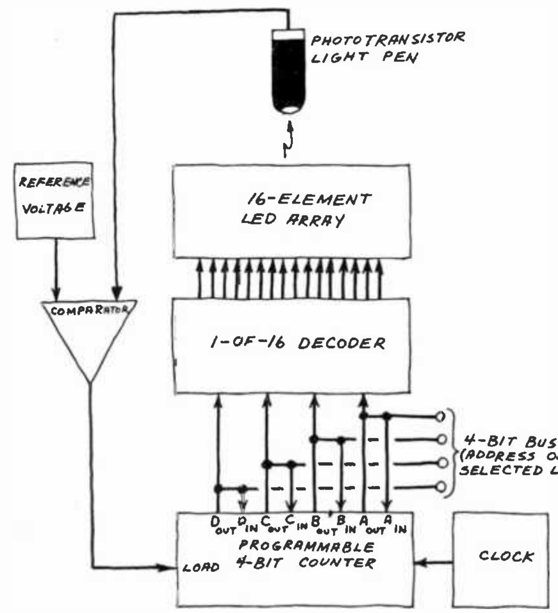


Fig. 4. Block diagram of a 16-position data-entry circuit controlled by a homemade light pen.

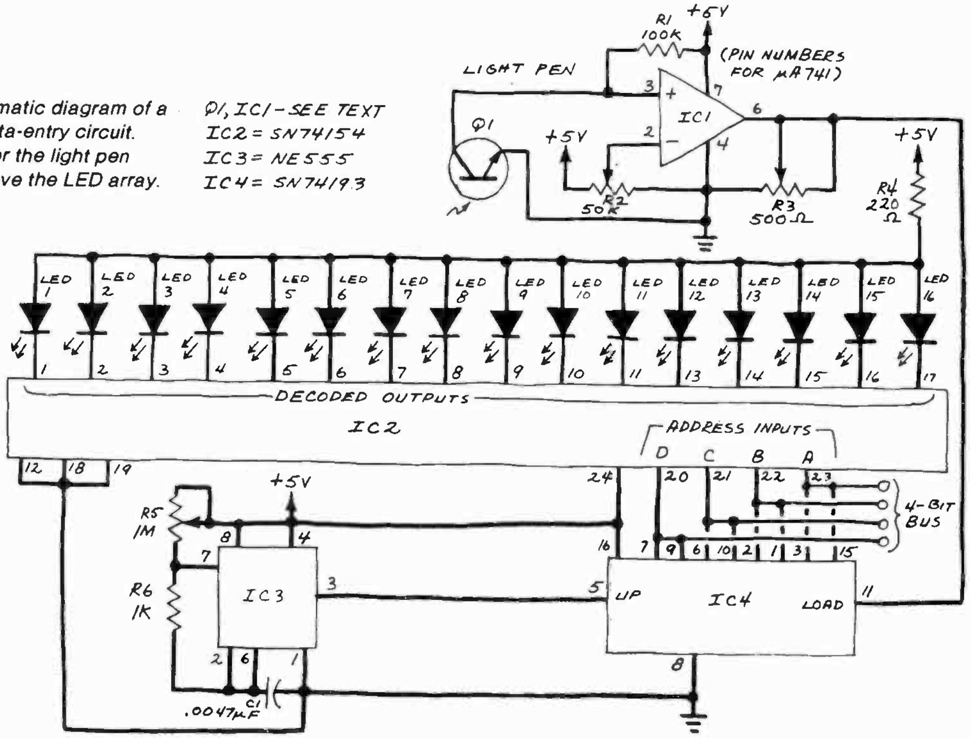
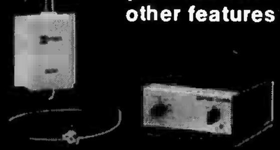
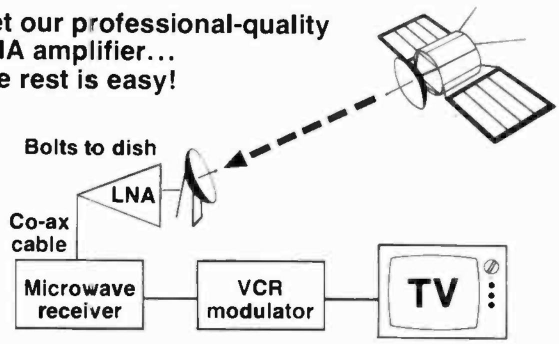


Fig. 5. Schematic diagram of a complete data-entry circuit. The circuit for the light pen appears above the LED array.

address of the selected LED will then appear on the 4-bit bus between *IC2* and *IC4*.

It's interesting to move *Q1* back and forth along the row of LEDs and watch them appear to track its movements. For best results, the scan rate should be adjusted so that all the LEDs glow dimly when none has been selected. ◇





English Broadcasts Audible in No. America

by Glenn Hauser

TIME[1] EST	TIME UTC/GMT	STATION	QUAL.[2]	FREQUENCIES, kHz[3]
4:00-4:15 a.m.	0900-0915	BBC	A	15070, 11955, 11750, 9640, 9510, 6195
4:00-4:15 a.m.	0900-0915	R. Japan[4]	B	9505
4:00-5:00 a.m.	0900-1000	R. Andorra	C	15026 (varies) (and Sun.)
4:00-5:30 a.m.	0900-1030	R. Australia	B	15115
4:00-6:00 a.m.	0900-1100	AFRTS	A	11805, 9700, 9530, 9590, 6030
4:15-6:00 a.m.	0915-1100	BBC	C	17790, 17695, 15070, (21660 Sat. & Sun.)
4:30-5:30 a.m.	0930-1030	V. of Germany	C	17780, 11850
4:45-6:15 a.m.	0945-1115	R. New Zealand	C	6105
5:00-5:15 a.m.	1000-1015	UN Radio	A	15250, 11090-LSB† 9565, (Tue.–Sat.)
5:00-5:30 a.m.	1000-1030	R. Japan	B	9505
5:00-5:30 a.m.	1000-1030	V. of Vietnam	C	12033, 10080
5:00-6:00 a.m.	1000-1100	R. Korea	C	11725, 9570, 15570, 9870
5:00-fade out	1000-	R. Australia	B	6045, 5995
5:00-10:00 a.m.	1000-1500	R. Moscow (via Cuba)	B	9600, 600 (5045 -1100)
5:00-11:02 a.m.	1000-1602	ABC, Perth	B	9610, 6140
5:20-5:30 a.m.	1020-1030	V. of Guatemala	B	6180, 640 (time varies widely)
5:30-6:30 a.m.	1030-1130	Sri Lanka Br. Corp.	C	17850, 15120, 11835 (not all Eng.)
5:30-7:00 a.m.	1030-1200	V. of Asia, Taiwan	D	5980 (Sun. 1030-1040) (time varies)
5:55-6:55 a.m.	1055-1155	R. Thailand	C	11905, 9655
6:00-6:15 a.m.	1100-1115	R. Japan	B	9505
6:00-6:30 a.m.	1100-1130	V. of Vietnam	C	12035, 10080
6:00-6:30 a.m.	1100-1130	R. Mogadishu	D	9585
6:00-6:56 a.m.	1100-1156	R. RSA	C	25790, 21535
6:00-7:00 a.m.	1100-1200	AFRTS	A	6030
6:00-7:30 a.m.	1100-1230	TWR-Bonaire	A	11815 or 15255
6:00-7:50 a.m.	1100-1250	R. Pyongyang	C	9977
6:00-8:00 a.m.	1100-1300	R. Australia	A	9580
6:00-8:30 a.m.	1100-1330	BBC	A-B	25650, 21710, 21660, 21550, 11775, 11750, 9510, 6195
6:00-9:00 a.m.	1100-1400	4VEH, Haiti	C	11835, 9770
6:00-10:00 a.m.	1100-1500	VOA	B	11715, 9565
6:00-11:00 a.m.	1100-1600	AFRTS	A	15430, 15330, 11805, 9700
6:15-6:30 a.m.	1115-1130	Vatican R.	C	21485, 17840 (not Sun.)
6:28-9:00 a.m.	1128-1400	CBC Northern Service	B-C	9625, 6065 (not all Eng.)
6:30-6:45 a.m.	1130-1145	R.R.I. Yogyakarta	C	5046
6:30-6:55 a.m.	1130-1155	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.)
7:00-7:15 a.m.	1200-1215	R. Japan	B	9505
7:00-7:15 a.m.	1200-1215	V. of Kampuchean People	C	11938, 9694 (vary)
7:00-7:20 a.m.	1200-1220	Vatican R.	B	21485 17900, 17840 (not Sun.)
7:00-7:30 a.m.	1200-1230	Kol Israel	C	25640, 17612.5, 21675
7:00-7:30 a.m.	1200-1230	R. Norway	C	21730
7:00-7:30 a.m.	1200-1230	R. Tashkent	C	11785, 9540, 6025
7:00-7:45 a.m.	1200-1245	V. of Germany	B	21600, 17875, 17765, 15410
7:00-7:45 a.m.	1200-1245	R. Berlin International	C	21540, 21465, 17700, 15320
7:00-7:55 a.m.	1200-1255	R. Peking	B	9820†
7:00-8:00 a.m.	1200-1300	V. of Turkey	D	17860, 15185
7:00-8:00 a.m.	1200-1300	HCJB, Ecuador	A	26020, 15115, 11740
7:00-10:00 a.m.	1200-1500	R. Moscow World Service	B	21530, 15150, 15135
7:00-10:00 a.m.	1200-1500	NYAB, Bhutan	D	7040
7:20-7:50 a.m.	1220-1250	R. Ulan Bator, Mongolia	C	11825, 6383 (not Sun.)†
7:30-7:55 a.m.	1230-1255	Austrian R.	B	21655
7:30-7:55 a.m.	1230-1255	R. Tirana	D	11965, 9515
7:30-8:00 a.m.	1230-1300	R. Sweden	C	21690
7:30-8:00 a.m.	1230-1300	BBC (English by radio)	C	21695
7:30-8:00 a.m.	1230-1300	R. Bangladesh	C	21770†, 15285
7:30-8:30 a.m.	1230-1330	TWR, Bonaire	A	15255 (Sat.; Sun.-1415)
7:30-8:30 a.m.	1230-1330	R. Maldives	D	4754
7:30-10:51 a.m.	1230-1551	WYFR, Family Radio	A	21525, 17845 (Sun. only)
7:35-7:45 a.m.	1235-1245	V. of Greece	C	21455, 17835, 11730 (Mon.-Fri.)
8:00-8:15 a.m.	1300-1315	R. Japan	B	9505
8:00-8:30 a.m.	1300-1330	R. Finland	B	15400
8:00-8:30 a.m.	1300-1330	R. Bucharest	C	17850, 15250, 11940
8:00-9:00 a.m.	1300-1400	R. Australia	C	11705, 9770, 6080
8:00-9:00 a.m.	1300-1400	R. Korea	C	11830, 7550
8:00-9:30 a.m.	1300-1430	HCJB, Ecuador	A	26020, 17890, 15115, 11740
8:00-10:50 a.m.	1300-1550	R. RSA	B	25790, 21535, 15220
8:00-12:00 a.m.	1300-1700	WYFR, Family R.	A	9535 (Sun. 1230-)
8:00-8:20 a.m.	1300-1320	R. Canada International	A	17860, 15440, 11955, 9575 (Mon.-Fri.)
8:15-8:45 a.m.	1315-1345	Swiss R. International	B	21570, 21520
8:30-9:20 a.m.	1330-1420	R. Nederland	C	17605
8:30-9:30 a.m.	1330-1430	R. Finland	B	15400 (Sun. only)
8:30-9:30 a.m.	1330-1430	V. of Vietnam	C	12035, 10080
8:30-10:00 a.m.	1330-1500	All India R.	C	15335, 11810
8:30-10:00 a.m.	1330-1500	R. Moscow World Service	B	17810, 12010
8:30-11:00 a.m.	1330-1600	BBC	B-C	25650, 21710, 21660, 21550, 21470, 15400 (from 1430), 15070
8:35-8:50 a.m.	1335-1350	BRT, Belgium	B	21525 (Mon.-Fri.)
8:57-11:55 a.m.	1357-1655	V. of Philippines	D	9578 (Sun.-1555) (not all English)
9:00-9:30 a.m.	1400-1430	R. Japan	B	9505
9:00-9:30 a.m.	1400-1430	R. Sweden	B	21615
9:00-9:30 a.m.	1400-1430	R. Norway	B	17840, 21730 (Sun. only)
9:00-9:30 a.m.	1400-1430	V. Rev. Party, N. Korea	D	4557, 4109
9:00-9:30 a.m.	1400-1430	R. Tashkent	C	11785, 9540, 6025

9:00-9:45 a.m.	1400-1445	R. Berlin International	C	21540, 21465, 17700
9:00-10:00 a.m.	1400-1500	V. of Indonesia	C	15200, 11789
9:00-12:00 a.m.	1400-1700	CBC Southern Service	A	17820, 11955 (Sun.)
9:00-12:30 a.m.	1400-1730	R. Australia	C	17795, 9770
9:00 a.m.-6:00 p.m.	1400-2300	CBC Northern Service	B-C	11720, 9625 (not all English)
9:30-10:00 a.m.	1430-1500	R. Finland	B	21475, 15400
9:30-10:25 a.m.	1430-1525	R. Nederland	B	21480, 11735
9:30-11:00 a.m.	1430-1600	HCJB, Ecuador	A	26020, 17890, 15115
9:30-11:00 a.m.	1430-1600	Burma Br. Ser.	D	5985, 5040
9:30 a.m.-5:00 p.m.	1430-2200	UN Radio	A	21670, 15410 (when in session)
9:35-10:20 a.m.	1435-1520	R. Nepal	D	3425 or 7105 or 9590
10:00-10:15 a.m.	1500-1515	R. Japan	C	9505
10:00-11:00 a.m.	1500-1600	V. of Rev. Ethiopia	D	9560
10:00-11:00 a.m.	1500-1600	BBC	B	17830, 15260 (Sat, Sun)
10:00-11:00 a.m.	1500-1600	R. Moscow	B	15150, 12030, 11905, 11720, 9750, 9710
10:00-12:30 a.m.	1500-1730	BSHKJ, Jordan	D	9560
10:30-11:00 a.m.	1530-1600	R. Afghanistan	D	4775 or 6230
10:30-11:00 a.m.	1530-1600	R. Yugoslavia	C	15300, 15240
10:30-11:00 a.m.	1530-1600	Swiss R. International	B	21570
10:30-11:30 a.m.	1530-1630	V. of Vietnam	C	15012, 10040
10:30 a.m.-5:00 p.m.	1530-2200	R. Moscow World Service (via Cuba)	B	11860 or 11840
10:35-10:45 a.m.	1535-1545	V. of Greece	D	21455, 17835, 11730 (Mon.-Fri.)
10:45-11:00 a.m.	1545-1600	R. Canada International	A	(17820 Mon.-Sat.), 21695, 15325
11:00-11:15 a.m.	1600-1615	R. Japan	C	9505
11:00-11:15 a.m.	1600-1615	R. Pakistan	C	21755, 21515, 21486, 17910, 17660†
11:00-11:30 a.m.	1600-1630	R. Norway	B	21730, 15345 (Sun. only)
11:00-11:30 a.m.	1600-1630	R. Portugal	C	21475 (not Sun.)
11:00-12:00 a.m.	1600-1700	R. Korea	B	11830, 9720
11:00 a.m.-12:09 p.m.	1600-1709	BBC	B	21710, 21550, 17880, 17830, 15260
11:00 a.m.-1:00 p.m.	1600-1800	AFRTS	A	17765, 15430, 15330, 11805
11:00 a.m.-4:00 p.m.	1600-2100	R. Moscow World Service	B	12060, 12010
11:00 a.m.-6:00 p.m.	1600-2300	VOA	A	26040, 21660, 21485, 17870, 15445, (15410 to 2200), (15250 from 1900)
-11:30 a.m.	-1630	R. Singapore	C	15199, 11940 (fade-in time varies) 5052, 5010
11:45-12:00 a.m.	1645-1700	R. Canada International	A	17820 (Mon.-Sat.), 15325, 21695
11:45-12:45 p.m.	1645-1745	R. Pakistan	C	15485, 11675
12:00-12:15 p.m.	1700-1715	R. Japan	C	9505
12:00-12:15 p.m.	1700-1715	Vatican R.	C	17900
12:00-12:30 p.m.	1700-1730	HCJB, Ecuador	B	26020, 21480, 17790†
12:00-1:00 p.m.	1700-1800	WYFR, Family Radio	A	21615, 15160, 11830
12:00-3:00 p.m.	1700-2000	4VEH, Haiti	C	11835, 9770 (Sun.)
12:00-5:00 p.m.	1700-2200	VOA	B	17785, 15205, 11760, 9760
12:05-12:55 p.m.	1705-1755	R. France International	B	21620, 21580, 21515, 17860, 17850, 17720, 15425, 15360, 15200
12:09-12:45 p.m.	1709-1745	BBC	B	17830, 15260 (Sat. & Sun. only) 15070
12:10-12:55 p.m.	1710-1755	BRT, Belgium	C	21525†
12:15-1:05 p.m.	1715-1805	V. of Germany	C	21600
12:45-3:00 p.m.	1745-2000	BBC	C	17705, 15400, 15070, 12095 (11820 from 1800)
12:45-5:30 p.m.	1745-2230	All India R.	C	11620
1:00-1:15 p.m.	1800-1815	R. Japan	B	9505
1:00-1:30 p.m.	1800-1830	R. Canada International	A	17820, 15260 (Sat. & Sun. - 1900)
1:00-1:30 p.m.	1800-1830	R. Norway	C	15175, 11860 (Sun. only)
1:00-2:00 p.m.	1800-1900	V. of Vietnam	C	15012, 10040
1:00-2:00 p.m.	1800-1900	WYFR, Family Radio	A	21615, 15425
1:00-2:00 p.m.	1800-1900	V. of Nigeria	C	15119, 15185
1:00-3:00 p.m.	1800-2000	R. Australia	C	21630, 17795
1:00-4:00 p.m.	1800-2100	R. Kuwait	C	11665
1:00-5:00 p.m.	1800-2200	B.S.K. Saudi Arabia	C	11854
1:00-5:00 p.m.	1800-2200	AFRTS	A	21570, 17765, 15430, 15330, 11790
1:15-1:45 p.m.	1815-1845	Swiss R. International	C	21585, 17830, 17850, 15170 or 15125
1:15-2:15 p.m.	1815-1915	R. Bangladesh	D	15285, 11765 (both vary) †
1:30-1:35 p.m.	1830-1835	UN Radio	A	19505-SSB, 15410 (Mon.-Fri.) 11960, 17740, 15305
1:30-2:00 p.m.	1830-1900	V. of Revolution, Guinea	C	15313 (varies) 9650 (Mon. Wed. and Fri.) (irregular)
1:45-2:15 p.m.	1845-1915	Sri Lanka Br. Corp.	C	17850, 15120, 15115, 11870
2:00-2:10 p.m.	1900-1910	R. Tahiti	C	15170, 11825 (exc. Sun)
2:00-2:15 p.m.	1900-1915	R. Japan	B	15270
2:00-2:30 p.m.	1900-1930	R. Canada International	A	17875, 15325, 11905 (Sat. & Sun. -2000)
			A	17820, 15260 (Mon.-Fri.)
2:00-2:30 p.m.	1900-1930	R. Afghanistan	C	15076 (varies) or 17742† or 15135
2:00-3:00 p.m.	1900-2000	HCJB, Ecuador	C	26020, 21480, 17790 †, 15300
2:00-5:00 p.m.	1900-2200	WYFR, Family Radio	A	21615, 21525, 15130, 11830
2:30-3:30 p.m.	1930-2030	V. of Iran	C	9022 or 9765
2:35-5:00 p.m.	1935-2200	TIFC, Costa Rica	C	9645 (Sun.)
2:45-4:15 p.m.	1945-2115	R. Free Grenada	C	15104 (time varies and irregular)
3:00-3:15 p.m.	2000-2015	R. Japan	B	15270
3:00-3:30 p.m.	2000-2030	R. Norway	C	15345 (Sun.)
3:00-3:30 p.m.	2000-2030	R. Canada International	A	17875, 17820, 15325, 11905 (Mon.-Fri.)
3:00-3:30 p.m.	2000-2030	Kol Israel	B	11610, 17710
3:00-4:15 p.m.	2000-2115	BBC	A	15260, 15070, 6175
3:00-12:00 p.m.	2000-0500	R. Moscow (via Cuba)	C	600
3:10-4:40 p.m.	2010-2140	R. Habana Cuba	A	15155 or 11920
3:15 p.m.-2:15 a.m.	2015-0715	R. New Zealand	C	15485†
3:30-4:00 p.m.	2030-2100	R. Portugal	C	11775†, 9605, 6025
3:30-4:20 p.m.	2030-2120	R. Nederland	B	21685, 17695, 17605, 15220, 9715
3:30-4:30 p.m.	2030-2130	V. of Vietnam	C	15012, 10040
3:30-4:30 p.m.	2030-2130	V. Turkey	C	11895, 11885†
3:30-5:00 p.m.	2030-2200	R. Andorra	C	6220

3:45-5:30 p.m.	2045-2230	All India R.	C	15110
3:50-4:40 p.m.	2050-2140	R. Habana Cuba	C	17750, 9770
4:00-4:15 p.m.	2100-2115	R. Japan	B	15270
4:00-4:30 p.m.	2100-2130	R. Algiers	C	21635, 11810, 11740, 9610†
4:00-4:30 p.m.	2100-2130	R. Budapest	C	11910, 9835, 9585
4:00-4:50 p.m.	2100-2150	R. RSA	B	21535, 17780, 15155
4:00-5:00 p.m.	2100-2200	V. of Nigeria	C	15185, 15119
4:00-5:00 p.m.	2100-2200	V. of Germany	C	9765, 7130
4:00-5:00 p.m.	2100-2200	R. Moscow	B	12010, 7390
4:15-6:00 p.m.	2115-2300	BBC	A	15260, 15070, 6175
4:15-7:00 p.m.	2115-2400	R. Free Grenada	B	15045 (time varies)
4:30-5:00 p.m.	2130-2200	R. Canada International	A	17820, 17875, 15150, 11945, 15325
4:30-5:00 p.m.	2130-2200	KGEI, San Francisco	C	15280
4:30-5:00 p.m.	2130-2200	HCJB Ecuador	C	26020, 21480, 17790, 15180†
4:30-5:00 p.m.	2130-2200	R. Sofia	B	9665, 9530†
4:30-5:30 p.m.	2130-2230	R. Baghdad	C	9745
4:40-5:40 p.m.	2140-2240	V. of Free China	C	17890, 15270, 11825
4:50-12:30 p.m.	2150-0530	R. New Zealand	C	17860
4:50-5:00 p.m.	2150-2200	R. Free Europe	C	15245†, 11825 (Fri.)
5:00-5:15 p.m.	2200-2215	R. Japan	B	17755, (via Portugal 15305 or 17735†)
5:00-5:30 p.m.	2200-2230	R. Norway	C	15175 (Sun. only) 11860, 11850
5:00-6:00 p.m.	2200-2300	CBC Radio	A	15325, 11925, 9760† (Mon.-Fri.)
5:00-6:00 p.m.	2200-2300	WYFR, Family Radio	A	21525, 15130, 11855, 5985
5:00-6:00 p.m.	2200-2300	R. Moscow	B	9765, 9530, 7440, 7165
5:00-6:00 p.m.	2200-2300	V. of Turkey	B	15360, 9515, 7215†
5:00-6:00 p.m.	2200-2300	R. Andorra	C	6225, 6215 (Sun.)
5:00-7:00 p.m.	2200-2400	AFRTS	A	25615, 21570, 15430, 15330, 11790
5:00-11:30 p.m.	2200-0430	VOA	A	21460, 17740, (26000 - 2400), 17820, 0100
5:15-5:30 p.m.	2215-2230	R. Yugoslavia	C	9620
5:30-6:00 p.m.	2230-2300	Kol Israel	A	17710, 15584, 11638, 9815
5:45-6:00 p.m.	2245-2300	SODRE, Uruguay	C	11885, 9515 (time varies)
5:45-6:00 p.m.	2245-2300	UN Radio	A	15225, 11830 (Mon.-Fri.)
6:00-6:30 p.m.	2300-2330	R. Japan	C	17755
6:00-6:30 p.m.	2300-2330	R. Sweden	B	9695, 11705
6:00-6:30 p.m.	2300-2330	R. Vilnius	B	15405, 7215, 7150
6:00-6:50 p.m.	2300-2350	Rdif. Argentina	C	11710 (Mon.-Fri.)
6:00-7:00 p.m.	2300-2400	4VEH, Haiti	B	11835, 9770
6:00-7:30 p.m.	2300-2430	BBC	A	15260, 15070, 11910, 9590, 9580, 9410, 7325, 6175, 6120, 5975
6:00-7:50 p.m.	2300-2450	R. Pyongyang	C	9977
6:00-8:00 p.m.	2300-0100	WYFR, Family Radio	A	5985 (17875 from 0000)
6:00-8:00 p.m.	2300-0100	CBC Southern Service	A	11850 (Sat. - 2330 and Sun. - 2400) 5960
6:00-8:00 p.m.	2300-0200	R. Moscow	A	17720, 15455, 15180, 15140, 12050, 11780, 9765, 9685, 9610, 9530, 9490, 7440, 7165
6:00 p.m.-1:07 a.m.	2300-0607	CBC Northern Service	B-C	9625, 6195 (not all English)
6:30-7:00 p.m.	2330-2400	V. of Vietnam	C	12035, 10080, 10040, 10010
6:35-6:55 p.m.	2335-2355	SODRE, Uruguay	C	11885, 9515 (time varies)
6:45-7:45 p.m.	2345-2445	R. Japan	C	17825, 15270
7:00-7:15 p.m.	0000-0015	R. Japan	C	17755
7:00-7:25 p.m.	0000-0025	R. Tirana	B	9750, 7065
7:00-7:30 p.m.	0000-0030	Kol Israel	A	15584, 11638, 9815
7:00-7:30 p.m.	0000-0030	R. Norway	C	11870, 11860 (Mon. only)
7:00-7:55 p.m.	0000-0055	R. Peking	B	17855, 17680, 15120
7:00-8:00 p.m.	0000-0100	R. Sofia	B	9705
7:00-8:00 p.m.	0000-0100	AFRTS	A	25615, 21570, 15330, 15345, 11790
7:00-9:00 p.m.	0000-0200	R. Luxembourg	C	6090 (Time varies)
7:00-9:00 p.m.	0000-0200	VOA	A	17730, 15205, 11740, 9650, 6130, 5995
7:00-12:00 p.m.	0000-0500	R. Moscow (via Cuba)	A	9600 or 6115
7:00-12:00 p.m.	0000-0500	FEBC Philippines	C	17810
7:00 p.m.-4:00 a.m.	0000-0900	UN Radio	A	6055 (when in session)
7:05-8:55 p.m.	0005-0155	Spanish Foreign R.	B	11880, 9630
7:15-8:00 p.m.	0015-0100	BRT, Belgium	C	15385 or 9760; 15175 or 11710
7:30-7:50 p.m.	0030-0050	SODRE, Uruguay	C	11885, 9515 (time varies)
7:30-8:00 p.m.	0030-0100	R. Prague	C	6055
7:30-8:00 p.m.	0030-0100	R. Kiev	B	17870, 15240, 15100, 9800, 7215, 7150
7:30-8:00 p.m.	0030-0100	La Cruz del Sur, Bolivia	D	4875 (Mon. only)
7:30-8:30 p.m.	0030-0130	R. Mexico	C	17765, 15430, 11770, 9705, 5985 (Fri. only)
7:30-9:00 p.m.	0030-0200	HCJB, Ecuador	A	15155†
7:30-9:30 p.m.	0030-0230	BBC	A	15260, 11835, 11750, 9580, 9410, 7325, 6175, 6120, 5975
7:30-9:30 p.m.	0030-0230	HCJB, Ecuador	B	26020, 9745, 15355
7:55-8:35 p.m.	0055-0135	TWR-Bonaire	B	11745†
8:00-8:15 p.m	0100-0115	R. Japan	C	17755
8:00-8:15 p.m.	0100-0115	Vatican R.	B	11845, 9605, 6015
8:00-8:20 p.m.	0100-0120	RAI, Italy	B	11800, 9575
8:00-8:25 p.m.	0100-0125	Kol Israel	A	15584, 11638, 9815
8:00-8:30 p.m.	0100-0130	R. Canada International	A	11940, 11850, 5960
8:00-8:45 p.m.	0100-0145	R. Berlin International	C	11975, 9730
8:00-8:55 p.m.	0100-0155	R. Prague	B	11990, 9740, 9540, 7345, 5930
8:00-8:55 p.m.	0100-0155	R. Peking	B	17855, 17680, 15120
8:00-9:00 p.m.	0100-0200	R. Confusion	C	14550 (one Mon. per month)
8:00-9:00 p.m.	0100-0200	R. Korea	C	15570, 15375
8:00-9:00 p.m.	0100-0200	V. of Free China	C	17890, 15345, 11825
8:00-9:00 p.m.	0100-0200	AFRTS	A	25615, 21570, 11790, 6030
8:00-10:30 p.m.	0100-0330	R. Australia	B	21740, 17795

8:00-11:50 p.m.	0100-0450	R. Habana Cuba	A	11930, 11725
8:00-12:00 p.m.	0100-0500	WYFR, Family R.	A	9715, (5985 from 0200)
8:20 p.m.-12:10 a.m.	0120-0510	R. Belize	C	3285, 834
8:20-8:50 p.m.	0120-0150	V. of Germany	A	15105, 11865, 9565, 9545, 6145, 6100, 6085, 6040
fade-8:30 p.m.	-0130	Faulkland Is. Broadcast Station	D	2370 (Mon. - 0030)
8:30-8:45 p.m.	0130-0145	V. of Greece	B	11730, 9655, 9515 (not Sun.)
8:30-8:55 p.m.	0130-0155	Austrian Radio	B	9770, 5945
8:30-8:55 p.m.	0130-0155	R. Tirana	B	9750, 7120
8:30-9:00 p.m.	0130-0200	R. Budapest	B	17710, 15220, 11910, 9835, 9585, (Wed., Fri. only)
8:30-9:25 p.m.	0130-0225	R. Bucharest	C	11940, 11840, 11735, 9690, 9570, 5990
8:30-9:30 p.m.	0130-0230	R. Japan	C	21640, 17825, 17725, 15235
8:45-9:15 p.m.	0145-0215	Swiss R. International	A	15305, 11715, 9725, 6135
9:00-9:15 p.m.	0200-0215	R. Japan	C	17755
9:00-9:25 p.m.	0200-0225	Kol Israel	A	15584, 11638, 9815*
9:00-9:30 p.m.	0200-0230	R. Canada International	A	11940, 11845, 5960
9:00-9:30 p.m.	0200-0230	R. Norway	B	11860, 9610, 9590 (Mon. only)
9:00-9:30 p.m.	0200-0230	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000† (not Mon.)
9:00-9:40 p.m.	0200-0240	R. Polonia	C	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
9:00-9:50 p.m.	0200-0250	R. RSA	B	15325 or 15220, 11900, 9585
9:00-9:55 p.m.	0200-0255	R. Peking	B	17680, 15230, 15120
9:00-10:00 p.m.	0200-0300	R. Nacional, Brazil	A	15290
9:00-10:30 p.m.	0200-0330	R. Cairo	B	12050, 9475
9:00-11:00 p.m.	0200-0400	R. Moscow	A	15455, 15180, 15140, 12050, 11780, 9765, 9700, 9635, 9610, 9580, 9530, 9490, 7440, 7165
9:00-11:30 p.m.	0200-0430	AFRTS	A	21570, 17765, 11790, 6030
9:30-9:45 p.m.	0230-0245	R. Pakistan	C	21590, 17835, 21745†
9:30-9:45 p.m.	0230-0245	UN Radio	A	15240, 6035, 15752-SSB 10869-SSB (Tue.-Sat.)
9:30-9:55 p.m.	0230-0255	R. Tirana	B	9750, 7120
9:30-10:00 p.m.	0230-0300	R. Lebanon	C	15170† (time varies)
9:30-10:00 p.m.	0230-0300	R. Sweden	C	11705, 9695
9:30-10:15 p.m.	0230-0315	R. Berlin International	C	11975, 9730
9:30-10:25 p.m.	0230-0325	R. Nederland	A	9590, 6165
9:30-10:30 p.m.	0230-0330	BBC	A	11750, 9580, 9410, 7325, 6175, 6120, 5975
9:30-12:00 p.m.	0230-0500	HCJB, Ecuador	A	15155, 9745, 11910, 26020
9:55-fade	0255-	R. One Zimbabwe	C	3396 (exc. Sun.)
10:00-10:15 p.m.	0300-0315	R. Japan	C	17755
10:00-10:30 p.m.	0300-0330	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000†
10:00-10:25 p.m.	0300-0325	R. Polonia	C	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
10:00-10:30 p.m.	0300-0330	R. Canada International	A	11940, 11845, 11770, 9535, 5960
10:00-10:30 p.m.	0300-0330	R. Portugal	B	11925, 9765
10:00-10:30 p.m.	0300-0330	R. Kiev	B	11690, 9800, 9735, 9505, 7400, 7215, 7150
10:00-10:30 p.m.	0300-0330	R. Australia	C	15260 (Fri.)
10:00-10:50 p.m.	0300-0350	V. of Free China	C	17890, 15270, 11825
10:00-10:55 p.m.	0300-0355	R. Prague	B	11990, 9740, 9540, 7345, 5930
10:00-10:55 p.m.	0300-0355	R. Peking	B	17680, 15120, 15230
10:00-11:00 p.m.	0300-0400	RAE, Argentina	C	9690 (Tue-Sat)
10:00-11:00 p.m.	0300-0400	Radiobrás, Brazil	C	15290†
10:00-11:00 p.m.	0300-0400	TIFC Costa Rica	C	9645, 5055, (Mon. 0235-0435)
10:00-11:00 p.m.	0300-0400	R. Baghdad	D	11925
10:00-11:15 p.m.	0300-0415	R. Uganda	B	15325 (irregular)
10:00-11:26 p.m.	0300-0426	R. RSA	B	15220, 11900, 9585, 7270
10:00-11:30 p.m.	0300-0430	R. Cultural, Guatemala	B	3300 (Mon. 0030--)
10:00 p.m.-1:00 a.m.	0300-0600	HRVC, Honduras	B	4820
10:00 p.m.-2:30 a.m.	0300-0730	VOA	A	15330, 15245, 9670, 6040, 6035, 5995
10:30-10:55 p.m.	0330-0355	R. Tirana	B	7300, 6200
10:30-10:55 p.m.	0330-0355	Austrian Radio	C	9770, 5945
10:30-11:00 p.m.	0330-0400	R. Australia	B	21680, 17890, 17870, 17795, 17725
10:30-11:15 p.m.	0330-0415	R. Berlin International	B	11975, 11890, 5955
10:30-11:30 p.m.	0330-0430	R. Korea	C	15570
10:30-11:45 p.m.	0330-0445	BBC	A	9410, 6175, 6120, 5975
10:30-11:00 p.m.	0330-0400	R. Finland	C	11755, 9645
10:30-12:00 p.m.	0330-0500	AWR Guatemala	C	5980†
10:30 p.m.-1:00 a.m.	0330-0600	R. Habana Cuba	A	11760, 11725
10:40-10:47 p.m.	0340-0347	V. of Greece	B	11730, 9650, 9515 (not Sun.)
10:50-11:10 p.m.	0350-0410	RAI, Italy	C	11905, 17795, 15330
10:51-10:58 p.m.	0351-0358	V. of Yerevan	C	17870, 15405, 15180† (Sun, Wed, Thu, Sat)
11:00-11:15 p.m.	0400-0415	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000† (Wed. & Fri) (Mon. to 0430)
11:00-11:15 p.m.	0400-0415	R. Japan	C	17755
11:00-11:30 p.m.	0400-0430	R. Bucharest	C	11940, 11840, 11735, 9690, 9570, 5990
11:00-11:30 p.m.	0400-0430	R. Canada International	A	11845, 11770, 5960
11:00-11:30 p.m.	0400-0430	R. Norway	C	6185 (Mon. only)
11:00-11:30 p.m.	0400-0430	R. Mozambique	C	4855, 3265
11:00-11:55 p.m.	0400-0455	R. Peking	B	17680, 15230, 15120
11:00-12:00 p.m.	0400-0500	XERF, Mexico	A	1570 (Mon.)

11:00-12:00 p.m.	0400-0500	R. Australia	B	21680, 21650, 21525, 17890, 17870, 17795, 17755, 17725, 15320, 15240, 15160
11:00 p.m.-1.00 a.m.	0400-0600	R. Moscow World Service	B	21530, 17880, 17825, 15460, 9610, 9530, 9490, 7370, 7310, 7240, 7215, 7150, 5940
11:00 p.m.-3:00 a.m.	0400-0800	R. Moscow	B	12050, 9730, 9580, 9505, 7170
11:05-11:50 p.m.	0405-0450	FEBA, Seychelles	C	11850
11:30-11:55 p.m.	0430-0455	Austrian R.	B	12015
11:30-12:00 p.m.	0430-0500	Swiss R. International	B	11715, 9725
11:30-12:00 p.m.	0430-0500	R. Sofia	B	9765 or 9530† or 7115
11:30 p.m.-2:00 a.m.	0430-0700	AFRTS	A	17765, 15330, 11790, 6030
11:45 p.m.12:45 a.m.	0445-0545	BBC	A	9510, 6175, 5975, 9410
11:55 p.m.-1:00 a.m.	0455-0600	V. of Nigeria	C	7255
12:00-12:15 a.m.	0500-0515	Kol Israel	B	21710, 15105, 11638, 15584, 15200
12:00-12:15 a.m.	0500-0515	R. Japan	C	15270
12:00-12:30 a.m.	0500-0530	R. Portugal	B	9765, 6185
12:00-1:00 a.m.	0500-0600	WYFR, Family R.	A	9705
12:00-1:00 a.m.	0500-0600	R. Australia	C	21680, 17890, 17870, 17725, 15240, 15160
12:00-2:00 a.m.	0500-0700	HCJB, Ecuador	B	9745, 6095, 11915, 26020
12:00-3:00 a.m.	0500-0800	R. Kuwait	C	21545†
12:00-5:00 a.m.	0500-1000	V. of Cuba	B	600
12:15-1:15 a.m.	0515-0615	Spanish Foreign R.	B	11880, 9630
12:22-12:30 a.m.	0522-0530	UN Radio	A	9540, 6055 (Tue.-Sat.)
12:30-12:50 a.m.	0530-0550	V. of Germany	A	11905, 9650, 9545, 6100, 5960
12:30-fade	0530-	R. Ghana	C	4980, 4195, 3366, 3350
12:30-1:25 a.m.	0530-0625	R. Nederland	B	9715, 6165
12:40-6:15 a.m.	0540-1115	R. New Zealand	C	11945
12:45-1:00 a.m.	0545-0600	Vatican R.	C	6190 or 6210
12:45-1:00 a.m.	0545-0600	UN Radio	A	9540, 6055 (Tue.-Sat.)
12:45-1:30 a.m.	0545-0630	V. of Clipperton RX4M	C	7390 or 7375
12:45-2:30 a.m.	0545-0730	BBC	B	15070, 11955, 11860, 9640, 9510, 9410, 7150, 6175
1:00-1:15 a.m.	0600-0615	R. Japan	C	15270
1:00-1:30 a.m.	0600-0630	V. of Germany	C	17875, 15275, 11905, 11765, 9700
1:00-1:30 a.m.	0600-0630	R. Norway	B	11920, 15175 (Mon. only)
1:00-1:30 a.m.	0600-0630	R. Australia	C	21680, 21525, 17870, 17795, 17755, 17725, 15240, 15160
1:00-2:00 a.m.	0600-0700	RAE, Argentina	C	9690 (Tue.-Sat.)
1:00-2:00 a.m.	0600-0700	R. RSA	C	21535, 17780, 15220
1:00-3:00 a.m.	0600-0800	V. of Nigeria	C	15185, 15119
1:15-1:30 a.m.	0615-0630	R. Canada International	B	11960, 11825, 9760, 9730 6140 (Mon-Fri)
1:25-3:55 a.m.	0625-0855	V. of Malaysia	C	15295, 12350, 9750
1:30-2:00 a.m.	0630-0700	R. Australia	B	21680, 17870, 17725, 15240, 15115
1:30-2:00 a.m.	0630-0700	Radio Polonia	B	9675, 7270
1:30-3:00 a.m.	0630-0800	R. Habana Cuba	A	9525
1:45-2:00 a.m.	0645-0700	R. Canada International	B	11960, 11825, 9760, 9730, 6140 (Mon-Fri)
1:45-2:00 a.m.	0645-0700	UN Radio	A	15125, 11735
1:57-4:55 a.m.	0657-0955	V. of Philippines	C	9578 (not all English)
2:00-2:15 a.m.	0700-0715	R. Japan	C	15130† (via Portugal)
2:00-2:30 a.m.	0700-0730	Swiss Radio Int.	C	21520, 15305, 9535, 6165
2:00-3:00 a.m.	0700-0800	Xandir Malta	C	9670 or 9550† (Sat. only) (irregular)
2:00-3:00 a.m.	0700-0800	V. of Vietnam	C	7512, 9840, 6383
2:00-3:30 a.m.	0700-0830	HCJB, Ecuador	C	15240†, 11835
2:00-4:00 a.m.	0700-0900	AFRTS	C	21670 (via Philippines)
2:00-4:00 a.m.	0700-0900	R. Australia	B	21680, 17725, 15115, 11740, 9570
2:00-4:00 a.m.	0700-0900	R. Condor, Ireland	D	11463, 6243 (Nov.) (Sun.)
2:00-5:30 a.m.	0700-1030	HCJB, Ecuador	C	11900, 9745, 6130
2:07-2:15 a.m.	0707-0715	UN Radio	A	17815, 15195 (Tue.-Sat.)
2:25-4:00 a.m.	0725-0900	TWR, Monte Carlo	B	9495† (and Sun.-1100)
2:30-3:25 a.m.	0730-0825	R. Nederland	B	9770, 9715
2:30-3:00 a.m.	0730-0830	R. Korea	B	11810, 9870
2:30-4:00 a.m.	0730-0900	BBC	B	15070, 11955, 9640, 9510
2:30-6:30 a.m.	0730-1130	Solomon Isl. Broadcasting	C	9545 or 5020 (Not all Eng.)
2:30-9:02 a.m.	0730-1402	ABC Melbourne	C	9680
2:37-2:45 a.m.	0737-0745	UN Radio	A	17815, 15195
2:45-4:30 a.m.	0745-0930	KTWR, Guam	B	11840
2:55 a.m.-fade	0755-	Action Radio, Guyana	C	5950
2:55-3:05 a.m.	0755-0805	V. of Guatemala	B	6180, 640 (time varies)
3:00-3:15 a.m.	0800-0815	R. Japan	B	9505
3:00-3:30 a.m.	0800-0830	R. Norway	C	9590 (Sun.)
3:30-3:15 a.m.	0800-0815	UN Radio	A	17860, 15235, 15125, 11735
3:30-3:35 a.m.	0830-0835	UN Radio	A	15250, 10385, 9565
3:30-3:45 a.m.	0830-0845	R. Vanuatu	C	7260, 3945
3:30-4:25 a.m.	0830-0925	R. Nederland	B	9715
3:30-5:00 a.m.	0830-1000	FEBC, Philippines	C	11765 or 11890

Explanatory Notes.

1. Times in first column are EST. For AST add 1 hour, CST, subtract 1 hour, MST, subtract 2 hours, PST, subtract 3 hours. Days of week are in GMT.
2. Quality. A—strong signal and very reliable reception. B—regular reception. C—occasional reception under favorable conditions. D—rarely audible. These ratings are for locations in the central USA. European and African stations are in general, more reliably received in eastern North America. Asian and Pacific stations are more reliably received in western North America. North American stations are received well except in areas too close to the transmitter site.
3. The information in this listing is correct to press time. However, frequencies and schedules are constantly changing. Listen to "DX Digest" on R. Canada International for late changes, Saturday at 2136; Sunday at 1934; GMT Mondays at 0106 and 0406.
4. R.—Radio; V.—Voice

† = frequent changes

PROJECT OF THE MONTH

An Op-Amp AM Radio

BY FORREST M. MIMS

THE CIRCUIT shown schematically in Fig. 1 is a simple AM radio receiver. You can assemble it and start to receive radio stations within minutes. This receiver does not generate enough output to drive a loudspeaker, but that's a small price to pay for a circuit which derives *all* of its operating power from the radio signal it receives.

The major factor that limits the sensitivity of the receiver shown in Fig. 1 (which is an updated version of the old-fashioned crystal radio) is the barrier potential across the pn junction of the diode detector. For the circuit to respond, the received signal must exceed about 300 millivolts if *D1* is a germanium diode such as the 1N34 and a hefty 600 millivolts if *D1* is a silicon device like the 1N914. To maximize the input signal level, a good antenna and earth ground should be used. The antenna should be a length of copper wire at least 10 feet long positioned as high and in the clear as possible. A low-resistance connection to a coldwater pipe that extends deeply into the earth or to some other good ground will help the receiver gather as much signal power as possible.

The threshold effect imposed by the diode restricts reception to relatively powerful stations. If the forward voltage drop across the diode could be eliminated, the receiver would be able to demodulate any strength signal.

Russel Quong of Palos Verdes, CA, has found a simple way to reduce the voltage drop of a standard silicon diode from 600 millivolts to only one millivolt or so. Russel's idea, which was described in a brief note on page 148 of the July 20, 1978 issue of *Electronics*, is to substitute an op-amp precision half-wave rectifier for the standard diode. I've tried several versions of this basic idea, one of which is shown in Fig. 2. They all work well.

The circuit in Fig. 2 can be divided into four sections, the first comprising antenna coil *L1* and tuning capacitor *C1*. These components form a simple tunable filter which enables individual stations to be selected from a broad band of received frequencies.

The received signal is detected or demodulated by the second section, a half-wave rectifier formed by *IC1A*, *D1*, *D2*, and *R1*. The demodulated signal is then amplified by the third section, a high-gain driver amplifier consisting of *IC1B*, *C3*, *R2*, and *R3*. Potentiometer *R3* governs the gain of this amplifier and therefore serves as a volume control.

In the output stage, transistor *Q1* functions as a simple power amplifier for driving a small 8-ohm speaker or an earphone. Resistors *R4* and *R5* set the base bias for *Q1*, and *R6* limits current through the speaker.

You can assemble most of the circuit on a small solderless breadboard. Variable inductance *L1* is a standard loopstick antenna coil with an adjustable ferrite core, and *C1* is a miniature 0-to-365-pF variable capacitor. Both these components used to be widely available, but you might now have trouble finding them because the demand for radio parts has seemingly been reduced to a trickle. None of my catalogs list either part, but I've seen them in some shops.

If you can't find *L1* and *C1* as new commercial items, salvage them from a transistor radio. The leads from the coil will be very fragile, so use care when disconnecting them from the radio's circuit board. One or more of the leads probably go directly to the tuning capacitor. If the coil has more than one tap, try all of them and use the one that gives best results.

If you can find an adjustable loopstick, substitute a fixed capacitor for *C1* if you prefer. Try values ranging from 100 to 250 pF. Higher values of capacitance will favor the low end of the AM broadcast band and lower values the high end.

In most areas, this radio will require an external antenna. If you live fairly close to several stations, you might find that a few feet of dangling copper wire will suffice. I live in a rural area 35 miles from each of several cities, and have had excellent results by clipping a short antenna lead to the dial stop on a rotary-dial telephone. This antenna allows my radio to pull in five stations with plenty of volume, and several others at somewhat lower levels. A good earth ground will help this receiver perform as well as it can. It is not as important to provide this receiver with a good earth ground as it is in the case of the "crystal" receiver described earlier, but this should be done if possible.

For room-filling volume, eliminate the output stage comprising *Q1* and its associated components, and connect an external power amplifier to pin 7 of *IC1B*. The amplifier can be a commercial unit such as Radio Shack's *Micro-Sonic Speaker-Amplifier*. Alternatively, you can construct a home-brew unit. For example, you can use the LM386 output stage of the general-purpose utility amplifier that was presented as the August 1980 "Project of the Month." ◇

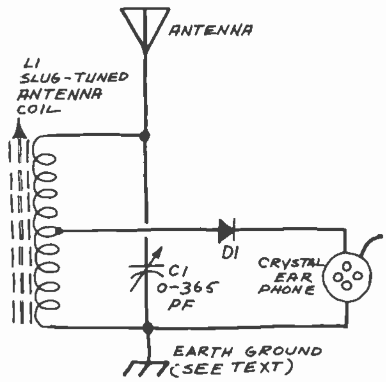


Fig. 1. Super-simple diode AM radio.

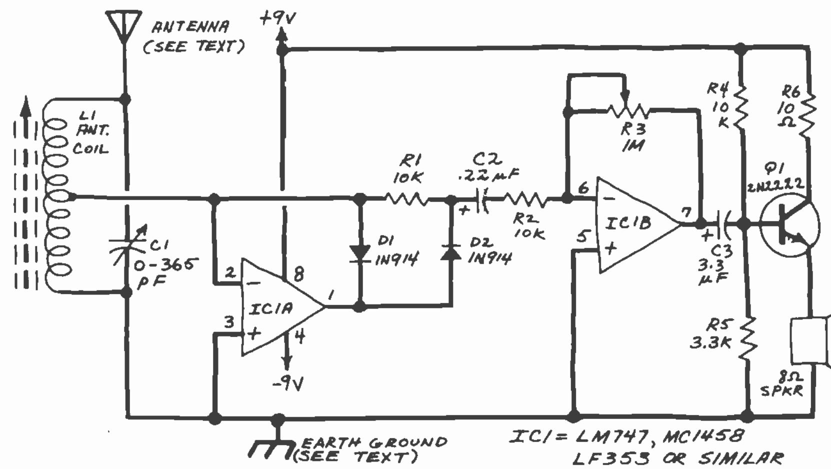


Fig. 2. An AM radio using an operational amplifier.

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7402N	20
7404N	25
7409N	23
7410N	20
7414N	70
7420N	20
7422N	39
7430N	20
7442N	58
7445N	74
7447N	58
7448N	77
7450N	20
7474N	35
7475N	49
7485N	88
7489N	1 85
7490N	43
7492N	43
7493N	43
7495N	69
74100N	1 20
74107N	35
74121N	34
74123N	59
74125N	45
74145N	77
74150N	1 20
74151N	69
74154N	2 00
74157N	69
74161N	87
74162N	1 25
74163N	87
74174N	96
74175N	95
74190N	1 15
74192N	87
74193N	85
74221N	2 75
74298N	1 65
74365N	89
74366N	89
74367N	89

74LS00 TTL	
74LS00N	35
74LS02N	35
74LS04N	55
74LS05N	40
74LS08N	45
74LS10N	45
74LS13N	55
74LS14N	1 25
74LS20N	45
74LS22N	45
74LS28N	45
74LS30N	45
74LS33N	75
74LS38N	75
74LS74N	1 25
74LS75N	1 00
74LS90N	1 00
74LS93N	1 00
74LS95N	1 10
74LS107N	65
74LS112N	65
74LS113N	45
74LS132N	89
74LS136N	65
74LS151N	1 10
74LS155N	1 10
74LS157N	1 10
74LS162N	1 65
74LS163N	1 65
74LS174N	2 00
74LS190N	1 25
74LS221N	2 50
74LS258N	1 60
74LS367N	1 65

LINEAR	
CA3045	90
CA3046	1 10
CA3081	1 80
CA3082	1 90
CA3089	2 95
LM301AN AH	35
LM305H	87
LM307N	35
LM308N	1 00
LM309K	1 50
LM311H N	90
LM317T K	3 75
LM318	1 35
LM320K 5	1 50
LM323K 5	5 95
LM320K 12	1 50
LM320K 15	1 50
LM320T 5	1 35
LM320T 8	1 35
LM320T 12	1 35
LM320T 15	1 35
LM324N	1 40
LM339N	1 00
LM340K 5	1 35
LM340K 8	1 35
LM340K 12	1 35
LM340K 15	1 35
LM340K 24	1 35
LM340T-5	1 25
LM340T 8	1 25
LM340T-12	1 25
LM340T-15	1 25
LM340T-18	1 25
LM340T-24	1 25
LM350	7 50
LM377	3 50
LM379	5 00
LM380N	1 00
LM381	1 60
LM382	1 60
LM703H	65
LM709H	28
LM723H-N	50
LM733N	85
LM741CH	35
LM741N	38
LM747H N	75
LM748N	35
LM1303N	1 75
LM1304	1 10
LM1305	1 27
LM1307	2 00
LM1310	2 75
LM1458	47
LM1812	7 50
LM1889	3 00
LM2111	1 75
LM2902	2 25
LM3900N	60
LM3905	1 75
LM3909N	95
MC1458V	50
NE550N	1 00
NE555V	39
NE556A	85
NE565A	1 00
NE566V	1 50
NE567V	1 00
NE570B	4 75
78L05	60
78L08	60
78M05	85
75108	1 75
75491CN	50
75492CN	55
75494CN	89

A to D CONVERTER	
8038B	4 50
8700CJ	13 95
8701CN	22 00
8750CJ	13 95
LD130	9 95
9400CJV F	7 40
ICL7103	9 50
ICL7107	14 25

CMOS	
CD4000	25
CD4001	35
CD4002	35
CD4006	1 10
CD4007	35
CD4008	28
CD4009	45
CD4010	45
CD4011	35
CD4012	28
CD4013	47
CD4014	1 25
CD4015	1 00
CD4016	55
CD4017	1 05
CD4018	94
CD4019	45
CD4020	1 02
CD4021	1 35
CD4022	1 10
CD4023	28
CD4024	75
CD4025	28
CD4026	2 50
CD4027	66
CD4028	85
CD4029	1 35
CD4030	45
CD4035	1 35
CD4040	1 35
CD4042	85
CD4043	85
CD4044	85
CD4046	1 67
CD4049	45
CD4050	49
CD4051	1 13
CD4060	1 42
CD4066	71
CD4068	40
CD4069	40
CD4070	50
CD4071	45
CD4072	45
CD4073	45
CD4075	45
CD4076	1 65
CD4078	40
CD4081	35
CD4082	35
CD4116	47
CD4490	5 50
CD4507	1 00
CD4508	4 25
CD4510	1 02
CD4511	94
CD4515	2 52
CD4516	1 10
CD4518	1 02
CD4520	1 02
CD4527	1 51
CD4528	79
CD4553	3 50
CD4566	2 25
CD4583	2 35
CD4585	1 10
CD40192	3 00
74C00	35
74C04	40
74C10	35
74C14	1 95
74C20	35
74C30	35
74C48	2 25
74C74	85
74C76	1 75
74C90	1 75
74C93	1 75
74C154	3 00
74C160	2 00
74C175	1 35
74C192	2 25
74C221	2 50
74C905	6 00
74C906	75
74C914	1 95
74C922	6 00
74C923	6 00
74C925	7 50
74C926	6 95
74C927	6 95

INTERFACE	
8095	65
8096	65
8097	65
8098	65
8T09	1 25
8T10	4 50
8T13	3 00
8T20	5 50
8T23	3 10
8T24	3 50
8T25	3 20
8T26	1 69
8T28	2 75
8T97	1 69
8T98	1 69

MOS/MEMORY RAM	
2101-1	2 95
2102-1	95
2102AL 4	1 34
2102AN-2L	1 60
2104A-4	4 95
2107B-4	3 75
2111-1	3 75
2112-2	3 95
2114L 300ns	6 75
2114L 450ns	5 95
4116 200ns	7 95
8 4116 200ns	49 00
2513B	6 30
MM5262	40
MM5280	3 00
MM5320	9 95
MM5330	5 94
PD411D-3	4 00
PD411D-4	5 00
P5101L	8 95
4200A	9 95
82S25	2 90
91L02A	1 50
HD0165-5	6 95
MM57100	4 50
GIAY38500 1	9 95
MCM66751A	9 95
9368	3 50
4100	10 00
416	16 00

CLOCKS	
MM5311	5 50
MM5312	3 90
MM5314	3 90
MM5369	2 10
MM5841	14 45
MM5865	7 95
CT7010	8 95
CT7015	8 95
MM5375AA N	3 90
MM5375AG N	4 90
7205	16 50
7207	7 50
7208	15 95
7209	4 95
DS0026CN	3 75
DS0056CN	3 75
MM53104	2 50

MICROPROCESSOR	
6502	10 95
6504	9 95
6522	9 95
6800	6 95
6802	11 95
6820	4 95
6850	5 95
8080A	5 95
8085	12 95
8086	75 00
Z80	9 95
Z80A	11 95
8212	2 90
8214	3 95
8216	2 90
8224	3 45
8228	4 95
8251	6 95
8253	15 00
8255	5 75
8257	10 95
8259	14 95
1802CP plas	13 95
1802DP plas	17 95
1861P	11 50
CDP1802CD	28 95
CDP1802D	35 00
CDP1861	15 95

UART/FIFO	
AY5 1013	5 50
AY5 1014	7 50
3341	6 95

PROM	
1702A	4 95
2513B upper case	8 75
2708	7 75
2716T1	18 00
2716 Intel	23 00
8-2716 Intel	160 00
2732	65 00
2758	22 50
8741A	60 00
8748	65 00
8748 8	60 00
8755A	55 00
N82S23	7 95
N82S123	6 50
N82S126	3 75
N82S129	8 50
N82S131	8 50
N82S136	8 75
N82S137	8 75
DM8577	2 90
8223	2 90

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8	15	22	30
14	14	24	35
16	16	28	42
18	27	36	58
20	29	40	57

2 level 14 pin ww 20

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PIN		PIN	
14	32	24	86
16	33	28	1 00
18	57	40	1 23

CRYSTALS	
1 MHz	4 50
2 MHz	4 50
4 MHz	4 25
5 MHz	4 25
10 MHz	4 25
18 MHz	3 90
20 MHz	3 90
32 MHz	3 90
32768 Hz	4 00
1 8432 MHz	4 50
3 5795 MHz	1 20
2 0100 MHz	1 95
2 097152 MHz	4 50
2 4576 MHz	4 50
3 2768 MHz	4 50
5 0688 MHz	4 50
5 185 MHz	4 50
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6 5536 MHz	4 50
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DL727 728	CA CC	500	1 90
DL747 750	CA CC	600	1 95
DL750	CC	600	1 95
FND359	CC	357	70
FND500 507	CC CA	500	1 35
FND503 510	CC CA	500	90
FND800 807	CC CA	800	2 20
3 digit Bubble			60
4 digit Bubble			80
DG8 Fluorescent			1 75
DG10 Fluorescent			1 75
10 digit display			1 25
7520 Clairex photocells			39
TIL311 Hex			9 50
MAN3640	CC	30	1 10
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MAN4640	CC	40	1 20
MAN4710	CA	40	95
MAN4740	CC	40	1 20
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MAN6740	CC	60	1 35

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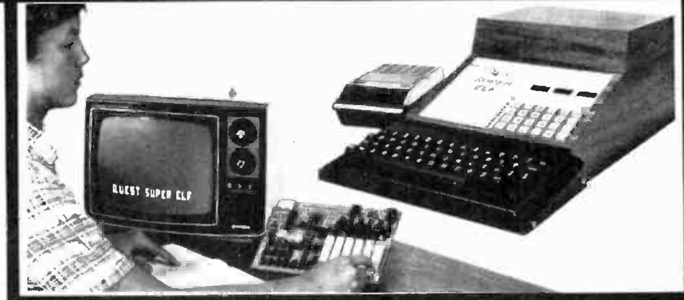

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The Super Elf includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during and after executing** instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

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Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95. High address option $8.95. Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** All metal Expansion Cabinet, painted and silk screened, with room for 5 S-100 boards and power supply **$57.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested.

Questdata, a software publication for 1802 computer users is available by subscription for $12.00 per 12 issues. Single issues $1.50. Issues 1-12 bound $16.50.

Tiny Basic Cassette **$10.00**, on ROM **$38.00**, original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50**. Games and Music **$3.00**. Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow you to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface**. Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf**. The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed**. EPROM can be used for the monitor and Tiny Basic or other purposes.

A 1K Super ROM Monitor $19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software. (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. If you have the **Super Expansion Board** and **Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports with full handshake**. They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set with ribbon cable** is available at $15.25 for easy connection between the **Super Elf** and the **Super Expansion Board.**

Power Supply Kit for the complete system (see Multi-volt Power Supply).

Announcing Quest Super Basic— *SECOND GENERATION*

A new enhanced version of **Super Basic** now available. Quest was the first company worldwide to ship a full size Basic for 1802 Systems. A complete function **Super Basic by Ron Cenker** including floating point capability with scientific notation (number range ± .17E³⁸). 32 bit integer ± 2 billion; multi dim arrays, string arrays; string manipulation; cassette I/O; save and load, basic, data and machine language programs, and over 75 statements, functions and operations.

Enhancements include increased speed, built-in provisions for Stringy Floppy, Floppy Disc, Printer Driver, I/O, user definable command library and statement renumbering.

Easily adaptable to most 1802 systems. Requires 16K RAM minimum for Basic and user programs. Source listing for both Serial and Parallel I/O included.

Super Basic on Cassette $40.00.

Gremlin Color Video Kit $69.95

32 x 16 alpha/numerics and graphics; up to 8 colors with 6847 chip; 1K RAM at E000. Plugs into Super Elf 44 pin bus. No high res. graphics. On board RF Modulator Kit **$4.95**

Elf II Adapter Kit $24.95

Plugs into Elf II providing Super Elf 44 and 50 pin plus S-100 bus expansion. (With Super Expansion). High and low address displays, state and mode LED's optional **$18.00.**

1802 16K Dynamic RAM Kit $149.00

Expandable to 32K. Hidden refresh w/clocks up to 4 MHz w/no wait states. Addl. 16K RAM **$63.00**

Super Elf 44 pin expansion board; 3 female and 1 male bus. Board plus 3 connectors **$22.95**

Tiny Basic Extended on Cassette $15.00
(added commands include Stringy, Array, Cassette I/O etc.)
S-100 4-Slot Expansion $ 9.95
Super Monitor VI.1 Source Listing $15.00

Super Color S-100 Video Kit $129.95

Expandable to 256 x 192 high resolution color graphics. 6847 with all display modes computer controlled. Memory mapped. 1K RAM expandable to 6K. S-100 bus 1802, 8080, 8085, Z80 etc.

Editor Assembler $25.00
(Requires minimum of 4K for E/A plus user source)
1802 Tiny Basic Source listing $19.00
Super Monitor V2.0/2.1 Source Listing $20.00

PROM Eraser

assembled, 25 PROM capacity **$37.50** (with timer **$69.50**). 6 PROM capacity OSHA/UL version **$69.50** (with timer **$94.50**).

Z80 Microcomputer

16 bit I/O, 2 MHz clock, 2K RAM, ROM Breadboard space. Excellent for control. Bare Board **$28.50. Full Kit $99.00. Monitor $20.00.** Power Supply Kit **$35.00. Tiny Basic $30.00**

S-100 Computer Boards

8K Static Godbout Econo IIA Kit	145.00
16K Static Godbout Econo XIV Kit	285.00
24K Static Godbout Econo VIIA-24 Kit	435.00
32K Static Godbout Econo X-32 Kit	575.00
16K Dynamic RAM Kit	199.00
32K Dynamic RAM Kit	310.00
64K Dynamic RAM Kit	470.00
Video Interface Kit	**$135.00**

80 IC Update Master Manual $55.00

Comp. IC data selector, 2700 pg. master reference guide. Over 51,000 cross references. Free update service through 1980. Domestic postage $3.50.

Modem Kit $60.00

State of the art, orig., answer. No tuning necessary. 103 compatible 300 baud. Inexpensive acoustic coupler plans included.

LRC 7000 + Printer $389.00

40/20 column dot matrix impact, std. paper. Interface all personal computers.
64/40/32/20 version **$405.00.** Optional cables available.

LRC 7000 printer interface cable for Super Elf with software $26.00

NiCad Battery Fixer/Charger Kit

Opens shorted cells that won't hold a charge and then charges them up, all in one kit w/full parts and instructions. **$7.25**

Rockwell AIM 65 Computer

6502 based single board with full ASCII keyboard and 20 column thermal printer. 20 char. alphanumeric display. ROM monitor, fully expandable. **$375.00.** 4K version **$450.00.** 4K Assembler **$85.00.** 8K Basic Interpreter **$100.00.**

Special small power supply for AIM65 assem. in frame **$54.00.** Complete AIM65 in thin briefcase with power supply **$499.00.** Molded plastic enclosure to fit both AIM65 and power supply **$47.50.** Special Package Price: 4K AIM, 8K Basic, power supply, cabinet **$599.00**

AIM65/KIM/VIM/Super Elf 44 pin expansion board; 3 female and 1 male bus. Board plus 3 connectors **$22.95.**

60 Hz Crystal Time Base Kit $4.40

Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy.

Video Modulator Kit $8.95

Convert TV set into a high quality monitor w/o affecting usage. Comp. kit w/full instruc.

Multi-volt Computer Power Supply

8v 5 amp, ± 18v .5 amp, 5v 1.5 amp, -5v .5 amp, 12v .5 amp, -12v option. ± 5v, ± 12v are regulated. Basic Kit **$29.95.** Kit with chassis and all hardware **$43.95.** Add $4.00 shipping. Kit of hardware **$14.00.** Woodgrain case **$10.00.** $1.50 shipping.

TERMS: $5.00 min. order U.S. Funds. Calif residents add 6% tax.
$10.00 min. order BankAmericard and Master Charge and COD. $1.00 insurance optional.
Shipping charges will be added on charge cards.

FREE: Send for your copy of our NEW 1980 QUEST CATALOG. Include 48¢ stamp.

7400

SN7400N	.25			SN74156N	.79
SN7401N	.20			SN74157N	.69
SN7402N	.25			SN74160N	.89
SN7403N	.25	SN7472N	.29	SN74161N	.89
SN7404N	.25	SN7473N	.35	SN74162N	.89
SN7405N	.29	SN7474N	.35	SN74163N	.89
SN7406N	.35	SN7475N	.49	SN74164N	.89
SN7407N	.35	SN7476N	.35	SN74165N	.89
SN7408N	.29	SN7480N	.50	SN74166N	1.25
SN7409N	.29	SN7482N	.99	SN74167N	2.79
SN7410N	.25	SN7483N	.69	SN74170N	1.95
SN7411N	.29	SN7485N	.89	SN74172N	4.95
SN7412N	.35	SN7486N	.35	SN74173N	1.39
SN7413N	.40	SN7489N	1.75	SN74174N	.99
SN7414N	.69	SN7490N	.49	SN74175N	.89
SN7416N	.29	SN7491N	.59	SN74176N	.79
SN7417N	.29	SN7492N	.45	SN74177N	.79
SN7420N	.25	SN7493N	.45	SN74179N	1.49
SN7421N	.29	SN7494N	.69	SN74180N	.79
SN7422N	.45	SN7495N	.69	SN74181N	2.25
SN7423N	.29	SN7496N	.69	SN74182N	.79
SN7425N	.29	SN7497N	3.00	SN74184N	2.49
SN7426N	.29	SN74100N	1.49	SN74185N	2.49
SN7427N	.25	SN74107N	.35	SN74190N	1.25
SN7429N	.39	SN74109N	.39	SN74191N	1.25
SN7430N	.25	SN74116N	1.95	SN74192N	.89
SN7432N	.29	SN74121N	.39	SN74193N	.89
SN7437N	.25	SN74122N	.55	SN74194N	.89
SN7438N	.40	SN74123N	.59	SN74195N	.69
SN7439N	.25	SN74125N	.49	SN74196N	.89
SN7440N	.20	SN74126N	.49	SN74197N	.89
SN7441N	.89	SN74132N	.75	SN74198N	1.49
SN7442N	.59	SN74136N	.75	SN74199N	1.49
SN7443N	1.10	SN74141N	.99	SN74221N	1.25
SN7444N	1.10	SN74142N	3.25	SN74251N	.99
SN7445N	.89	SN74143N	3.49	SN74276N	1.95
SN7446N	.79	SN74144N	3.49	SN74279N	.79
SN7447N	.69	SN74145N	.79	SN74283N	1.49
SN7448N	.79	SN74147N	1.95	SN74284N	3.95
SN7450N	.20	SN74148N	1.29	SN74285N	3.95
SN7451N	.20	SN74150N	1.25	SN74365N	.69
SN7453N	.20	SN74151N	.69	SN74366N	.69
SN7454N	.20	SN74152N	.69	SN74367N	.69
SN7459A	.25	SN74153N	.79	SN74368N	.69
SN7460N	.20	SN74154N	1.25	SN74390N	1.49
SN7470N	.29	SN74155N	.79	SN74393N	1.49

74LS

74LS00	.29			74LS192	1.15
74LS01	.29			74LS193	1.15
74LS02	.29	74LS92	.75	74LS194	1.15
74LS03	.29	74LS93	.75	74LS195	1.15
74LS04	.35	74LS95	.99	74LS197	1.19
74LS05	.35	74LS96	1.15	74LS221	1.19
74LS08	.29	74LS107	.45	74LS240	1.95
74LS09	.35	74LS109	.45	74LS241	1.95
74LS10	.29	74LS112	.45	74LS242	1.95
74LS11	.75	74LS113	.49	74LS243	1.95
74LS12	.35	74LS114	.49	74LS244	1.95
74LS13	.59	74LS122	.89	74LS245	2.95
74LS14	.99	74LS123	1.25	74LS247	1.19
74LS15	.35	74LS125	.89	74LS248	1.19
74LS20	.35	74LS126	.55	74LS249	1.19
74LS21	.35	74LS132	.99	74LS251	1.49
74LS22	.35	74LS133	.89	74LS253	.99
74LS26	.35	74LS136	.49	74LS257	.89
74LS27	.35	74LS138	.89	74LS258	.99
74LS28	.35	74LS139	.89	74LS260	.69
74LS30	.29	74LS151	.89	74LS266	.69
74LS32	.35	74LS153	.89	74LS273	1.95
74LS33	.59	74LS154	1.75	74LS279	.75
74LS37	.45	74LS155	1.19	74LS283	1.09
74LS38	.49	74LS156	1.19	74LS290	.99
74LS40	.35	74LS157	.89	74LS293	.99
74LS42	.89	74LS158	.99	74LS298	1.25
74LS47	.89	74LS160	1.15	74LS352	1.29
74LS48	1.15	74LS161	1.15	74LS353	1.29
74LS49	1.15	74LS162	1.15	74LS365	.75
74LS51	.29	74LS163	1.15	74LS366	.75
74LS54	.29	74LS164	1.25	74LS367	.75
74LS55	.29	74LS165	1.25	74LS368	.75
74LS73	.45	74LS168	1.19	74LS373	1.95
74LS74	.45	74LS169	1.19	74LS374	1.95
74LS75	.59	74LS170	2.49	74LS375	.89
74LS76	.45	74LS173	1.39	74LS386	.69
74LS78	.49	74LS174	.99	74LS393	2.49
74LS83	.89	74LS175	.99	74LS399	2.49
74LS85	1.25	74LS181	2.95	74LS670	2.49
74LS86	.45	74LS190	1.25	81LS95	1.95
74LS90	.59	74LS191	1.25	81LS97	1.95

74S

74S00	.50			74S244	3.25
74S02	.50			74S251	1.45
74S03	.50	74S133	.55	74S253	1.45
74S04	.55	74S134	.69	74S257	1.35
74S05	.55	74S135	1.19	74S258	1.35
74S08	.50	74S136	1.75	74S260	.79
74S09	.50	74S138	1.35	74S280	2.95
74S10	.50	74S139	1.35	74S287*	4.95
74S11	.50	74S140	1.15	74S288*	4.95
74S15	.50	74S151	1.35	74S373	3.49
74S20	.50	74S153	1.35	74S374	3.49
74S22	.50	74S157	1.35	74S387*	5.95
74S30	.50	74S158	1.35	74S471*	19.95
74S32	.55	74S174	1.59	74S472*	19.95
74S40	.55	74S175	1.59	74S473*	19.95
74S51	.50	74S188	4.95	74S474*	21.95
74S64	.50	74S194	1.95	74S475*	21.95
74S65	.50	74S195	1.95	74S570*	7.95
74S74	.79	74S196	3.95	74S571*	7.95
74S86	.79	74S240	2.95	74S572*	19.95
74S112	.79	74S241	2.95	74S573*	19.95
74S113	.79	74S242	3.25	74S940	3.15
74S114	.79	74S243	3.25	74S941	3.15

* LIMITED AVAILABILITY ON THESE PROMS

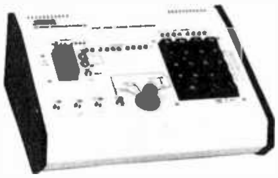
CA—LINEAR

CA3013H	2.15			CA3089N	3.75
CA3023H	3.25			CA3096N	3.95
CA3039H	1.35			CA3130H	1.39
CA3046N	1.30	CA3081N	2.00	CA3140H	1.25
CA3059N	3.25	CA3082N	2.00	CA3160H	1.25
CA3060N	3.25	CA3083N	1.60	CA3401N	.59
CA3080H	1.25	CA3086N	.85	CA3600N	3.50

CD—CMOS

CD4000	.39			CD4082	.39
CD4001	.39			CD4093	.99
CD4002	.39			CD4098	2.49
CD4006	1.19			CD4506	.75
CD4007	.25	CD4041	1.49	CD4507	.99
CD4009	.49	CD4042	.99	CD4508	3.95
CD4010	.49	CD4043	.89	CD4510	1.39
CD4011	.39	CD4044	.89	CD4511	1.29
CD4012	.25	CD4046	1.79	CD4514	3.95
CD4013	.49	CD4047	2.50	CD4515	2.95
CD4014	1.39	CD4048	1.35	CD4516	1.49
CD4015	1.19	CD4049	.49	CD4518	1.79
CD4016	.59	CD4050	.69	CD4519	.89
CD4017	1.19	CD4051	1.19	CD4520	1.29
CD4018	.99	CD4052	1.19	CD4526	1.79
CD4019	.49	CD4053	1.19	CD4528	1.79
CD4020	1.19	CD4056	2.95	CD4529	1.95
CD4021	1.39	CD4059	9.95	CD4543	2.79
CD4022	1.19	CD4060	1.49	CD4562	11.95
CD4023	.29	CD4066	.79	CD4566	2.79
CD4024	.79	CD4068	.39	CD4583	2.49
CD4025	.23	CD4069	.45	CD4723	1.95
CD4026	2.95	CD4070	.55	CD4724	1.95
CD4027	.69	CD4071	.49	MC14409	14.95
CD4028	.89	CD4072	.49	MC14410	14.95
CD4029	1.49	CD4073	.39	MC14411	14.95
CD4030	.49	CD4075	.39	MC14412	11.95
CD4035	.99	CD4076	1.39	MC14419	4.95
CD4040	1.49	CD4081	.39	MC14433	13.95

JE608 PROGRAMMER
2708 EPROM PROGRAMMER



- 3 separate Display Registers: 8 LED's for Hex Key entries, 10 LED's (2" 2") for Address Register and 8 LED's for Data Memory Register. The Data Memory Register displays the content of the RAMs from the EPROM Chip.
- Development of microprocessor systems by means of a ribbon cable from the programmer panel test socket to the EPROM socket on the microprocessor board.
- Rapid checking verification of programmed data changes.
- User may move data from a master to RAM's or write into RAM's with keyboard entries.
- Allows manual stepping manipulation (up and down) at any address location.
- Stand alone EPROM Programmer consisting of:
  A 19-key Hexadecimal Keyboard assembly, Programmer Board assembly with 4 power supplies and a LED/Test Socket Panel Board assembly. The Test Socket is zero force insertion type. Power requirements: 115VAC, 60Hz, 6W.
- Compact desk top enclosure. Color coordinated designer's case with light tan panels and molded end pieces in mocha brown. Size: 3½"H x 11"W x 8½"D. Weight: 5 lbs.

The JE608 EPROM Programmer is a completely self contained unit which is independent of computer control and requires no additional systems for its operations. The EPROM can be programmed from the Hexadecimal Keyboard or from a pre-programmed EPROM. The JE608 Programmer can emulate a programmed EPROM by the use of its internal RAM circuits. This will allow the user to test or pretest a program for a system, prior to programming a chip. Any changes in the program can be entered directly into the memory circuits with the Hexadecimal Keyboard so that rewriting the entire program will not be necessary. The JE608 Programmer contains a Programmer Board with 25 IC's and including power supplies of -5V, +5V, +12V and +26V. The Hexadecimal Keyboard and LED Test Socket Panel Board are separate assemblies within the system.

JE608K KIT $399.95
JE608A Assembled and tested $499.95

DISCRETE LEDS

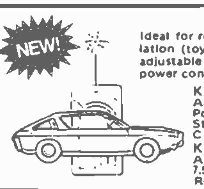
XC556R	.200" red	5/$1	MV50	.085" red	6/$1	XC111R	.190" red	5/$1
XC556G	.200" green	4/$1	XC209R	.125" red	5/$1	XC111G	.190" green	4/$1
XC556Y	.200" yellow	4/$1	XC209G	.125" green	4/$1	XC111Y	.190" yellow	4/$1
XC556C	.200" clear	4/$1	XC209Y	.125" yellow	4/$1	XC111C	.190" clear	4/$1
XC22R	.200" red	5/$1	XC526R	.185" red	5/$1			
XC22G	.200" green	4/$1	XC526G	.185" green	4/$1	INFRA-RED LED		
XC22Y	.200" yellow	4/$1	XC526Y	.185" yellow	4/$1	¼"x⅛"x1/16" flat		
MV10B	.170" red	4/$1	XC526C	.185" clear	4/$1	IRL — 5/$1		

DISPLAY LEDS

C.A. — Common Anode C.C. — Common Cathode

Type	Polarity	Ht	Price	Type	Polarity	Ht	Price
MAN 1	C.A.—red	.270	2.95	DL741	C.A.—red	.600	1.25
MAN 2	5x7 D.M.—red	.300	4.95	DL746	C.A.—red ± 1	.630	1.49
MAN 3	C.C.—red	.125	.25	DL747	C.A.—red	.600	1.49
MAN 52	C.A.—green	.300	1.25	DL750	C.C.—red	.600	1.49
MAN 54	C.C.—green	.300	1.25	DL338	C.C.—red	.110	.35
MAN 71	C.A.—red	.300	.75	FND70	C.C.	.250	.69
MAN 72	C.A.—red	.300	.75	FND358	C.C. ± 1	.357	.99
MAN 74	C.C.—red	.300	1.25	FND359	C.C.	.357	.75
MAN 82	C.A.—yellow	.300	.49	FND503	C.C. (FND500)	.500	.99
MAN 84	C.C.—yellow	.300	.99	FND507	C.A. (FND510)	.500	.99
MAN 3620	C.A.—orange	.300	.49	HDSP-3401	C.A.—red	.800	1.50
MAN 3630	C.A.—orange ± 1	.300	.99	HDSP-3403	C.C.—red	.800	1.50
MAN 3640	C.C.—orange	.300	.99	5082-7613	C.C.,R.H.D.—red	.300	1.25
MAN 4610	C.A.—orange	.400	.99	5082-7620	C.A.,L.H.D.—yel.	.300	1.25
MAN 6610	C.A.—orange—DD	.560	.99	5082-7623	C.C.,R.H.D.—yel.	.300	1.25
MAN 6630	C.A.—orange ± 1	.560	.99	5082-7730	C.A.,L.H.D.—red	.300	.99
MAN 6640	C.C.—orange—DD	.560	.99	5082-7731	C.A.,R.H.D.—red	.300	1.25
MAN 6650	C.C.—orange ± 1	.560	.99	5082-7750	C.A.,L.H.D.—red	.430	1.75
MAN 6660	C.A.—orange	.560	.99	5082-7751	C.A.,R.H.D.—red	.430	1.25
MAN 6710	C.A.—red—DD	.560	.99	5082-7760	C.C.,R.H.D.—red	.430	1.75
MAN 6750	C.C.—red ± 1	.560	.99	5082-7300	4x7 sgl. dig. RHD	.600	22.00
MAN 6780	C.C.—red	.560	.99	5082-7302	4x7 sgl. dig. LHD	.600	22.00
DL704	C.C.—red	.300	1.25	5082-7304	Overnge. char. (±1)	.600	19.95
DL707	C.A.—red	.300	1.25	LIT-1	Photo Xsistor Opto-Isol.		.69
DL728	C.C.—red	.500	1.49	MOC3010	Optically Isol.Triac Driver		1.25

RADIO CONTROL CIRCUITS



Ideal for remote control systems which use pulse amplitude modulation (toy cars, boats, tanks, etc.) Features: five function control, adjustable steering angle, suitable for 27 and 47MHz bands and low power consumption.

KB-4428 TRANSMITTER $4.25
Abs. max. rating (TA@25°C). Supply volt.: Vcc1 12VDC. Power Dissip.: PD: 300mW; Temp. range: Oper. 0-+50°C — Storage -30— +125°C. Rec. oper. volt.: 7-11V. Crystal or CR Oscillation circuits acceptable.

KB-4429 RECEIVER $5.95
Abs. max. rating (TA@25°C). Supply volt.: Vcc1: 11V, Vcc2: 7.5V. Power Dissip.: 600mW. Temp. range: Oper. 0 ± 50°C. Rec. oper. volt.: VOP1 7-11V — VOP2 3-6V.

LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

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ASST. 1	5 ea.	10 Ohm 12 Ohm 15 Ohm 18 Ohm 22 Ohm 27 Ohm 33 Ohm 39 Ohm 47 Ohm 56 Ohm	50 pcs.	$1.95
ASST. 2	5 ea.	68 Ohm 82 Ohm 100 Ohm 120 Ohm 150 Ohm 180 Ohm 220 Ohm 270 Ohm 330 Ohm 390 Ohm	50 pcs.	$1.95
ASST. 3	5 ea.	470 Ohm 560 Ohm 680 Ohm 820 Ohm 1K 1.2K 1.5K 1.8K 2.2K 2.7K	50 pcs.	$1.95
ASST. 4	5 ea.	3.3K 3.9K 4.7K 5.6K 6.8K 8.2K 10K 12K 15K 18K	50 pcs.	$1.95
ASST. 5	5 ea.	22K 27K 33K 39K 47K 56K 68K 82K 100K 120K	50 pcs.	$1.95
ASST. 6	5 ea.	150K 180K 220K 270K 330K 390K 470K 560K 680K 820K	50 pcs.	$1.95
ASST. 7	5 ea.	1M 1.2M 1.5M 1.8M 2.2M 2.7M 3.3M 3.9M 4.7M 5.6M	50 pcs.	$1.95

ASST. 8R Includes Resistor Assts. 1-7 (350 pcs.) $10.95 ea.

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INTERSIL

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7045EV/Kit*	Stopwatch Chip, XTL	22.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	28.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
72011DR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
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7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	11.10
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7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
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7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
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7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
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7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
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74C86	.99	74C173	1.39	74C923	5.75
74C89	6.95	74C174	1.39	74C925	7.50
74C90	1.29	74C175	1.39	74C926	7.50
74C93	1.29	74C192	1.69	80C95	.79
74C95	1.59	74C193	1.69	80C97	.79

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TL071CP	.79	LM340T-12	1.25	LM710N	.79
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TL082CP	1.19	LM341P-15	.75	LM739N	1.19
TL084CN	2.19	LM342P-5	.69	LM741CN	.35
LH0094CD	36.80	LM342P-12	.69	MC1741SCG	3.00
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LM305H	.99	LF353N	1.00	LM1458CN	.59
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LM320K-15	1.35	LM392N	.69	LM3905CN	1.25
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50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (Solid) CAPACITORS

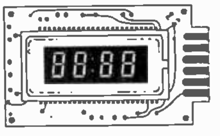
.1/35V	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.19	.16	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

National Semiconductor Clock Modules

12VOC AUTOMOTIVE/ INSTRUMENT CLOCK



APPLICATIONS:
- In-dash autoclocks
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Features: Bright 0.3" green display. Internal crystal time-base. ± 0.5 sec./day accur. Auto.display brightness control logic. Display color filterable to blue, blue-green, green & yellow. Complete—just add switches and lens.

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16K DYNAMIC RAM (150NS)
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(8 EACH $23.95) (100 EACH $250.00/lot)

MM2114-3 . . . . $5.95 each
4K STATIC RAM (300NS)
(8 EACH $43.95) (100 EACH $450.00/lot)

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- Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
- Erases up to 4 chips within 20 minutes.
- Maintains constant exposure distance of one inch.
- Special conductive foam liner eliminates static build-up.
- Built-in safety lock to prevent UV exposure.
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- Complete with holding tray for 4 chips.

UVS-11E **$79.50**

Jumbo 6-Digit Clock Kit

- Four .630"ht. and two .300"ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE747 .... **$29.95**

6-Digit Clock Kit

- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE701 .... **$19.95**

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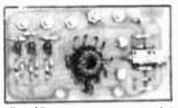
Uses LM309K. Heat sink provided. PC board construction. Provides a solid 1 amp @ 5 volts. Can supply up to ±5V, ±9V and ±12V with JE205 Adapter. Includes components, hardware and instructions. Size: 3½" x 5" x 2"H

JE200 .... **$14.95**



ADAPTER BOARD —Adapts to JE200— ±5V, ±9V and ±12V

DC/DC converter with +5V input. Toriodal high speed switching XMFR. Short circuit protection. PC board construction. Piggy-back to JE 200 board. Size: 3½" x 2" x 9/16"H

JE205 .... **$12.95**

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DP8255	Prog. Peripheral I/O (PPI)	9.95
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DP8259	Prog. Interrupt Control	14.95
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DP8304	8-Bit Bi-Directional Receiver	3.95
DP8307	8-Bit Bi-Directional Receiver	3.95
DP8308	8-Bit Bi-Directional Receiver	3.95

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MC6828	Priority Interrupt Controller	10.95
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MC6850	Asynchronous Comm. Adapter	6.95
MC6852	Synchronous Serial Data Adapter	6.95
MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
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2650	MPU	16.95
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MC 56802	MPU w/Clock (65K Bytes Memory)	11.95
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INS8030N-4	CPU—Sgl. Chip 8-Bit (128bytes RAM)	19.95
INS8040N-4	CPU (256 Bytes RAM)	24.95
INS8070N	CPU—64 Bytes RAM	24.95
P8085	CPU	19.95
INS8900	CPU—16-Bit	29.95
TMS9900JL	MPU—16-Bit	49.95

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MM506H	Dual 100-Bit Static	.50
MM510H	Dual 64-Bit Accumulator	.50
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MM5035N	Octal 80-Bit	9.95
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2518N	Hex 32-Bit Static	4.95
2522V	Dual 132-Bit Static	2.95
2524V	512-Bit Dynamic	.99
2525V	1024-Bit Dynamic	2.95
2527V	Dual 256-Bit Static	2.95
2528V	Dual 250-Bit Static	4.00
2529V	Dual 240-Bit Static	4.00
2532N	Quad 80-Bit Static	2.95
3341PC	Fifo (Dual 80)	6.95

DATA ACQUISITION

AF100-1CN	Universal Active Filter 2.5%	5.95
AF121-1CJ	Touch Tone Low Pass Filter	19.95
AF122-1CJ	Touch Tone Low Pass Filter	19.95
LM308AH	Super Gain Op Amp	1.00
LM134Z	Constant Current Source	1.30
LM335Z	Temperature Transducer	1.40
LF356N	JFET Input Op Amp	1.10
LF398N	Sample & Hold Amplifiers	3.95
LM399H	Temp. Comp. Prec. Ref. (.5ppm/C°)	4.95
ADC0804LCN	8-Bit A/D Converter (1 LSB)	4.95
DAC0806LCN	8-Bit D/A Converter (0.78% Lin.)	2.25

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ADC0817CCN	8-Bit A/D Converter (16-Ch. Mult.)	10.95
DAC1000LCN	10-Bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008LCN	10-Bit D/A Conv. Micro. Comp. (0.20%)	8.95
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DAC1022LCN	10-Bit D/A Converter (0.20% Lin.)	5.95
DAC1222LCN	12-Bit D/A Converter (0.20% Lin.)	9.95
CD4051N	8-Channel Multiplexer	1.19
AY-5-1013	30K BAUD UART	5.95

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1103	1024x1 Dynamic	.99
2101 (8101)	256x4 Static	3.95
2102	1024x1 Static	1.75
21L02	1024x1 Static	1.95
2111 (8111)	256x4 Static	3.95
2112	256x4 Static MOS	4.95
2114	1024x4 Static 450ns	5.95
2114L	1024x4 Static 450ns Low Power	6.95
2114-3	1024x4 Static 300ns	7.49
2114L-3	1024x4 Static 300ns Low Power	7.95
2117	16,384x1 Dynamic 350ns (house marked)	4.95
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MM5261	1024x1 Dynamic Fully Decoded	.99
MM5262	2Kx1 Dynamic	.25
MM5280/2107	4096x1 Dynamic	4.95
MM5290J-2(4116)	16K Dynamic 250ns (UPD416)	6.95
MM5298J-3A	8K Dyn. 200ns (lower ½ of MM5290J)	4.95
7489	16x4 Static	1.75
UPD414/MK4027	4K Dynamic 16-pin	4.95
TMS4044-45NL	4K Static	14.95
TMS4045	1024x4 Static	14.95

PROMS/EPROMS

1702A	2K UV Erasable PROM	5.95
2708	8K EPROM	9.95
TMS2716	16K EPROM (-5V, +5V, +12V)	19.95
2716Intel(2516)TI	16K EPROM (Single +5V)	17.95
2732Intel(2532)TI	32K EPROM	49.95
2758	8K EPROM (450ns) (Single +5V)	7.95
5203	2048 PROM	14.95
82S23(74S188)	32x8 PROM (Open Collector)	4.95
82S115	4096 Bipolar PROM	19.95
82S123(74S288)	32x8 Tri-State Bipolar PROM	4.95
82S185	8K PROM	29.95

ROM'S

2513(2140)	Character Generator (Upper Case)	9.95
2513(3021)	Character Generator (Lower Case)	9.95
2516N	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

NMOS READ ONLY MEMORIES

MCM66710P	128x9x7 ASCII Shifted w/Greek	13.50
MCM66740P	128x9x7 Math Symbol & Pictures	13.50
MCM66750P	128x9x7 Alpha. Control Char. Gen.	13.50

MICROPROCESSOR MANUALS

M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

SPECIAL FUNCTION

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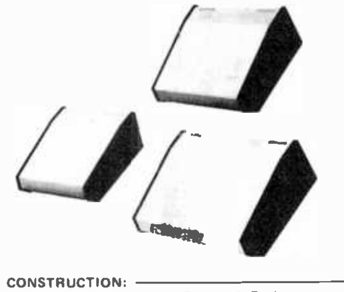

- High strength epoxy molded end pieces in mocha brown finish.
- Sliding rear/bottom panel for service and component accessibility.
- Top/bottom panels .080 thk alum. Alodine type 1200 finish (gold tint color) for best paint adhesion after modification.
- Vented top and bottom panels for cooling efficiency.
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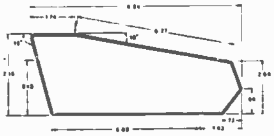
The "DTE" Blank Desk Top Electronic Enclosures are designed to blend and complement today's modern computer equipment and can be used in both industrial and home. The end pieces are precision molded with an internal slot (all around) to accept both top and bottom panels. The panels are then fastened to ¼" thick tabs inside the end pieces to provide maximum rigidity to the enclosure. For ease of equipment servicing, the rear/bottom panel slides back on slotted tracks while the rest of the enclosure remains intact. Different panel widths may be used while maintaining a common profile outline. The molded end pieces can also be painted to match any panel color scheme.



Enclosure Model No.	Panel Width	PRICE
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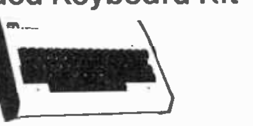
JE610 ASCII Encoded Keyboard Kit



The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and −12V @ 10 mA for operation. Features: 60 keys generate the 128 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector.

JE610 (Case not included) **$79.95**
K62 (Keyboard only) $34.95

Desk-Top Enclosure for JE610 ASCII Encoded Keyboard Kit

Compact desk-top enclosure: Color-coordinated designer's case with light tan aluminum panels and molded end pieces in mocha brown. Includes mounting hardware. Size: 3½"H x 14½"W x 8¾"D.

DTE-AK $49.95

SPECIAL: JE610/DTE-AK PURCHASED TOGETHER (Value $129.90) $124.95

JE600 Hexadecimal Encoder Kit

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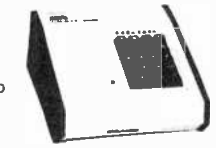

The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation.

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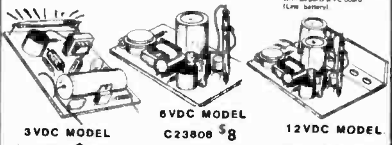

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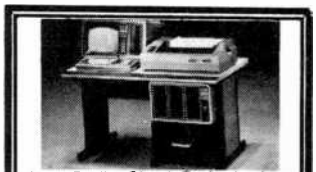

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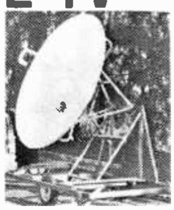

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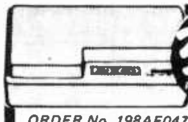

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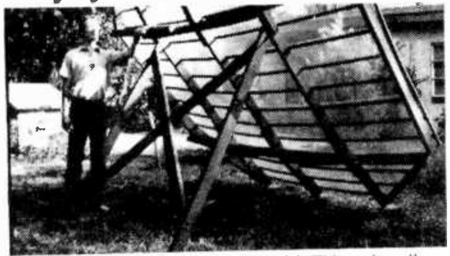

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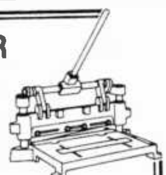

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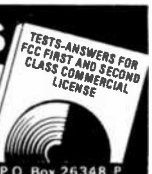

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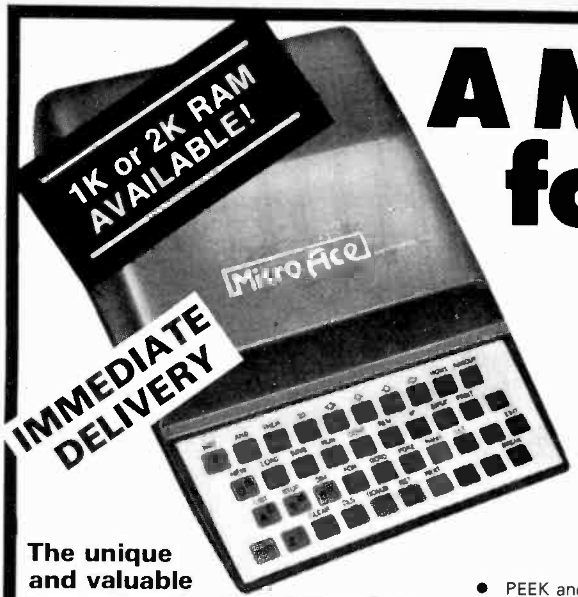

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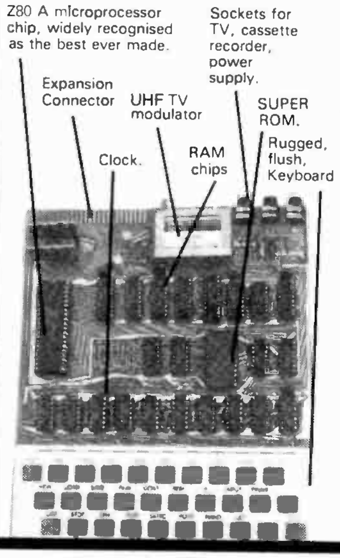

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CIRCLE NO. 40 ON FREE INFORMATION CARD

Entertainment Electronics

By Harold A. Rodgers
Executive Editor

The End of the Beginning

BEAUTY, says the old saw, is in the eyes of the beholder. Realism, according to the visual sciences, is to be found in the very same place.

For example, were an objective "eye" to look at a motion picture, it would see, far from continuous motion, a succession of still images. Similarly, that which the human eye assembles into a color television image would be a series of moving streaks or, depending on the persistence of the phosphors in the CRT, a series of near-random blobs. These systems for reproducing visual information work as efficiently as they do because the people who designed them were able to exploit the characteristics of the eye and present to it just what is necessary to form a continuous image. The objective character of the system is important only insofar as it relates to design goals arrived at through knowledge of visual perception as well as hardware.

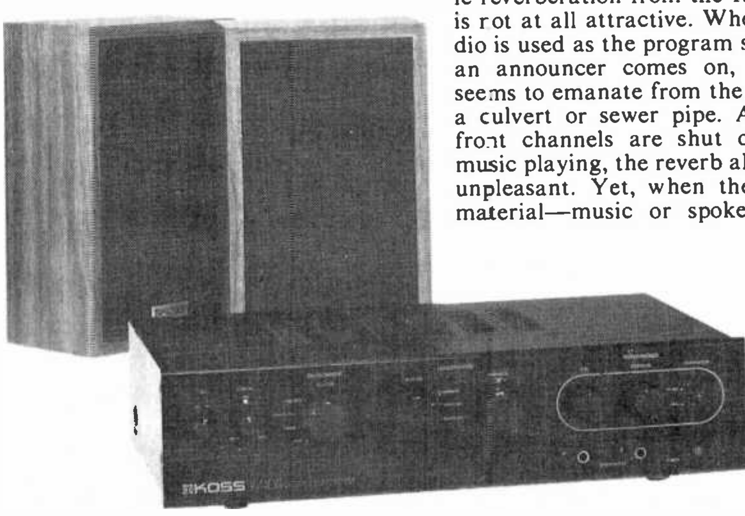
In audio reproduction, largely because the ear is less well understood than the eye, a good deal of confusion prevails. Worse yet, much of what *is* known about hearing is ignored. Rival factions debate whether the ear or objective measuring equipment provides the better means of evaluating and designing equipment. Ironically, many times the ear is used where test equipment would be better and vice versa.

For example, subjective listening tests have been used to investigate differences between pieces of equipment. That's all well and good if we are talking about audible differences and differences of preference. But when differences in slew rate, distortion, or phase response are at issue, test equipment must have the upper hand. And how often does advertising copy imply—ignoring the perceptual thresholds that apply—that if low distortion is good, lower distortion must be better? Were motion-picture engineers to design the way some of their audio colleagues do, film would be shot at 240 frames per second instead of the cutomary 24, and the "state of the art" would be approaching 2,400.

Checking Out the Axioms. Even some of the basic assumptions on which audio reproduction is based may not hold water under close examination. For example, it is most often implicitly assumed that the closer the resemblance between the signal waveform presented to the listener's ear and that picked up by the microphone in the recording session, the better the reproduction will be. This, however, is not necessarily the case. As Robert Berkovitz, one of the authors of the "Loudspeaker Focus," in last April's issue of POPULAR ELECTRONICS, pointed out, a time-delay system—something that most listeners find advantageous—does nothing to improve an input/output waveform match. As a case in point, I will recount some experiences with a time-delay unit.

The Koss K/4DS Digital Delay System is designed for simplicity of operation and, apparently realistically, relieves the user of fine control over some parameters. Length of delay and degree of recirculation are selected from four preset models ranging from CLUB (the smallest and least reverberant) through THEATER and CONCERT HALL to AUDITORIUM (the most reverberant). All the listener need do is select one and set the level of the reverberation to match that of the front channels.

Integral power amplifiers are included in the unit, each rated at 20 watts. This, somewhat surprisingly, is adequate even when the front channels have hundreds of watts available, probably because the reverb process flattens out the peak-to-average ratio of the signal. A 200-watt amplifier reproducing program material with a 15-dB peak-to-average ratio would reach its rated limit on peaks when the average output power is only about 12 watts. If reverberation reduces the peak/average ratio to, say, 8 dB, at 20 watts, the amp will reach its limits at about 5 watts continuous power—just about right if sensitivities of the front and back speakers are comparable. While cleanliness of sound is related to unclipped peaks, the sense of loudness corresponds more closely to average power.



The Koss unit also can drive two sets of headphones (naturally), with provisions for adding reverb. A momentary-contact pushbutton cancels the reverb to allow comparison. This button affects the headphone section only. After we had completed our test, Koss informed us that the unit is offered with a pair of suitable speakers (which we didn't test) at a suggested price of $459.

Listening to the unit was in many ways what might be called an ear-opening experience. First, the unit gave very satisfactory results with cheap, single-driver loudspeakers that would have been close to marginal working by themselves. Second, the addition of the processed signal not only enhanced the impression of space in recorded program material, but actually seemed to contribute clarity.

One of my favorite tests of a listening system or environment could be called the "audibility-of-string-section-inner-voices test." I try to ignore the first violins and the cellos and double basses, while concentrating on the second violins and violas. Frequently, I find these parts obscured or very nearly buried, even when following the score so that I know just what I am trying to hear. That the Koss system actually made these inner voices more audible and the texture more transparent was startling. After all, not even natural reverberation can do that. Normally, moving an ensemble from a "dry" to a reverberant space decreases articulation.

What makes this effect even more puzzling is that, by itself, the synthetic reverberation from the Koss "box" is not at all attractive. When FM radio is used as the program source and an announcer comes on, the voice seems to emanate from the far end of a culvert or sewer pipe. And if the front channels are shut down with music playing, the reverb alone is also unpleasant. Yet, when the program material—music or spoken voice—

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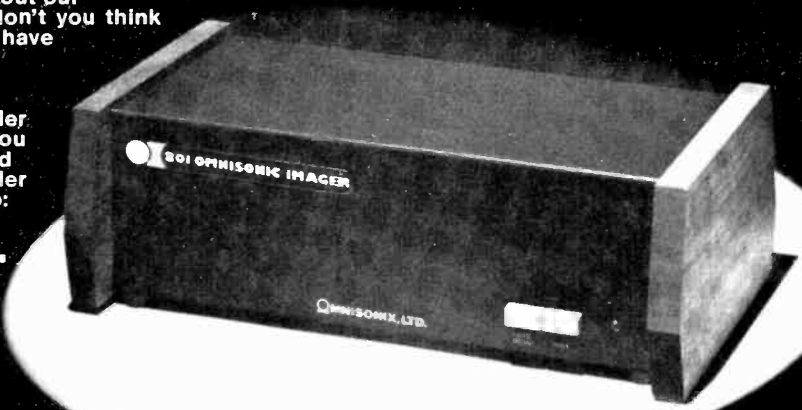

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has sufficient reverberation recorded with it in the first place so that the synthetic addition cannot be singly identified, the overal effect is superb and includes the aforementioned increase in clarity. Apparently, my earlier concerns about signal recirculated through a delay adding coloration are unfounded. (I had favored using delay without recirculation.) As long as the relative front/back levels are set reasonably, it doesn't seem to matter.

Why Does It Work? Shocking as it may seem, no one really knows. Clearly, the notion that one is simulating the diffuse reverb of a concert hall doesn't hold up. If it were true, requirements for the auxiliary speakers would be more critical, particularly with regard to bass energy. Why a relatively low-level signal with so much latitude in its composition and derivation can so profoundly affect the subjective auditory experience is at this point anybody's guess.

But this, it seems to me, is exactly the problem with contemporary audio engineering: We have become highly expert with circuitry and its quirks, but we have not carefully and fully defined what the circuitry must accomplish. Nothing is to be gained by making vanishingly small distortion even smaller or by making "improvements" in phase response that listeners have found perfectly satisfactory to begin with. Rather, we should be investigating some of the mysteries of psychoacoustics and putting the circuitry to work intelligently. The early pioneering days are over, and nothing will be achieved by traveling the old trails in space-age Conestoga wagons. The challenges for today exist—it's time to get serious. ◇

Audiophile Recordings

By Harold A. Rodgers
Executive Editor

NATALIE COLE: ***Thankful***. Mobile Fidelity Sound Labs MFSL 1–032. The mastering and production of this album are impressive indeed. The sample we received was free of even minor warpage, and sonic blemishes were virtually absent. What continues to be amazing is how much clarity Mobile Fidelity's disc mastering process can extract from a regular analog master tape.

When it comes to content, however, matters are less salutary. Natalie Cole may not have achieved the superstardom that many people expected of her on the basis of her parentage, but she is certainly a highly talented and competent artist. Unfortunately, this album, with its general blandness, doesn't really reflect that. The music is pleasant, but seldom moving. It seems odd that, with the benefit of hindsight, Mobile Fidelity would choose to represent Ms. Cole with one of her lackluster offerings. ◇

MICHAEL MURRAY [plays] BACH [on] THE GREAT ORGAN AT METHUEN: ***Passacaglia and Fugue in C minor, Fantasia and Fugue in G minor ("The Great"), Toccata in F, two chorale preludes.*** Telarc DG-10049. With its ability to produce timbres suitable for baroque music and still have great power in its sound, the Methuen Memorial Music Hall organ is an unusual instrument. Furthermore, Michael Murray shows it off outstandingly in the performances on this disc. Textures are always clear enough to allow Bach's kaleidoscopic polyphony to be heard, yet when, as in the G minor Fantasia, Bach demands "good lungs" from the organ, the big sound is there with almost no loss of clarity. Murray's tempos seem particularly well chosen—they leave the music energetic yet well poised.

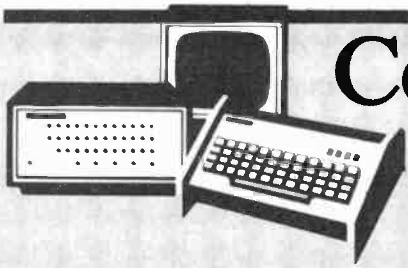
Of course, some of the fine effect of this record results from the way in which it was recorded and produced. There is sufficient reverberation to provide a sense of fullness without turning the sonic texture into echoey mud. Dynamic range is excellent, as is frequency balance. This is a real treat for lovers of Bach's organ music—and if you don't like organ music, this may just change your mind.

RŮŽIČKOVÁ ENCORE ALBUM. Zuzana Růžičková, harpsichord. Denon PCM NCC-8503-N. This is an interesting collection of short harpsichord pieces (except for the final three Bartók pieces, which are borrowed from piano literature) that, true to the title of the album, are suitable for encores. Unfortunately, the liner notes for this album are in Japanese, and the only way to find out what the various pieces are is to read them from the label on the disc itself.

The good news is that Růžičková and the recording engineers have conspired to capture a series of exquisitely intimate moments of harpsichord music. For example, anyone who thinks the tone of this instrument is insubstantial and dies out at once is in for a surprise. Not only is the sustaining power considerable, but Růžičková shows how expressively it can be used.

CORRECTION

Due to a printer's error, the Omnisonix ad in last month's issue had an incorrect price. The suggested price is $199.00.



Computer Bits

By Carl Warren

Interesting Items and BASIC Conversion.

SINCE Christmas is upon us, you just might be thinking about a little something electronic for yourself or one of the children. One item that you might consider is the 8085AT microcomputer system from Paccom. This single-board computer (SBC) is priced at $299.95 completely built and tested, and a kit is $249.95

What makes this SBC a worthwhile buy is that it can be used as a controller or a trainer. The unit comes with the 8085A Cookbook and the 8080/8085 Software Design Book 1 written by the dynamic trio of David Larsen, Jonathan Titus, and Christopher Titus. The trainer used in conjunction with these books will certainly strengthen your knowledge about 8- bit processor software design.

More on Modems. It seems that since I started keeping you abreast of happenings in system-to-system communication, more keeps coming. Specifically, modem manufacturers are sensitive to the needs of small-system owners and are offering a lot of performance for a relatively low price.

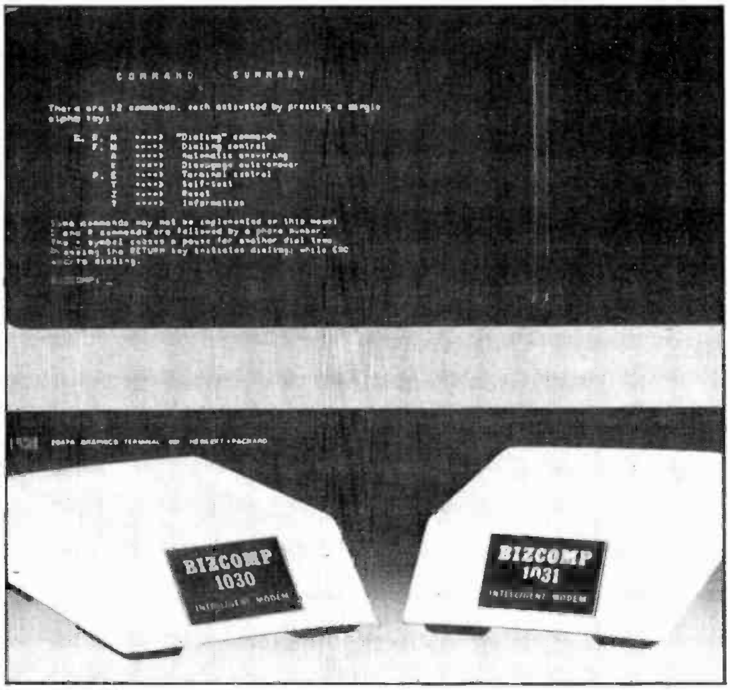
For example, I recently had the pleasure of visiting Dennis Hayes, president of Hayes Microcomputer Products. Dennis was one of the first to make a bus-oriented modem for S-100 systems. This unit, dubbed the Micromodem 100, is still available at $399 with a microcoupler that eliminates the need for a separate Data Access Arrangement (DAA). Dennis advised me that although the trend is to unitized systems like the Apple, S-100 bus systems are still popular.

The Micromodem 100 isn't the big news though—the company's Micromodom II for the Apple II is. This $379 unit includes a modem board that fits on the Apple bus, a microcoupler to attach it to the phone line, cables, and firmware on Read Only Memory (ROM). The ROM code is the secret to the power of the unit. It permits you to use your Apple in some very sophisticated communications operations. Among the many features of the Micromodem II are:

- Auto answer
- Auto dial
- Auto data transfer
- Bell system 103 compatibility
- Full duplex operation

Hayes has further enhanced his product by providing what I consider the most comprehensive manuals offered for any product today. In them, numerous subroutines are provided for functions such as answering a ringing phone and sending an acknowledgement tone, automotive dialing, and sending text data by phone. The entire package provides high quality at reasonable cost.

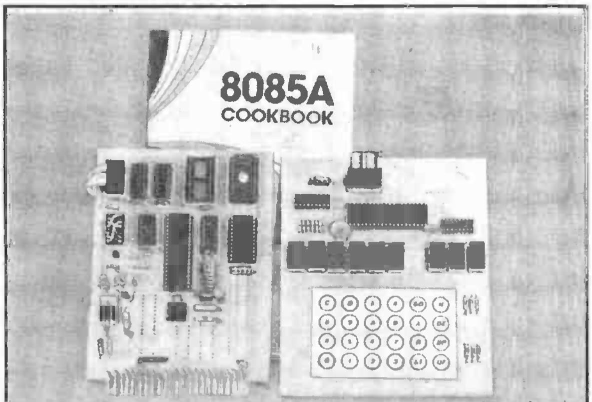
As good as they are, the Hayes modems are system dependent and, consequently, leave the field open for competitors. One such company, Bizcomp, offers a series (1030) of intelligent modems designed to fit any computer with a serial interface. Prices for the Bizcomp units range from $395 for the model 1030 to $495 for the 1031.



Flexible stand-alone intelligent modem series from BIZCOMP.

The modems incorporate an 8-bit microprocessor and an on-board ROM to establish the interactive features of the unit. With any of the 1030 series you have auto answer, dial, Bell 103 compatibility, and a selection of baud rates from 110 to 300.

What's especially exciting is that you can have the intelligent interactive dialogue features with just a terminal and the Bizcomp modem—a computer isn't even required. According to Bizcomp, the idea is to provide a microprocessor modem system at low cost, while allowing a user the



The 8085AT single-board computer from Paccom can be used as a controller or trainer.

Write and run programs–the very first night–even if you've never used a computer before!

You're up and running with video graphics for just $99.95 — then use low cost add-ons to create your own personal system that rivals home computers sold for 5-times ELF II's low price!

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Own a powerful home computer system, starting for just $99.95–a price that gets you up and running the very first night...with your own TV for a video display. $99.95 ELF II includes RCA 1802 8-bit microprocessor addressable to 64k bytes with DMA, interrupt, 16 registers, ALU, 256 byte RAM, full hex keyboard, two digit hex output display, stable crystal clock for timing purposes, RCA 1861 video IC to display your programs on any video monitor or TV screen *and 5-slot plug-in expansion bus (less connectors) to expand ELF II into a giant!*

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Master ELF II's $99.95 capabilities, then expand with GIANT BOARD . KLUGE BOARD...4k RAM BOARDS...TINY BASIC...ASCII KEYBOARD . LIGHT PEN...ELF-BUG MONITOR...COLOR GRAPHICS & MUSIC SYSTEM... TEXT EDITOR...ASSEMBLER...DISASSEMBLER. VIDEO DISPLAY BOARD *.and–*

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Master This Computer In A Flash!

Regardless of how minimal your computer background is now, you can learn to program an ELF II in almost no time at all. Our *Short Course On Microprocessor & Computer Programming*–written in non-technical language–guides you through each of the RCA COSMAC 1802's capabilities, so you'll understand *everything* ELF II can do...*and how to get ELF II to do it!* Don't worry if you've been stumped by computer books before. The *Short Course* represents a major advance in literary clarity in the computer field. You don't have to be a computer engineer in order to understand it. Keyed to ELF II, it's loaded with "hands on" illustrations. When you're finished with the *Short Course*, neither ELF II nor the RCA 1802 will hold any mysteries for you.

In fact, not only will you now be able to use a personal computer creatively, you'll also be able to read magazines such as BYTE...INTERFACE AGE...POPULAR ELECTRONICS and PERSONAL COMPUTING and fully *understand* the articles. And, you'll understand how to expand ELF II to give you the exact capabilities you need!

If you work with large computers, ELF II and the *Short Course* will help you understand what they're doing.

Get Started For Just $99.95, Complete!

$99.95 ELF II includes all the hardware and software you need to start writing and running programs at home, displaying video graphics on your TV screen and designing circuits using a microprocessor–the very first night–even if you've never used a computer before.

ELF II connects directly to the video input of your TV set, without any additional hardware. Or, with an $8.95 RF modulator (see coupon below), you can connect ELF II to your TV's antenna terminals instead.

ELF II has been designed to play all the video games you want, including a fascinating new target/missile gun game that was developed specifically for ELF II. But games are only the icing on the cake. The real value of ELF II is that it gives you a chance to write machine language programs–and machine language is the fundamental language of all computers. Of course, machine language is only a starting point. You can also program ELF II with assembly language and tiny BASIC. But ELF II's machine language capability gives you a chance to develop a working knowledge of computers that you can't get from running only pre-recorded tape cassettes.

ELF II Gives You The Power To Make Things Happen!

Expanded, ELF II can give you more power to make things happen in the real world than heavily advertised home computers that sell for a lot more money. Thanks to an ongoing committment to develop the RCA 1802 for home computer use, the ELF II products–being introduced by Netronics–keep you right on the outer fringe of today's small computer technology. It's a perfect computer for engineering, business, industrial, scientific and personal applications.

Plug in the GIANT BOARD to record and play back programs, edit and debug programs, communicate with remote devices and make things happen in the outside world. Add Kluge (prototyping) Board and you can use ELF II to solve special problems such as operating a complex alarm system or controlling a printing press. Add 4k RAM Boards to write longer programs, store more information and solve more sophisticated problems.

ELF II add-ons already include the ELF II Light Pen and the amazing ELF-BUG Monitor–two extremely recent breakthroughs that have not yet been duplicated by any other manufacturer.

The ELF-BUG Monitor lets you debug programs with lightening speed because the key to debugging is to know what's inside the registers of the microprocessor. And, with the ELF-BUG Monitor, instead of single stepping through your programs, you can now display the entire contents of the registers on your TV screen. You find out immediately what's going on and can make any necessary changes.

The incredible ELF II Light Pen lets you write or draw anything you want on a TV screen with just a wave of the "magic wand." Netronics has also introduced the ELF II Color Graphics & Music System–more breakthroughs that ELF II owners were the first to enjoy!

ELF II Tiny BASIC

Ultimately, ELF II understands only machine language–the fundamental coding required by all computers. But, to simplify your relationship with ELF II, we've introduced an ELF II Tiny BASIC that makes communicating with ELF II a breeze.

Now Available! Text Editor, Assembler, Disassembler And A New Video Display Board!

The Text Editor gives you word processing ability and the ability to edit programs or text while it is displayed on your video monitor. Lines and characters may be quickly inserted, deleted or changed. Add a printer and ELF II can type letters for you–error free–plus print names and addresses from your mailing list!

ELF II's **Assembler** translates assembly language programs into hexidecimal machine code for ELF II use. The Assembler features mnemonic abbreviations rather than numerics so that the instructions on your programs are easier to read–this is a big help in catching errors.

ELF II's **Disassembler** takes machine code programs and produces assembly language source listings. This helps you understand the programs you are working with...and improve them when required.

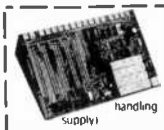
The new ELF II Video Display Board lets you generate a sharp, professional 32 or 64 character by 16 line upper and lower case display on your TV screen or video monitor–dramatically improving your unexpanded $99.95 ELF II. When you get into longer programs, the Video Display Board is a real blessing!

Now Available!

☐ **A-D/D-A Board Kit** includes 1 channel (expandable to 4) D-A, A-D converters, $39.95 plus $2 postage & handling.

☐ **PILOT Language**—A *new* text-oriented language that allows you to write educational programs on ELF II with speed and ease! Write programs for games...unscrambling sentences...spelling drills..."fill in the missing word" tests, etc.! PILOT is a must for any ELF II owner with children. *PILOT Language on cassette tape, only $19.95 postpaid!*

☐ **Game Package** on cassette tape (requires 4k RAM), $9.95 plus $2 postage & handling.



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☐ RCA 1802 User's Manual $5 postpaid

☐ Tom Pittman's Short Course On Microprocessor & Computer Programming teaches you just about everything there is to know about ELF II or any RCA 1802 computer. Written in non-technical language it's a learning breakthrough for engineers and laymen alike. $5 postpaid

☐ Deluxe Metal Cabinet with plexiglas dust cover for ELF II $29.95 plus $2.50 p&h

☐ I am also enclosing payment (including postage & handling) for the items checked below!

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Total Enclosed $ ______
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CHARGE IT! Exp. Date ______
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ALSO AVAILABLE FOR ELF II

☐ **GIANT BOARD**™ kit with cassette I/O, RS 232-C/TTY I/O, 8-bit P I/O, decoders for 14 separate I/O instructions and a system monitor/editor $39.95 plus $2 p&h

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☐ ELF II Tiny BASIC on cassette tape. Commands include SAVE, LOAD, ±, ×, ÷, ( ), 26 variables A-Z, LET, IF/THEN, INPUT, PRINT, GO TO, GO SUB, RETURN, END, REM, CLEAR, LIST, RUN, PLOT, PEEK, POKE. Comes fully documented and includes alphanumeric generator required to display alphanumeric characters directly on your tv screen without additional hardware. Also plays tick-tack-toe plus a drawing game that uses ELF II's hex keyboard as a joy stick. 4k memory required. $14.95 postpaid

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☐ **Disassembler** on cassette tape takes machine code programs and produces assembly language source listings to help you understand and improve your programs. $19.95 on cassette tape

SAVE $9.90—Text Editor, Assembler & Disassembler purchased together, only $49.95! (Require Video Display Board plus 4k memory.)

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ASCII/BAUDOT, STAND ALONE

Computer Terminal

COMPLETE FOR ONLY... $149.95

The Netronics ASCII/BAUDOT Computer Terminal Kit is a microprocessor-controlled, stand alone keyboard/terminal requring no computer memory or software. It allows the use of either a 64 or 32 character by 16 line professional display format with selectable baud rate, RS232-C or 20 ma. output, full cursor control and 75 ohm composite video output.

The keyboard follows the standard typewriter configuration and generates the entire 128 character ASCII upper/lower case set with 96 printable characters. Features include onboard regulators, selectable parity, shift lock key, alpha lock jumper, a drive capability of one TTY load, and the ability to mate directly with almost any computer, including the new Explorer/85 and ELF products by Netronics.

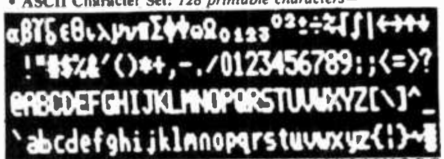
The Computer Terminal requires no I/O mapping and includes 1k of memory, character generator, 2 key rollover, processor controlled cursor control, parallel ASCII/BAUDOT to serial conversion and serial to video processing—fully crystal controlled for superb accuracy. PC boards are the highest quality glass epoxy for the ultimate in reliability and long life.

VIDEO DISPLAY SPECIFICATIONS

The heart of the Netronics Computer Terminal is the microprocessor-controlled Netronics Video Display Board (VID) which allows the terminal to utilize either a parallel ASCII or BAUDOT signal source. The VID converts the parallel data to serial data which is then formatted to either RS232-C or 20 ma. current loop output, which can be connected to the serial I/O on your computer or other interface, i.e., Modem.

When connected to a computer, the computer must echo the character received. This data is received by the VID which processes the information, converting to data to video suitable to be displayed on a TV set (using an RF modulator) or on a video monitor. The VID generates the cursor, horizontal and vertical sync pulses and performs the housekeeping relative to which character and where it is to be displayed on the screen.

Video Output: *1.5 P/P into 75 ohm (EIA RS-170)* • **Baud Rate:** *110 and 300 ASCII* • **Outputs:** *RS232-C or 20 ma. current loop* • **ASCII Character Set:** *128 printable characters—*



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

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☐ **Video Display Board Kit alone (less keyboard), $89.95** plus $3 postage & handling.

☐ **12" Video Monitor** (10 MHz bandwidth) fully assembled and tested, $139.95 plus $5 postage and handling.

☐ **RF Modulator Kit** (to use your TV set for a monitor), $8.95 postpaid.

☐ **5 amp Power Supply Kit In Deluxe Steel Cabinet** (±8VDC @ 5 amps, plus 6-8 VAC), $39.95 plus $2 postage & handling.

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flexibility of incorporating it into a computer.

Software can be written that uses the power of the modems in concert with that of a base computer. Since the modem has its own control and logic, the communications package can be written in any language you have running. This system looks ideal as an add-on for a Heath system, especially if you're setting up a store-and-forward message system.

Adding More Functions to an H-89. I know that many of you have the Heath H-89 microcomputer system, and have been looking for a variety of ways to upgrade it. Well, Magnolia Microsystems has the answer, especially if you're interested in adding a 10M-byte Winchester disk. Magnolia is offering the Corvus 112 10M-byte Winchester disk with intelligent controller and the MMS 89 interface board for $5,350. The interface and patches to Digital Research's CP/M operating system are the value added by Magnolia.

The interface board consists of two parallel I/O ports for communicating with the Corvus controller and space for the existing serial ports used by the computer. (You simply move the components from your existing serial board to the Magnolia board.) The interface fits on the H-89 bus slot and requires no modifications that would void the Heath warranty. Magnolia recommends that you also purchase the PROM upgrade that puts memory at a zero base, thus permitting use of standard CP/M.

A Most Unbelievable "Magazine." Imagine the following: You sit down at your computer system, insert a disk, and try software projects others have done, as well as reading about new ideas. The "magazine," Micro Media, lets you really do this. For example, there's a convert BASIC that allows you to translate from one version to another (it doesn't work in all cases, though). Micro Media comes on disk for either the Heath H-89,. Radio Shack TRS-80, or Apple II micro-computer systems. The annual subscription rate is $55. (If you want to nibble before you bite, you can order a single issue for $11.95. Be sure to specify the system you have.)

So You Want to Convert a BASIC Program? I imagine that many of you from time to time have run across a program you just had to have run on your machine. But what do you do when it's written in a version of BASIC that you don't have, or one that's somewhat obscure? (I started researching the problem about two years ago and, to date, have identified 111 versions of BASIC, 23 of which were developed by Microsoft.)

Translation from one version to another is more tedious than difficult, but it requires that you have the manuals that explain the use of the BASICs you are translating between, and an understanding of how the language works in the first place. In cases where it will work, an automatic translater such as that mentioned above is most convenient.

Hand translation is the next and most tedious method. For this, I'd suggest you get a copy of David Lein's The BASIC Handbook for reference. David provides information on many versions of BASIC and offers valuable translation tips.

Assuming that you have assembled all of the required manuals and guides, your next step is to dive right in and go for it. Begin by taking a listing of the program. If you can get it into your machine, so much the better. Of course, there are versions of BASIC that won't permit this. Since each line is translated on insertion to a buffer, you'll get an error.

Once you have some form of listing to work from, follow the outline in Fig. 1, writing down functions and breaking the program into parts. The key is to translate on a routine-to-routine basis, rather than attacking the whole program at once. Thus you are essentially rewriting the program, using the original as an outline.

Most of the statements used in BASIC programs are fairly straightforward and can be used as originally written. The big problem occurs when translating disk I/O and graphics functions since virtually every machine handles these differently. In cases where disk operations and graphics are employed, your best bet is to break these out as subroutines, and write them in accordance with the specs of your BASIC. But remember, BASIC doesn't support mass storage I/O or graphics. These functions have been added over time and are considered extensions. They rely on the system monitor firmware and the operating system in order to work.

An interesting aspect of BASIC is that you can establish macro calls in the form of subroutines that can be defined to simulate a function not supported by your BASIC. Suppose you see a program written for the TRS-80, for example, and you have just become the owner of a Mits 680b using the old Microsoft BASIC. Your goal is to make that program work as it would on the TRS-80 (for this example no disk I/O is implied). Let's first look at the original program:

```
10 CLS                          :REM CLEAR THE SCREEN
20 I = O                        :REM ZERO THE COUNTER
30 FOR I = 1 to 25              :REM START LOOP
40 PRINT "THIS IS A TEST"       :REM PRINT MSG TO CRT
50 NEXT I                       :REM INCREMENT COUNTER
60 END
```

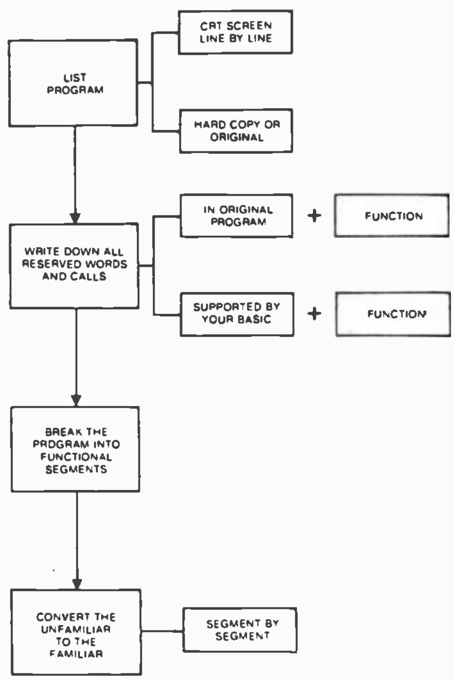

Fig. 1. Procedure for converting a BASIC program.

Notice that the program is straightforward. Nothing fancy, but it won't run on the 680b! The first line will generate a syntax error, meaning that there is something in it that the BASIC in use doesn't understand—in this case, CLS. To the TRS-80, CLS is a special function that tells the system monitor: "Clear the screen by blanking all the available picture elements (pixels)."

The 680b operates with an external terminal that may or may not have a blanking feature and is separate from the internal operation of the computer. Accordingly, the terminal may not have a method of clearing the screen with a control character (which incidentally, would be easy). Instead, a counter much like the main program body is called for. Therefore, the new program will look like this:

```
10 GOSUB 100
20 I = 0
30 FOR I = 1 TO 25
40 PRINT "THIS IS A TEST"
50 NEXT I
60 END
100 FOR C = 1 to 16      :REM SCREEN HAS 16 LINES
110 PRINT                :PRINT A BLANK LINE
120 NEXT C               :INCREMENT THE COUNTER
130 RETURN               :GO BACK WHERE YOU CAME FROM
```

The rest of the program stays the same, as it contains nothing not known to the 680b version of BASIC. In this case, both BASICs are of Microsoft design, which helps, since they are reasonably similar.

Now, here's something for you to do. Write a conversion program that will take the program in this example and translate it for some other machine, such as a Heath, Apple or an Atari 800. I'll show you a program that performs this translation in an upcoming issue, and how to convert an Apple graphics program to work on the Heath H-89 and Radio Shack TRS-80.

Should you, in the meantime, come up with a good idea on how to convert programs, send me a note, in care of the magazine. Or, if you have a program you want to convert and aren't sure what to do, let me know (enclose a stamped, self-addressed envelope); I probably can help. Those of you that are on the Micronet can reach me at ID [70003,133]. ◇

MORE INFORMATION

For additional information about products and services mentioned here, contact the companies directly.

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By Leslie Solomon
Senior Technical Editor

Hardware

Apple Music. The Music Machine Nine can produce nine voices and requires only one Apple slot. It can use presently available software compatible with other music boards. Two high-impedance, low-level outputs are provided with six voices assigned to each channel. $199. Address: Advanced Computer Products, 1310 E. Edinger, Santa Ana, CA 92705, (Tel: 714–558–8813).

Minimal 6802 System. The Model SBC-02 computer is a 4-chip system on a 6" × 6" pc board and features a 6802 processor, 128 bytes of RAM, 2K of ROM and a parallel/serial I/O port. A Wire-Wrap area is also provided. An optional monitor (HUMBUG in a 2716 EPROM at $40) can be used to provide program entry and control, single stepping, breakpoints, and other front-panel-like functions. Other options include 4K floating-point BASIC in ROM, a cross assembler for 6802 development, and other utilities. Bare board with instructions $25, $75 for parallel I/O kit, or $150 wired and tested. Address: Star Kits. Box 209, Mt. Kisco, NY 10549.

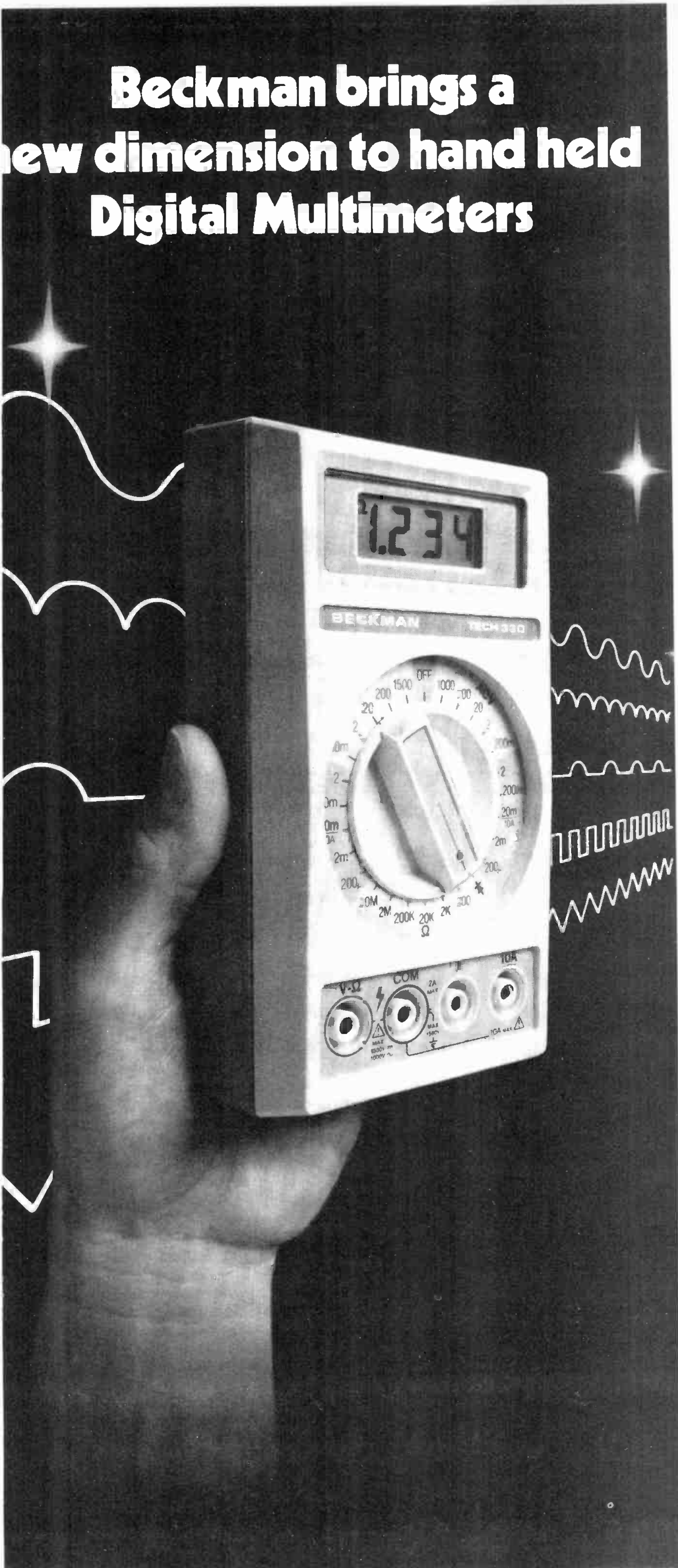
Terminal for the Blind. Total Talk is a computer terminal that converts data into full-word synthetic speech. It consists of a keyboard, two

processors, a CRT screen and speech synthesizer. Phonetic characters plus rules for enunciation are fed into the synthesizer and the product is clear synthetic speech for a blind computer operator. The operator can listen to a page, a selected line, or a single word. Speech rate can be set between 45 and 720 words/minute with pitch, tone, and volume adjustable. $5,995. Speak Easy is a subset of Total Talk without the editing and cursor control capabilities. $4,000. Address: Maryland Computer Services Inc., 502 Rock Spring Ave., Bel Air, MD 21014 (Tel: 301-879-3366/838-8888).

Scrub-A-Daisy. This print-wheel cleaning system is to be used with Daisy, Diablo, Qume, and Wang print wheels, as well as IBM word processor and mag card wheels. The cleaner removes ink, carbon, dirt, and static accumulations from the wheel characters. It comes in a self-storing container. $13.95. Address: Vikor Company, Inc., 51 Lake St., Box 3123, Nashua, NH 03061 (Tel: 603-889-8530).

Software

picoFORTH for the 1802. picoFORTH, a subset of polyFORTH, is available for the 1802 (disk or PROM) and the 8080. It can be upgraded at any time with the Source, Target Compiler, or Multitasker, to full polyFORTH. A File Management option package is also available. In addition to the current versions, pico-



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The TECH 330 also accurately measures the entire audio band up to 20 kHz. But that's not all you can expect from Beckman's top-of-the-line multimeter.

Measurement Comparison Chart

Waveforms (Peak = 1 Volt)	Average Responding Meter	Beckman TECH 330	Correct Reading
Sine Wave	0.707V	0.707V	0.707V
Full Wave Rectified Sine Wave	0.298V	0.707V	0.707V
Half Wave Rectified Sine Wave	0.382V	0.500V	0.500V
Square Wave	1.110V	1.000V	1.000V
Triangular Sawtooth Wave	0.545V	0.577V	0.577V

You also get 0.1% basic dc accuracy, instant continuity checks, 10 amp current ranges, a separate diode test function, 22 megohm dc input impedance, and an easy-to-use rotary switch.

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FORTH will soon be implemented for the 8086, 6800, and LSI-11 systems. $495. Address: FORTH, Inc., 2309 Pacific Coast Hwy, Hermosa Beach, CA 90254 (Tel: 213-372-8493).

Stars on Your Screen. Comp-U-Sky is a high-resolution graphics program for Apple computers that interacts with the user via text and game paddles to locate, identify, and provide information on stellar objects. It requires 48K of memory, Applesoft in firmware, and one disk drive. It presents a display of eight directions and directly overhead. The viewing "eye" can be changed from the North Pole to a South Sea isle. The program adjusts for latitude and longitude, viewing time and date, including earth precession. Right ascension and declination are provided for all objects in the tables. Constellations, planets, sun, moon, and stars are presented in high-resolution graphics. A calculation utility is provided for performing equatorial, ecliptic, horizontal and precession conversions. $39.95 on diskette. An advanced version having multiple star tables is $79.95. Address: Scharf Software, Box 18445, Irvine, CA 92713 (Tel: 714-557-9206).

Heath Source Codes. The Heath Company is offering source codes for its internally developed systems software and firmware. Source codes released include Cassette Assembler, Debugger, Editor, BASIC, and HDOS. Also being offered are firmware for the H-17 and H-89 disk controllers as well as the firmware used by the H-19 terminal. $25 per listing, except HDOS at $195. The H-19 code includes code on diskette and character generator ROM. All products remain copyrighted. Address: Heath Company, Dept. 350-390, Benton Harbor, MI 49022.

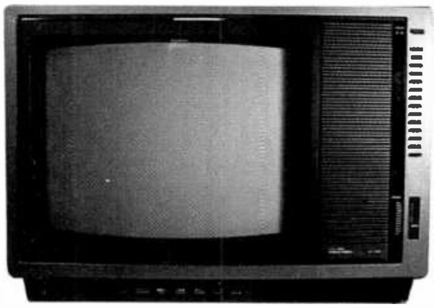
Pencil Sharpener. This program (Pencil Sharpener) turns the powerful Electric Pencil II into a complete word processing system. A letter or announcement is created using the Pencil and saved on disk. The Pencil Sharpener is told the name of the data file that contains the names, addresses, phone numbers, order information, etc. The Sharpener will then replace key words in the letter with the appropriate items of information and print a personalized letter using the Electric Pencil. Hundreds of letters can be processed. It also includes utility routines to set up data files using standard mailing list or BASIC programs, You can even configure your system to print subscripts, superscripts, dual fonts, etc. $195. Address: Software Hows, MicroDaSys, Box 36275, Los Angeles, CA 90036 (Tel: 213-731-0877).

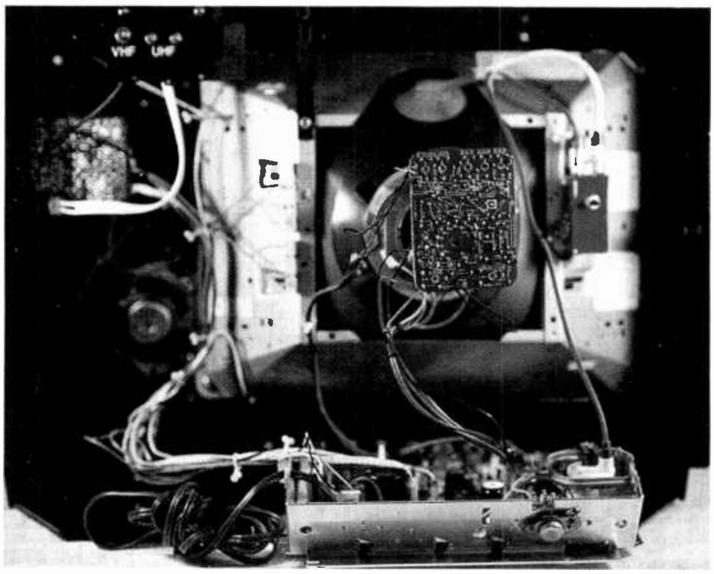
Durango F-85. CP/M for the Durango F-85 system can support up to four floppy drives and enables this system to accept BASIC, COBOL, PASCAL, word-processing systems, communication software such as BSTAM, and almost all accounting packages. $170. Address: Lifeboat Assoc., 1651 Third Ave., New York, NY 10028 (Tel: 212-860-0300).

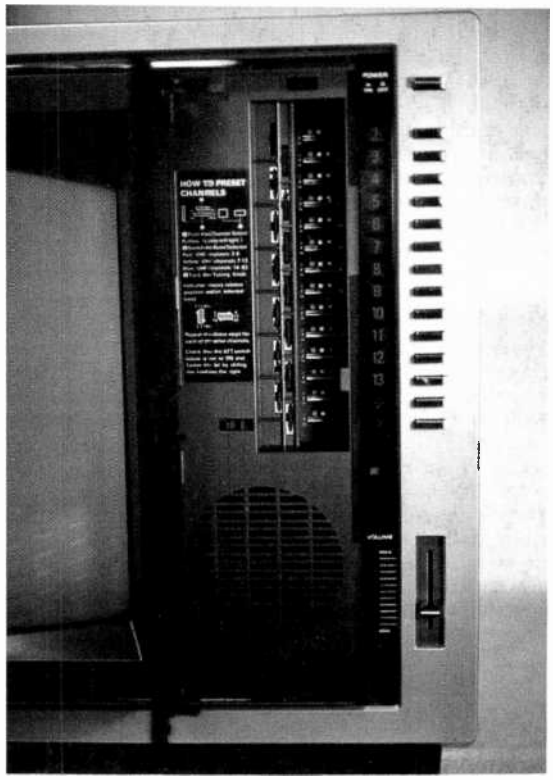
Job Cost System. The "Project Boss" for the TI 99/4 computer is a disk-based program to assist the project manager and consultants on construction jobs in the financial management of individual projects. Job cost, estimates, bids, or budgets can be prepared. The software allows a flexible accounting system for individual jobs, and preparation of reports on the budget, costs to date, current estimated completion costs, and variances from the projected costs. The system requires three disk drives and a printer. It is also available for the Apple and TRS-80. $94.95. Address: Charles Mann and Assoc., 7594 San Remo Trail, Yucca Valley, CA 92284 (Tel: 714-365-9718).

Popular Electronics Tests

Sony's 19" KV-1913/1914 Color TV







Features a noise-free picture and convenient serviceability

A CLOSE look at Sony's 1980-1981 TV receivers in comparison to Trinitron models of previous years reveals salutary changes. A typical example of this upgrading is seen in the intermediate 19-inch KV-1913/1914 chassis, which has a suggested retail price of $579.95. Unlike its predecessors, this chassis is amenable to servicing. Central to this serviceability is its single-board construction, with plug-in connections to the tuners, deflection yoke, audio section—and just about everything else.

This chassis contains a half-dozen integrated circuits that provide features such as noise cancellers in both sync and intermediate-frequency amplifiers, a sharp band-skirt surface acoustic wave (SAW) filter, a preamplifier between tuner and i-f's, and push-pull audio output. Only 23 discrete transistors are used throughout the entire chassis; seven are in the receiver's unitized tuners. High-voltage holdown, sensible dc regulation, nonflammable resistors in strategic locations, and a 5-ampere line fuse appear to do a good job of overall protection, too. There's even a power-on indicator.

Sony's color-TV hallmark, the Trinitron picture tube, complete with three cathodes, four sets of grids, and four high-voltage plates for horizontal static convergence, is a prominent feature in this receiver. In the past, the Trinitron required a fairly large parabolic waveform synchronized with horizontal scan for dynamic convergence, which was added to the dc voltage applied to the outer deflection plates. Now, apparently, horizontal static control on the high-voltage output assembly is pretty much dc, with vertical and horizontal dynamic convergence executed principally by variable (ring) position magnets on the

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Audio Product of the Month

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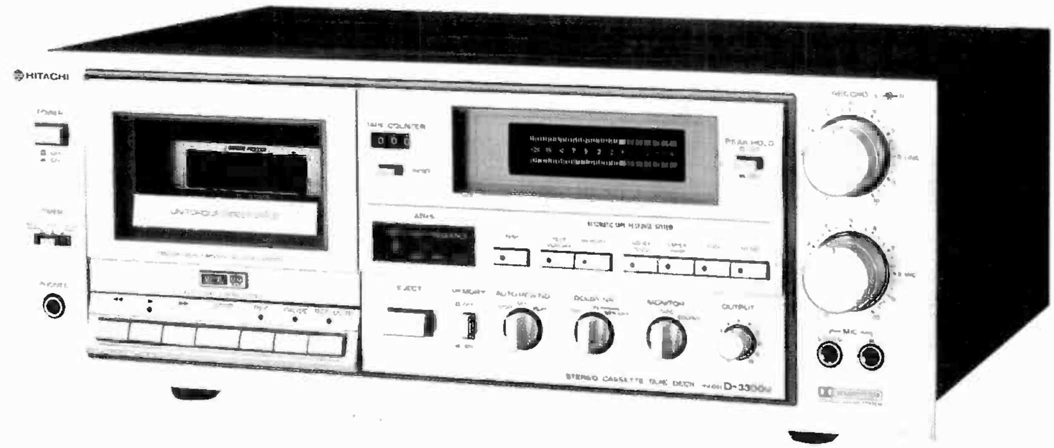

Hitachi D-3300M Stereo Cassette Deck

Features Automatic Tape Response System to set optimal recording parameters

THE Hitachi D-3300M is a three-head, two-motor cassette deck featuring the microprocessor-controlled ATRS (Automatic Tape Response System) developed by Hitachi and used in a slightly different form in its top-of-the-line Model D-5500M. Although some of the convenience features of the D-5500M have been deleted from the lower-priced D-3300M, in their essentials the two machines are very much alike.

The D-3300M has metal-tape record/play capability, a double Dolby system for monitoring off the tape with correct frequency response and noise levels, solenoid-operated tape transport functions, and fast-acting fluorescent peak-level indicators that hold readings above 0 dB for an extended time.

Some unusual operating modes, such as auto rewind PLAY/STOP, are found in the recorder. It can be set to automatically rewind a tape at the end of play and stop when the beginning has been reached or go into PLAY and repeat the tape indefinitely. There is also a conventional memory rewind that stops the tape when the index counter returns to a 000. The D-3300M can be controlled from an external clock timer in the power line for unattended recording or playback.

The Hitachi D-3300M is 17"W × 10"D × 6½"H and weighs 18½ pounds. Suggested list price is $700.

General Description. In most respects, the front-loading D-3300M presents a conventional appearance, with light touchbuttons below the cassette door controlling the transport through solenoids. Colored lights above the buttons show the selected mode of operation. A REC MUTE button kills the incoming signal to the recording circuits while it is held in. This allows material to be conveniently deleted from a recording.

Although they are electrically and magnetically distinct, the record and playback heads of the D-3300M are housed in a single case. Separate line and microphone input record-level controls are provided, and the two sources can be mixed. Each control is actually a pair of clutch-coupled potentiometers for individual channel-level adjustment. Playback level is controlled by a single knob.

The fluorescent peak-level indicators—a pair of horizontal lines formed of closely spaced luminous segments—are calibrated from −20 dB to +6 dB and respond very rapidly to program peaks. Pressing PEAK HOLD causes the maximum level above 0 dB to be displayed until the button is pressed a second time, or the recorder is shut off.

Most novel among features of the Hitachi D-3300M is the Automatic Tape Response System (ATRS). To use it, one first selects the basic tape type by pressing one of four pushbuttons. They are marked UD-ER (NOR), UD-EX (CrO_2), FeCr, and METAL. In general, ferric tapes will use the NOR setting, while ferricobalt or chromium-dioxide tapes take the CrO_2 setting. A green light in the center of each button glows when it is active.

Next the machine is put into the REC mode and the button marked TEST is pressed. The automatic test sequence begins and, after about 10 seconds, the tape rewinds to the start of the test section and the machine stops. At this point, the red light in the center of the TEST MEMORY button comes on, signifying that optimal parameters of bias, record level, and equalization are stored in the computer's memory. If desired, the recording can be made without further use of the ATRS controls. The data is retained in the memory, even with power off, with the aid of two silver cells.

Alternatively, one can store the computer-derived information in a

(Continued on page 130)

My father always told me that there were certain advantages to putting all your eggs in one basket. "John," he said, "learn to do one important thing better than anyone else, and you'll always be in demand."

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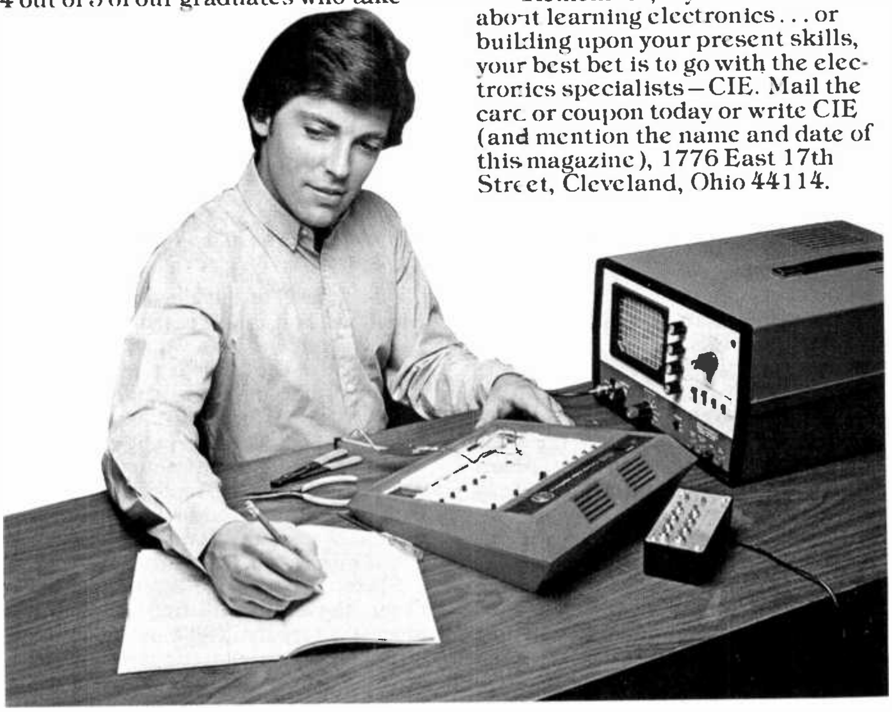

Pattern shown on oscilloscope screen is simulated.

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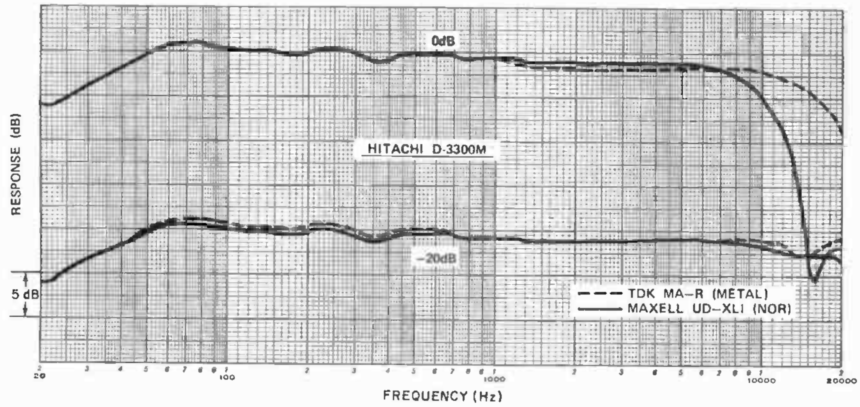

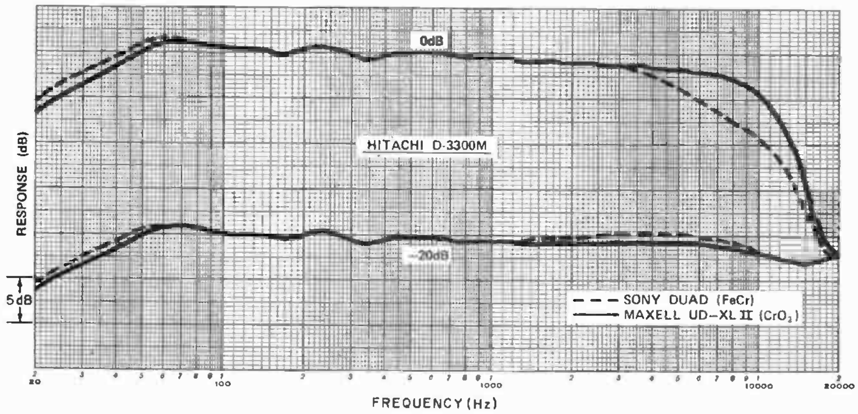

Frequency-response curves for four different types of tape.

(Continued from page 125)

memory assigned only to the tape-type button that was used for the ATRS operation. This releases the TEST MEMORY for use with another type of tape. To load this data into the regular memory, it is only necessary to press in TEST MEMORY and the adjacent MEMORY button in that order, holding both in and releasing TEST MEMORY first. From that point on, touching the tape type button will optimize the recorder for that particular tape formulation. The information assigned to each button can be changed at any time by running another tape through TEST and loading the TEST MEMORY into MEMORY.

A window next to the buttons contains red lights that illuminate in rapid sequence to show which test frequency (1, 7, or 15 kHz) is being used at any time during the ATRS operation. A fourth light (BATT) shows that the memory batteries are installed and operating properly; if the batteries become weak or are absent, this light flashes.

In the automatic test, the computer first records a 1-kHz standard level tone on the tape and checks the playback level. If the primary tape selection is incorrect, or if the leader tape is passing over the heads, the red light in the TEST button flashes, indicating an error.

If the correct tape type has been selected, the machine's logic circuits vary the bias current in 32 steps, noting which value gives the maximum playback level as the bias is increased, and again as it is decreased. The average of those two bias values is stored and used for the following tests. Next, the recording level is varied in 32 steps (0.25 dB per step) to find the value that gives a correct playback level at 1 kHz. Then, frequencies of 7 kHz and 15 kHz are recorded in turn, with the computer adjusting equalization in 32 steps to obtain uniform output at all three frequencies.

Since there is some interaction between these adjustments, the entire process is repeated two more times before the parameter settings are stored in TEST MEMORY. During the tests, the turns of the tape hubs are monitored by the computer so that the tape is rewound to where the test began.

When the stored data is transferred to the individual tape memories, it is available at any time the associated buttons are pressed. This transfers the information in 5-bit data units to the peripheral circuits, establishing bias, level, and equalization.

Although the D-3300M lacks the wireless remote-control feature of the D-5500M, it has an optional cable-connected remote-control unit that operates all the transport functions.

Laboratory Measurements. For our bench tests we used Maxell UD-XLI for NOR, Maxell UD-XLII for CrO_2, Sony Duad for FeCr, and TDK MA-R for metal tape. Frequency response at −20 dB was virtually identical for all the tapes, typically ±2 dB from 35 to 20,000 Hz, with a slightly depressed output above 10 kHz and a falling response below 50 Hz. Differences between the tapes became more apparent in measurements taken from a 0-dB record level. Here, the two Maxell tapes showed a falling response above 8 kHz, which intersected the −20-dB response curve between 15 and 20 kHz. The Duad tape response began to fall off at 4 kHz, but it did not meet the −20-dB curve until 18 kHz. Not surprisingly, the TDK MA-R metal tape was flat to 10 kHz, falling off moderately to −8 dB at 20 kHz, where it was till 12 dB above the −20-dB response.

Dolby tracking was fairly good at levels of −20 and −30 dB, with response changing by no more than 2 dB at any frequency when the Dolby system was turned on. At −40 dB the tracking was nearly perfect. The switchable MPX filter had no effect on the response up to 15,000 Hz, but attenuated the 19,000 Hz response by at least 30 dB.

Playback frequency response was measured with BASF (DIN) and TEAC 116SP test tapes (for the 120- and 70-microsecond playback characteristics respectively). Both responses were well within ±1 dB over the full range of the tapes (from 30 or 40 to 10,000 Hz).

A 0-dB recording indication required a line input of 71 to 72 mV at 1 kHz, the corresponding maximum playback level was between 0.49 and 0.70 V, depending on the tape (the Duad gave the lowest output and UD-XLI the highest). Microphone sensitivity for 0 dB was 0.82 mV; overload occurred at 62 mV.

Third-harmonic distortion in the playback of a 1-kHz tone recorded at 0 dB was between −37 and −44 dB (1.4 to 0.63%) depending on the tape. Metal tape gave markedly lower distortion than any of the others. The input level that gave 3% distortion in the playback was about +2 to +2.5 dB for the ferric tapes, +5.5 dB for the Duad tape, and +6.5 dB for metal tape. Referred to that level, the unweighted signal-to-noise ratio (S/N) in the output was 54 to 55 dB with all the tapes except UD-XLI (NOR) which measured 50.5 dB. Using the Dolby system and CCIR/ARM weighting, the NOR tape gave a 60.5-dB S/N reading; UD-XLII, 64.5 dB; metal, 65.8 dB; and the Sony Duad (FeCr), 66.7 dB. Noise increased by only 2.5 dB through the microphone input at maximum gain.

The fluorescent "meters" responded with exactly correct "vu" ballistic characteristics, and their 0-dB indications corresponded with the 200-nWb/m standard Dolby level. Tape speed was 0.75% slow, and in the fast-wind speeds, a C60 cassette was moved from one end to the other in 92 seconds. Flutter was extremely low, meeting Hitachi's specification of 0.023% wrms. A weighted peak (CCIR) reading reached 0.04%. These are excellent flutter data.

User Comment. The short ATRS cycle time of about 10 seconds makes it perfectly practical to use it before making any recording, instead of using a set of previously stored data in one of the tape memories. This also has the advantage of compensating for any possible batch-to-batch differences in tape properties.

One demanding test of a cassette deck's fidelity is to record FM tuner interstation noise and compare the playback with the incoming signal. This had to be done via the amplifier's tape monitor switch, since the "source" playback from the tape deck was slightly brighter than the incoming signal. Playback from the D-3300M was almost perfectly accurate with UD-XLII tape, even at a −6-dB recording level—and very nearly as good at 0 dB! UD-XLI performed nearly as well. Sony Duad gave a distinctly duller sound than either ferric tape in this test, and the TDK MA-R playback was slightly *brighter* than the incoming signal, even at levels of 0 dB or higher! This recorder proved itself capable of making highly accurate recordings of just about any program one might encounter. With records and FM broadcasts, it was audibly perfect in its reproduction of the original program.

Although everything on the D-3300M worked with total smoothness and freedom from "bugs", one must practice with this machine in order to use it with confidence. For example, the procedure for making the ATRS alignment and storing it in memory is not at all obvious from the control markings. It is necessary to read the manual and make a few trial runs to render it as automatic for the operator as for the recorder. Also, the operation of the PAUSE button is somewhat unusual. A momentary touch on the button stops the tape, without disengaging RECORD if it is in use. However, to release PAUSE, the "play" button must be touched. It is not necessary to use REC simultaneously, since the machine's logic system will remember that it was in the recording mode.

Since Hitachi's introduction of ATRS, similar systems have appeared in some competitive machines. All the others we have seen sell for more than the D-3300M, and to our knowledge none can top its performance. This is an excellent recorder that eliminates tape characteristics from the recording equations. Essentially, the only differences between tapes as far as the D-3300M is concerned are minor variations in residual noise.—*Julian D. Hirsch*

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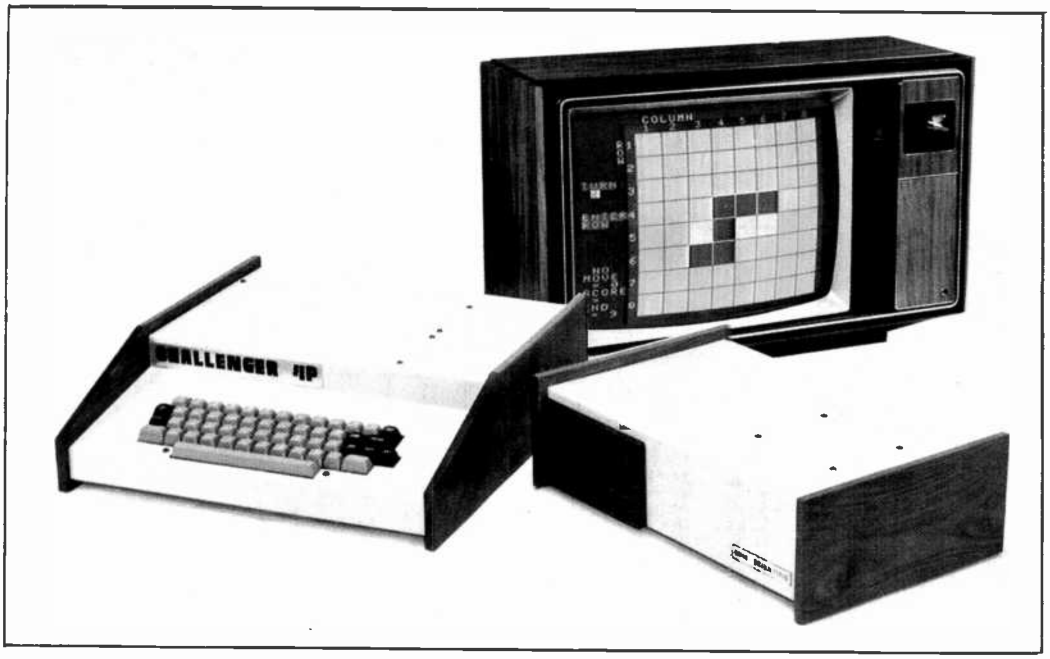


Ohio Scientific's Challenger Model C4P-MF Microcomputer

ON ITS capabilities alone, Ohio Scientific would have been justified in naming the Challenger Model C4P-MF microcomputer the "I/O Machine." An outgrowth of the basic Model C4P, a $698 computer, the MF version reaches new dimensions of utility through its numerous input/output provisions and other useful special features.

The rear panel tells much of the story. It has 16 parallel I/O lines, RS-232 ports for a 300-baud modem and a 300/1200-baud printer, an interface for fire and intrusion detectors, a real-time clock, and an accessory bus connector for an external 48-line I/O board, PROM blaster or whatever. And there's a GT option that nearly doubles the C4P-MF's speed, which is already twice that of the basic C4P. Also, the C4P-MF uses a mini-floppy for mass storage, in contrast to the cassette used in the C4P. In addition, the computer has keypad interfaces, joystick interfaces, voice and music generation, a built-in audio amp, an ac remote-control interface, and a full-color display system.

As it comes, the C4P-MF incorporates a single mini-floppy drive (with BASIC on disk) and a minimum of 24K of RAM. Moreover, it can be expanded to 48K RAM and two mini-floppy drives. With its 53-key keyboard, the computer main frame is no larger than an office typewriter (17½" W × 16¼"D × 4½"H). The disk drive measures 14½"W × 10"D × 4½" H. Suggested retail price is $1799 for the 24K version, $2199 for the 48K version.

Hardware Description. The C4P-MF is built around a 6502A microprocessor, the same one used in the PET, Atari and Apple computers. This CPU is known for its speed and somewhat limited addressing modes. In the OSI system, the clock rate is 2 MHz, slowed to 1 MHz during cycles that reference the monitor ROM.

In its minimal configuration the Challenger contains 24K bytes of RAM. When the video display accessory is included, an extra 2K bytes is added to manage the screen. Since the display area is memory mapped, it can be addressed as part of the main memory and used by programs. OSI advises that this will "mess up the display." The 24K of RAM resides on a separate pc board and is implemented in 2114 static RAM chips. Static RAM chips are not prone to the soft errors sometimes found in dynamic RAM chips. Therefore, circuitry for error detection and correction is not required. A socket for a 2716 EPROM, the largest the address lines can handle, is provided on the CPU board.

Mass Storage. A 5¼" disk drive using single-sided, single-density, soft-sectored (one index hole) diskettes provides mass storage for the C4P-MF. Each diskette can hold 79,872 bytes, and a second drive can be added as an option. No cassette interface hardware is provided.

Display. A raster-type, conventional TV scan is used. The composite video output from the computer is 1 volt peak-to-peak. Source impedance is about 22 ohms, and the manual recommends the use of a high-input impedance monitor. The display is organized as 64 characters per line, and 32 lines per screen. Under software control, the number of characters per line may be reduced to 32 for better legibility on an unconverted TV receiver. The position of the display on the raster is fixed, and although a good horizontal margin is left, the vertical margin is not enough to prevent the top line from appearing "above" the viewable screen. Some slight ringing and overshoot can also be observed in the display.

Characters are created in a matrix eight dots by eight lines with the lowest cell line blank, except when a descender is used. As the lowest cell line abuts the topmost line of the character cell below it, the descender will merge into the character below. Commas and semicolons do not project below the baseline of their cells.

The dot rate of 13.5 MHz requires a monitor video bandwidth of 6.75 MHz for optimum display of 64 characters per line. Such a bandwidth is usually available from a monochrome monitor and modified TV receivers in which the 3.58-MHz (chroma) and 4.5-MHz (sound) traps have been bypassed or disabled.

Of the total of 256 characters (including space) contained in the character-generator ROM, 96 comprise the full ASCII alphanumeric set. The remaining 160 are patterns that can be combined to create graphics. No software-writable character set is available, and no hardware is provided for cursor generation. BASIC uses an underscore character that cannot co-exist with another character. A cursor effect is possible by setting a color over one or more characters. This is subject to the limitations imposed by the color subcarrier (which can produce an annoying "dot crawl" over a monochrome display).

The C4P-MF can, under software control, be set to a color display mode, in which each character position has a four-bit color number (in memory) associated with it. Three of the bits specify the color (any of seven hues, black, or the hue overlaid with black), while the fourth bit specifies whether the character or the background is to assume the specified color. If the video assumes the color, then the background becomes black, and vice versa. Colors may be used in any order desired. The color of the rightmost character background is continued to fill the screen as the background color for the entire raster.

This background color extends right up to the following horizontal sync pulse, which, at a width of 4.5 µs, is within NTSC specifications. At variance with the NTSC specification, the 3.58-MHz color-reference burst starts right at the trailing edge of the horizontal sync pulse, rather than with the slight (380-ns) delay specified by NTSC. Also, the color burst has its negative peaks rather than its zero level coincident with the pedestal (back porch) of the horizontal sync. Since the back porch is assumed to be the blanking level and there is no gap between the end of the burst and the video line, there is no blanking level "set-up" reference. In some receivers, this may cause poor operation of the sync, agc and chroma circuits.

Keyboard. A 53-key, typewriter-like keyboard is used in the C4P-MF. Layout is standard, with offset keys, sloped profile, and matte keytops for reduced reflections. Auto repeat is provided.

Conventional alphanumerics use 42 keys, 8 are used for control functions, and one is the "break" key that transmits no character, but instead resets the CPU. All keys are software defined and any number of them can be held down at once and detected. The keytops are not marked with control characters or characters such as left arrow, right arrow, at-sign, etc. The equivalencies of shifted characters and their functions must be dug out of the manual—where they are not clearly given.

". . . this computer offers easy entry to the field and lots of room for exploration."

To operate the system bootstrap, one must depress the shift-lock key. This may seem awkward, but it is a valuable safety feature.

Input/Output. A serial communications port with two connectors, one for a printer and the other for a modem, serve the C4P-MF. Both cannot be used at once. The voltage levels do not meet RS-232 standards, but represent a compromise between the need to include a separate negative power supply and the fact that most serial devices can accept signals that range between 0 and +5 volts. RS-232 inputs on some peripherals may include a pull-up resistor to hold a disconnected input in the high state. The low logic level of the C4P-MF's serial output is produced by a resistor to ground, so the current sourced by pull-up resistors could produce a permanent "high" indication.

The ACIA (a form of UART) used in the serial port will inhibit its transmitter-empty flag if the CTS (clear to send) signal is not presented to it. This signal, supplied from the printer port as the C4P-MF is shipped, can be jumpered to a permanent "ready" condition.

Baud rates are selected from a range of 75 to 9600, and a 110-baud setting is not provided (this precludes use of a TTY as a hard-copy printer). Only two baud rates (with one four times the other) can be selected under software control. As the unit is shipped, the baud rates are 300 and 1200. Accuracy is 99.84%.

Two parallel ports driven by one PIA (peripheral interface adapter) are provided. By means of software, the 16 bits can be independently configured as inputs or outputs. Only data bits are present and no strobe bits that will set interrupts are provided. Thus, the program must test the status of bits from the external device to determine if a flag signal is presented. This means that latching and handshaking must be externally performed.

The PIA outputs are capable of sinking 1.6 mA in the low logic level and sourcing 1.0 mA at 1.5 volts in the high state. This restricts the maximum termination load to 1.31 kΩ returned to 2.5 volts. This does not permit the use of terminated transmission lines for long interconnections. Maximum cable length that can be driven by these outputs is about 10 feet (3 meters).

In addition to the PIA, a set of buffered data lines is brought out to a socket on the rear panel that can be connected to an external PIA (or its equivalent). The sockets for these signals, as well as the PIA ports, are conventional 16-pin DIP types suitable for IC's but not the most durable I/O connectors.

Eight resistors, arranged in a divider, form an eight-bit resistive D/A (digital-to-analog) converter. These resistors, accurate to within 5%, make the smallest variation possible under program control 0.4% (1 part in 255). Output precision is 5%. Because of an output coupling capacitor, low-frequency response of the D/A is −3 dB at 9.5 Hz. Conversion speed is limited by program execution.

The D/A converter can be turned off under software control and the built-in tone generator turned on. This generator, operating between 20 Hz and 20 kHz, provides a square wave whose frequency is divided down from that of a master oscillator using any of 256 divisors selected via software. Direct memory access (DMA) is not possible with the C4P-MF, since the address drivers are permanently enabled.

The two joysticks provided in the C4P-MF package are conventional in use in that their movement controls that of an on-screen object, while depressing the joystick button controls another action. However, since the software keeps testing at the joystick port at all times, and the two joysticks are equivalent to an active keyboard when out of their "neutral" positions, false data can be incidentally input. This can "bomb" the program before it starts to run. The external 10-key keypads are the equivalent of a conventional numeric cluster as used in many terminals and computers.

Also quite useful is the remote-control option (a modified version of the BSR X-10 home wireless control system), whose command console can handle up to 16 channels of lights and/or appliances. As supplied by OSI, the package includes two modules for appliances and two for lights, along with appropriate software. In order to prevent remote-control interrupts from wiping out BASIC programs that may be running, the first statement of a remote-control program should save the current BASIC program on diskette. That way, its execution can be resumed after the interrupt is serviced.

Power Supply. The C4P-MF operates from 120 V ac and a separate power line and switch are provided for the disk chassis. Series-pass regulated power supplies are used: two in the C4P and one in the disk drive. The supplies in the computer chassis were loaded to 1.6 amperes of excess current before their regulators automatically shut down.

Both the C4P-MF and the disk were powered from a variable autotransformer and the line voltage was lowered at approximately 0.1-volt ac per second to simulate a power-line "brownout" condition. No ripple appeared on the video display until 85.3 volts rms was reached, and the program—which was causing the head to seek back and forth across the diskette—stopped operating at 68.4 V.

Other System Factors. The C4P-MF is provided with an internal four-card bus structure in which three positions are occupied. In the fourth position, a cable-adapter board blocks some of the space a circuit board might occupy. The bus structure is "nonstandard" and there is no mention in the manuals of plug-in cards that are available for bus use. The rear-panel I/O connector allows connection of three external PIA's through the AC-12 option that can interface up to 48 bits in either input or output operation. Since DMA is not available, interrupts are generated strictly on the CPU board and there is no provision for I/O interrupts. The user is thus restricted to peripherals provided by OSI.

A program was written to force the DOS (and disk head) to seek and load another program located at the opposite side of the diskette. This second program forced the DOS to go back across the diskette and pick up the original program and continue the cycle. Thus, the disk mechanism went back and forth from inner to outer track continuously, making the average half-cycle time an accurate measure of the access time including seek time, rotational latency, and program execution time. Sixty-four full head cycles occured in 50 seconds, producing a 300-ms access time.

To reduce time from a "cold" start and to allow more frequent access to the disk, OSI allows the disk-drive motor to run continuously as long as power is applied. As the mean-time-before-failure (MTBF) for the small dc motors used in 5-inch disk systems is on the order of 1800 hours, the extra operating time is of no special import, though it does count against overall MTBF.

Reset procedure is simple—all that is necessary is to depress the BREAK key. The system then puts up a clear screen and asks for the bootstrap source which can only be the C4P-MF disk. If anything else is specified, the operating system enters its monitor program and allows you to poke around and examine memory.

On start-up, you get the option of entering the monitor, entering DOS, or "unlocking" the BASIC. Before you can enter your BASIC program, you must first clear the BASIC start-up program. Using the disk bootstrap will lose any BASIC program you may have keyed in prior to reverting to the boot. Before going out of BASIC, for any reason, it is prudent to store your data on diskette, since not much will be left after a restart.

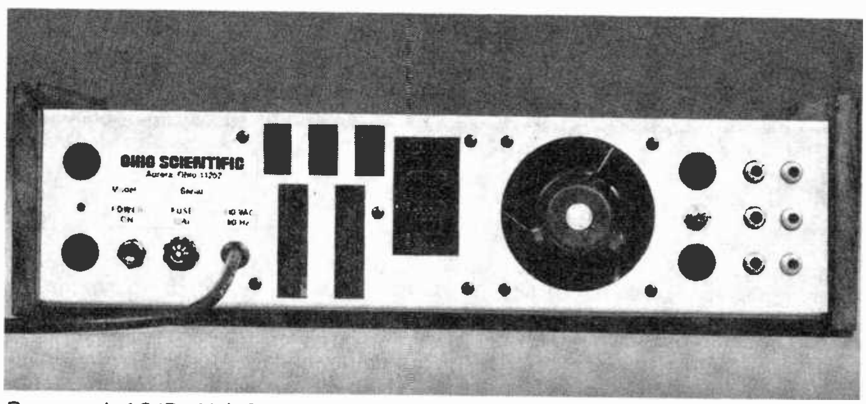
User Notes. The C4P-MF is clearly designed for use in personal and educational applications. (For engineering/professional use, there's a GT option of the C4P-MF that uses a 6502C microprocessor with ultra-fast static memories.) In its chosen bailiwick, the system offers definite advantages. Its relative simplicity makes learning to use it easy, and its elaborate I/O facilities can save the drudgery (and expense) of engineering interfaces with the outside world.

It's not suggested that the TV monitor be placed atop the mainframe because stray signals radiated from the mainframe can cause a slight "swimming" of the horizontal sweep. A compact setup is best achieved, therefore, by setting the disk drive on the mainframe and the TV monitor a foot or so away. Both the monochrome monitor and the color-TV receiver we used for display purposes were capable of presenting 32-character lines with clarity. On the video monitor, the 64-character lines were superb. We found that the merging of descenders with the character below is only a minor nuisance; it becomes less vexing as one gets used to it.

The BASIC provided with the C4P-MF is excellent and provides all the expected functions. Start-up procedure, which is unusual, seems awkward at first, but soon becomes easy.

Owing to the large number of I/O modes, the C4P-MF encompasses, we were unable to test all of them. Using the software provided, it appears to be relatively easy to control a number of external devices. Since the system also includes a real-time clock, it is possible to activate or deactivate controlled devices at preset times.

With the excellent OSI disk-based software available—including an Information Management System, Word Processor, and a library of program development tools—and with its color graphics, animation capabilities, audio output, joystick controls and a number of personal programs, the C4P-MF is a good buy. While it is true that someone who becomes seriously involved in computers might eventually outgrow it, this computer offers easy entry to the field and lots of room for exploration. ◇



Rear panel of C4P with I/O ports.

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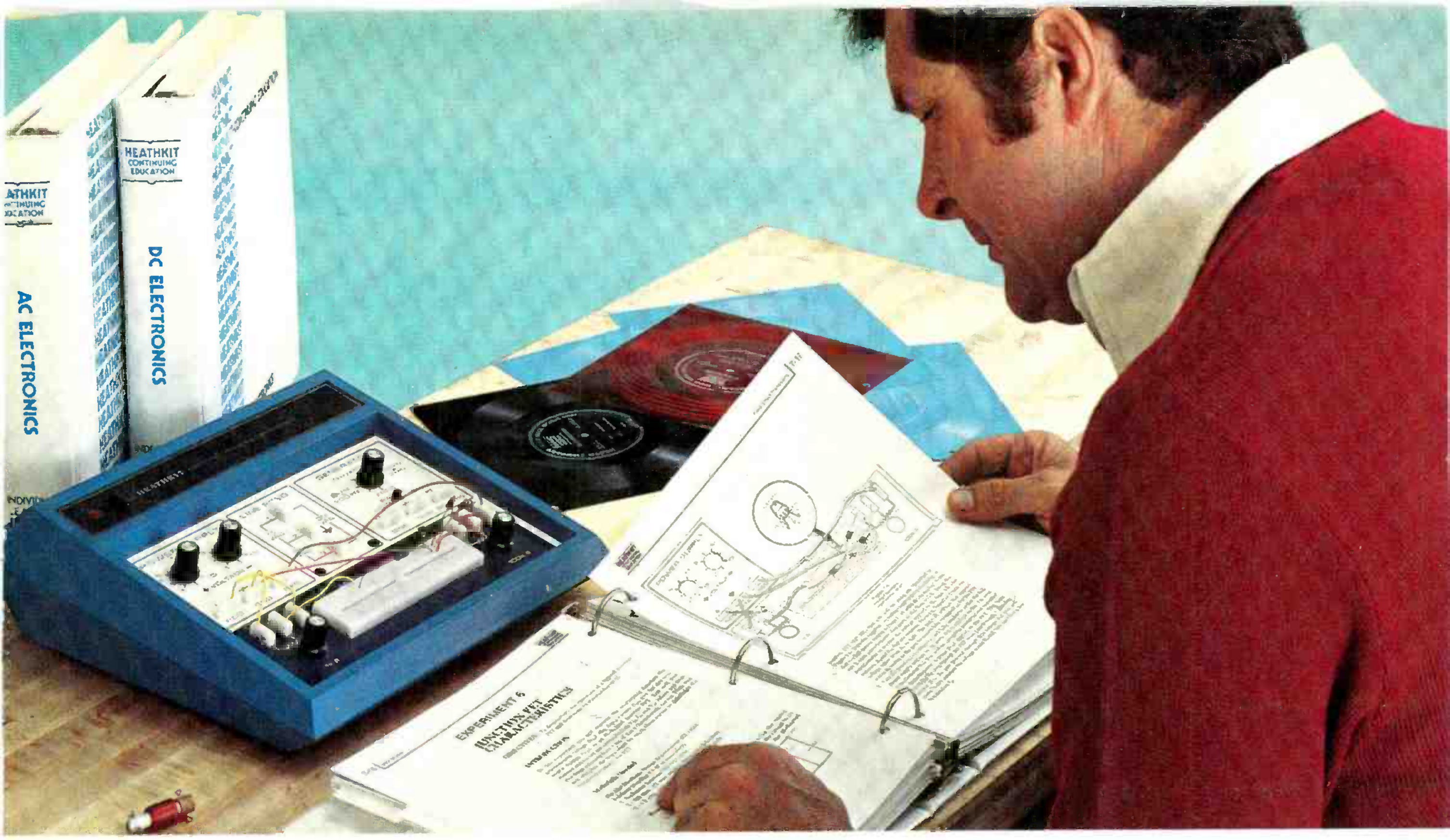

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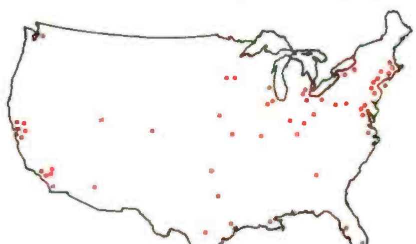

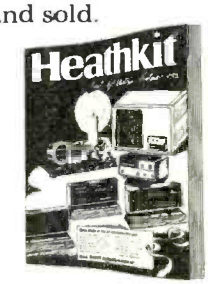

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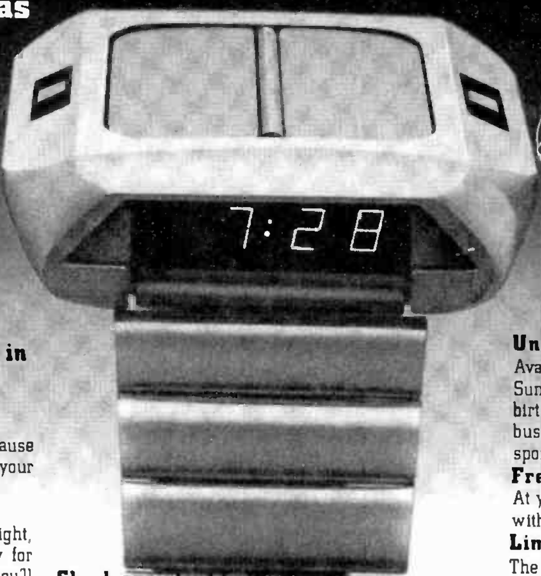

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