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WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE AUGUST 1982/$1.25

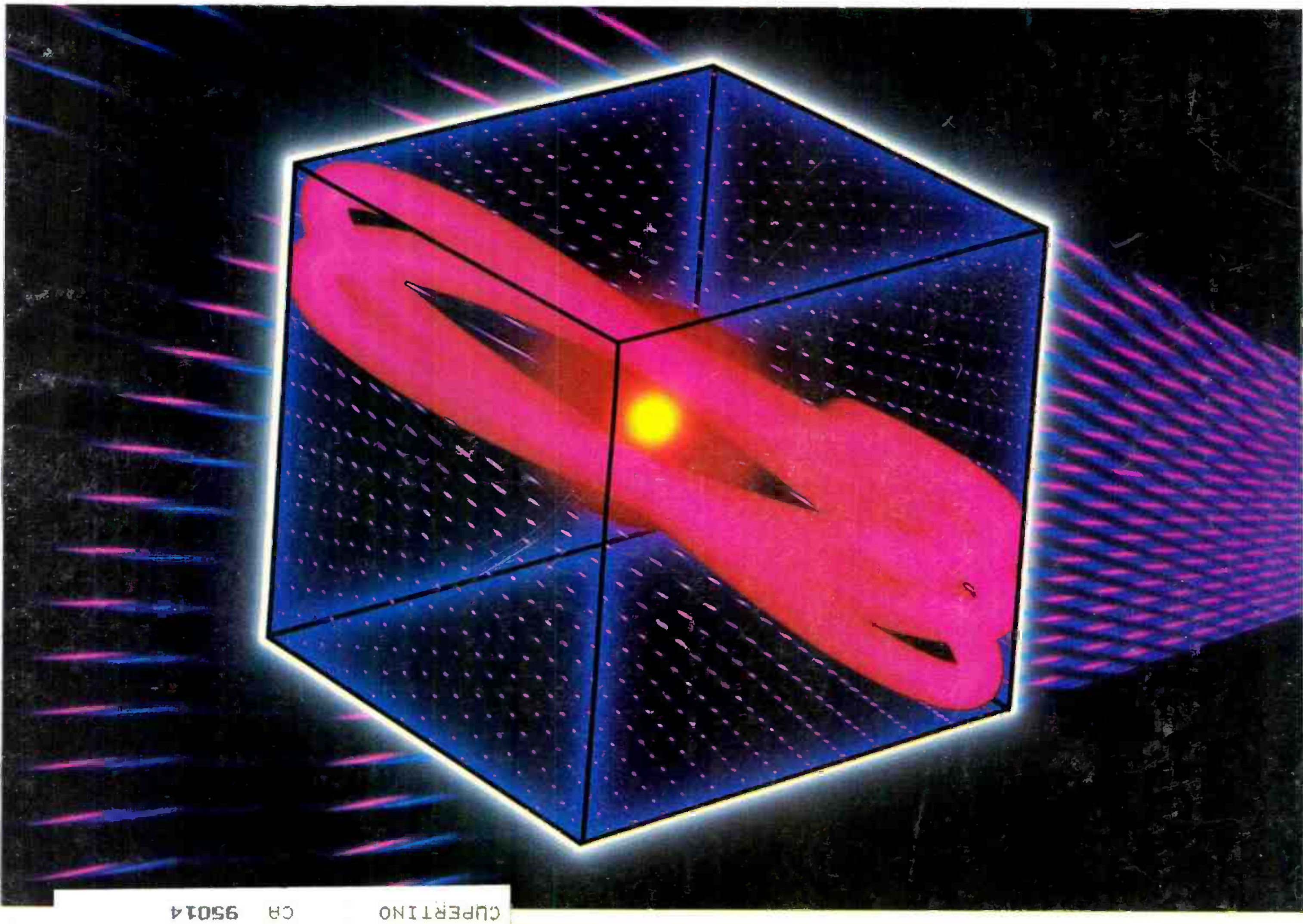
Loran-C for Boat Navigating

Math Software for Elf Computers

The State of Stereo TV Sound

SPECIAL FOCUS ON

Home Energy-Saving Applications



…n This Issue:

…T200-4 Microcomputer

…-Kardon PM650 Stereo Amplifier

GE 19PC3708W 19" Color TV Receiver

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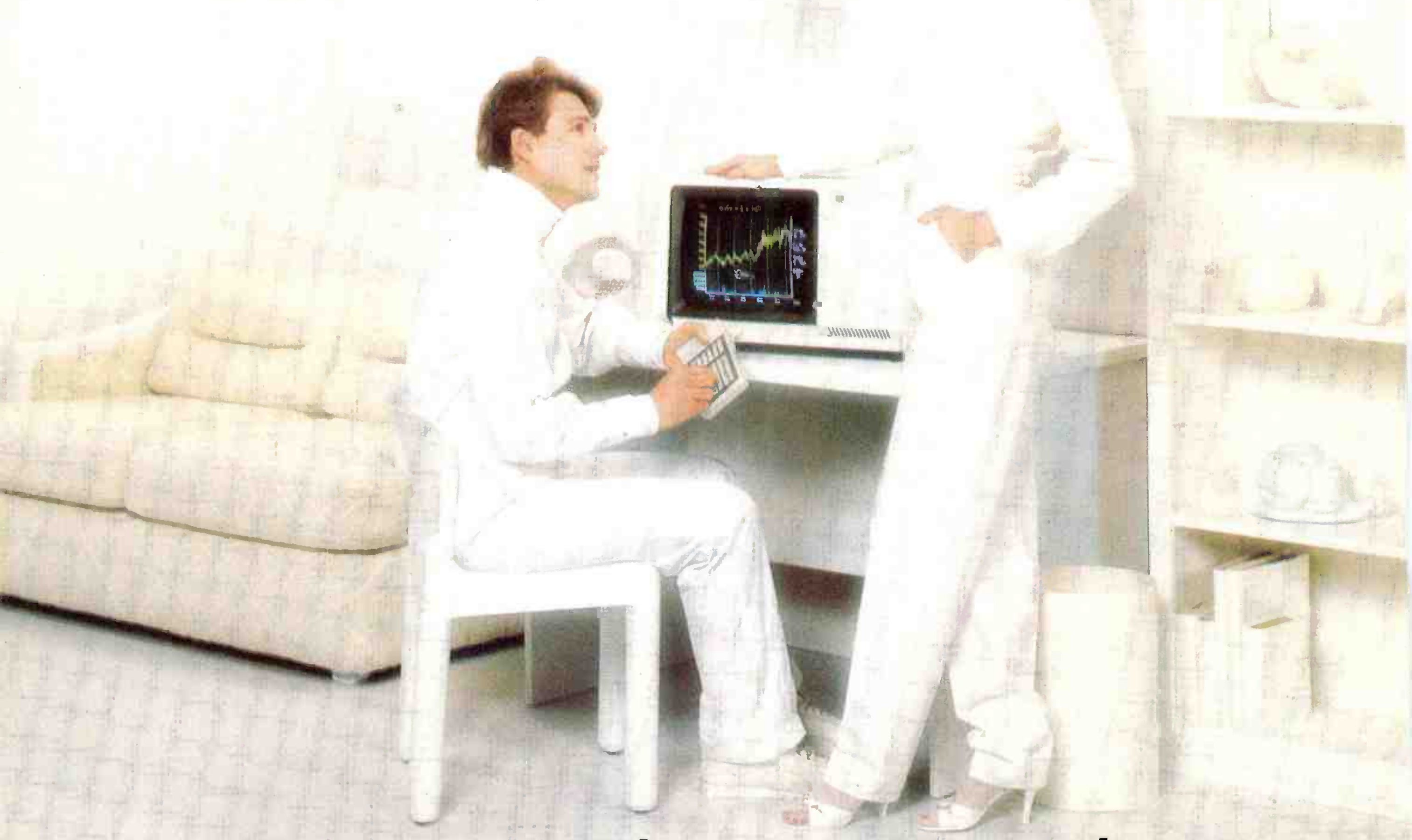

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Someday is today with the CompuServe Information Service. CompuServe is available through a local phone call in most major U.S. cities. It connects almost any brand or type of personal computer or terminal with our big mainframe computers and data bases. All you need to get started is an inexpensive telephone coupler and easy-to-use software.

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CIRCLE NO. 9 ON FREE INFORMATION CARD

AUGUST 1982 VOLUME 20, NUMBER 8

Popular Electronics

Special Focus on Home Energy Savings

Feature Articles

Construction Articles

Equipment Reviews

Columns

Departments

COVER GRAPHICS BY STEVEN HUNT

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THE $99.95 PERSONAL COMPUTER.

Introducing the Sinclair ZX81.

If you're ever going to buy a personal computer, now is the time to do it.

The Sinclair ZX81 is the most powerful, yet easy-to-use computer ever offered for anywhere near the price: only $99.95* completely assembled.

Don't let the price fool you. The ZX81 has just about everything you could ask for in a personal computer.

A breakthrough in personal computers.

The ZX81 is a major advance over the original Sinclair ZX80 – the first personal computer to break the price barrier at $200.

In fact, the ZX81's 8K extended BASIC offers features found only on computers costing two or three times as much.

Just look at what you get:

- Continuous display, including moving graphics
- Multi-dimensional string and numerical arrays
- Mathematical and scientific functions accurate to 8 decimal places
- Unique one-touch entry of key words like PRINT, RUN and LIST
- Automatic syntax error detection and easy editing
- Randomize function useful for both games and serious applications
- 1K of memory expandable to 16K
- A comprehensive programming guide and operating manual

The ZX81 is also very convenient to use. It hooks up to any television set to produce a clear 32-column by 24-line display. It comes with a comprehensive programming guide and operating manual designed for both beginners and experienced computer users. And you can use a regular cassette recorder to store and recall programs by name.

Sinclair technology is also available in Timex/Sinclair computers under a license from Sinclair Research Ltd.

EDITORIAL

Free Energy

Many people point to the sun as a source of free energy. It really isn't, of course, just as hydro power and wind power aren't free. Converting these energy sources requires the expenditure of much money, which in many instances is not as economical as employing fossil fuels and their accompanying converters.

We're all fascinated by the sun, naturally, and anticipate that at some distant time there will be an economic crossover point where it would pay to make more use of it. However, solar power is indeed being used today for a variety of purposes, though it still represents a very minor source of energy.

As you know, there are tax breaks available to sweeten the cost of voluntary use of solar power for home space heating and for hot-water heating. The basic reason for this incentive is to diminish the use of oil, a significant portion of which is imported at high cost. Given such an allowance, it is claimed that the system saves money for energy use after a moderate period of time for amortization of new equipment and installation costs. But it is subsidized by our taxes.

Feasibility studies are being made for an attractive, science-fiction-like possibility for solar power generation from large satellites. These satellites would be exposed to continuous sunlight, collecting solar energy and transmitting it through microwaves to collection points on earth. It is said, however, that such an undertaking would be the costliest technological venture ever attempted.

At present, the greatest saving in energy appears to be through conservation in one form or another. This route is represented by using less energy through buying automobiles with better gas mileage, eliminating unnecessary automobile trips, raising air conditioning thermostats in the summer and lowering heating thermostats in the winter, buying appliances that consume less energy, and by automatic energy management.

The latter approach is explored in this issue by a few interesting, innovative articles. One reduces fuel use through a more efficient heat-system blower-motor control. Another presents plans for a novel thermostat that can be set well below the traditional 55°F minimum of standard thermostats. Also in this home energy-saving focus are an inexpensive electric power meter that tells you quickly how much electricity any appliance consumes and ways to use photovoltaic cells to recharge batteries using the sun as the power source.

Should you want to explore solar power further, a recent book, the "Photovoltaic Product Directory and Buyers Guide," will give you a good working knowledge on the subject for use in a home. (Order #DE81030186, $13.50, from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.)

Art Salsberg

Popular Electronics

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Explore the excellence of your ZX81 with a

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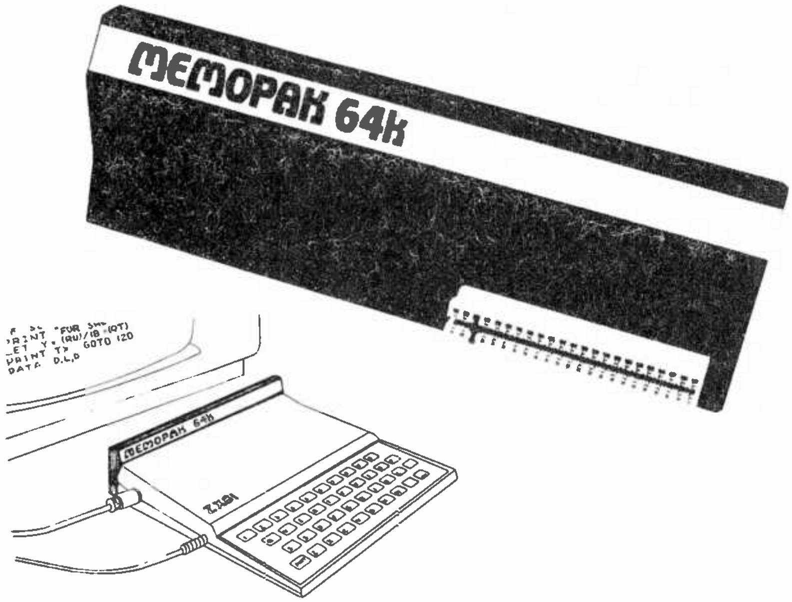

MEMOPAK 64k memory extension for $179.95

Give your diminishing memory more byte.

MEMOPAK 64K RAM $179.95

The Sinclair ZX81 has revolutionized home computing. The MEMOPAK 64K RAM extends the memory of ZX81 by a further 56K to a full 64K. It is neither switched nor paged and is Directly Addressable. The unit is user transparent and accepts such basic commands as 10 DIM A (9000). It plugs directly into the back of ZX81 and does not inhibit the use of the printer or other add-on units. There is no need for an additional power supply or leads.

Description of memory

0-8K . . . Sinclair ROM
8-16K . . . This section of memory switches in or out in 4K blocks to leave space for memory mapping, holds its contents during cassette loads, allows communication between programs, and can be used to run assembly language routines.
16-32K . . . This area can be used for basic programs and assembly language routines.
32-64K . . . 32K of RAM memory for basic variables and large arrays. With the MEMOPAK 64K extension the ZX81 is transformed into a powerful computer, suitable for business, leisure and educational use, at a fraction of the cost of comparable systems.

MEMOTECH
Memory Extention Specialists

Memotech Corporation
7550 West Yale Ave., Suite 200
Denver, Colorado 80227
Ph.(303) 986-1516

MEMOPAK 16K RAM $59.95

With the addition of MEMOPAK 16K, your ZX81 will have a full 16K of Directly Addressable RAM. It is neither switched nor paged and enables you to execute longer and more sophisticated programs and to hold an extended data base.

The 16K and 64K Memopaks come in attractive, custom-designed and engineered cases which fit snugly on to the back of the ZX81 giving a firm connection.

Free service on your MEMOPAK

Within the first six months, should anything go wrong with your MEMOPAK, return it to us and we will repair or replace it free of charge.

Try MEMOPAK with no obligation

You can use our MEMOPAK in your home without obligation. After 10 days if you are not completely satisfied, simply return it for a full refund.

Coming soon . . . . .

A complete range of ZX81 plug-in peripherals:

- MEMOTECH Hi-Res Graphics
- MEMOTECH Digitising Tablets
- RS232 Interface
- Centronic Interface and
- Software Drivers

All these products are designed to fit "piggy-back" fashion on to each other and use the ZX81 power supply.

Further information forthcoming.

Memotech Corp. 7550 W. Yale Ave. Suite 220 Denver, Colo. 80227

Yes! I would like to try the Memopak. I understand that if I'm not complete satisfied, I can return it in 10 days for a full refund.

☐ Check
☐ Visa
☐ MC

	Price †	Qty.	Amount
Memopak 64k RAM	$ 179.95		
Memopak 16k RAM	$ 59.95		
Shipping and Handling	$ 4.95	———	$ 4.95
		Total	

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† U.S. Dollars

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PE08

CIRCLE NO. 32 ON FREE INFORMATION CARD

LETTERS

Computer Comparisons

I liked the article "Computers—Which One Is for You" in the May issue. I particularly enjoyed the fact that you compared the user features of the computers rather than covering the technical and hardware features only. It was the best comparison of computers I have seen.—*T. Sunday, Klamath Falls, OK.*

Macro-Editor/Assembler Availability

I enjoyed the excellent review of the TRS-80 Model III computer in your May issue, but I believe there was an error with regard to availability of software. Radio Shack does not carry a Macro-Editor/Assembler for the Model III at this time. However, a Macro-Editor/Assembler, called M-ZAL, that is compatible with the Model III, is available from our company.—*D.C. Willen, President, Computer Applications Unlimited, Box 214, Rye, NY 10580.*

Wrong Flip-Flop Answer?

In "Learning Quizes for Electronics" (May 1982), the Flip-Flop Quiz seems to contain an error. In question 3, since the J input received the last pulse and a clock pulse occurred too, shouldn't the flip-flop's Q output have been a 1 instead of a 0.—*R.A. Finnegan, Merrick, NY.*

It seems that your view of the starting time of the input pulses was different from what the author intended. He started the timing with zero at the left. You obviously interpreted it to be on the right. It would have been clearer if we had included a time scale.—Ed.

Likes Program Development Board

I recently finished building the CPU module and Program Development Board from the series "Designing with the 8080 Microprocessor" by Randy Carlstrom. I have programmed big machines (such as the IBM 3089) and I was interested in learning about microcomputers. The material in the articles was well presented and the features available on the PDB left little to be desired. Keep up the good work and let's see more of this type of article.—*Robert Cox, Jacksonville, FL.*

OUT OF TUNE

In "Enhance TV Sound with Stereo" (May 1982), the resistance for *R24* and *R25* in the Parts List should have been 390 ohms, as it was on the schematic.

In "Learning Quizes for Electronics" (June, p 70), in the Digital Counter Quiz, the note reading "FF_1 is initially turned on" should have been with part 2 of the quiz not part 1.

NEW PRODUCTS

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

DEC Personal Computer

The Rainbow 100, Digital Equipment Corp.'s entry in the personal computer field, is designed to run both 8- and 16-bit application software from a wide variety of independent suppliers. These include the Select Information Systems Word Processor, Microsoft's Multiplan Spred Sheet Calculator, and the Mark Williams Co. "C" Compiler. The Rainbow 100 will run a hybrid version of the CP/M-80 and CP/M-86 and can use other operating systems such as Microsoft's MS-DOS, the same as IBM and others. DEC has also provided an advanced communications package to enable the Rainbow 100 to transmit from a CP/M file to a host computer and vice versa. It uses Z80 and 8088 microprocessors and has a maximum of 256K bytes of memory. The mass data storage is 800K bytes in 5¼" double-density, dual drives. This can be expanded to 1.6M bytes of floppy-disk storage or 5M bytes of Winchester disk storage. The CRT display is a 12" monochrome of 24 lines by 80 or 132 characters. Options include a 5¼", 5M-byte external hard disk, a color video monitor and character cell graphics. Language support includes MBASIC and the C Compiler. $3495.

Circle No. 89 on Free Information Card

Microprocessor-Equipped Turntable

The Denon DP-52F turntable uses a microprocessor to control arm motion, motor speed, record sensing, and ON/OFF functions. A servo mechanism is reported to continuously adjust tracking force and anti-skating pressure for optimum stylus-disc contact, correcting for warps and resonance. The DP-52F has an ac servo-motor direct-drive platter with magnetic-pulse speed monitoring, and automatic sensing of the

presence and size of a record. A smoked acrylic dust cover is provided. Control pads include a REPEAT button. Wow and flutter is rated at 0.012%; rumble at −78 dB. Dimensions are 17.9"W × 5.1"H × 16.7"D. $525.

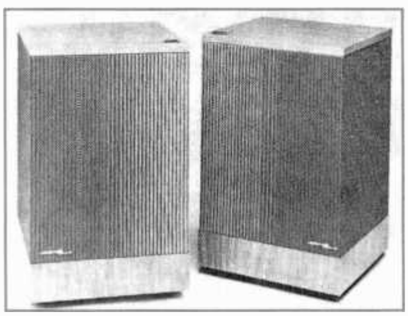
Circle No. 90 on Free Information Card

Wahl Soldering Station

The Iso-Tip 7470 Micro Soldering Station is reported to eliminate continuous switching (and the voltage spikes that can damage electrical equipment) by maintaining an even tip temperature. The unit is totally grounded and can be adjusted to any temperature between 500° and 700°F. It comes with a sponge holder, tip-wiping sponge, soldering iron, and stand (which takes up 12 sq. in. of bench space).

CIRCLE NO. 91 ON FREE INFORMATION CARD

Bose Speakers



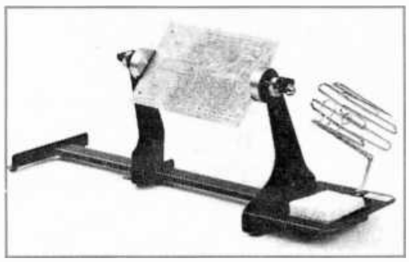
The 501 Series III Direct/Reflecting loudspeakers from Bose are floor-standing units with a dual-frequency crossover network. According to Bose, woofers and tweeters are allowed to operate simultaneously over more than a full octave, thereby avoiding the effects of phase shift. There are two separate protection systems: a current-sensitive circuit for the tweeters and a thermal overload circuit for the woofer. If the circuits detect an energy level high enough to cause damage, they absorb the excess power without interrupting the music. The drivers consist of one 10" woofer and two 3" tweeters (inward and outward "firing"). Nominal impedance is 8 ohms; crossover transition frequencies are 1.5 kHz and 2.5 kHz; power rating is 20 W min., 100 W max. Cabinet is walnut-grain vinyl veneer and dimensions are 24"H × 14½"W × 14½"D. $680 per pair.

CIRCLE NO. 92 ON FREE INFORMATION CARD

A/D System for Apple

Applied Engineering announces availability of a memory-buffered analog/digital system for all versions of the Apple computer. Called the A/D Board, this peripheral consists of an eight-bit successive-approximation A/D converter, an eight-channel multiplexer, and an 8 × 8 RAM. A/D conversion takes place on a continuous channel-sequencing basis, and data is automatically transferred to an on-board memory at the end of each conversion. The converter has a speed rated at 0.078 ms/channel, a full-scale voltage range from ±5 to ±15 V dc and an operating temperature from 0° to 70°C. Accuracy is given as 0.3%. Applications include monitoring ambient weather conditions, light intensity, pressure, rpm, etc. $129.

PC Board Holder



The PCBH-50 from OK Machine and Tool Co. is designed for use as a printed circuit board holder and solder station. The unit is spring-loaded for easy board removal and a self-locking end support adjusts to different board widths (up to 10" × 12"). A board can be rotated 360° and locked at any angle. Also included is a soldering iron holder and a cleaning tip sponge. The PCBH-50 can be either free-standing or mounted on a workbench.

CIRCLE NO. 94 ON FREE INFORMATION CARD

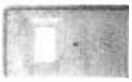
Rechargeable Video Battery Pack

Cinema IV's Porta-Power II battery pack is reported to permit the simultaneous use of a video camera, VCR, and halogen spotlight. A built-in voltmeter determines the remain-

THE PROBLEM:

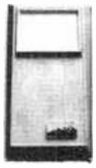
SOLUTION:

PROTECT YOUR HOME AND BUSINESS WITH A PROFESSIONAL SECURITY SYSTEM BEFORE YOU'RE THE VICTIM!!



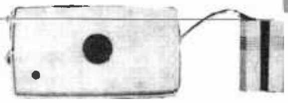
Panic Button

Photoelectric Smoke Detector/ Transmitter



Infrared Motion Detector/ Transmitter

Guardex 4300 Control Panel



Door/Window Transmitters

HOW MUCH COULD I SAVE WITH A GUARDEX SYSTEM?

WHAT TYPE OF SYSTEM IS BEST FOR ME?

BURGLARY, HOLD-UP, MEDICAL OR FIRE?

We have security consultants available to review your needs right over the telephone. Our toll free numbers are listed below. Our new Guardex 4300 professional security system can be tailored for almost every requirement. The Guardex 4300 can monitor for burglary **plus** your choice of hold-up, medical emergency or fire.

WHAT IS THE GUARDEX 4300 SYSTEM?

The Guardex 4300 system is built around the 4300 microprocessor-communicator control panel. To the 4300 control panel you add wireless sensors for doors and windows, infrared motion detectors, photoelectric smoke detectors and emergency panic buttons. All the sensor/transmitters operate up to a year on a 9 volt radio battery and require no wiring to the control panel.

HOW DOES A CENTRAL STATION ALARM WORK?

When a burglary, fire or medical sensor is tripped, a signal is sent to the control panel up to 200 feet away. The control panel starts a siren screaming and starts an electronic telephone dialer programmed to call our central monitoring station. The receiver at our central station decodes the telephone message and displays the type of emergency to the operator. Stored in the computer is all the information required to dispatch for each emergency. Within seconds, your local Police Department, Fire Department or Paramedics have been notified.

The central station is staffed 24 hours a day, 7 days a week with trained personnel to quickly dispatch emergency services. We can monitor your home or business anywhere in the continental United States over toll free WATS lines.

SIMPLE INSTALLATION - SIMPLE TO OPERATE

The biggest cost of most central monitored security systems is all the labor to completely wire the building. With the wireless Guardex 4300 system **you** can install the complete system in less than an hour with only a screwdriver. (If you're not the handyman type, installations are available in many areas.)

Guardex 4300 Control Panel - $499.95
Includes backup battery and power supply.
Door/Window Transmitters, Magnetic Switch - $43.45 ea.
Infrared Motion Detector/Transmitter - $179.95
Photoelectric Smoke Detector/Transmitter - $89.95
Emergency Medical/Hold-up Panic Button - $39.95
Siren with 50 Feet of Wire - $39.95

DEALERS NEEDED

Make money installing our alarms in your area. If you have a general knowledge of electronic equipment and take pride in your work, call us to see if your area is still available. Work part time or full time, evenings and weekends call and ask for Field Installation Department.

30 Day Money Back Guarantee - 1 Year Warranty

SPECIAL LIMITED TIME OFFER!! ORDER A SYSTEM OVER $900.00 AND RECEIVE ONE YEAR MONITORING FREE!
(Regular price at $19.95 per month is $239.40.)
It's like getting a 26% discount on your system!

GUARDIAN ELECTRONICS, INC.

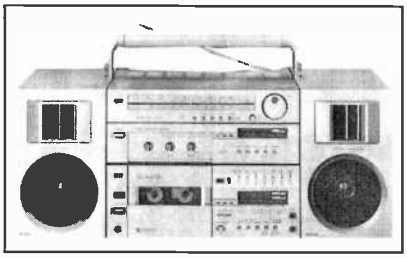
VISA master charge

Call during California business hours for your no obligation consultation.
Outside CA Toll Free (800) 423-5499
Inside CA Collect (213) 889-1414
31117 W. Via Colinas, PE • Westlake Village, CA 91362

CIRCLE NO. 21 ON FREE INFORMATION CARD

ing running time; and the charger recharges the 12-V/11.3-A battery in 12 to 16 hours. In addition, the unit has a circuit breaker built-in and can be used with an auto charge cord (optional) to charge the battery from an automobile cigarette lighter socket. Dimensions are 7½" × 8" × 2½"; weight is 9 lb. $200. **Address:** Cinema IV, P.O. Box 1045, Newport Beach, CA 92663.

Compact Audio System



The new Sansui P-Compo CP-5 converts readily from a mini-component system to a portable. Components can be stacked or placed side-by-side, with the speakers immediately adjacent or widely separated. A top handle facilitates carrying. The system consists of the Model CP-R5 tuner/amplifier, the CP-F7 cassette deck, and 4" bass reflex speakers. The tuner/amp offers four-band radio reception (AM, FM, SW1, SW2), quartz-synthesizer tuning, and 13 W/ch output. The amplifier section features a bridged output circuit with direct coupling. The deck has IC logic controls, automatic program search, record mute, and Dolby noise reduction. In addition, there are 5-LED level indicators, a timer/standby mechanism, a tape counter, a three-position tape selector, and a self-contained design that permits listening to the deck on its own. Wow and flutter is rated at 0.05%, and S/N at 54 dB with metal tape without Dolby. $490.

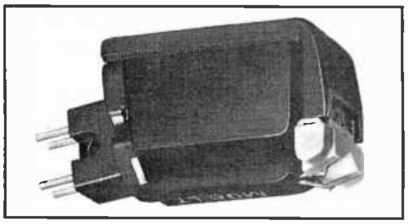
CIRCLE NO. 95 ON FREE INFORMATION CARD

Two New Terminals from Hazeltine

Hazeltine has introduced two new computer terminals—the Executive 10 and the Esprit II. The former ($1195) features eight programmable function keys, a split-screen display, and a business graphics character set. It also has a programmable 25th status line and a full set of editing features. The Esprit II ($645) is the latest in a low-cost line of terminals, featuring editing capabilities, character insert/delete, and local print. It is buffered and can display the full 128-character ASCII code.

Circle No. 96 on Free Information Card

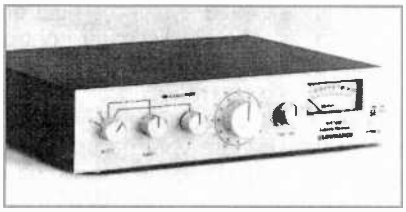
Linear-Tracking Phono Cartridge



Shure Brothers has announced a new direct plug-in phono cartridge especially designed for use with linear-tracking turntables. Designated Model M96LT, it has a telescoped shank structure and a lightweight magnet reported to give a frequency response flat from 20 to 20,000 Hz. The cartridge has a biradial elliptical diamond stylus that tracks at 1.25 g. $80.

CIRCLE NO. 97 ON FREE INFORMATION CARD

TV Satellite Receiver



A new satellite receiver, the System 7, has been announced by Lowrance Electronics. It provides detent tuning, in conjunction with automatic frequency control tuning, for quick channel selection. If fine tuning is needed, states the manufacturer, it typically spans only one transponder to prevent channel crosstalk. An optional remote control is also available. The audio section has selectable tuning for 6.2 and 6.8 MHz and can receive stereo broadcasts, as well as the usual mono. The System 7 also has a signal strength meter, direct audio and video outputs with a video invert switch, and a built-in modulator selectable for channels 3 or 4. I-f frequency is 70 MHz, with a 30-MHz bandwidth. $1325.

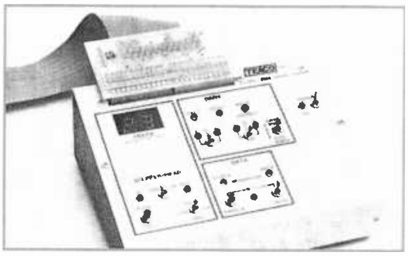
CIRCLE NO. 98 ON FREE INFORMATION CARD

Cassette Deck Cleaner

Allsop's new Ultraline Cassette Deck cleaning system (Model 71300) features cartridge-mounted independent cleaning felts that can individually clean heads, capstans, and pinch rollers. A gear-driven wiper arm, upon which the head-cleaning felt is mounted, is said to increase the versatility of the cleaner by assuring uniform cleaning of all types of cassette decks, including those with three-motor drives and takeup-reel sensors. Equipped with two sets of capstan pinch roller felts, the Ultraline is also suitable for auto-reverse decks. The cassette cleaner includes a ½-oz bottle of Allsop cleaning solution. $10.

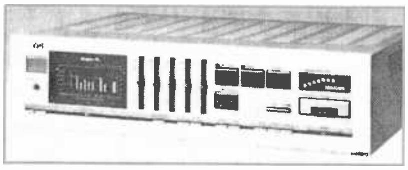
CIRCLE NO. 99 ON FREE INFORMATION CARD

Floppy Drive Tester



TEACO'S CD2-3 is said to offer the user of floppy drives three levels of testing: isolation of the drive from computer problems; a check of the chasis components and their mechanical operation; and troubleshooting of the component level on the circuit board. The unit's capabilities include: testing of single- or dual-sided drives, testing of all tracks (with a 0.5" track counter), single-step or continuous testing, head load troubleshooting, dynamic indication of index pulse rate, "Ready Status" display, separate testing of clock and data functions, and erasure verification. $275. **Address:** The Computer Center, Div. of TEACO INC., P.O. Box E, Michigan City, IN 46360.

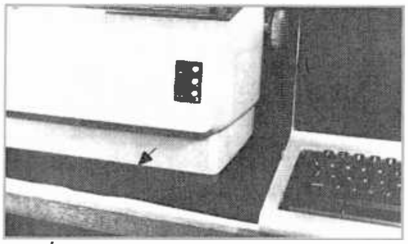
Amplifier with Built-in Equalizer



The A-X50 stereo integrated amplifier from JVC is equipped with a five-band SEA graphic equalizer rather than the customary bass/treble tone controls, with each control adjusting narrow-frequency bands centered at 63, 250, 1000, and 16,000-Hz. A peak indicator is calibrated to correspond to the five center frequencies of the equalizer and to show each response on a fluorescent display. Also shown are right and left total response and the aggregate response for both channels. Other features include a selector for MM or MC phono cartridges, a touch volume up-down control, and a muting switch. Its "Super-A" circuit design is said to provide the advantages of class-A operation at higher efficiency. The amplifier has a rated output power of 65 W/ch into 8 ohms from 20 to 20,000 Hz with a THD of 0.007%. Intermodulation distortion is given 0.005% at rated output. $430.

CIRCLE NO. 100 ON FREE INFORMATION CARD

Computer Static Mat



Designed to drain away static electricity before it can cause any damage to voltage-sensitivie IC chips, the Stati-Ex mat from Spirig Enterprises is intended for use with microcomputer installations consisting of a terminal, disc drives, and a printer. Made of electrically conductive rubber, the one-millimeter thick mat is also reported to be insensitive to heat; if you use it as a work surface, a hot ball of solder will not burn through. Dimensions are 100 cm × 50 cm. $20. **Address:** S.A.T. South End Bridge Circle, Agawam, MA 01001.

ENTERTAINMENT ELECTRONICS

By Len Feldman

Stereo TV Is Coming Soon

IN Japan, TV viewers have been able to listen to many programs in stereo for nearly four years. When feature films made in other countries are shown on Japanese TV, the viewer has the option of listening to a dubbed, Japanese sound track or to the original. In Germany, with its wide-bandwidth (7 MHz per channel) PAL system, room was found for a second audio r-f carrier; and stereo TV was initiated in September of last year. Yet, in the United States, the only way you can enjoy over-the-air stereo TV is by combining a stereo FM receiver with your set when simulcasts of concerts are offered through the cooperative efforts of a TV channel and an FM station.

But all that is likely to change very soon. At a recently conducted Midwest Acoustics Conference held in Chicago, entitled "Audio Technology for Video," Mr. E.M. Tingley provided an update on the work of the Multichannel TV Sound Committee. It is this committee, operating under the aegis of the Electronic Industries Association (of which Mr. Tingley is a Staff Vice President of Engineering) that has been studying and testing three basic systems for the transmission of multi-channel TV audio for more than three years. Now, all of the data regarding the three proposed systems has been sifted down to a comprehensive report, and by late fall of this year, that report, along with a recommendation for a specific industry-endorsed system for stereo/bilingual TV standards, will be submitted to the Federal Communications Commission.

Whenever any new broadcast service is to be authorized, one of the chief concerns of the FCC is that it be compatible with existing service and with existing equipment. This is especially true in the case of multi-channel TV audio, since there is hardly a home in the U.S. that does not have at least one TV set. The majority of receivers are color sets, and represent an investment that should not have to be replaced when stereo or bilingual audio begins. The "mono" set must be able to receive a mono equivalent (left-plus-right) of the stereo program or, in the case of bilingual broadcasts, the primary language in which the program is transmitted.

Other matters of concern to the FCC are possible interference problems that may arise from the new transmissions as well as degradation in signal quality and possible excessive use of spectrum space. Broadcasters, on the other hand, are concerned with coverage and do not want to lose viewers if signal-to-noise performance is degraded by the new service. As Mr. Tingley explained, all of the three proposed systems do in fact cause a loss of audio signal-to-noise ratio (much as stereo FM offers poorer signal-to-noise performance at great distances from the station compared with mono FM).

However, since picture signal coverage has always been poorer than audio coverage in TV broadcasting, Mr. Tingley pointed out that as long as audio coverage does not decrease below that of video coverage, broadcasters will not object. To achieve this result, one of several proposed companding noise-reduction systems may be used as part of the broadcast standard.

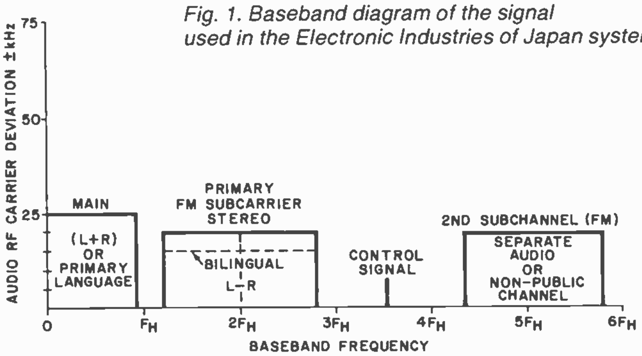


Fig. 1. Baseband diagram of the signal used in the Electronic Industries of Japan system.

Three Systems for TV Stereo. All three proposed stereo TV systems achieve mono compatibility because the *sum* of the left and right channel signals is used to frequency-modulate the main audio carrier, just as the mono signal modulates that carrier now. A difference signal (left-minus-right) is used to modulate a *subcarrier* the way a difference signal (L−R) is now used to modulate the double-sideband suppressed AM 38-kHz subcarrier in stereo FM broadcasting. The major differences among the three systems, however, are in the nature and frequency of this subcarrier.

A similarity between the three systems is in the addition of a second, frequency-modulated subcarrier located at a baseband frequency of 78.67 kHz—five times the horizontal TV line rate. This additional subcarrier is intended for other audio service in the future.

The EIAJ System. The Electronic Industries Association of Japan has proposed a multi-channel stereo TV system for use in the U.S. that is very similar, but not identical, to the one that has been in operation in Japan for several years. As illustrated in the baseband diagram of Fig. 1, this system employs an FM subcarrier with a frequency of 31.47 kHz, or twice the horizontal line frequency (F_H = 15.734 kHz).

As in all the proposed systems, the main audio carrier is modulated to a maximum of ±25 kHz by a "sum" (L + R) signal. The stereo difference subchannel is *frequency*-modulated by the difference signal (L − R) with maximum deviation of the center frequency of the subchannel reaching ±10 kHz. When stereo is broadcast, this first subchannel modulates the main r-f carrier by ±20 kHz (this is indicated by the height of the block in Fig. 1). But if this first subcarrier is used for bilingual (second language) transmission, it deviates the main carrier by only ±15 kHz.

Audio frequency response for both main and subchannels is flat from 50 Hz to 15 kHz, and the pre-emphasis used for main and subchannels is the same as that currently used (75 μs). The control tone shown at $3.5F_H$ provides the data to automatically switch receivers from the stereo mode to the bilingual mode.

Odd-Multiple Subcarrier. Telesonics, a small Midwest company, was formed for the sole purpose of promoting its stereo/bilingual TV broadcast system. The baseband frequency distribution is illustrated in Fig. 2. In this system, a double-sideband suppressed AM subcarrier is used to modulate the main carrier with stereo difference or bilingual information. The system is very similar to the

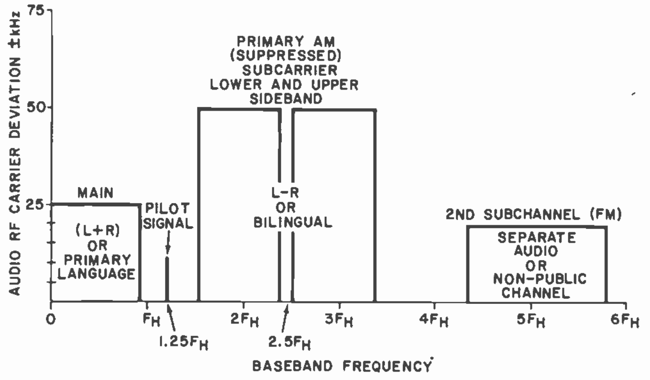


Fig. 2. Complete signal used in Telesonics TV audio system.

now-familiar stereo FM broadcast system used throughout the world.

What makes the system unique, however, is Telesonics' choice of a primary subcarrier frequency that has been set, not at a multiple of the horizontal TV line rate, but at 2.5 times that rate, or 39.939 kHz. The system requires a pilot signal that at one half the subcarrier frequency, happens to fall very near the 19 kHz pilot frequency used in stereo FM; specifically, at 19.668 kHz.

Because the use of an AM subcarrier inherently results in a poorer signal-to-noise ratio, Telesonics has elected to let the subcarrier modulate the main carrier by a full ±50 kHz. The result is a mono-to-stereo signal-to-noise degradation that is only marginally worse than that encountered with the all-FM EIAJ system.

In addition, Telesonics claims certain advantages in its ability to reject specific noise impulses caused by interaction between the video and audio carriers. They also claim lower overall distortion than is possible with an FM subcarrier, because the latter, when operated with a limited bandwidth, tends to "lop off" sidebands needed to accurately transmit and reproduce complex audio waveforms.

Scan-Rate Synch. The Zenith Stereo TV system also uses an amplitude-modulated suppressed double-sideband subcarrier for transmission of the stereo difference or second-language audio signals. Instead of using a pilot carrier for receiver synchronization and reconstitution of the suppressed carrier, (such as the 19-kHz stereo pilot used in FM, co-invented by Zenith), the TV horizontal line scan rate itself is used. The center frequency of the suppressed carrier is therefore set at exactly twice the horizontal line rate ($2F_H$). As shown in the diagram of Fig. 3, the additional FM subcarrier is again located at 5 F_H, as it is in the other two systems.

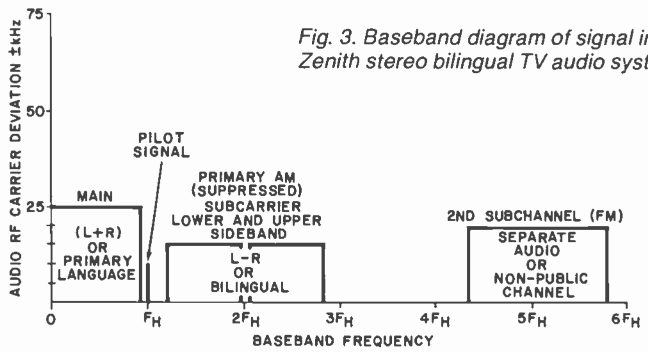


Fig. 3. Baseband diagram of signal in the Zenith stereo bilingual TV audio system.

Signal-to-Noise Degradation. When Mr. Tingley presented his progress report concerning stereo/bilingual TV in Chicago, he was not prepared to disclose all the results of the laboratory and field tests. He did, however, tell us that the EIAJ system exhibited the least signal-to-noise degradation compared with mono TV audio; about 15 dB. Next came the Telesonics system, with a decrease in S/N of about 16 dB. The greatest degradation of signal-to-noise was experienced with the Zenith system, with a decrease in S/N ratio of around 20 dB.

Readers who are familiar with the 23 or so dB of signal-to-noise degradation experienced when switching from mono FM to stereo FM may be surprised by these figures, but when you consider the fact that TV audio (even in mono) starts out with a 10-dB disadvantage compared with FM audio, the figures don't look all that good. The 10-dB disadvantage arises because maximum deviation of the FM carrier in mono FM is ±75 kHz, whereas the audio carrier in TV is only modulated to a maximum of ±25 kHz, or one third as much.

Calculations made by the Multichannel TV Sound Committee showed that in Grade B service areas (the end of the service area deemed to be "protected" by FCC regulations for TV), the best possible audio signal-to-noise ratio works out to be around 65 dB. Subtracting 15 dB from this (under the best conditions for the EIAJ system), brings the figure down to a barely acceptable signal-to-noise ratio of only 50 dB. For the other systems, S/N ratio is even poorer.

Companding Considered. For these reasons, the committee has been considering the possible use of companding or noise-reduction systems as part of a standard system for stereo or bilingual TV audio broadcasting. Interested parties were invited to submit their proposals. Those who responded included Dolby (which offered its newest consumer noise reduction system, Dolby C); dbx, Inc. (which offered a *modified* version of its well-known noise reduction/dynamic expansion system); and CBS, Inc. (which proposed the use of its CX system now being used as a disc companding system.

In addition to the basic tests and evaluations involving transmissions, the committee undertook a program of listening tests to evaluate the effectiveness of the three companding systems by simulating conditions that would prevail with AM and FM subcarriers in Grade A (close-in) and Grade B TV reception areas. One requirement insisted upon by the committee was that the companding systems offer both stereo and mono compatibility (to protect the investment of the owners of old mono sets as well as new, stereo TV sets not equipped with companding circuitry). This requirement apparently reduced the effectiveness of the proposed noise reduction systems so that there was no "clear winner."

The Committee is now considering altering the requirement to mono compatibility *only*. This would mean that all future sets built with stereo decoding would also have to include the noise-reduction circuitry that is eventually chosen as the industry standard. In this way, more effective companding circuits would be applied to the noisier stereo/bilingual subcarrier, but the main carrier containing the mono information would not be affected. These newer companding considerations are not, however, expected to delay the Committee's work.

If the present timetable is maintained, the FCC should be presented with an industry report and system recommendation in October or November 1982. Assuming that the FCC acts quickly, we could have an approved stereo TV broadcast system as early as mid-1983. Of course, if the FCC once again insists upon issuing another "marketplace" decision, (see "The AM Stereo Situation" in the July "Entertainment Electronics" column) we could also end up with *three* totally incompatible stereo TV systems. Furthermore, if the FCC leaves the choice of companding systems up to the "marketplace" we'll have *nine* possible system permutations. ◇

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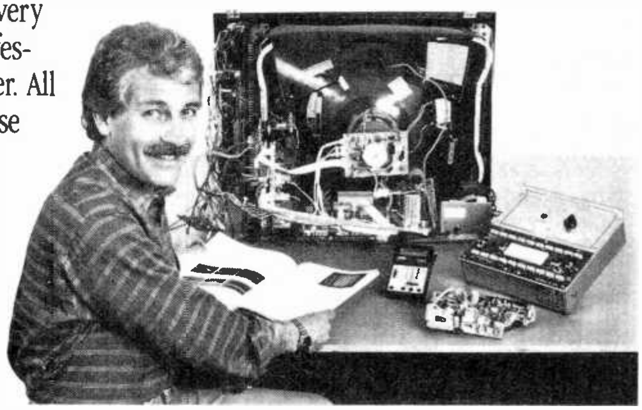
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Audio Product of the Month

CHOSEN BY THE EDITORS OF POPULAR ELECTRONICS

Harman-Kardon PM650 Integrated Amplifier

THE Model PM650 is one of Harman-Kardon's new high-current-capability integrated amplifiers. It has an instantaneous current output capability of 40 A, which enables it to drive very low load impedances (such as those presented by some loudspeakers at certain frequencies and parallel pairs of low-impedance speakers) without distortion or damage to the amplifier. The absence of the usual current-limiting circuits in the output stages also eliminates this as a potential source of distortion.

The H-K PM650 has a rated output of 50 W per channel into 8 ohms from 20 to 20,000 Hz with less than 0.03% total harmonic distortion. It has a complete array of control functions, including selectable terminating capacitance for the phono cartridge, yet presents a neat and uncluttered appearance.

The overall dimensions of the H-K PM650 are $17^3/_8$" W × 16"D × $5^1/_8$" H. It weighs 26 lb. Suggested retail price of the amplifier is $369.95.

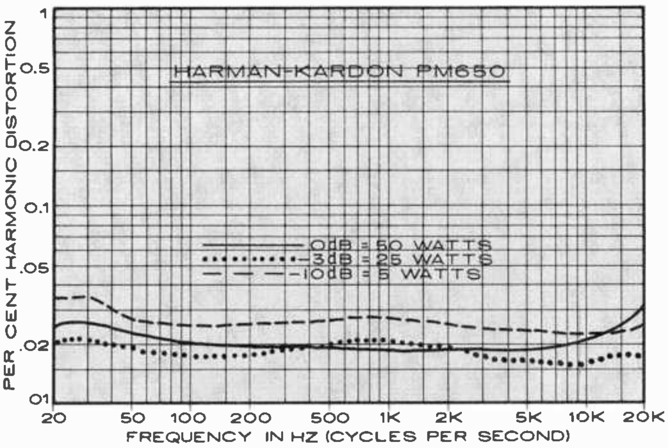
General Description. Harman-Kardon has been a proponent of wide-band circuitry for many years, and the Model 650 continues that tradition. Its low-level frequency response is specified as 4 to 140,000 Hz +0/−3 dB, with a 2-μs rise time and an 80-V/μs slew rate.

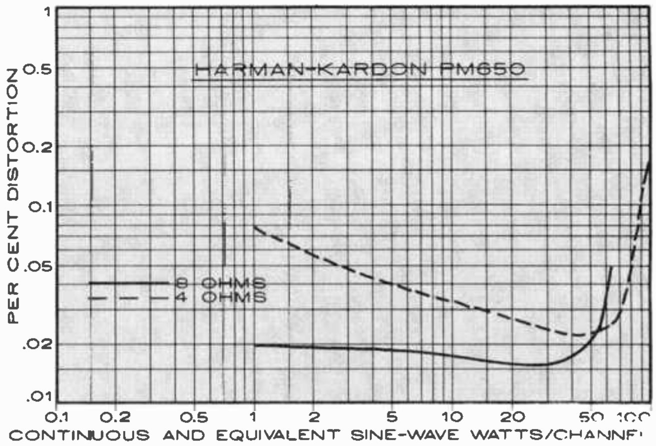
Except for its large VOLUME knob, all the control knobs of the H-K PM650 are of identical size (¾"). Its other front-panel controls are "push on, push off" buttons of different sizes and shapes, according to their function—except that the three FUNCTION (input selector) buttons are mechanically interlocked. A narrow tinted-glass window across the top of the panel conceals identifier words that light to show the selected program source, and whether one or both of the two TAPE circuits has been selected, as well as an ON indicator next to the POWER switch button. The separation of the program and tape recorder selection functions makes it possible to listen to one program source while dubbing or making tapes from another.

The three input sources are AUX, TUNER, and PHONO. A small button gives an additional choice of MM (moving magnet) or MC (moving coil) cartridge inputs through separate sets of input jacks and preamplifier stages. The MM input also has a small front-panel knob that terminates a cartridge in a capacitance of either 100, 150, 200, or 300 pF, in addition to 47-kilohm input resistance.

Laboratory Measurements. Following a one-hour preconditioning period with both channels driving 8-ohm loads at 1000 Hz with one-third of rated power, and five minutes of full-power operating, the output of the Model PM650 clipped at 68 W per channel with both channels operating, giving a Clipping Headroom rating of 1.34 dB. As claimed by the manufacturer, the PM650 delivers progressively higher output power as the load impedance is reduced. Into 4 ohms, it developed 102 W per channel; and into 2 ohms its output was an impressive 141 W. This limit was set by the tripping of the amplifier's internal protective circuit breaker; and actual waveform clipping was not observed with 2-ohm operation.

When we drove the amplifier with the pulsed Dynamic Headroom test signal, the maximum power output was 79 W into 8 ohms, giving the amplifer a Dynamic Headroom rating of 2 dB. We also performed the Dynamic Headroom test at two lower load impedances, obtaining 139 W into 4 ohms and 208 W into 2 ohms. The 1000-Hz distortion of the PM650 was between 0.016% and 0.02% for all output powers up to 50 W, and only 0.05% at 65 W. When driving 4-ohm loads, the distortion varied from





Distortion at 1000 Hz for power outputs between 1 and 100 W.

Percent harmonic distortion vs. frequency into 8 ohms.

0.023% to 0.2% for power outputs between 1 and 100 W. The distortion with a 2-ohm load could not be measured because the circuit breaker tended to trip quickly at fairly high power outputs. Across the full 20-to-20,000- Hz frequency range and at power levels from 5 to 50 W, the distortion was between 0.016% and 0.035%.

The amplifier's sensitivity for a reference output of 1 W was 18 mV (AUX) and 0.09 mV (PHONO MM), with an A-weighted S/N ratio for either input of 79.5 dB referred to 1 W. The amplifier was stable with reactive loads, and its slew factor exceeded our measurement limit of 25. The intermodulation (IM) distortion was measured with equal amplitude input signals of 19 and 20 kHz, having a combined peak amplitude equal to that of a 50-W sine-wave signal. This level served as the 0-dB reference. A spectrum analysis of the amplifier output (driving 8-ohm loads) showed a −82-dB second-order IM product at 1000 Hz, and a −83-dB third-order product at 18 kHz. The fifth-order intermodulation distortion at 17 kHz was measured as −88 dB.

The amplifier's tone controls had conventional characteristics—the bass control moves the low-end turnover frequency between 150 and 300 Hz, and the treble control positions high-end response curves that are hinged at about 3 kHz. The loudness compensation boosted both low and high frequencies as the volume setting was reduced, but the amount of boost was moderate and did not cause any unpleasant alteration in sound quality. The SUBSONIC filter response was down 2.5 dB at 20 Hz, which was our lower measurement limit, and the HIGH CUT filter response was down 3 dB at 6 kHz. It appeared to roll off the output at 12 dB per octave above the audio range, but we could not determine the ultimate slope of the SUBSONIC filter response.

The amplifier's RIAA phono equalization was accurate within ±0.5 dB from 20 to 20,000 Hz. It was affected only slightly by the inductance of a typical phono cartridge connected to the input (the total change was only about 1 dB from 1 to 20 kHz). The PHONO (MM) input impedance was 55 kilohms in parallel with capacitance values of 175, 225, 275, or 375 pF—depending on the setting of the front-panel switch. The MC input had a 400-ohm resistance. The MM input overloaded at a very good 240 mV at 1000 Hz and at slightly higher levels at 20 and 20,000 Hz.

User Comment. Not only did the H-K PM650 sound as sweet and clean as would be expected from its fine measured performance, it also managed to sound like a much more powerful amplifier than its ratings would suggest. In fact, the more current we drew from the amplifier, the more impressive it became (especially when we paralleled several pairs of speakers to form a very low-impedance load). This is hardly a normal condition—many amplifiers rebel at this sort of treatment, yet the PM650 takes it in stride.

While we do not necessarily subscribe to the theory that sonic performance is improved when the amplifier bandwidth is far in excess of the audible frequency range, it seems unarguable that a high-current output capability, low distortion and noise level, and complete stability—regardless of load—result in an amplifier with a very fine sound.

We also appreciate the PM650's lack of switching transients or other disturbing sounds, and overall smooth operation. Even the delayed connection of the speakers that allows the amplifier circuits to stabilize is done in a graceful fade (instead of the usual abrupt "click") In short, this is a fine product, well-suited for situations where one might ordinarily expect that far more powerful amplifiers are required. —*Julian Hirsch*

CONTROLS AND INDICATORS

FRONT PANEL:

Knobs:

BASS and TREBLE: Tone controls.
BALANCE: Control to center stereo image.
MODE: Selects REVERSE, STEREO, and MONO modes.
TAPE OUT: Controls the signal delivered to external tape decks. Positions marked SOURCE, TUNER, OFF, and COPY (twice). The two copy settings are for dubbing tape deck 2 to deck 1 and vice versa.
VOLUME
CAP. TRIM: Selects phono (MM) input capacitance of NORMAL, +50 pF, +100 pF, +200 pF.

Pushbuttons:

POWER: Large rectangular button at left.
SPEAKERS 1, SPEAKERS 2: Activates two pairs of speaker outputs independently of each other.
TONE DEFEAT: Bypasses tone control circuits.
SUBSONIC: Inserts high-pass filter at app. 15 Hz.
HIGH CUT: Inserts low-pass filter at app. 6 kHz.
LOUDNESS: Inserts Fletcher-Munson compensation into volume control circuit.
CARTRIDGE: Selects moving magnet (MM) or moving coil (MC) phono cartridge input.
TAPE MONITOR 1 and 2: Connects playback outputs of either external tape deck to the amplifier's circuits for playing tape or monitoring recordings. TAPE 1 has priority.
FUNCTION: Mechanically interlocked buttons for selecting program sources: AUX, TUNER, and PHONO.

Display: Illuminated words and numerals show selected program source and TAPE MONITOR settings, as well as power ON.

REAR PANEL:

Jacks: Standard phono jacks for all signal inputs and outputs.
Speaker System: Insulated binding posts for two pairs of speakers. Insert stripped ends of wires and clamp firmly.

Popular Electronics Tests

General Electric Model 19PC3708W 19" Color TV

THE General Electric Model 19PC3708W 19" color TV receiver features the company's new "PC" unitized printed-circuit board, replacing some of last year's EC chassis models. Its design promises easier servicing and higher reliability owing to a slide-out servicing provision and fewer connectors and components, as well as 27% less weight.

This is a direct or manual-tuning receiver with separate vhf and uhf mechanical tuners. A VIR (Vertical Interval Reference) pc board plugs into the main chassis's unitized board. The solid-state design makes use of five integrated circuits for sweep oscillator; audio; chroma-video; VIR; and i-f, agc, and detector sections—thereby reducing the set's parts count.

The front panel employs two concentric channel selectors, one for vhf and the other for uhf; an on-off volume control; on-off VIR switch; and thumbwheel controls for adjusting color, tint, brightness, and picture. A room-light sensor automatically adjusts color picture quality in accordance with room lighting conditions. At the rear of the chassis are controls for focus, vertical hold, sharpness, and horizontal hold adjustments.

The cabinet, which consists of simulated walnut on high-impact plastic, measures 17" H × 19" D × 24" W, and weighs 47 lb. Estimated future retail price for this color TV receiver is $480.

General Description. Channel selection is accomplished by a separate rotary switch, with concentric, push-in, fine tuning for vhf and uhf channels, and a separate, illuminated indication next to each switch. The receiver's i-f section uses a SAW (Surface Acoustic Wave) filter and separate adjustments for the 41.25-MHz audio trap, and the 45.75-MHz trap for adjacent channel interference. A single IC performs the amplification, video and audio detection, noise filtering, automatic fine tuning (aft) and automatic gain control (agc) functions, and also includes a preamplifier for the video and the audio i-f (4.5 MHz).

The vertical and horizontal sync and the deflection sections use standard circuits. However, in an effort to reduce weight and in the interest of energy-efficiency, all dc voltages except one are obtained from the high-voltage flyback section. The ac power supply provides only one voltage, the well-regulated 116 V dc, to operate the horizontal oscillator and flyback driver. A separate current-sensing and regulator circuit controls the high voltage (HV), which, if excessive current is drawn, will automatically disable the 116 V dc regulator. Thus, service technicians should keep in mind that a HV defect can cause loss of the 116 V dc as well.

A single IC also performs all of the color sync, automatic color control (acc), color i-f amp, color killer, and demodulating and matrixing functions. The three-color output amplifiers are mounted on a separate pc board at the base of the three-gun, in-line color picture tube, and receive the Y or brightness signal on their emitters. Direct-current coupling, together with diode dc-level control, provides excellent dc restoration.

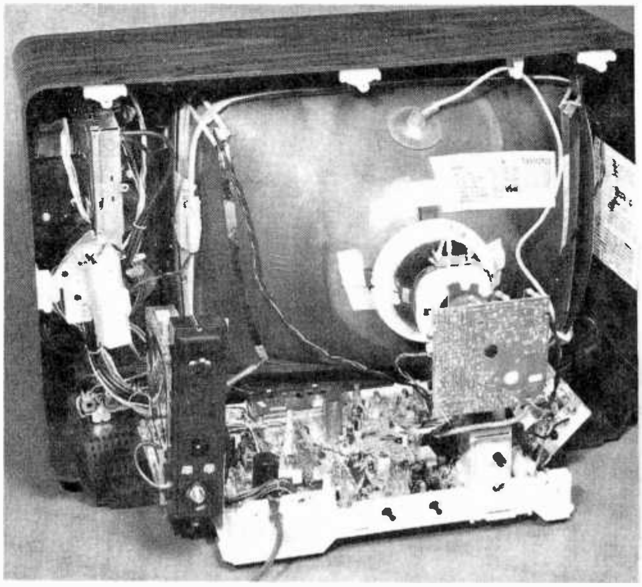
The outstanding technical feature of the Model 19PC3708W, however, is the VIR II Broadcast Controlled Color System, introduced in 1980. The VIR board contains a special, 24-pin DIP IC (Matsushita AN5330) and six transistors. It connects to the main chassis, and to the VIR on-off switch and the VIR LED indicator.

The special VIR IC performs all of the VIR functions in a compact space. When a broadcast station uses a VIR signal (not all stations do), the receiver can lock in the same tint and chroma levels being transmitted. The line-recognizer section uses the composite sync signal, together with the horizontal blanking pulse, to find the vertical sync pulse and to count down to the 19th line. Outputs from the recognizer section are sensed by the VIR circuitry. When the VIR signal is detected, a LED indicator lights up.

A tint-controller section receives the R minus Y (R – Y) signal, which is then compared against the color signal obtained from the VIR reference. Manual tint-control voltage and the tint-preference control voltage (from the acc cir-

GENERAL ELECTRIC MODEL 19PC3708W 19" COLOR TV RECEIVER LABORATORY DATA

Parameter	Measurement
Sensitivity, vhf (Ch. 3):	−55 dBm
Sensitivity, uhf (Ch. 20):	−52 dBm
Noise figure, vhf (Ch. 3):	8 dB
Noise figure, uhf (Ch. 20):	15 dB
Video bandwidth to CRT (−6 dB):	3.85 MHz
R-f oscillator frequency stability: (Ch. 3, 105 to 130 V ac, 2 hr)	0.085 MHz
R-f oscillator frequency error: (Ch. 3)	0.0615 MHz
Agc dynamic range:	65 dB
Dc restoration:	95%
Horizontal linearity:	100% left, 95% right
Vertical linearity:	98% top, 95% bottom
Convergence:	95% at worst area
Dc voltage regulation, B+: (105 to 130 V ac)	98%
High-voltage regulation: (105 to 130 V ac)	93%
Power rating:	75 W



Rear of chassis, which pulls out for serviceability.

cuit) are compared with the VIR information. The resulting output then goes to the color-sync circuit in the main chassis. The color controller section operates in a similar manner, but its input is the combination of the B−Y and the Y signal. The Y signal is also clamped to the proper black level in the Y amp.

The mechanical layout of the new GE chassis is intended for easy servicing. The main pc board can be withdrawn from the cabinet and locked into a stable servicing position, with the cabinet resting on its side. This permits access from both sides. Also, the pc board layout supplied with the service manual certainly makes it easy to find individual parts and test points.

We found that the letters and numerals on the main pc board and on the CRT socket pc board were not very legible, but that may have been due to the printing on our particular set. We also noted that some of the test points are located between larger components, making it difficult to reach them with a standard scope probe.

Test results summarized in the accompanying table indicate that the GE Model 19PC3708W has good vhf sensitivity and noise figure. Measuring −55 dBm at 300 ohms corresponds to about 8 μV input, for a noise-free picture. The uhf sensitivity of −52 dBm corresponds to double, or 16 μV, which also promises good fringe-area performance. Unfortunately, the relatively higher noise figure for the uhf tuner limits the effectiveness of the VIR system to relatively noise-free signals.

The video bandwidth of 3.85 MHz was measured with the sharpness control set at its midpoint. We also observed that this control reduced the video response curve to 3.80 MHz at its soft setting and caused a +3-dB peak at 3.75 MHz at the sharp setting. Since the sharpness control is located at the rear of the set, the owner does not ordinarily worry about it. Its effect on a normal picture is barely noticeable, but on a weak signal it seems to sharpen the edges of displayed images.

R-f oscillator frequency stability and accuracy were measured with the aft operating. Considering that this is not an electronically tuned or a crystal-controlled system, stability and accuracy are quite acceptable. The remaining parameters are affected by the VIR performance and were measured with the VIR system in operation. They indicate very good dc restoration, excellent linearity and convergence, and no noticeable pincushion effect.

Applying a color-bar pattern on channel 3 proved to produce good color fidelity, even though the VIR system was not operating (a VIR signal must originate at a transmitter). Figure 1 shows a scope photo of the composite video signal as it entered the color i-f section. At an amplitude of about 0.5 V and with the 3.58-MHz sine-wave burst perfectly reproduced, this photo quantifies the observed picture quality. The results of applying a gray scale (staircase) signal were equally good. Apparently, the factory adjustment for frequency response, gray scale, linearity, convergence, and pincushion effect were precise.

According to GE's service manual the 116 V dc (from which the other dc voltages are derived) should be adjusted to within 0.5 V, but the regulation of that voltage only covered 98%. Assuming the 2% difference to be equally distributed, this means that the 116 V dc could change by ±1.16 V. However, we noticed no degradation of performance, even with changes in line voltage from 105 to 130 V ac. The stated range of regulation for the high voltage is from 26 to 28.5 kV, which is about 10%, and the measured values were better than that.

User Comments. Performance of this 19" color TV receiver was especially fine in terms of picture quality. Colors appeared crisp and sharp, with a bright and steady picture.

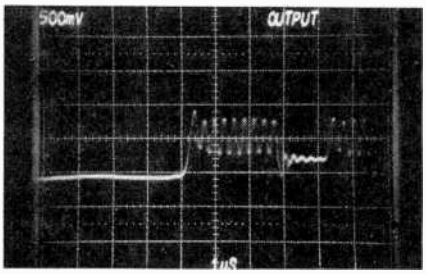


Fig. 1. Color-bar video at i-f input shows almost perfect sine wave.

The VIR color control system was a boon in maintaining correct colors as we switched channels—provided the TV station was transmitting the VIR signal. Since many cable TV and educational TV stations do not transmit the VIR signal, it provides no automatic assistance in these instances. Moreover, it was annoying to switch from a perfectly tuned VIR channel to one that required adjustments because the signal was not used. Furthermore, the fine-tuning adjustment had to be precisely adjusted to activate the VIR circuitry.

The mechanical tuners worked very well. In the interest of long-term reliability, however, which appears to be boosted in this set with the new main pc board, we prefer electronic tuning. In addition, mid-band and super-band cable stations are not available with them. (One can view these stations when subscribing to a cable service, however, with a supplied cable channel selector.) Using mechanical tuners contributes to a lower price, though.

In summary, we liked the overall performance of the Model 19PC3708W, and particularly appreciate the easy serviceability of the receiver as compared to earlier GE models. —*Walter Buchsbaum*

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Popular Electronics Tests

Toshiba T200-4 Computer System

TOSHIBA'S new T200/T250 Computer System is an integrated desktop business computer that includes a dot-matrix printer and a software package. Software accompanying the system consists of word processing, CP/M, Microsoft BASIC-80, and CBASIC 2. More business-application software is available as an option.

The only difference between the T200 computer and the T250 computer is the data-storage capacity. Whereas the T250 has drives with a storage capacity of 1M bytes/drive, the T200 is equipped with 5¼", double-sided, double-density drives with a capacity of 180K bytes/drive. There are single- and dual-drive models available for both the T250 and the T200.

This test review covers the T200-4 computer, which has two 5¼" drives. Suggested retail price for this system is $5750, including the software package and the printer.

The T200-4 computer is mounted in a desktop cabinet made of reinforced fiberglass and metal. It has two vertically mounted disk drives and a 12-in. CRT. A detached keyboard is connected to the housing by cable.

The typewriter-style keyboard has 85 keys, including 10 programmable function keys and a numeric keypad. The keys are mounted at a 15-degree typing angle, for greater visibility, and the typing keys are white, while control keys are black. The keyboard is controlled by an 8279 keyboard controller chip and the keyswitches have N-key rollover.

Implementation. The T200-4 is implemented as a single-board computer with the disk controller and the I/O circuits on separate boards. The microprocessor is a Toshiba 8085 operating at 5 MHz. The RAM memory consists of 64K bytes of dynamic RAM controlled by an 8257 programmable DMA (Direct Memory Access) controller IC.

The disk controller subassembly circuit board is mounted over the main system board. It uses an NEC 765 controller chip and phase-locked-loop circuits to control up to four disk drives. The drives themselves are quiet and reliable.

The 12-in., green-phosphor CRT has a wide bandwidth (22 MHz) and displays an 80-character, 25-line format in a high-resolution 8-by-8-character matrix. The CRT is not used at its rated capability—an example of Toshiba's conservative design philosophy.

The I/O circuit board is located at the rear of the machine and is connected to the main board by a shielded cable. The T200-4 comes with a parallel input port for the keyboard, an 8-bit parallel port configured for a Centronics printer, and an RS-232C serial port.

The T200-4 is completely shielded. All RFI and EMI sources are covered with a ventilated aluminum cover. This shielding and the weight of the power supply make the T200-4 computer a very solid unit. The table-top computer weighs 66 lb, and the associated keyboard unit weighs 4.4 lb. The computer unit measures 21¾" W × 13" H × 17" D. The keyboard unit is 17¾" W × 3⅛" H × 8½" D.

Power requirements for the computer are 115-V ac, at 60 Hz. Without the printer, the computer uses under 2.2 A.

The dot-matrix printer supplied with the system has a full 15-in. carriage, permitting a full-sized 132-column printout. It prints 125 characters per second bidirectionally. The character set is derived from a 9-by-7 dot matrix with a spacing of 10 characters per inch, and a line spacing of 6 lines per inch. The print mechanism is a full-stroke unit, which means that the print head is mounted on a helical cam that causes the head to move the full 132 columns on each pass. However, the operation is fairly quiet for a dot-matrix printer. A pin-feed roller handles paper flow, and a plastic window is provided to observe printing. All the controls are on the front panel. The printer weighs 31.0 lb and measures 22" W × 7½" H × 14½" D. It operates on 115-V, 60-Hz ac power and uses less than 1 A of current.

This printer is designed for data processing, and is not intended for word-processing applications. However, a high-density dot-matrix printer (such as a C. Itoh Model 8510) can be connected in place of the system printer to provide better print quality.

Software. The system software consists of Digital Research's CP/M operating system. However, the software is not of the same quality as the hardware. The implementation of CP/M is still undergoing change. (The CP/M version 1.2 we tested does offer improvements in terms of handling the CRT.)

We particularly liked the T200-4's booting. The screen tells you to insert the diskette, then the rest of the booting process is automatic.

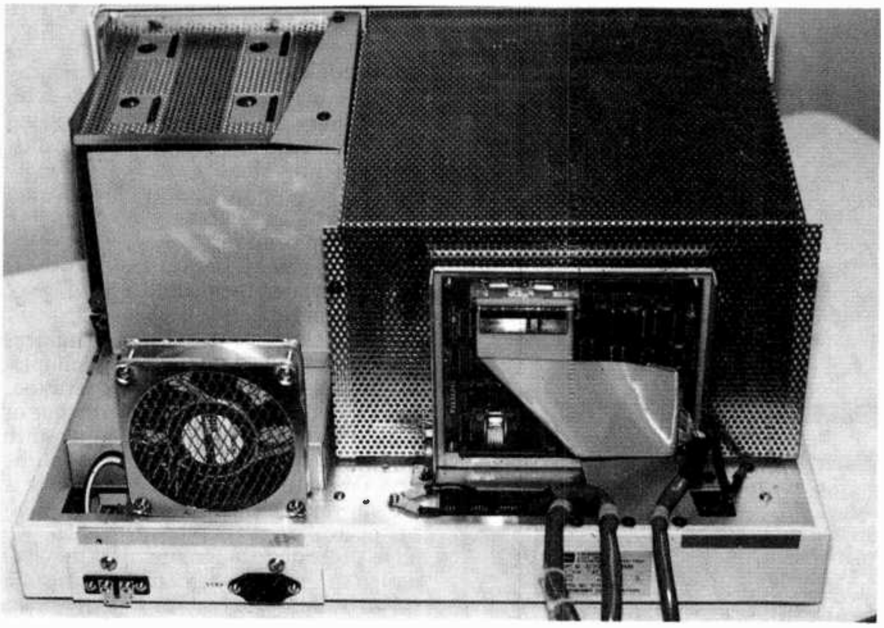
Making backup diskettes or data diskettes is equally simple. First, enter FORMAT. This will cause the Toshiba format program to load and tell you that the source is on the A drive and the destination on the B drive. Then the program asks you if you're ready. Formatting with verification of tracks is quick (less than a minute for the full operation), and errors are detected, giving track and sector.

A system diskette is made using the system-generating program called TOSGEN. Unlike other CP/M-based systems, there is no need to run the MOVCPM program to generate a memory image of the system size. In fact, this utility doesn't exist on the supplied system diskette, nor is it really needed. When used, TOSGEN lets you choose (a) just the system tracks, (b) the entire diskette to be copied, or (c) to quit the operation.

Like formatting a diskette, creating a new system diskette is quick. (It takes under a minute for the system tracks and about two minutes for the entire diskette to be copied.) As a test, we copied the entire diskette, using the Peripheral Interchange Program (PIP). This took just three minutes—with verification.

As good as the surface functions are, Toshiba's implementation of CP/M still leaves something to be desired. For example, all the ports except the RS-232C port are initialized on power-up. A separate diskette is needed to use the serial port, and yet another diskette is required to set baud rates, parity, and direction. Unfortunately the serial drivers aren't implemented in the Basic Input Output System (BIOS) of CP/M, nor is there room to do so. But Toshiba claims that an updated version of CP/M that handles all the I/O correctly is being readied.

Toshiba offers a full range of applications packages for the T200-4, including business, word processing, and communications. For this review, we used Wordstar 3.0, Microplan (an electronic spread sheet), and Whiz (a communications package). Wordstar is priced at $495, Microplan runs $495, and WHIZ can be had for $150.



Using a well-shielded modular design, the T200-4 permits ease of maintenance and is virtually RFI and EMI free.

All of the applications software packages are preinstalled and ready to run on the computer. However, this fact is not mentioned in Toshiba's documentation. This may cause the user to try and install the packages according to instructions in the software manuals. If this is done, the user will find that there is no mention of the Toshiba computers in the menus displayed by the INSTALL programs. Toshiba says that they are aware of the problem, and efforts are underway to correct the documentation.

Even though the basic T200-4 is an excellent machine, and Toshiba is making efforts to improve the software interface, documentation is not particularly good. The documents provided include a reprint of Digital Research's CP/M manuals and reprints of all the application package manuals. Very little information is provided about the machine operation, and virtually no in-depth technical detail is currently available.

Toshiba has employed the services of a California-based documentation company, called The Writery, to improve the T200-4's documentation.

Evaluation. The T200-4 is a data-processing tool that is as functional as any of the other high-end microcomputer systems currently available. And it's a breeze to set up. All we did was remove it from the box, plug in the printer system, and attach the keyboard.

Each of the interface cables is tied in directly to the machine and requires no plug-in. Electrical cables are designed to be plugged into the back of the system. The I/O cables are multi-wire, heavily shielded types. Unfortunately, the keyboard cable is extremely stiff and a little too short, so moving the detached keyboard around to a comfortable position can be difficult.

The keyboard uses a design similar to Wang, in that the essential function keys are located on the top row, including the CONTROL key. After a couple hours of use, this layout proved more of an asset than a detriment. We also liked the keyboard's ability to re-boot the system—simply depress the CONTROL key and IPL key. The PRINT key allows you to automatically send output to the printer with a single keystroke. Want to lock the keyboard? Just depress the KEY-LOCK key.

Below the first disk drive is a CRT intensity control so the operator can easily set the screen intensity to fit the room lighting. The CRT also employs an etched screen to reduce glare and eyestrain—a real help in an office environment.

During our testing for RFI/EMI, we were unable to detect any measurable radiation, even with the machine's cover removed. Apparently, good internal shielding, several wide ground paths, and shielded and grounded cables have eliminated potential RFI/EMI difficulties.

Our basic speed test of 10 GOSUB 10, using BASIC-80, yielded an average time-to-error of 0.29 seconds—revealing an excellent handling of memory processing. Using a 14,000-character Wordstar file, we found that average screen updates took only 14 seconds, from top-of-file to end-of-file. In addition, to load 24K bytes of BASIC-80 required only 5 seconds, and loading Wordstar took just 5.2 seconds, with the first overlay coming after a scant 1.2 seconds. Printing the file took approximately 3 minutes—slightly longer using Wordstar's spooler.

Using our disk test, which is a BASIC program that writes an entire disk with the letter "A" and then retrieves it, took an average of 27 seconds. Using Digital Research's PL/I Chess program to develop a maximum processing speed, we found that it took an average of 1.83 seconds to compile and load the program; this is benchmarked against an Altos 4-

MHz Z80 hard-disk system of 3 minutes. All in all, the T200-4 is a very fast machine.

To test the application capability of the T200-4 we used Chang Laboratories' Microplan Electronic Worksheet. This package requires the use of CRUN2 as a host run-time package, and employs full screen attributes of the T200-4, including inverse video.

Although we are normally biased against application packages that require host languages, Microplan proved the exception for several reasons. First, it provided easily understood screen help messages and always displays its menu to the right of the worksheet. Second, the documentation is good and can be understood by a first-time computer user. Also, the system is quick. This speed is partly a function of the hardware, but it shows that the code has been optimized for processing speed.

User Comments. The T200-4 was designed as a general-purpose system, with the primary use being word processing and the secondary use data processing. Consequently, some license was taken by the designers in presenting the software applications packages.

We would have prefered that programs such as Microplan and Wordstar be implemented to take full advantage of the extremely flexible keyboard.

In the case of the Whiz communications package, we would prefer its implementation as a background operation. This would allow the user to trap out of an application, capture data on another machine, and then re-enter the application. (We understand this aproach to be a very distinct future possibility.)

Regarding the keyboard cable, we have suggested to Toshiba that they redesign the interface to permit the use of a coiled telephone-type cord rather than the stiff cable now being used. But regardless of the problems, we generally liked the T200-4. It proved very reliable—even when operated in our 100°F hot box, and under heavy smoke conditions.

Even though the T200-4 is being marketed as a data-processing system, we think Toshiba should drop the current printer and offer either the C. Itoh 8510 as the replacement or the Epson MX-100. (The Epson MX-100 is needed if a full carriage is required). The current printer isn't flexible enough.

In addition, we think that a full technical manual should be made available, as well as a quick-reference card for basic system use.

An important attribute, we found in our discovery sessions, was that the Toshiba system is designed for upward growth. Its architecture suggests the capability of adding a 16-bit co-processor and perhaps networking capability. Should business data processing be what you're buying the system for, the T200-4 could fit nicely into your plans.

CIRCLE NO. 102 ON FREE INFORMATION CARD

COMPUTER BITS

By Les Solomon

Accessories and Software

I SUPPOSE many of you, as I do, keep an eye out for new products that will make your system more powerful or easier to use. The SK8088 cpu board from SKI Electronics is a good example. This is a $329 dual-mode, 16-bit, S-100-bus, board that plugs directly into your present S-100 system and works in conjunction with your 8-bit cpu card.

The 8-bit processor board acts as the bus controller. However, when 16-bit software is loaded into the computer, control passes to the SK8088. To avoid taking away 8-bit software compatibility, the SKI board permits switching back to the 8-bit board when necessary. This is a technique of master/slave operation whereby a system of bus arbitration and semiphores (flags) is used to switch cpu masters between cycles.

To take advantage of the full power of the system arrangement permitted on the IEEE 696 (S-100 bus), the board implements the full 24-bit addressing for a 16M-byte address range. It comes in a 5-MHz standard version, with an 8-MHz upgrade available. You don't have to worry about getting rid of your 8-bit memory either. The SK8088 works well, but slower, with 8-bit memory. However, it takes two bus cycles for a 16-bit transfer.

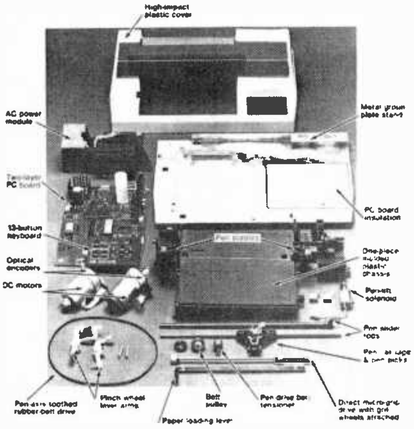
If you decide to get this board, be aware that it may not work with all so-called S-100 systems. The problem is in the implementation of the bus. In older versions (Altair, Imsai) the bus is defined a great deal differently than in IEEE 696 conventions. In addition, these older machines have ground planes and power rails. So be sure you understand what you have before you buy a board.

Using RAM Storage. I recently ran across a company doing something I really considered significant with high-speed RAM—using it for storage. The company, Axlon Inc., offers some very unique memory products, including Ramdisk, which is for the Apple or IBM PC and has 320K bytes of 200-ns memory and battery backup. The memory functions like two 35-track floppy-disk drives and is compatible with the necessary operating systems. The company says the price is about the same as a dual floppy drive.

Axlon offers similar products for the Atari, but the memory products are designed to plug into an available cartridge slot. You have the choice of a Ramcram to boost your Atari 400 or 800 to 48K or the Ramdisk for just the Atari 800. This gives you 128K of memory that acts as a high-speed disk drive.

If you are interested in communications, Axlon also has a personal communication terminal. Measuring $1^5/_8$" × $3^9/_{16}$" × $6^3/_4$" and weighing 11 oz., the handheld unit has a tactile keyboard with 43 functional keys to provide 64 upper-case ASCII characters. The display is a 16-character fluorescent indicator and has a 220-character receive memory that permits scrolling. The terminal, called the Hotline, has a "cool" price of $400.

You have probably noticed the increased interest in semiconductor nonrotating memory ("semidisks"). They increase your system operational throughput without impacting its operational aspects. For example, the Magnolia Invisible Disk that I discussed last month is used in my Zenith 89 laboratory system—especially when performing some system or software tests. We load the software into this very high-speed disk and reduce our overall access time. You do have to be careful, however, with some software that expects everything to be on the lowest defined system diskette, rather than the logged-in disk. Also you have to be certain that your power supply is solid, since a power drop-out will cause you to loose valuable data on the semidisk.



Parts breakdown of Hewlett-Packard's 7470 plotter shows simplicity of design.

The Master Plotter. If you have an extra $1550 and want a sophisticated plotting system, then the HP 7470 is exactly what you are looking for. This unit takes advantage of a new low-cost plotting technique and has a resolution (step size) or 25 μm (1/1000 in.), a repeatability of 100 μm, pen acceleration of 2 Gs, and pen-down and pen-up velocities of 35 and 50 cm/s, respectively. It uses either $8^1/_2$" or 11" paper.

One of the special features of the plotter is the way it senses, picks and replaces its pens. It is aware at all times of which pen to use, where to find it, and where to return it. It can be programmed to select from either of two pen groups at appropriate moments during a plot. The system automatically caps and uncaps the pens to keep the ink from drying out.

The 7470 uses Hewlett-Packard's micro-grip drive system developed last year for large-format printers. It avoids heavy moving arms and paper transport drums and belts. The technique involves moving the paper in one direction (x axis) and the pen in the other (y axis). In this way, the inertia is minimized to include only the mass of the drawing medium and the pen. The microgrip drive consists of two rotating metal grip wheels, which hold each edge of the paper firmly against a hard-rubber pinch wheel.

The microscopic points created in the paper by the wheels are used by the plotter for realigning and maintaining registration to ensure repeatability. This is not found on similar plotters.

The plotter uses an MC6802 microprocessor, has 8K bytes of ROM for storing all the plotting programs (including irregular-shape tables) and interfaces either through the HP-IB bus (IEEE-488) or RS-231C, thus making it universal to virtually any microcomputer currently available.

I haven't had time yet to use the plotter extensively, so a report on how well it works will have to wait till later.

Speaking of Software. With an increasing emphasis on computer communications, it is not surprising that software companies are rapidly getting on the communications bandwagon with many products. Many of them we have covered in the past. Recently, though, we came across some interesting packages developed by IE systems, Inc. to permit micros to speak to mainframes. All the software works with standard protocols and greatly upgrades the state of the microcomputer communications art.

One of these packages is the Bisync-80 group—designed to support synchronous communications between CP/M systems and IBM or similar hosts (any system with bisync protocols). Features include a user configuration module, hardware diagnostics, line trace, error checking, carriage control decoding and flexible EBCDIC/ASCII translation.

Another package, the 80/3780, provides full IBM 2780/3780 emulation on 8080, 8085 and Z80-based systems. This software costs $990. Note that you'll only need this package if you plan to operate in the IBM environment as a Remote Job Entry (RJE) terminal. Typically, this implies short-haul (under 20 miles) communication over dedicated metal or fiber-optic lines at speeds of 9600 baud and above.

More practical from the standpoint of the microcomputer user, are asynchronous (character) communications. IE supports 8080/8085, Z80 or 8088/8086 systems with at least 16K of RAM, one floppy CP/M or MSDOS and an asynchronous serial port (Z80-SIO), 8251, 8250,8274, NEC 7201, TMS 5501, or PMMI-103) for $495.

Asynchronous communications is normally established over ordinary phone lines using modems that transfer data at rates of 110 to 1200 bps. Be aware though that, on dedicated short-haul lines, 19.2K baud is possible.

All of the IE's software is available on diskette preconfigured to your requirements. If you own a host computer such as a VAX, PDP-11 or DEC10 or 20, IE can support your communications needs for these mainframes also at prices from $1940 to $5940.

Interestingly, many of the functions that take place in asynchronous communications can be likened to a disk system. If you think of your communications setup as being like a diskette, with each device scattered around the tracks (interleaved), you can get an idea of the functions of software that uses polling techniques. Incidentally, this is the technique used in networking software to allocate resources to the network and basically avoid collisions.

Communication Terminals. Because low-cost communication is becoming increasingly important, two companies are offering specialized terminals. Tymshare, through Equipment Products Marketing, has the Scanset Models 410 at $495 and Model 415 for $649. The first requires an external modem but provides automatic log-in, the second includes a built-in modem, automatic dialer, and automatic log-in.

Both models take up one square foot of desk space, have a 9" diagonal screen with 24 lines by 40 or 80 characters, and have limited graphics capability. The terminals were built by the French firm Matra and they use Cermatek modems and filters.

Each terminal has six multi-function keys and permits up to 12 user-defined tasks to be assigned to the programmable keys. The autodialer feature allows dialing up to 36 numbers stored in the terminal's battery-supplied CMOS memory. User menus guide the process and a built-in speaker lets you know the line status. Unfortunately, Matra uses a small keyboard with flat button keys, making the system almost unusable as a true data-entry terminal.

Offering similar capability but with a full-size keyboard and modular approach is the Zenith Data Systems ZT-1 communication terminal. Priced at $695, the ZT-1 is housed in a keyboard with 63 functions—26 alphabetic, 10 numeric, 4

Zenith ZT-1 communication terminal.

cursor, and special function keys. Like the Scanset, the ZT-1 is Bell-103 compatible. It has a 300-baud modem, plugs into any standard RJ-11C, 12C, or 13C jack, supports pulse dialing, has NTSC composite video (RS-170 compatible) and provides a serial I/O from 110 to 2400 baud. In addition, it has an 8-bit Centronics parallel port for printer support.

Zenith has gone to a great deal of trouble in the firmware to provide single-key dialing, sign-on, and all the necessary communication functions. The user can change the terminal's communication parameters, including word size, parity, and stop bits. Numbers can be added to the 26-slot directory.

More Than a Game. Computer games aren't always games in the truest sense. Two that we recently ran across are Roots/M from Commsoft (665 Maybell Ave., Palo Alto, CA 94306. Tel. 415-493-2184) for $124.95, and Unit Conversion Master from Mako Data Products (1441-B N. Red Gum, Anaheim, CA 92806. Tel. 714-632-8583) for $19.95. Both are written to operate under CP/M and can be used with virtually any terminal.

The Roots-M package is a unique program designed to help you trace your family tree. It comes with an extremely well-written manual with illustrations that not only explains the software but describes genealogy in general.

The software works by using a series of fill-in screens for entering pertinent data—marital and blood relationships, letters, financial records, travel information—anything you can find out about your ancestors. The program uses this data to generate a pedigree chart, and draws relationships between individuals, how families intertwine, and traces all the vital statistics.

Roots/M is one of the best data-base management systems we have seen, and it is very easy to use. The authors have provided numerous well-planned help messages, and tips on finding out who *you* really are.

The Mako Data Unit conversion Master is primarily designed to work with the Heath H-89 system, and uses its screen attributes to good advantage. What makes this package exciting is that you can enter length, volume, acceleration, mass, etc. in whatever units your originl data is given and then determine the correct conversion to the units of any other system (including cgs). Over 18,000 possible conversions are at your fingertips. The package is not really a game, and it strips away uncertainty when dealing with unfamiliar units or unwieldy data. ◇

FOR MORE INFORMATION

For additional information on the products mentioned here, contact the manufacturer directly:

Axlon Inc.,
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408-448-6111

Hewlett-Packard Corp.
3000 Hanover St.
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415-857-1501

IE Systems Inc.
Box 359, 98 Main St.
Newmarket, NH 03857
603-659-5891

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The Axlon Ramdisk offers 200-ns access and 320K bytes of storage for Apples and IBM PCs.

MICROCOMPUTERS–SYSTEM PERFORMANCE

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203-678-0323

FT. LAUDERDALE, FL
7173 W. Broward Blvd.
Plantation
305-791-7300

HIALEAH, FL
4705 W. 16th Ave
305-823-2280

JACKSONVILLE, FL
8262 Arlington Expwy.
904-725-4554

TAMPA, FL
4019 W Hillsborough Ave
813-886-2541

ATLANTA, GA
5285 Roswell Rd
404-252-4341

HONOLULU, HI
98-1254 Kaahumanu St.,
Pearl City
808-487-0029

CHICAGO, IL
3462-66 W. Devon Ave.
312-583-3920

DOWNERS GROVE, IL
224 Ogden Ave
312-852-1304

INDIANAPOLIS, IN
2112 E 62nd St.
317-257-4321

MISSION, KS
5960 Lamar Ave.
913-362-4486

LOUISVILLE, KY
12401 Shelbyville Rd
502-245-7811

KENNER, LA
1900 Veterans
Memorial Hwy.
504-467-6321

BALTIMORE, MD
1713 E Joppa Rd.
301-661-4446

ROCKVILLE, MD
5542 Nicholson Lane
301-881-5420

PEABODY, MA
242 Andover St.
617-531-9330

WELLESLEY, MA
165 Worcester Ave.
617-237-1510

DETROIT, MI
18645 W. Eight Mile Rd.
313-535-6480

E. DETROIT, MI
18149 E. Eight Mile Rd
313-772-0416

HOPKINS, MN
101 Shady Oak Rd
612-938-6371

ST. PAUL, MN
1645 White Bear Ave
612-778-1211

BRIDGETON, MO
3794 McKelvey Rd
314-291-1850

OMAHA, NE
9207 Maple St.
402-391-2071

ASBURY PARK, NJ
1013 State Hwy 35
201-775-1231

FAIR LAWN, NJ
35-07 Broadway (Rt 4)
201-791-6935

AMHERST, NY
3476 Sheridan Dr
716-835-3090

JERICHO, L.I. NY
15 Jericho Turnpike
516-334-8181

ROCHESTER, NY
937 Jefferson Rd.
716-424-2560

N. WHITE PLAINS, NY
7 Reservoir Rd.
914-761-7690

GREENSBORO, NC
4620-C W. Market St.
919-299-5390

CINCINNATI, OH
10133 Springfield Pike.
Woodlawn
513-771-8850

CLEVELAND, OH
28100 Chagrin Blvd
216-292-7553

COLUMBUS, OH
2500 Morse Rd
614-475-7200

TOLEDO, OH
48 S. Byrne Rd
419-537-1887

OKLAHOMA CITY, OK
2727 Northwest
Expressway
405-848-7593

FRAZER, PA
630 Lancaster Pike
(Rt. 30)
215-647-5555

PHILADELPHIA, PA
6318 Roosevelt Blvd.
215-288-0180

PITTSBURGH, PA
3482 Wm Penn Hwy.
412-824-3564

WARWICK, RI
558 Greenwich Ave
401-738-5150

DALLAS, TX
2715 Ross Ave
214-826-4053

FORT WORTH, TX
6825-A Green Oaks Rd.
817-737-8822

HOUSTON, TX
1704 W. Loop N
713-869-5263

SAN ANTONIO, TX
7111 Blanco Road
512-341-8876

MIDVALE, UT
58 East 7200 South
801-566-4626

ALEXANDRIA, VA
6201 Richmond Hwy.
703-765-5515

VIRGINIA BEACH, VA
1055 Independence Blvd.
804-460-0997

SEATTLE, WA
505 8th Ave. N.
206-682-2172

TUKWILA, WA
15439 53rd Ave. S.
206-246-5358

MILWAUKEE, WI
5215 W. Fond du Lac
414-873-8250

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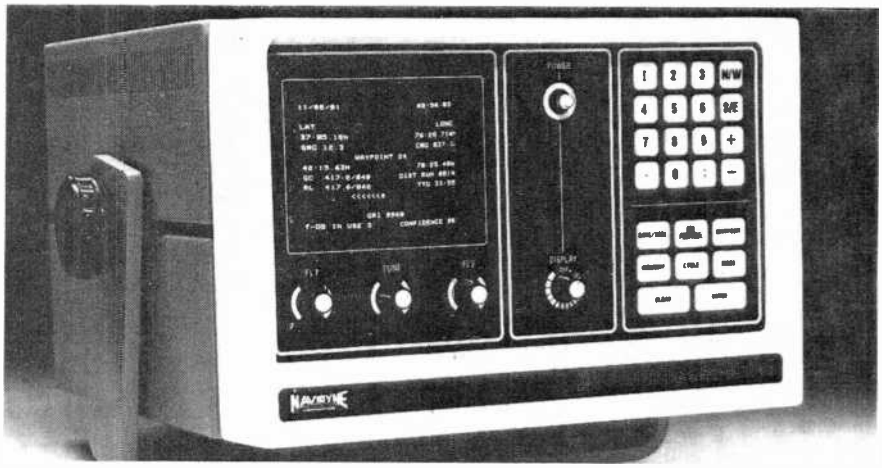
Loran-C
A Marine Long Range Navigation Tool

by Ken Englert

Microprocessor technology lowers prices 20-fold and reduces equipment size. Here's how Loran-C pinpoints locations many hundreds of miles from a coast line, plus an equipment buyer's guide.

MIX the serious boating enthusiast's need for accurate navigation when out of sight of a coastline with today's electronics, and you get a minor miracle called Loran-C (Long Range Aid to Navigation). And with equipment prices down from $20,000 to under $1000, you don't have to be a wealthy yachtsman to enjoy its benefits.



The Navidyne ESZ-7000 shows all navigation and routing information simultaneously on a CRT display.

What is Loran? Loran is a radio navigation system using land-based transmitters and shipboard receivers to enable anyone within reception range to easily determine his position at any time, in any weather. Loran C (other forms of Loran have been phased out) provides a positioning accuracy of at least one-tenth of a nautical mile. In addition, it offers a "repeatability" (measuring how precisely you can return to a given set of coordinates) that's theoretically accurate to within 50 feet.

Loran tranmsitter stations now blanket virtually the entire North American coastline, parts of the North Atlantic and Europe (including most of the Mediterranean), the North Pacific, and the Caribbean. Daytime range of a Loran-C transmitter is about 1200 miles, while nighttime coverage extends to an estimated 2000 miles.

Loran's usefulness is not restricted to boating. It can prove invaluable for rescue work in the mountains or desert or for recreation in remote areas—anyplace, in short, that involves the question: "Where am I?"

How Loran-C Works. Loran operates on the basis of a specific amount of time it takes for a radio signal to travel between any two geographical points. Although travelling at the speed of light, radio waves still require a finite and measureable time to traverse the distance between a given transmitter and a receiver. To effect this, the Coast Guard maintains a series of land-based transmitters that broadcast Loran signals (at a frequency of approximately 100 kHz). When picked up by an on-board Loran receiver, these signals can be processed into very precise positional information.

The key to accuracy with Loran-C is precise signal timing. A group or "chain" of Loran transmitters works together in an area and transmits signals that are in exact synchronization. The master station of the group transmits nine pulses. Simultaneously, the secondary stations (there may be two to four secondary stations in any Loran chain) transmit eight pulses at a slight interval after the master signal, with each secondary station transmitting in sequence. The on-board receiver is smart enough to recognize the master and secondary signals and differentiate between them (as well as those Loran signals received from other parts of the world) by unique frequency and pulse characteristics.

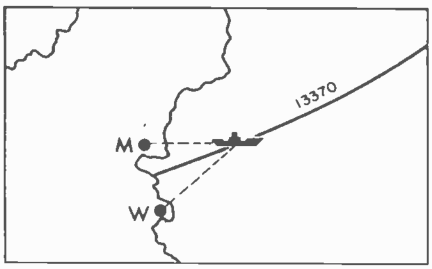


Fig. 1. A line of position (LOP) plotted between two Loran-C stations.

The Loran-C receiving unit is broken down into two sections: the actual receiver, whose job it is to pull the signals out of the air and amplify them to a useful level, and the computing section, whose function is to extract the data that tell the user exactly where he is. The computing side very precisely measures the arrival time of each of the received signals (in microseconds) from the master and secondary station transmitters. It is the *difference* in the arrival times between the master and secondary signals that is used to calculate your position in reference to those transmitters.

This time difference (called TD) corresponds to a hyperbolic line that describes a specific unit of time lying between each station. Different times will correspond to a different hyperbolic line. Each time-difference line can be used by the Loran operator as a navigation line of position (LOP).

Here's how it works: Let's assume a master station at point *M* and a secondary station at point *W*, as in Fig. 1. Our on-board receiver picks up both signals and displays a digital readout of the differential time interval of the signals. We take this number, called a TD, and plot a LOP corresponding to that value on a chart with Loran time difference lines overlayed on it. Let's say that our Loran receiver gives us a reading of 13370.0. Although there are many points on our chart that will correspond to the same 13370.0-microsecond time difference, they will all be plotted along one line. This line of position is similar to a line of longitude or latitude. It differs in that it is not perfectly straight, but hyperbolic in shape. Also, it is located somewhere between the two stations and, of course, is restricted to the reception range of the Loran signals.

Now, we still have not pinpointed our exact location. All we have done is place ourselves somewhere along a line on a chart. This is like saying we are somewhere on Main Street. To be precise, we need a cross-street reference. To find it, we measure the time difference between the master station and another secondary station in the same Loran chain. This time-difference reading places us on another line (Fig. 2). Next, we observe where the two LOPs intersect on our chart. If our boat were to move in any direction, the TD readings on the Loran would chronicle our journey at any given moment.

The Loran Signal. A pulse-coded low frequency (LF) signal is used in the Loran-C system. Loran operates between the frequencies of 90 and 110 kHz, with a carrier frequency of 100 kHz. A low-frequency band was chosen to take advan-

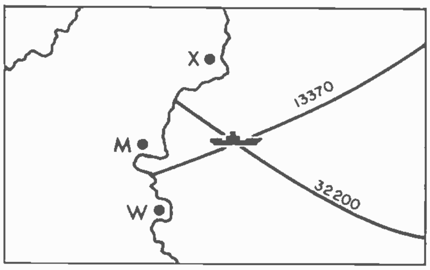


Fig. 2. A second reading referred to a third station gives a cross reference.

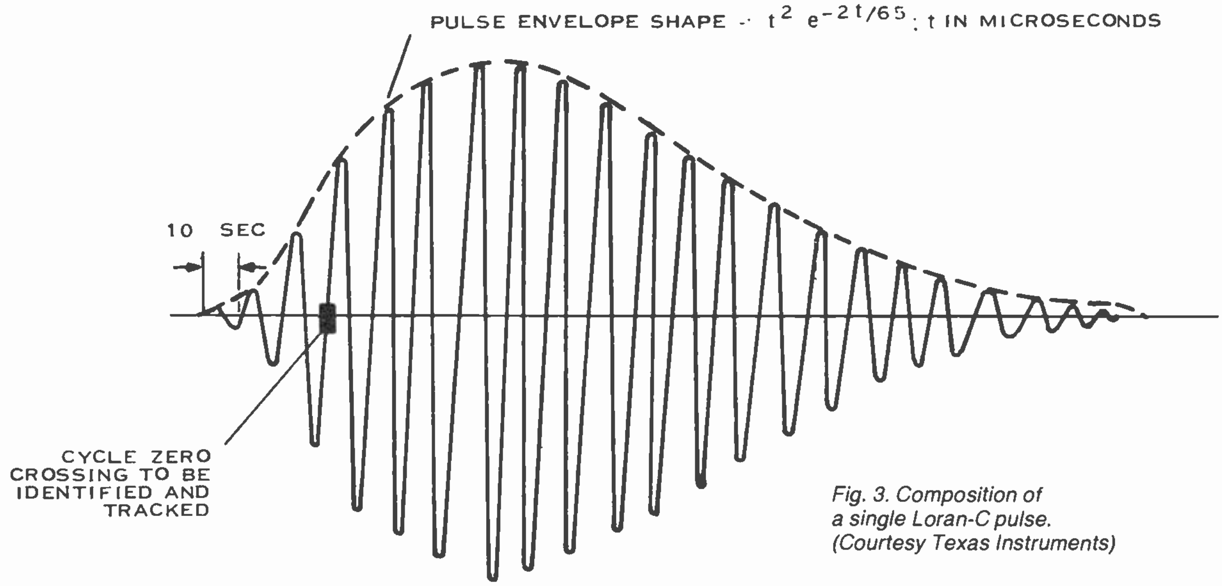


Fig. 3. Composition of a single Loran-C pulse. (Courtesy Texas Instruments)

tage of its stable and predictable propagation characteristics and relatively long range (typically, 800 to 1200 nautical miles).

Each station in the Loran chain transmits a series of pulses of specific number and duration (a single Loran pulse is shown in Fig. 3). The master and secondary stations in any Loran chain transmit groups of these pulses and form a combined Loran chain signal at a specific GRI (Group Repetition Interval). The master station signal requires 10,000 μs for transmission, while each secondary requires 8000 μs. The master station pulse group is made up of 8 pulses with a 1000-μs spacing between them, followed by a ninth pulse with a 2000-μs spacing from the eighth pulse. Secondary station pulse groups can be recognized by eight pulses spaced 1000 μs apart.

Figure 4 shows a typical Loran GRI made up of one master and three secondary transmitter signals. Notice that the pulses forming the first secondary station signal, designated "X," are not transmitted until the master pulse group has completed its transmission. Similar time delays place the second (Y) and third (Z) secondary signals in their respective positions in the GRI sequence. At that point, the master station begins to rebroadcast its signal and the sequence is repeated. The spacing between the pulse groups varies according to the Loran receiver's location within a given Loran chain.

Figure 5 shows many lines of position formed by plotting points where the TDs of the received signals of M and X are the same. By plotting a series of LOPs between the master and each of its secondaries, we create a grid-like overlay on a chart for the area of interest. This is the actual Loran chart.

How a Loran Receiver Works. Now that we have a good idea of how a Loran system works and what the signal looks like, let's discuss how an on-board receiver recognizes, tracks and processes that signal, using Texas Instrument's TI-9000 as a representative model.

Figure 6 is a block diagram of the TI-9000 receiver. An accompanying flow chart shows the sequence of what is taking place inside the receiver.

The first thing that happens when you switch the set on is that you trigger a system self-check and a processing routine called RESET. The RESET function has four tasks to perform: (1) checking the ROMs; (2) checking the RAMs; (3) initializing the RAMs for Broadband Search; and (4) waiting for you to enter the GRI for the Loran chain in your area via the receiver's front panel keyboard.

At the end of the initial RESET sequence, and before you enter your GRI (an interval of approximately two seconds), the receiver's display will show all "8s," showing it is ready for operation.

After the GRI has been entered, the set immediately goes into Broadband Search and starts to look for signals from the

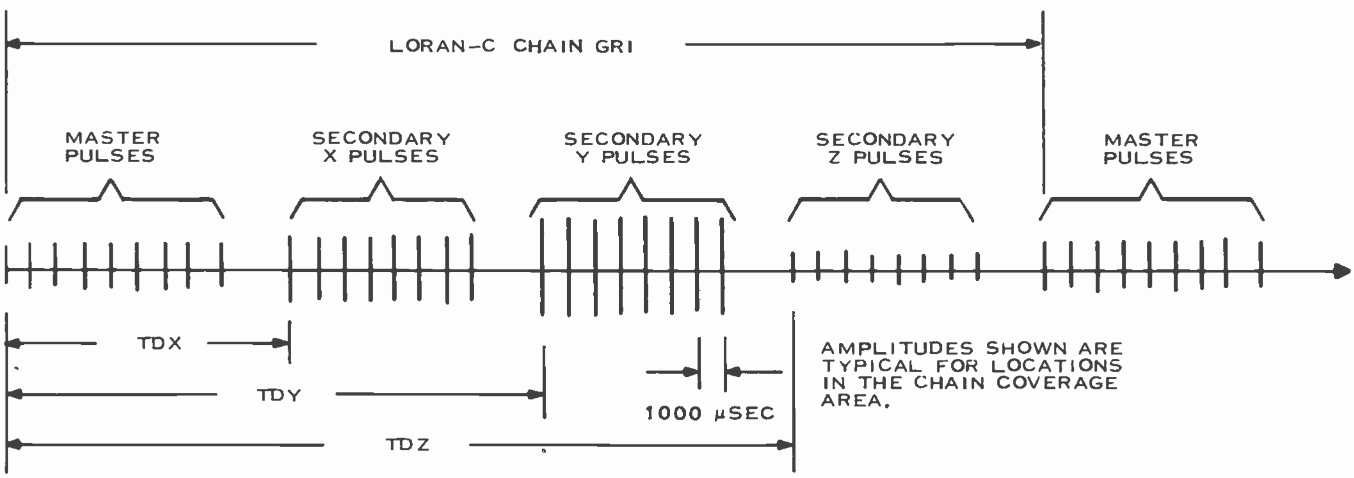


Fig. 4. The received Loran-C signal Group Repetition Interval. (Courtesy Texas Instruments)

master and secondary stations from your selected GRI. The input into the antenna's preamplifier consists of a 100-kHz r-f pulse train. The r-f power supply board takes the 100-kHz signal, processes it through a narrowband filter, and produces a digital output consisting of r-f Out and Envelope (ENV) Out signals. (As its name implies, the power-supply section of the r-f/Power Supply Board also takes the 11-to-16-V dc input and creates

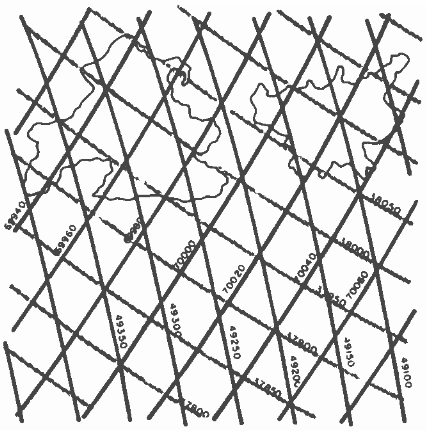
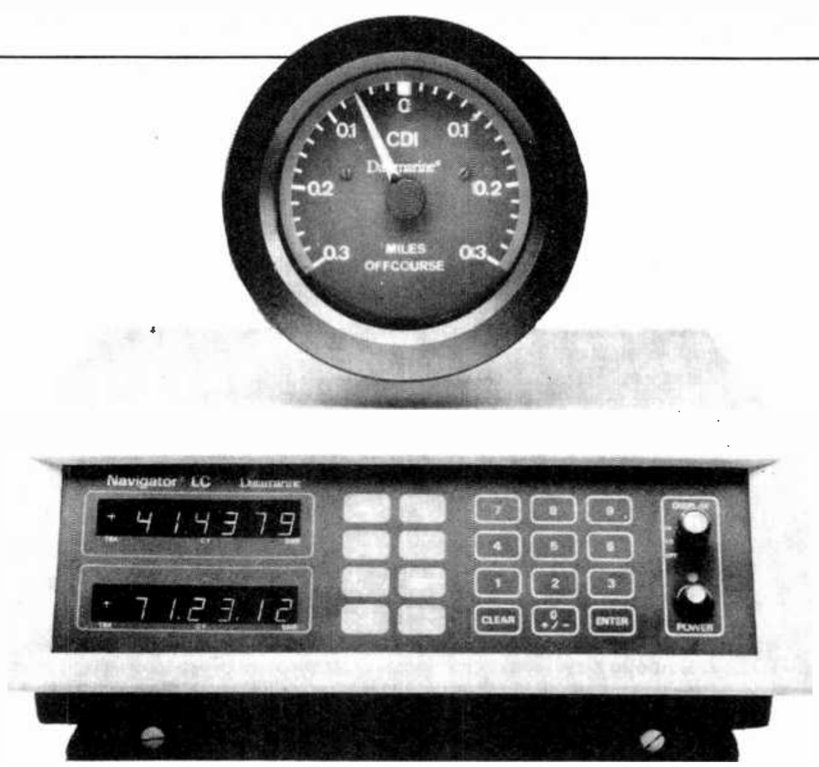


Fig. 5. The actual Loran chart is a grid-like overlay of LOPs.



Datamarine's CDI remote steering indicator allows the user to put his boat on course and then indicates deviation from a straight line path.

the regulated +5, +15, −15, and +180 V dc output voltages which are required in other parts of the receiver.) The r-f signals are fed to a sampling register on the Processor Board. The Timing and Strobing Board controls the sampling register and serially shifts the output data to the Communications Register Unit (CRU), which is a part of the microprocessor.

The microprocessor then processes the data and identifies the master and secondary signals. (It is mandatory that the master signal be found and used as the starting point.) After the master is isolated, a broadband search identifies the secondary signals. If the secondary signals are not found in the broadband search, the process will be automatically repeated by starting over and looking for the master. This process is called Background Search and is performed automatically if the secondary signals are missed.

The microprocessor is controlled by a stored instruction program built into its ROMs, and by the keyboard instructions it gets from the operator. RAMs are used by the microprocessor for data storage and retrieval. The microprocessor also cues the Timing and Strobing Board in the generation of system-timing pulses.

After processing, the data output is sent to the Display/Control Board, where decoding takes place. The end product—the Loran time-difference reading—is shown on the receiver's front panel digital display.

Using a Loran-C Receiver. Operating a Loran-C set is simple. For an illustration, let's again look at the Texas Instruments Model TI-9000. It features a keyboard for entering data and selecting navigational information. Once you understand it you can enter and recall navigational information effortlessly.

The keyboard consists of 20 keys divided into four functional groups (see Table I).

SRD's CLX-85M gives digital reading of distance to first waypoint, bearing, distance off course, and cruising speed.

Increasing Accuracy. Given a choice of more than two TDs (up to four, depending on the Loran chain), the operator can increase his accuracy by selecting those that assure the best possible position determination. Three factors determine TD accuracy: the distance from the transmitting stations, baseline extensions, and TD crossing angles.

The distance from the stations is important because stations more than about 1200 miles away tend to be subject to noise and the possibility of an added time delay from sky-wave interference. (Remember, we are relying on the stability and predictability of ground-wave reception for Loran-C accuracy.)

The baseline for a TD is a straight line connecting the master and the secondary stations. The baseline extension is formed by extending this line beyond

TABLE I—KEYBOARD LAYOUT (Texas Instruments Model TI-9000)

Data Entry Keys

0—9	**Digit Keys**	Enters numbers 0 through 9
+/−	**Change Sign Key**	Makes it possible to enter a negative as well as a positive number.
CLR	**Clear Key**	Clears or erases numbers in the display.
ENTR	**Enter Key**	Instructs unit to enter the number seen on the display into the internal computer's memory.

Primary Operating Keys

GRI	**Group Repetition Interval Key**	Allows operator to choose which Loran chain or group of Loran transmitters they wish to receive signals from. A four digit code is used to select the proper stations to "listen" for.
AUTO	**Automatic Key**	Provides automatic display of up to 4 selected TDs. (As this model can only display one TD reading at a time, several TDs are displayed sequentially for 5 seconds at a time.)
TD	**Time Difference Key**	Can be used to "freeze" a particular time difference reading for continuous display. This key is also used to store and recall selected TDs.

Secondary Function Keys

MON	**Monitor Key**	Allows operator to select one of two codes in monitoring Loran transmitting station performance. **MON-1**—Indicates Signal-to-Noise ratio of the received signal. A reading of 999 is the highest and best. Readings below approximately 670 indicate a poor signal. **MON-2**—Oscillator offset frequency. The number displayed indicates the number of cycles (out of a million cycles) that the receiver's internal oscillator is off frequency. A number greater than plus or minus 30 indicates your set will have to be adjusted.
MODE	**Mode Key**	Displays the 6-stage signal processing sequence of your receiver and aids in acquiring a usable signal.

Special Function Keys

TRK ΔTD	Allow the operator to override the signal selection process under certain adverse conditions to make an otherwise unusable signal usable.

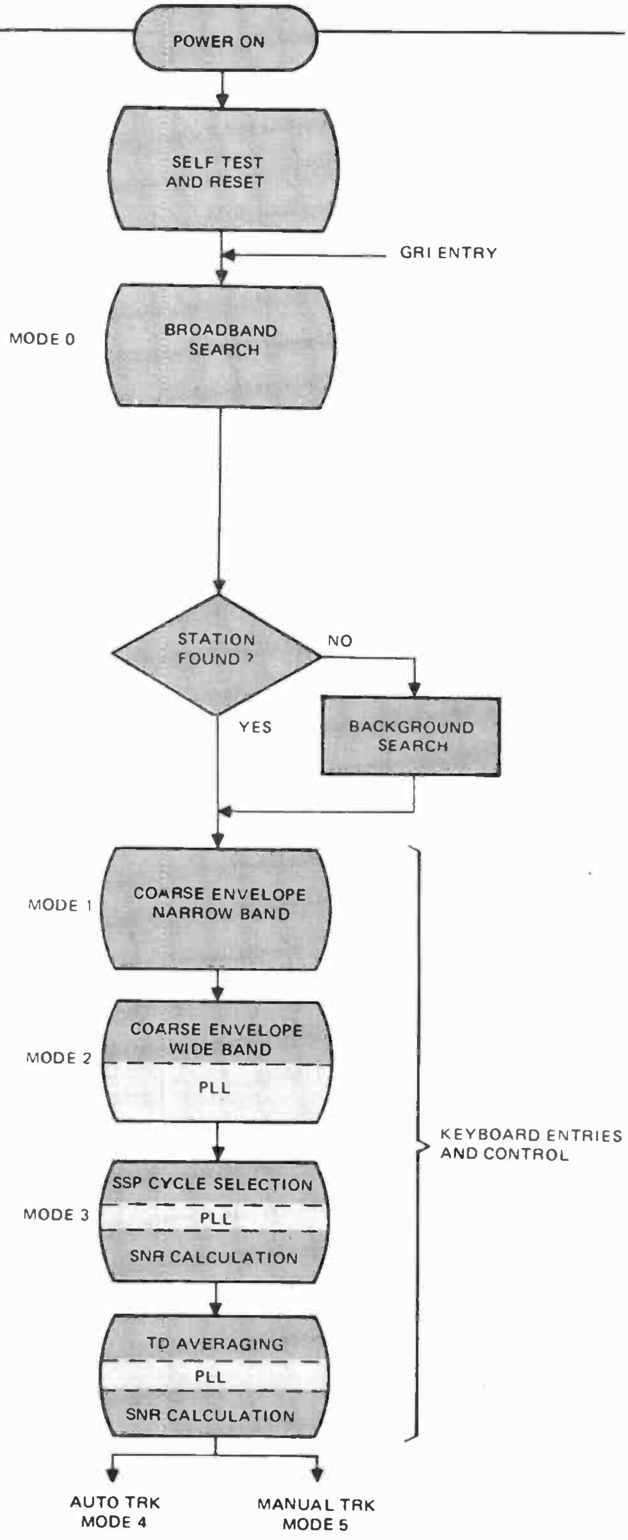


Fig. 6. At right is a flow chart showing the sequence of events taking place inside a receiver. A block diagram of the Texas Instruments TI-9000 receiver is shown on the opposite page.

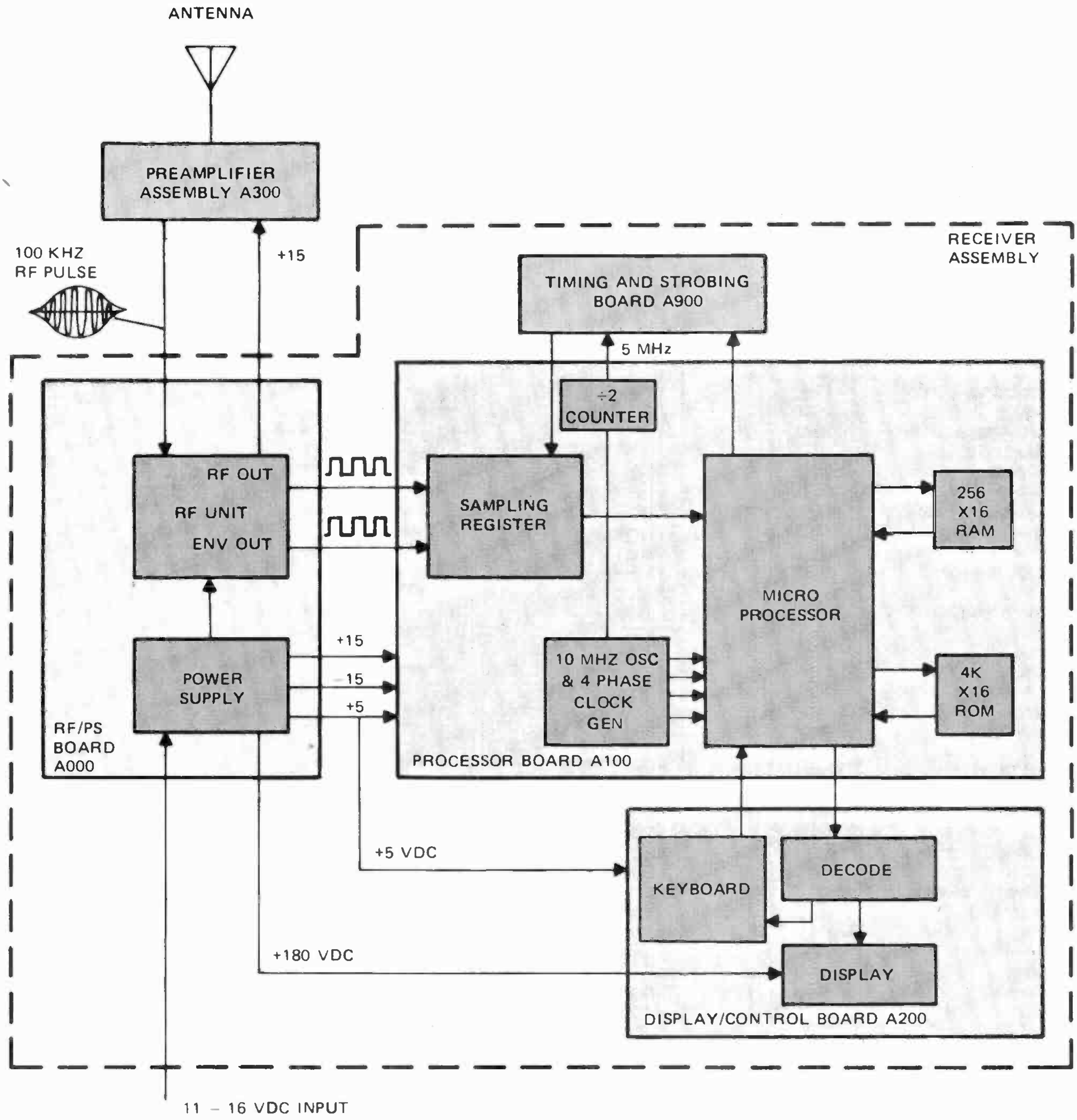
both stations. The significance of this line is that the use of TD LOPs on or near the baseline extension will adversely affect your accuracy since a relatively large distance will produce a relatively small change in a displayed TD.

TD crossing angles (formed when two TD LOPs cross on a chart) also affect accuracy. Your reading will be most accurate when the angle is 90°, and less accurate the further you get from 90°.

Selecting a Loran Receiver. Variety is an understatement when describing all the new models of Loran-C receivers available today. Here are some guidelines to help you make an intelligent selection.

For good precision, your Loran should read-out in at least six digits. The displays themselves come in several basic types including incandescent, fluorescent, gas discharge, LED, LCD, and even a CRT. That choice is mostly subjective and should be considered with your particular needs in mind.

Since you need two TD readings to determine your position, a Loran that has a dual readout is easiest to use. Less-expensive models employ a single TD readout—alternating readings every couple of seconds. Other single-readout models display the last few digits of two TD readouts (since the first few digits will not change in a given area anyway).



Notch filters are important—the more filters, the better. In Loran, electrical noise interference is your mortal enemy. A notch filter "notches out," or reduces noise to a manageable level. While all Loran-C systems have internal notch filters, others have the additional flexibility of external units on the control panel. The latter are operator adjustable. The fixed filters are set specifically for the predominant interfering noise frequency in your region. The adjustable filters are to help compensate for noise interference when cruising in other areas. A note of warning when buying a model that features internal or fixed notch filters: Shy away from mail-order or other out-of-the-area purchases, as the notch filters may not have been set for the interfering noise frequencies in your area. This can mean all the difference between having a set you can use and one you can't. If you are planning long-distance cruising, you should consider getting adjustable front-panel notch filters. The additional external filters complement the noise suppression of the internal filters and give you some control over local noise conditions.

A remote or second station is not usually necessary on most boats, but models are available that will drive a remote display if you have the desire or need.

Direct readout conversion from TDs to latitude and longitude heads the list as the most welcome and useful feat that some top-of-the-line equipment can accomplish. This feature is particularly helpful in fringe ares where Loran lines have not been fully plotted, or if a full set of charts with Loran-C LOP overlays are not on-hand.

Other new tricks that the more sophisticated models can perform include:

• Calculating the speed and course from your last position or waypoint.

• Estimating the time at a given speed to your next waypoint.

• Registering the amount of error (called cross-track error) in distance and direction while traveling between two waypoints.

BUYER'S GUIDE—LORAN-C RECEIVERS

Manufacturer and Model	Price ($)	No. of TD (LOP) Displays	Display type	Lat./Long. readout	No. of waypoints in memory	Ext. notch filt.	Steer R/L ind.	Inter-faces with auto-pilot	Computes naviga-tional data
Datamarine Navigator 4000	2795	2	Gas discharge	x	8	x	x	x	x
Digital Marine Electronics									
Northstar 6000	3995	2	LED	x	1	x	x	x	x
Northstar 7000*	5390	2	LCD	x	120		x	x	x
Epsco C-NAV SX	2995	2	Gas discharge	x	8	x	x	x	x
Furuno LC-200 MK-II	1795	2	LED		0	x			
LC-70	2795	2	LCD	x	32	x	x	x	x
Micrologic ML-2000N	1795	1	LCD	x	10		x	x	x
ML-3000	2695	2	LCD	x	200	x	x	x	x
Mieco C-Master IV**	1895	2	LCD		10		x	x	x
Morrow Eagle									
LCS-4000	1095	2	LED		8		x	x	
LLC-4000	1995	2	LED	x	5		x	x	x
Navidyne ESZ-7000	4950	2	CRT	x	25	x	x	x	x
Nelco Autofix 9000	1695	2	Fluores-cent		30	x	x	x	x
Racal-Decca 1024	1295	2	Fluores-cent		5	x	x	x	x
Ray-Jefferson 260	795	2	Fluores-cent		0				
Raytheon									
Ray Nav 3000	1195	2	LED		0				
Ray Nav 6000	3995	2	LED	x	1	x	x	x	x
Ray Nav 750	2195	2	LCD	x	50		x	x	x
Seatron 2000	895	3	Fluores-cent		0				
Simrad TL-838***	1495	2	LED		x				
TL-856	2495	2	LED	x	10	x	x	x	x
Si-Tex 717	2995	2	LCD	x	58	x	x		x
757C	1995	2	LCD	x	8	x	x		x
SRD Labs CLX-85	1995	2	LED	x	9		x	x	x
CLX-95	2795	2	LED	x	100		x	x	x
Texas Instruments									
TI-9000A	1295	1	Gas discharge		0	opt.			
TI-9000S	1495	1	Gas		1	opt.	x		
TI-9900	2495	2	Gas	x	10	opt.	x	x	x
Trimble 5A	2995	1	LCD	x	1				x
50A	3695	1	LCD	x	100		x	x	x

*Displays up to 200 plain English messages.
**Latitude/longitude converter optional.
***Latitude/longitude connector w/nav. computer optional.

MANUFACTURERS' ADDRESSES

Datamarine International, Inc.
53 Portside Dr.
Pocasset, MA 02559

Digital Marine Electronics Corp.
(Northstar)
30 Sudbury Rd.
Acton, MA 01720

Epsco Marine
411 Providence Highway
Westwood, MA 02090

Furuno USA
271 Harbor Way
So. San Francisco, CA 94080

Micrologic
20801 Dearborn St.
Chatsworth, CA 91311

Mieco
109 Beaver Ct.
Cockeysville, MD 21030

Morrow
4740 Ridge Dr. N.E.
P.O. Box 7078
Salem, OR 97303

Navidyne Corp.
11824 Fishing Point Dr.
Newport News, VA 23606

Nautical Electronics Co. (Nelco)
7095 Milford Industrial Rd.
Baltimore, MD 21208

Racal Decca
P.O. Box G
#1 Commerce Blvd.
Palm Coast, FL 32037

Ray-Jefferson
Main & Cotton Streets
Philadelphia, PA 19127

Raytheon Company
676 Island Pond Rd.
Manchester, NH 03103

Seatron Marine Electronics
4312 Main St.
Philadelphia, PA 19127

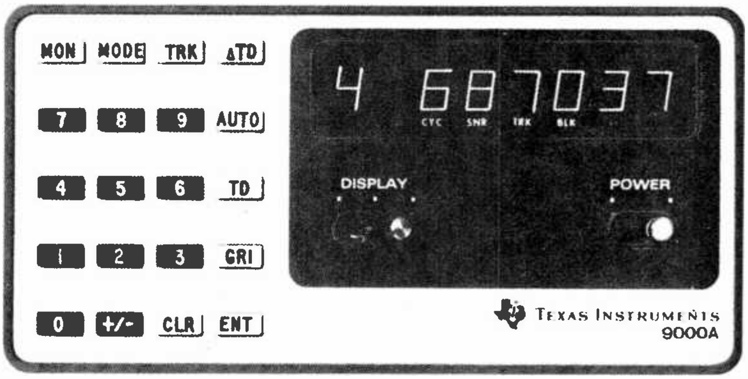
Simrad, Inc.
2215 N.W. Market St.
Seattle, WA 98107

SiTex
St. Petersburg/Clearwater Airport
P.O. Box 6700
Clearwater, FL 33518

SRD Labs
381 McClincey Ln.
Campbell, CA 95008

Texas Instruments
P.O. Box 405, MS3438
2501 S. Highway 121
Lewisville, TX 75067

Trimble Navigation
1077 Independence Ave.
Mountain View, CA 94043



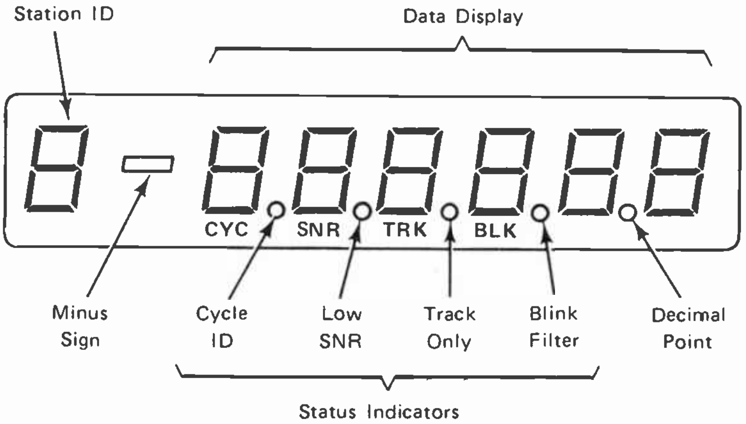


Photo at top shows location of controls and indicators on the TI-9000. The diagram below explains the various digital readouts.

- Automatically plotting Great Circle waypoints (navigators often prefer a Great Circle route on long trips).
- Automatic sequencing of several different waypoints.
- Keeping an "eye" on your boat when you are anchored and sounding an alarm if your boat drifts from its anchor.
- Keeping time on a precision 24-hour chronometer.
- Indicating elapsed time.

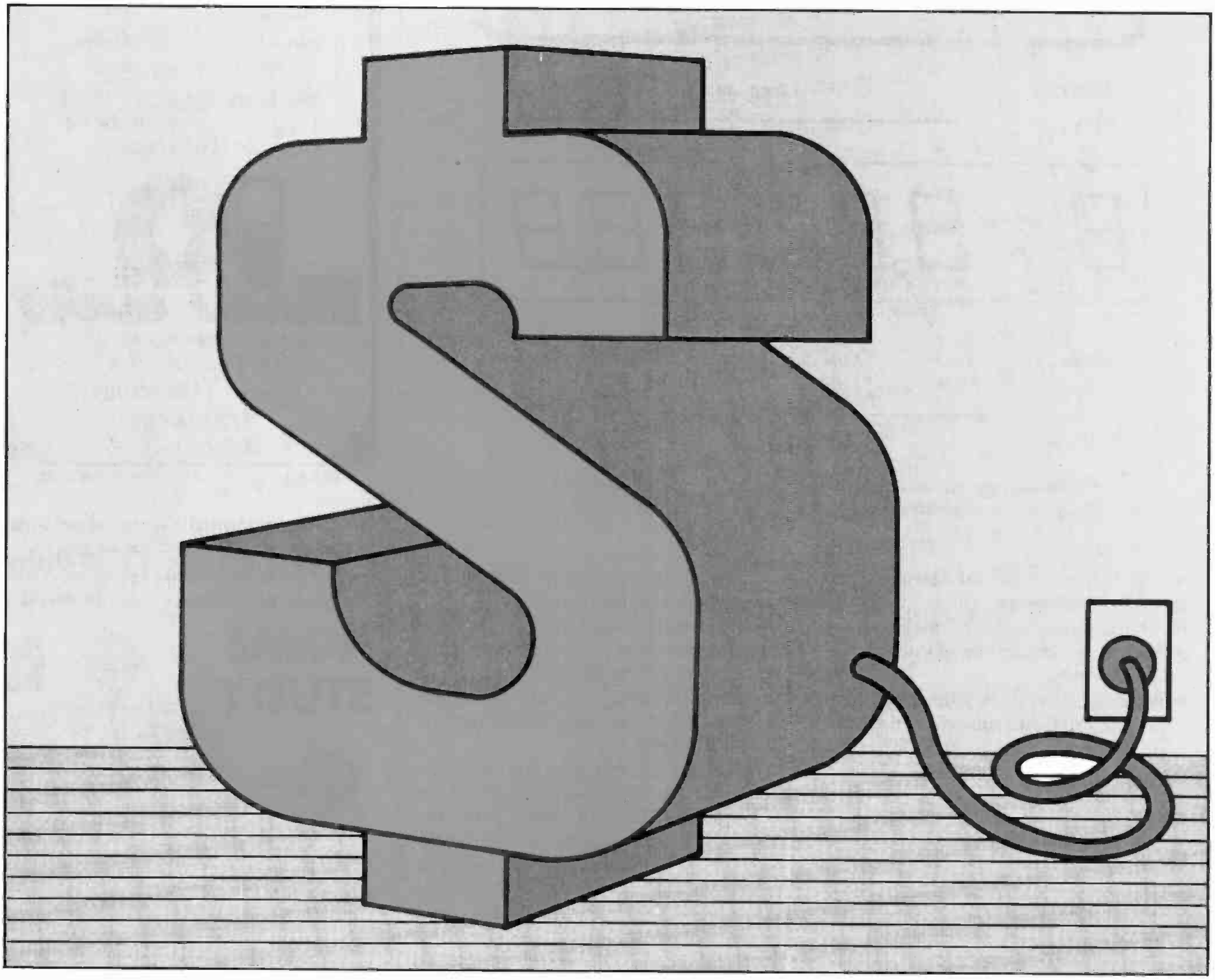
External acessories can extend the usefulness of many Loran receivers, and the list of options seems to be limited only by the imagination. For example, a remote analog steer-right/steer-left meter is available on some models. One company's remote-course deviation indicator not only indicates whether or not you are on course, but will also trigger an audible signal or light when you get within 0.5 nautical mile of your destination. Datamarine's small Course Deviation Indicator is designed into a round, waterproof, bulkhead-mounted case that permits use where it may be subjected to sea spray and waves.

One of the most interesting in the list of Loran-C add-ons is a chart recorder. It uses output data from some Loran receivers to drive a plotter that charts a permanent record of where you have been sailing. Its real value becomes obvious when you use it to literally steer your boat down a pre-drawn line on a marine chart. Other manufacturers use a CRT display instead of chart paper to produce an electronic video plotter. Data output from any Loran model can be used to turn your receiver into an electronic First Mate that can issue commands to your auto-pilot.

If the idea of your pilot "talking" to your auto-pilot makes you feel left out, be not jealous, O Brave Mariner. Texas Instruments has an option to lend vocal cords to its Model TI-9900. Using a speech synthesizer, the TI-9930 audibly reports your position periodically, your elapsed time from system turn-on, the speed, range and bearing to your next waypoint, the time to go to next waypoint, cross-track error, the signal-processing status of the Loran, what waypoints have been stored in its memory, and any Loran transmitter problems. It will also caution you about marginal signal reception, and warn you when prompt action must be taken.

Finally, the Northstar 7000 Loran, from Digital Marine Electronics, sports a real sense of humor in its memory bank. Instead of diplomatically calling to the attention of the operator that he or she has made an error, the 7000 display reads out "Baloney" or "No Way Jose." You, of course, can make the receiver walk the plank. ◇

Special Focus on Home Energy Saving



New "Vacation" Thermostat, Set to Just Above Freezing, Saves Heating Costs

by Tom Fox

HAVE you ever planned to take a winter vacation or a weekend ski trip and wondered what to do about the wasted heat in your home while it is vacant? Obviously, you cannot shut off your furnace because a freeze might cause your waterpipe to burst. So you set your thermostat to its lowest point, typically 54°F, as any energy-conscious person would. But you still waste energy since water doesn't freeze until the temperature reaches 32°F. Here's how to lower your thermostat further, to just above freezing, and perhaps save twice as much on your energy bill as compared to the 54°F setting. (See the Table at the end of this article for comparative savings.)

A True Energy-Saving Thermostat. A new temperature-sensing reed switch is the basis for design of the energy-saving thermostat. It can be reliably preset to a temperature between 35° and 40°F and requires only the simplest type of support circuitry. Moreover, no calibration whatsoever is needed.

The first step in wiring the energy-

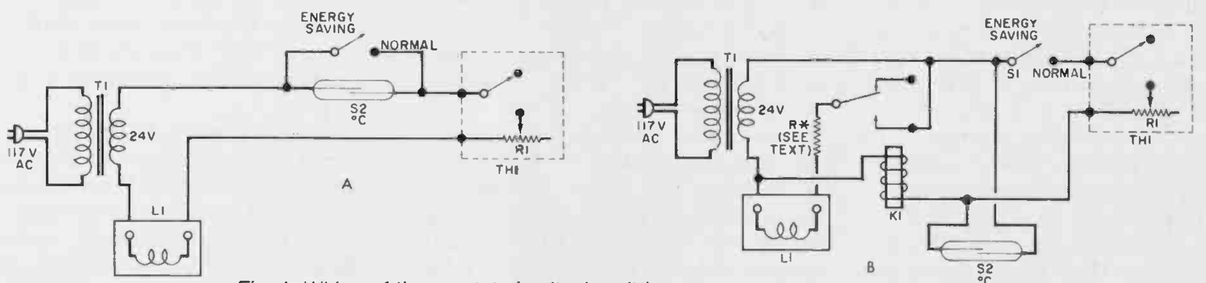


Fig. 1. Wiring of thermostat circuit when it is less than 375 mA (A) and more than 375 mA (B).

PARTS LIST (Fig. 1)

K1—24-V ac (75 ohms or more) relay, 2-A normally open contacts (Potter & Brumfield KA5AY-24VAC or Guardian 1310-4C-24VAC or equivalent)
R*—12-W (or more) resistor (see text)
S1—Spst switch (dpdt for 3-wire heating control system)(see text)
S2—Freeze sensor (MCI TS-5B19)
Misc.—Thermostat wire, solder, labels, screws, etc.

Note: The following is available from Magicland Electronics, 4380 S. Gordon, Fremont, MI 49412: MCI TS-5B19 freeze sensor (trip point guaranteed by MCI to be between 1° and 7°C) at $6.25 each, postpaid, via first class mail. Also available are the TS-5B19A (trip point 38°F ±2°F), TS-5B19L (trip point 35°F ±2°F), and TS-5B19H (trip point 42°F ±2°F) at $9.85 each,postpaid.

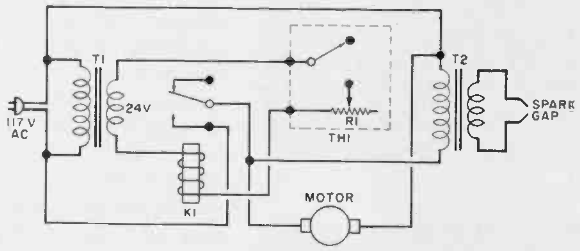
saving thermostat into your heating system is to find out how much current flows through your present thermostat. You can look up this information, but it's preferable to take measurements.

To measure the current, you will need an ac milliammeter that can read to 1000 mA. Disconnect the two wires from your thermostat and connect the meter's leads to these wires. Make a note of the current. If it is less than 375 mA, only a spst switch and a temperature-sensing reed switch are required to make a complete energy-saving system.

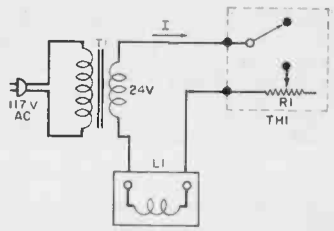
Now measure the resistance of your thermostat's heat anticipator. With the wires to the thermostat disconnected, set the thermostat as high as it will go, making sure the contacts close. Connect an ohmmeter across the thermostat's terminals and make a note of the measured resistance. This resistance we will call *R1*.

Figure 1A shows how to add an energy-saving thermostat to a furnace that requires less than 375 mA of control current. Be sure to use #18 thermostat wire when making connections. Locate switch *S1* near your present thermostat and label it NORMAL when it is closed and ENERGY-SAVING when open. The temperature-sensing reed switch, *S2*, can be mounted either next to the old thermostat or in an area of the house where freezing could be especially damaging while you're away.

TYPICAL FURNACE-CONTROL CIRCUITRY



A



B

Most, but not all, oil and gas furnaces use low-voltage (24 V ac) thermostat control systems. Figure A shows a simplified wiring diagram of a typical oil-fired furnace. *T1* is a 24-V transformer and *TH1* is a low-voltage thermostat with an adjustable heat anticipator (resistance *R1*). Relay *K1* has normally open contacts and a 24-V ac coil. The oil-pump motor and ignition transformer *T2* lead to the spark gap. (Numerous safety-related circuits and components of the furnace are not shown.)

The operation of a typical oil-fired furnace is simple. When the temperature of the thermostat drops below its setting, the contacts close and 24 V ac is applied to *K1*'s coil. With its coil energized, *K1* pulls its contacts closed and line voltage is applied to the motor and *T2*. The motor *M1* then starts pumping oil, while *T2* steps up the voltage to between 10,000 and 12,000 V. The high voltage from *T2*'s secondary causes a spark and the oil ignites. Not mentioned are the many safety-related circuits such as flame detector, oil-overflow detector, overheat controls, etc.

A grossly oversimplified wiring diagram that is typical of either a gas or oil furnace is shown in Fig. B. Here *L1* is either a 24-V relay or control-valve operator. *T1* and *TH1* are exactly the same as before. (For simplicity, the furnaces's other electrical parts are not shown.)

The operation of the device is simple. When *S1* is closed, the circuit operates exactly as it did originally—*S2* is bypassed and only thermostat *TH1* controls the valve operator *L1*. When *S1* is in the ENERGY-SAVING position, *S2* controls *L1* because *TH1*'s contacts will always be closed in the temperature range of interest, which is 35° to 40°F.

If you find that more than 375 mA normally flows through your present thermostat, it is best to have *S2* control a relay instead of controlling *L1* directly. This insures a long life for *S2*. The relay will then control *L1*. Figure 1B shows a suitable circuit for this.

In addition to relay *K1*, Fig. 1B shows optional resistor *R**. This is a 12-W or larger unit whose resistance is equal to that of the thermostat's heat anticipator *R1*. (*R** limits *L1*'s current to the same value it was originally. *R** is probably not needed in most systems and its use is optional. To be on the conservative side, however, it it recommended that *R** be placed in series with *L1*.)

When connecting *K1* to the furnace's circuit, make sure you use #18 thermostat wire. Mount *K1* in the same general area as the furnace's other electrical parts. As before, label *S1* NORMAL when closed and ENERGY-SAVING when open. Relay *K1* can be any type having a 24-V ac coil that draws less than 375 mA and has normally open contacts with a 2-A or higher rating.

Now, with *S1* in the NORMAL position, only *TH1* controls *K1*. The reason is that *S2*'s contacts are only closed when the temperature approaches freezing—which we assume never happens when *S1* is in the NORMAL position (except for a power outage or furnace failure). With *S1* in the ENERGY-SAVING position, *TH1* is disconnected from the circuit and only *S2* controls *K1*. When *K1*'s coil is energized, its contacts are pulled closed, 24 V is applied to *L1* and the furnace starts up.

The wiring diagrams shown in Fig. 1 pertain to 2-wire heating thermostat circuits as well as most newer types of heating/cooling thermostat circuits with 3, 4 or 5 wires. However, if you have a 3-wire, 24-V ac heating thermostat (rare today) that controls less than 375 mA, you can't use either circuit. But, don't despair! You can easily construct an energy-saving thermostat. See Fig. 2. The only significant change from Fig. 1A is that a dpdt switch is used instead of the spst type.

The best place to mount the temperature-sensing reed switch is close to your present thermostat. In addition to economizing on wire, this location will probably save the most energy since it is usually centrally located. Be careful, though! While the furnace will keep the area in the vicinity of the sensor well above freezing, some critical regions, usually located near an outside wall, may fall below freezing on a bitter cold night.

To be on the safe side, locate *S2* in a critical area. A good place would be near a water pipe that has caused trouble in the past. Actually, you can place as many sensors around the house as you like. By doing this, the circuit will continually monitor all areas that can be damaged by freezing. The furnace will go on whenever one sensor gets cold enough. (When wiring additional sensors into the circuit, be sure to connect them in parallel.)

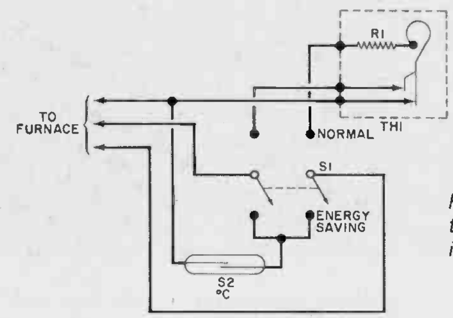


Fig. 2. Wiring for a three-wire thermostat system when current is less than 375 mA.

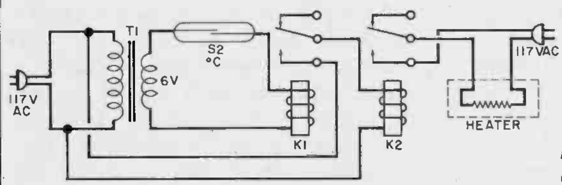


Fig. 3. Freeze-proof electric heater control.

PARTS LIST (Fig. 3)

K1—6-V ac (12 ohms or more) relay, 5-A normally open contacts (Potter & Brumfield KA5AY-6VAC or equivalent)
K2—120-V ac power relay, 15-A contacts (Potter & Brumfield PRD1AYO-120VAC or equivalent)
S2—Freeze sensor (MCI TS-5B19. See Parts List for Fig. 1)
T1—6.3-V ac transformer
Misc.—Electric heater (see text), electric plug, #14 wire, solder screws, etc.

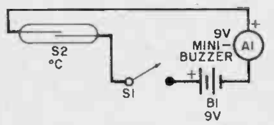
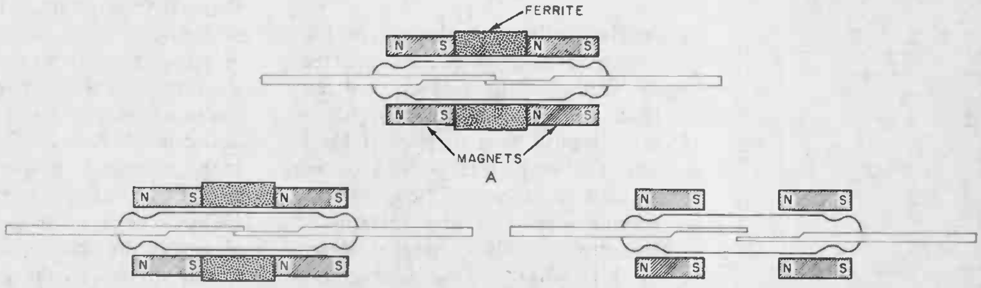


Fig. 4. Circuit for an audible frost-alert system.

PARTS LIST (Fig. 4)

A1—9-V solid-state mini-buzzer (Sonalert)
B1—9-V battery
S1—Spst switch (optional)
S2—Freeze sensor (MCI TS-5B19L. See Parts List for Fig. 1)

HOW A TEMPERATURE-SENSING REED SWITCH WORKS

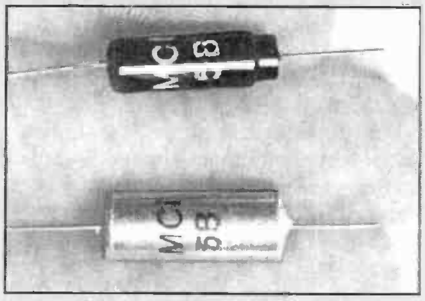


A temperature-sensing reed switch consists of a rhodium-contact reed switch hermetically sealed in glass, two permanent magnets that surround the glass, and a ferrite ring sandwiched between the magnets (Fig. A). The switch depends on the interaction of the magnets and the ferrite for its operation.

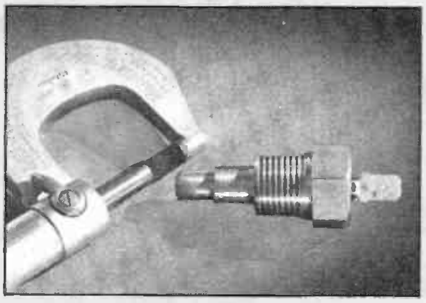
The ferrite ring is the temperature-sensing component of the device. It is magnetic below its *Curie temperature* but nonmagnetic above it. (The Curie temperature of a ferrite material is the temperature above which the ferrite's ability to conduct flux is severely reduced.) To get some idea of how temperature affects the sensor, refer to Fig. B. Here the temperature is below the ferrite's Curie temperature and thus the ferrite is magnetic. Notice how the magnetic flux lines travel easily through the ferrite. Since the ferrite is magnetic, the magnetic field in the area of the contacts is sufficient in strength to keep them closed.

Now assume the sensor is heated so that the ferrite exceeds its Curie temperature (Fig. C). The warmed-up ferrite is now nonmagnetic and its reluctance increases dramatically. Because of its high reluctance, the ferrite cannot easily conduct lines of flux. This results in a reduction in magnetic field strength near the reed switch's contacts. Since the magnetic force holding the contacts closed has now weakened substantially, the contacts open. (Note that since the ferrite is now nonmagnetic, it is eliminated from the drawing.) When the ferrite cools to below its Curie temperature, it becomes magnetic again. The magnetic field increases, so the contacts close once again.

The freeze sensor we are particularly interested in is the TS-5B19 manufactured by Midwest Components, Inc. (Muskegon, MI). It is a temperature-sensing reed



Temperature-sensing reed switches.



Metal-packaged freeze sensor.

switch with ferrite material that has a Curie temperature of approximately 39°F. These sensors come in metal or plastic packages. The metal-packaged sensor can withstand temperatures as high as 400°C (750°F), while the less-expensive plastic-packaged model is limited to use with temperatures below 125°C (257°F).

Though the switches are used primarily as freeze sensors here, the ferrite material can have a wide range of Curie temperatures from −10°C to 250°C.

Characteristics of the TS-5B19. Most factory-run TS-5B19's have a trip point near 39°F. MCI guarantees that all TS-5B19's will close their contacts before the temperature drops to 1°C (33.8°F) and will not close before 7°C (44.6°F). Note that all trip points assume falling temperatures. The rising temperature trip point is several degrees higher.

The TS-5B19 series of sensors have contacts rated at 10 W or 12 VA maximum. Maximum voltage is 100 V dc or 120 V ac. The contacts can carry up to 1 A but have only a ½-A "make" rating. The maximum recommended operating temperature is 257°F.

All temperature-sensing reed switches are magnetic in nature. Because of this, some precaution should be taken when locating most kinds, including the freeze sensor. The switches should be kept at least ⅛" from any iron or steel and at least ¾" from any magnetic-field producing device (i.e. magnet, transformer, motor, solenoid, similar sensors, etc.). It is also recommended that the leads not be cut. However, bending is okay. If these precautions aren't followed, the trip point will be changed.

The sensors are completely waterproof. Additionally, gasoline, motor oil, calcium chloride, or Freon has no effect on them. However, alcohol, strong sulfuric acid, and some other chemicals will destroy plastic-packaged models.

A Freeze-Proof Room. Some people have a small storage building or small room in an unheated garage that is unsuitable for storing items that must be kept from freezing. Also, some utility rooms or even half-baths are left unheated to economize. On a bitter cold night, this can lead to frozen and cracked pipes and other problems. If the area is sufficiently insulated and relatively small, it can be kept freeze-proof quite economically by using a 120-V, U.L. electric heater in conjunction with a control like the one shown in Fig. 3. This control is also suitable for keeping a small greenhouse frost-free.

In Fig. 3, *T1* is an inexpensive 6.3-V ac filament transformer typically available from surplus electronics stores. Relay *K1* has normally open contacts rated at 5 A and its coil is rated at 6 V, 500 mA ac (or less). Relay *K2* can be any 120-V ac power relay that has contacts rated at 15 A or more. Be sure to use #14 U.L. wire in this circuit. This type of circuit, with some modifications (such as replacing *K2* with a heavy-

ENERGY SAVING AROUND THE COUNTRY

	Average heating degree days	Average wintertime heating savings by using 38°F instead of 54°F	Average wintertime heating savings by using 38°F instead of 68°F
NORTHEAST			
Boston	6000	40-45%	80-90%
Cleveland	6154	40-45%	80-90%
New York	5000	45-50%	85-95%
NORTH CENTRAL			
Chicago	6300	40-45%	80-85%
Detroit	6325	40-45%	80-85%
Minneapolis	8310	35-40%	60-65%
MIDSOUTH			
Louisville	4640	45-50%	85-95%
St. Louis	4750	45-50%	90-95%
Washington, DC	4211	45-55%	90-95%
SOUTH			
Atlanta	3095	50-100%	90-100%
Dallas	2290	55-100%	90-100%
Memphis	3227	45-95%	90-95%
WEST			
Albuquerque	4292	45-50%	90-95%
Anchorage	10,911	30-35%	50-60%
Salt Lake City	5983	40-45%	80-90%
Seattle	5185	45-100%	85-100%
Spokane	6835	40-45%	80-85%

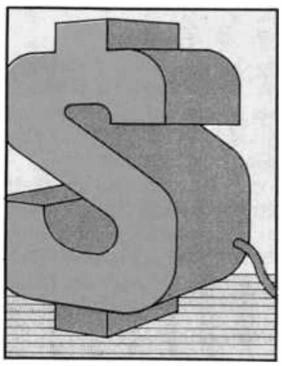
duty relay that has dpst contacts), can be used to control a 240-V ac electric heater.

A Simple, Reliable Frost Alarm. Often, one would simply like to be alerted to the fact that the temperature has dropped close to freezing. A typical application would be a frost alert for a garden. The temperature-sensing reed switch can be placed in the garden to sound an alarm when frost threatens.

The simplicity of the circuit is shown in Fig. 4. In addition to the sensor, a 9-V battery and a solid-state buzzer are all that are required. Switch *S1* is optional. Locate the sensor as close as possible to the plants you want to protect. The sensor can simply be set on the ground, if desired.

Another possible use of this circuit is as a freeze detector for unheated basements or in some simple solar hot-water systems. Since current only flows in the circuit when a freeze threatens, battery life should exceed one year.

The table at left shows how much you might expect to save in heating bills by using the methods described here. It depends, of course, on where you live and how far down you set your thermostat. ◇



Triac Motor Control for Warm-Air Systems Reduces Fuel Use and Eliminates Cool Spots

by Anthony Caristi

DOES the blower motor of your warm-air heating system have just one speed? If so, your furnace is not operating at optimum efficiency. In a warm-air heating system, the air should move through the heat exchanger of the furnace at a velocity that continuously varies with the temperature of the plenum.

Another shortcoming of your warm-air heating system as it is designed might be that the blower motor shuts off at times. Since a warm-air system has no inertia, you may feel a chill when the blower stops even though the room temperature is high enough to trip the thermostat and turn the burner off. Nowadays, warm-air systems are designed with a "continuous air circulation" feature. This means that the burner cycles on and off frequently, keeping the plenum warm enough to maintain continuous blower operation.

With the enexpensive and easy-to-build circuit described here, you can add both a variable-speed blower-motor control and continuous air circulation to your warm-air heating system.

Circuit Operation. The heart of the revised blower-motor control is a triac. A triac is a three-electrode semiconductor device that is triggered into conduction in response to a gate signal. The action of a triac is similar to that of a silicon-controlled rectifier (SCR), except that it can conduct current in both directions, as required in an ac circuit. As shown in the schematic (Fig. 1), a signal is applied to the gate of the triac through a thermister and diac *D2*. (A diac is a solid-state trigger device that has a breakdown voltage similar to that of a zener diode, except that it works in either direction.)

An RC time constant composed of thermistor *TCR1* and capacitor *C4* prevents the triac from delivering power to the motor for part of each half cycle of the 117-V ac waveform. When plenum temperature is low, *TCR1* has a high resistance. This lengthens the time required for the voltage to increase sufficiently to trigger the triac into conduction through *D2*. When plenum temperature is high, the triac is triggered into conduction earlier in the cycle, resulting in more power being delivered to the motor and higher operating speed.

A second trigger circuit, composed of *R2, C3,* and diac *D1,* is used to ensure that the motor operates at a minimum speed regardless of the temperature (and resistance) of the thermistor. A minimum blower speed is necessary since the furnace cannot operate with a blower turning too slow or not at all.

For heating and cooling systems, an optional switch has been included in the circuit so that the proportional motor control can be overridden during the cooling season. The switch provides sufficient gate signal to the triac to ensure maximum blower-motor speed.

Components *R1, C1, C2,* and *L1* are included in the circuit to smooth the steep wavefronts generated by the triac and help reduce radio-frequency interference, which is inherently produced in switching circuits such as this.

Construction. The circuit can be constructed on a small printed-circuit board measuring about 3" by 3". The only external components are the thermistor and optional switch *S1*. Figure 2 shows a full-size foil pattern, and Fig. 3 shows the parts layout.

Since this circuit is powered directly from the ac power line, all capacitors

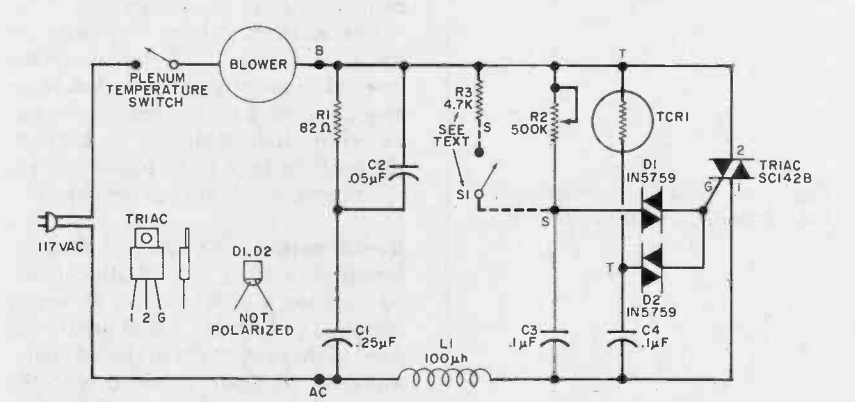


Fig. 1. The blower-motor control circuit is based on the use of a triac.

PARTS LIST

C1—0.25-µF, 200-V tubular capacitor
C2—0.05-µF, 200-V tubular capacitor
C3,C4—0.1-µF, 200-V tubular or disc capacitor
D1,D2-1N5758 diac or equivalent
L1—100-µH, 5-A choke (see text)
R1—82-ohm, ¼-W, 10% composition resistor
R2—500-kilohm, pc-mount potentiometer
R3—4.7-kilohm, ¼-W, 10% composition resistor
S1—Spst switch
TCR1—200-kilohm at 25°C thermistor (Keystone Part No. RL1004-104550-155-D1 or equivalent)
Triac—SC142B or similar

Note: The following are available from Anthony Caristi, 69 White Pond Rd., Waldwick, NJ 07463: pc board at $3.50; triac at $3.50; diacs at $2.00 each; thermistor at $5.00. Please include $0.50 for postage.

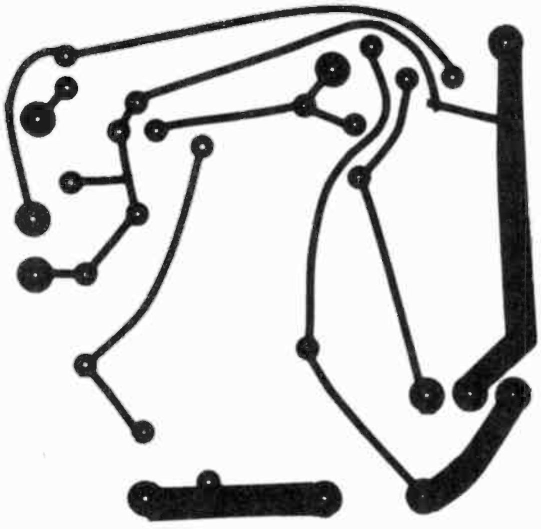


Fig. 2. Actual-size foil pattern for the printed circuit board.

must have at least a 200-V rating. Do not use low-voltage types designed for solid-state circuits.

The blower motor will draw several amperes through the triac during operation, which will result in some power being dissipated in the device. It is recommended that a small heat sink be used to help keep the triac from overheating. A simple heatsink can be constructed by bending a 1" by 3" piece of sheet aluminum into a U shape. Drill a hole through the center of the aluminum and mount the triac and heatsink to the printed circuit board with a #4 machine screw and nut. Use heat sink compound between the mounting tab of the triac and the heat sink for best heat conduction. Be sure to keep the heat sink completely insulated from any metal part of the furnace when installing the pc board.

Inductor *L1* can be easily constructed by winding about 15 turns of #20 enamel wire on a wood or plastic 3/8"-diameter form. The inductance of *L1* is not critical, but do not use wire of smaller gauge since *L1* must be able to carry the full load current of the blower motor without overheating. The same caution applies to the foil pattern which is shown in Fig. 2. Be sure to keep the conductive paths to the triac wide (as illustrated).

The pc board can be mounted inside the furnace where the other electrical controls are located. The schematic diagram and printed-circuit layout are marked with the letters AC, B, S, and T, which will help you identify connections to the external parts of the circuit.

Run a pair of wires for the thermistor from the "T" terminals on the pc board up to a convenient place on the plenum where the thermistor can readily sense temperature changes. Drill a small hole in the plenum sheet metal to insert the thermistor so that the air flow will pass over it. Be sure to insulate the thermistor and its connections so that no possible short-circuit to the metal parts of the furnace can occur.

If this should happen, the pc board or its components could be destroyed. Do not cover the head of the thermistor with insulation, since this will tend to make the component less sensitive to the changing temperature of the plenum.

Checkout and Adjustment. Before applying power to the furnace, check all connections to make sure the wiring is correct. To set the minimum blower speed, temporarily turn on the furnace by manually adjusting the plenum temperature switch or connecting a jumper across the switch to complete the circuit. (This must be done while the plenum is cool. If necessary, run the blower with the gas or oil burner off until the plenum is cool to the touch.) Then adjust *R2* for the minimum desired blower speed.

Now reset the plenum switch back to its original position (which should be somewhere between 90° and 110° F), or remove the temporary jumper. Set the room thermostat so that it calls for

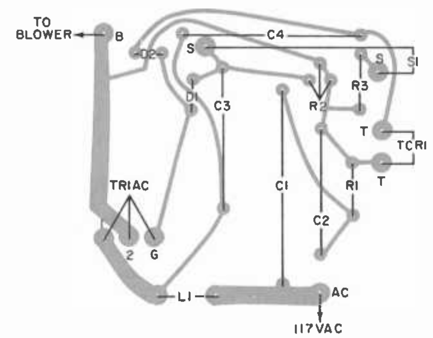
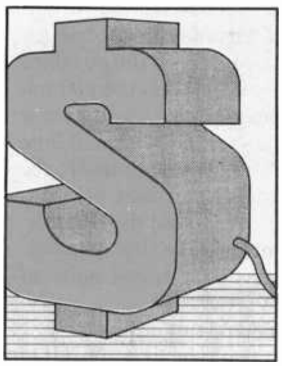


Fig. 3. Use this guide to assemble the components on the pc board.

heat. Now, as the furnace heats up and the blower comes on, the blower speed will automatically increase as the plenum temperature rises. Conversely, when the thermostat shuts the burner off, the blower speed will decrease as the plenum cools.

Ideally, the blower will continue to operate at minimum speed until the thermostat turns the burner on again. This continuous air circulation will greatly enhance the comfort level of your home, and will help you conserve heating fuel too. ◇



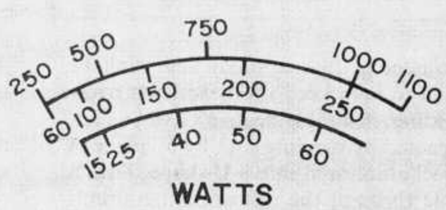
Power Meter Keeps Tabs of How Much Electricity an Appliance Uses

by Cass Lewart

WITH electrical and electronic products abounding in homes and electric power costs so high, it would be interesting and valuable to know how much power each one consumes. The inexpensive power meter described here enables you to accurately determine ac electric consumption for appliances rated between 15 and 1100 watts. It can also be used for diagnostic work when repairing appliances.

Circuit Operation. The current in the appliance under test passes through resistors *R1* and *R5*, *R6* and *R7*, or *R1* through *R5*, depending on which of three ranges is selected. A voltage drop of up to 2 V ac across the resistors operates panel meter *M1*. (The meter has a built-in rectifier.) Two zener diodes, *D1* and *D2*, and resistors *R8* and *R9* protect the meter from overload. Optional fuses *F1* and *F2* further protect the circuit components from overloads.

Fig. 1. Cut out this dial and glue it on the old meter.



The meter is calibrated directly in watts, assuming 117 V on the power line and a basically resistive load. If the appliance being tested consists of a motor with a light inductive load, divide the readings by 1.1. To obtain current in amperes, divide the reading by 117.

Construction. The unit can fit comfortably in a 5" x 3" x 6" plastic cabinet. (Do not use a metal cabinet for safety reasons.) Cut a 1 ⅞" round hole in the front of the cabinet for the panel meter, using the template provided with the meter. (An easy way to cut this hole is with a nibbler tool.) Then cut another hole in the front for switch *S1* and three holes in the back of the cabinet for sockets *SO1, SO2,* and the ac power cable. Put a rubber grommet into the hole to protect the cable insulation. Then install two tie-down terminal strips. Keep all resistors away from cabinet walls as the resistors may get hot.

The next step is to pry off the front cover of the panel meter and replace the dial. Remove the two Phillips screws and dial, being careful not to damage the pointer. Cut the new dial from Fig. 1 and glue it over the old dial. Then reassemble the panel meter. Wire the resistors and zener diodes as shown in Fig. 2.

Setup and Use. Plug the Power Meter into an outlet. There should not be any reading. If you know the approximate power rating (wattage) of the appliance you are going to test, plug it in the appropriate socket, *SO1* or *SO2.* If you don't know the approximate power rating of the appliance, always start with *SO1* (250-1100 W).

If you get a low (or no) reading, plug the appliance into *SO2* (60-250 W). If you still get a low (or no) reading, depress *S1* for the most sensitive range (15-60 W). Failure to follow these instructions can result in damage to the Power Meter.

After you take the reading, remove the Power Meter from the circuit and plug the appliance directly into the outlet. Remember, the range of the meter is approximately 15 to 1100 W. It should not be used with appliances such as air conditioners, large electric stoves, or dryers that draw more than the maximum current.

Estimating Electricity Cost. You can estimate how much it costs to run a particular appliance like a tube-type color TV set by using the following

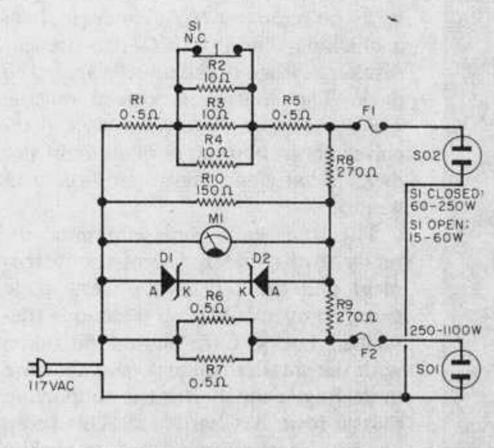


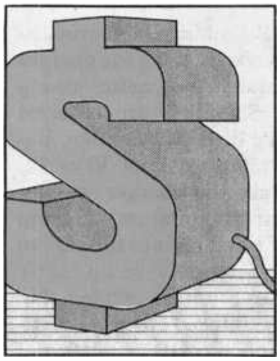
Fig. 2. The range of the meter is determined by which socket is used and whether S1 is open or closed. the zener diodes and R8 and R9 protect the meter.

PARTS LIST

D1,D2—4-V zener diode
F1—5-A fuse (optional)
F2—15-A fuse (optional)
M1—VU meter (Calectro D1-930 or equivalent, see text)
R1,R5,R6,R7—0.5-ohm, 10-W resistor
R2,R3,R4—10-ohm, ½-W resistor
R8,R9—270-ohm, ½-W resistor
R10—150-ohm, ½-W resistor
S1—Spst normally closed, pushbutton switch, 3-A rating or better
SO1,SO2—117-V jack
Misc.—Hardware, plastic cabinet, wire solder, etc.

method. First determine how much electricity the TV set uses with the Power Meter (approximately 350 W). Next, check the cost of electricity in your area (in a typical residential area like northern New Jersey, cost is currently \$0.09 per kilowatt-hour). Then estimate the time of operation. If the set were used for six hours each day, the cost of electricity could be calculated as shown here.

350 W × 6 hr/day
× 30 days/mo × \$0.09/1000 W-hr
= \$5.67/mo. ◇



How to Use Solar Energy to Recharge Your Batteries

by Ed Karns

THE prices of photovoltaic cells, commonly called solar cells, are dropping to the point where experimenters can start exploring solar-power applications.

Since solar cells generate power only when illuminated, they are popularly used to charge batteries. Such solar-powered battery chargers are easy to make. You can get started quickly in this energy-related area with the four simple designs presented here. Although some of the designs illustrated were developed for use with radio-controlled model airplanes, they can be used for many other solar chargers.

Basic Power. The circuit shown in Fig. 1 was used to charge a nominal 9.6-volt battery to power a radio-controlled (RC) transmitter. The "rule-of-thumb" is that the number of solar cells to use is equal to the required battery voltage divided by 0.4. (The typical voltage that most solar cells generate in sunlight is 0.45 V, with 0.4 chosen here to provide a design cushion.) The current requirement of the cells should be sufficient to charge the battery. Thus, in this application, 24 cells were used (9.6/0.4).

When the voltage across the solar array shown is greater than the battery voltage, diode *D1* is forward-biased, allowing current to flow to the battery. However, if the battery voltage is higher than that of the solar array (due to a passing cloud, etc.), diode *D1* is reverse-biased and acts as an open switch to protect the array. Since the voltage drop across *D1* is 0.7 V (typical for a silicon diode), it is less than 10% of the total voltage and its effect can be ignored.

The current capacity of a solar array is determined by the required load current, the amount of time the load is used, and the length of time the array is exposed to light.

Since a solar cell delivers its maximum power in bright sunlight, the effects of cloudy or hazy days must be compensated for. Since the charging rate for the battery used in Fig. 1 was about 90 mA, the solar array was designed to deliver more current to account for the dark intervals. This is why the author elected to use 150-mA solar cells.

Depending on the brightness of the sunlight, the solar array can deliver 12 or more volts (at reduced current). Since a NiCd battery "likes" to be charged to at least 1.35 V per cell, and there are eight cells in the 9.6-volt battery used, the total voltage applied to the battery should be limited to 10.8 volts (1.35 × 8). Zener diode *D3* was selected to keep the supplied voltage to 11 volts (the closest zener to 10.8 volts). The voltage drop across silicon diode *D1* is the same as that across *D2*, so that the voltage drop across *D3* is equal to the maximum voltage across the battery. Since the load may not always be plugged into the solar array, zener *D3* should be capable of dissipating all the array power without destructing. This is why a 5-watt zener is used in this 1-watt circuit.

The circuit shown in Fig. 2 was designed so that the array could be mounted inside the wings of an RC airplane, with a "transparent" covering.

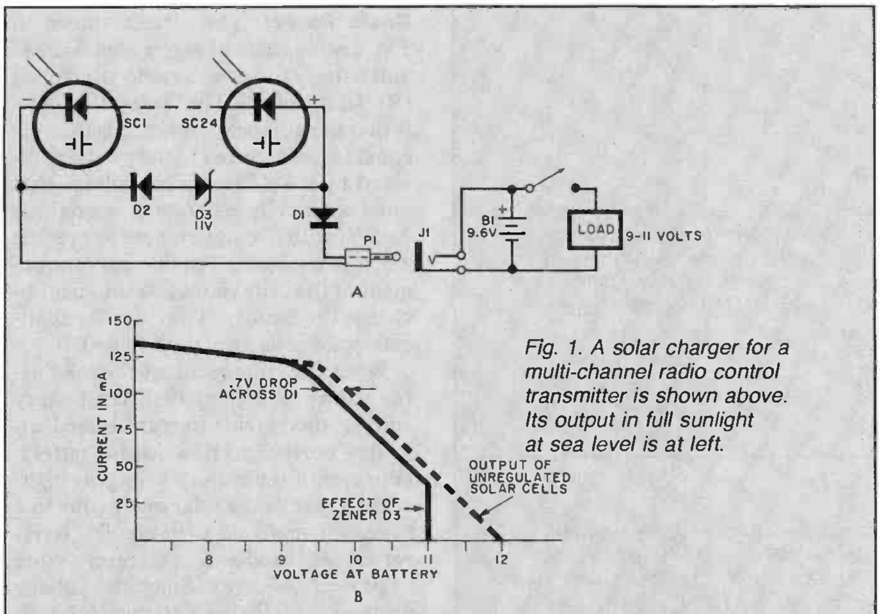


Fig. 1. A solar charger for a multi-channel radio control transmitter is shown above. Its output in full sunlight at sea level is at left.

PARTS LIST (Fig. 1)

F1—9.6-V rechargeable battery
D1, D2—IN4001 diode (or similar)
D3—11-V, 5-W zener diode (SK3392 or similar)
J1—Miniature connector
P1—Miniature plug
SC1-SC24—150-mA, edge-cut solar cell
Note: The following is available from Departure Co., 339 Myrtle Ave., Cotati, CA 94928: complete kit of parts including solar cells, diodes, hookup wire, solder, etc. (No. 150-10) at $65. Also available separately are individual 150-mA solar cells (No. 150-1) at $2.10 each. California residents, add 6% sales tax. For UPS shipment in US, add $3.

To maintain balance, the array was divided in half, with one half in each wing. The battery had to handle the RC receiver and the servos used to control the airplane.

In this particular application, the load (receiver and servos) was about 50 mA when the servos are idle (about 80% of the time), reaching about 300 mA when two or three servos are operating. We estimated an average drain of about 120 mA from the battery. When this amount is added to the losses due to the "transparent" array covering (estimated at 20 mA), and the misorientation of the arrays with the sun (estimated at 20 mA), the total becomes about 160 mA. Since there is always the possibility of extensive cloud cover, coupled with the fact that we do not like to crash an expensive RC plane due to lack of control, we elected to overspecify the solar array by 100%, with the closest cells having a 300-mA capacity.

Note that blocking diode *D1*'s voltage drop of 0.7-volt is almost 20% of the 4.8-volt battery voltage and must be compensated for in the voltage portion of the array. Since 4.8 volts requires 12 solar cells (4.8/0.4), to compensate for the *D1* drop, 14 cells (5.6 volts) were used, seven on each side. Note that the array voltage can exceed 7 volts depending on light level and loading. Zener diode *D5* coupled with diodes *D2, D3,* and *D4* limit the array voltage to a maximum of 6.4 V (4.3 + 0.7 + 0.7 + 0.7). When the *D1* drop is accounted for, 5.7 V reaches the battery. *LED1*, connected across the three silicon diodes is optional, and indicates when the arrays are delivering their rated power. The voltage drop across *D2, D3,* and *D4* (all silicon diodes) is 2.1 V, enough to operate the LED.

Regulated Power. The circuit in Fig. 3 shows the ability of a low-power (50-mA cells) solar charger to do a large job. The load was a digital meter having a 750-mA current requirement. Since the device is used only about once every other day (at most), and then for less than five minutes, the 50-mA solar array is adequate.

Note the absence of a zener diode. The battery is allowed to float up to about 14.5 V since the load is protected by 5-volt regulator *IC1*. Always include a blocking diode (like *D1*) to prevent discharge when the solar cells are in the dark. The charger is placed on the workbench close to a window, and receives about two hours of sunlight per day, about four days per week in winter.

The solar cells were laminated directly to the metal case of the instrument and the cell arrays were made using an oven-soldering technique (described later). Care should be taken with the smaller cell arrays as they are quite fragile until after the supporting plastic resin has hardened. This setup has been in operation for quite a while without resorting to a line-powered charger.

The circuit shown in Fig. 4 uses 600-mA solar cells and was designed for a small (28-foot) sailboat that spends its winter moored in the bay and thus requires marker lights. This charger provides enough power to operate the lights and a small electrical bilge pump. The boat goes for weeks before the auxiliary engine is required to fully charge the battery.

Diode *D1* and fuse *F1* prevent the destruction of *LED1* and the solar array in the event of accidental polarity reversal (as in the case of "jump-starting" the engine or other odd circumstances). When all is correct, *LED1* will glow steadily, going out only when the battery is under a heavy load or in the event of a short in the boat's electrical system.

The solar cells should be laminated to marine plywood, making the charger corrosion-resistant and quite strong mechanically. Scratches are repaired by painting on a little plastic resin. Extra solar cells (36, instead of 30 or 32) are used because the charger was intended to be mounted flat on the cabin roof instead of tilted up into the sun, to insure sufficient output even on partly cloudy days and in the winter. No maintenance is required except periodically washing off the salt deposits and adding distilled water to the battery. *PS1* is a weatherproof photoswitch that applies power to marker lamps *L1* and *L2* when it gets dark.

An excellent trickle charger for automotive 12-V batteries can be made by using thirty 150-mA solar cells with a voltage-regulator circuit such as that shown in Fig. 4. The entire solar array can be made into a square about 8" on a side and about ¾" thick, using ⅜" plywood, #16 (or heavier) leads, and large alligator clips (paint the positive one

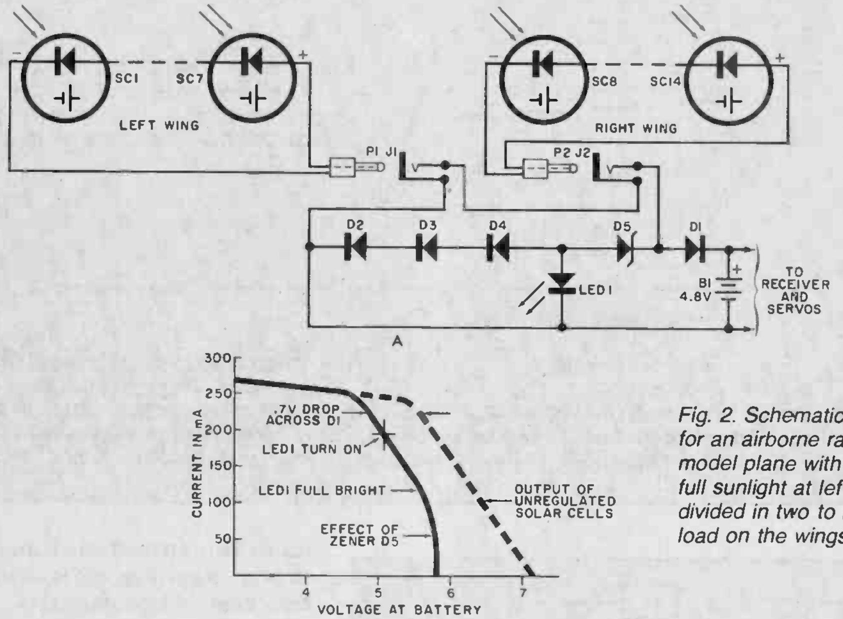


Fig. 2. Schematic of a solar charger for an airborne radio-control model plane with its output in full sunlight at left. The array is divided in two to balance the load on the wings of the plane.

PARTS LIST (Fig. 2)

B1—4.8-V rechargeable battery
D1-D4—IN4001 diode (or similar)
D5—4.3-V, 5-W zener diode (SK3380 or similar)
J1, J2—Miniature connector
LED1—20-mA red light emitting diode
P1,P2—Miniature plug
SC1-SC14—300-mA solar cells

Note: A complete kit of parts, including solar cells, diodes, LED, etc., is available (No. 300-5) for $85. Also available separately is the 300-mA solar cell (No. 300-1) at $5.80 each. See Fig. 1 for ordering information.

red). A fully charged lead-acid battery will survive −50° F without freezing. This is an important consideration for vehicles left outdoors and unused for long periods during the winter.

The trickle charger will bring a low auto battery up to a full charge with about eight hours of full sun and will not interfere with automotive voltage-regulation circuits.

Acquiring Solar Cells. A great many mail-order houses have solar cells in their catalogs. Some of these cells are factory-fresh, others are edge cuts left over when square cells are cut from round silicon wafers, and still others are rejects that do not deliver 100% of their rated power. Real bargains are available, but it is a good idea to always test every cell. A 100-W light bulb, placed 6 to 8 inches above a cell, should generate 0.45 to 0.52 V and at least 25% of the cell's rated current.

Unless you intend to provide a solid mount for your cell arrays, try to avoid cells that are mechanically weak. Also, stick to blue/gray cells, as these have an anti-reflective coating and will generate power even when the sun is close to the horizon (high incidence angle).

Examine the grid pattern on the sensitive surface of the cells, and look for a lot of small grid lines that radiate out from a common point or common bus. The less efficient cells have only three or four thick grid lines.

Avoid cells without a solder plating on the rear. Broken solar cells can be repaired, but it requires patience and a steady hand.

Construction Hints. Solar cells are manufactured in high-temperature ovens, so they are not bothered by soldering-iron temperatures. Use irons of 25 to 60 W, and don't press down on the delicate cells. Soldering on the back (positive contact) is usually only a matter of applying enough heat to make a shiny solder puddle, not a dull, gray blob. Solder time is usually about 10 seconds, although reheating is no problem.

Soldering on the grid pattern of the active side (negative contact) can present some difficulties. Try to avoid reheating a grid line more than two or three times as the exotic metals in the grid can flow into the solder and away from the cell. Perform all soldering operations on a piece of white paper as the hot cells can pick up dirt that might not come off after cooling.

Some solar cells lend themselves nicely to the oven soldering technique. The 50-, 100-, and 150-mA cells are ideal for this. Deposit a small drop of solder at the point of contact on the back side, and a small solder trail on the main grid line on the front. Arrange a group of 6, 8, or 10 cells in the bottom of a Pyrex cake dish so they overlap at the points of contact. Then put the dish in a household kitchen oven (not a microwave), set at 500 to 550°F, and allow it to "bake" for about 20 minutes.

The solder will reflow and make a very good electrical and mechanical connection. Let the dish and solar array cool down before removal from the oven in case the solder is still liquid. If the cell array sticks to the dish, use a little alcohol or acetone to dissolve the

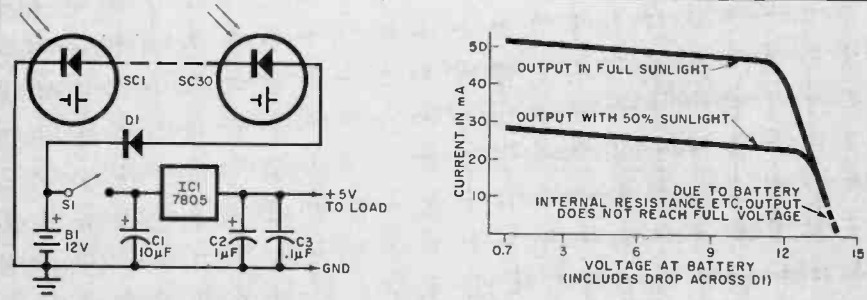


Fig. 3. Using a low-power solar charger on a digital meter having a 750-mA current requirement. The device is seldom used so the 50-mA output is adequate.

PARTS LIST (Fig. 3)

B1—12-V rechargeable battery
C1—10-µF, 25-V electrolytic
C2—1-µF, 10-V electrolytic
C3—0.1-µF, disc capacitor
D1—IN4001 diode (or similar)
IC1—7805 5-V regulator
S1—Spst switch
SC1-SC30—50-mA, edge-cut solar cell
Note: A complete kit of parts, including solar cells, diodes, capacitors, etc., is available (No. 050-12) for $37.50. Also available separately is the 50-mA solar cell (No. 050-1) at $1.10 each. See Fig. 1 for ordering information.

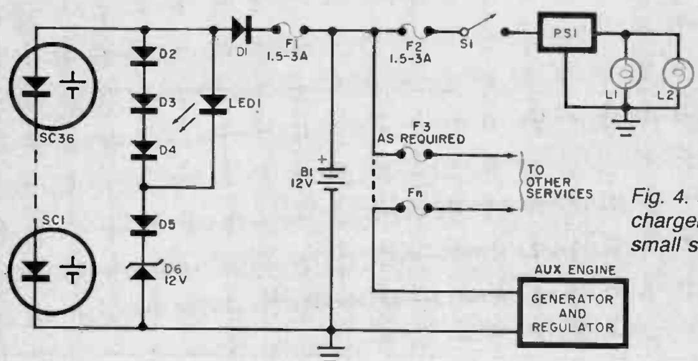


Fig. 4. solar charger for a small sailboat.

PARTS LIST (Fig. 4)

B1—12-V deep-cycle marine battery
D1-D5—IN4005 diode (or similar)
D6—12-V, 50-W zener diode (ECG5254 or similar)
F1,F2—1.5-to-3-A fuse
LED1—20-mA red light emitting diode
PS1—Weatherproof photo switch for 12-V system
S1—Spst switch
SC1-SC36—600-mA solar cells
Note: A complete kit of parts, including solar cells, diode, LED, etc., is available (No. 600-12M) at $385. Also available separately is the 600-mA solar cell (No. 600-1) at $10.60 each. See Fig. 1 for ordering information.

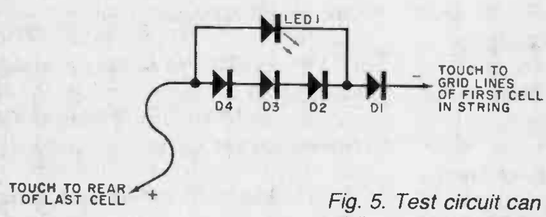


Fig. 5. Test circuit can be used with groups of five to 500 cells and outputs of 10 mA to 1A.

PARTS LIST (Fig. 5)

D1-D4—IN4001 diode (or similar)
LED1—20-mA red light emitting diode

rosin. This method eliminates a lot of step-by-step wiring and is often used by solar-charger manufacturers.

Testing Solar Arrays. The test circuit shown in Fig. 5 can be used with groups of five to 500 cells, and current outputs of 10 mA to 1 A. *LED1* will glow when any group of five or more cells are positioned 6" to 8" from a 100-W light bulb. The diodes bypass everything over about 2.1 V so *LED1* is properly biased. The solar cell arrays are inherently short-circuit protected, so the only limiting factor is the ability of the diodes to pass current. For cell arrays with outputs up to 3 A, use 1N1056 or 1N1226 diodes, or similar.

Mounting Solar Cells. Cells should be positioned by laminating the groups of tested cells to anything relatively rigid, such as 3/8" plywood or 3/64" aluminum sheet. Give the surface a couple of thick coats of clear plastic resin (clear fiberglass resin is available at hobby, boat, or auto-body shops), and allow to set.

Then add a third coat. While it is still wet, fit the assembled and tested solar cell array in place. Finally, paint on three or more coats of plastic resin to completely encapsulate the cells, hook-up wire, diodes, and LED. This makes the entire package corrosion-resistant. If you are mounting onto metal, the plastic will insulate the cells.

There are many companies that make available silicon photovoltaic cells for solar-power use, including Radio Shack and Edmund Scientific (Barrington, NJ). Also, the parts list includes a supply source for parts used in the projects presented here. ◇

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A 16-BIT **MATH PACKAGE** FOR ELF COMPUTERS

Software provides all basic mathematic functions and operations on a minimum 1802-cpu configuration

BY R.S. FITZGERALD

WHILE there are many cassette-based programs for the Elf microcomputer based on the 1802 cpu, there are few that run on its minimum configuration of 256 bytes. This article describes a 16-bit mathematics package that will indeed operate in a minimum system. The package includes operators and functions for addition, subtraction, multiplication, division, negation, and absolute values. All of these are implemented in a package using only 134 bytes.

Since this package, which we call "MATH 16," depends upon the use of the stack operations, it would be best to review them before discussing operation of the package. The stack is a variable-sized data-storage area that can be located in any convenient memory area. It is addressed by a pointer called the stack pointer (SP). The stack grows in size as the SP moves upward (lower memory addresses), much like a stack of dishes in a spring-loaded dish compartment. Also like a stack of dishes, it shrinks as the bytes are removed. Stack operations are defined in "Stack Operations—A Review," accompanying this article.

The object code representation of "MATH 16" appears in Table I. The program is assembled starting at location 70 hex. This allows room for 5 operands on the stack in a 256-byte Elf (probably more than you'll ever need), and ample space for some type of monitor in low memory. Of course, if your Elf (or any other 1802-based microcomputer has more than 256 bytes of memory, "MATH 16" can be moved around to suit your needs. If you intend to do this, remember to modify the addresses in your calling routines and the jump addresses within "MATH 16."

The stack can exist any place in memory that is convenient, the only restriction being that the stack pointer (RX) must be R_2. All of the subroutines leave RX pointing at the next available byte on the stack. Thus, the value in the stack pointer will be one less than the address of the most-significant byte of the number on the top-of-stack (TOS). Each of the functions is terminated with a SEP R_3 instruction to return to the calling routine. If your driver routine uses some other register than R_3 as the program counter, these SEP instructions must be changed to reflect this.

Table II lists the entry point addresses for the various "MATH 16" subroutines. The functions are executed by performing a subroutine call to the address corre-

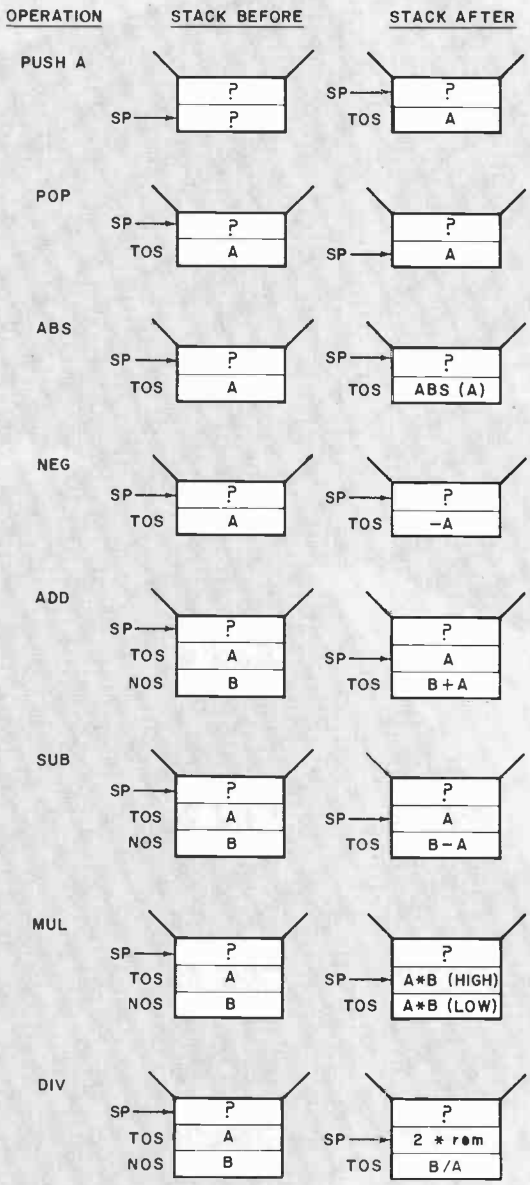
TABLE I—MATH 16 MACHINE-LANGUAGE PROGRAM

70	60	72	BF	72	60	F5	73	9F	75	73	D3	60	72	BF	72	60
80	F4	73	9F	74	73	D3	60	F0	73	FE	CF	D3	C4	60	60	F8
90	00	F7	73	F8	00	77	73	D3	60	72	BF	F0	AF	F7	FE	73
A0	52	F8	11	AE	F8	04	AD	F0	76	52	60	2D	8D	3A	A7	22
B0	22	22	2E	8E	C6	D3	C4	22	3B	A4	12	8F	F4	73	9F	74
C0	52	30	A4	60	72	BF	F0	AF	F7	FE	73	52	F8	11	AE	60
D0	60	60	F8	04	AD	F0	7E	73	2D	8D	3A	D5	60	60	2E	8E
E0	C6	D3	C4	8F	F5	73	9F	75	52	33	CF	60	8F	F4	73	9F
F0	74	52	FC	00	30	CF	00	00	00	00	00	00	00	00	00	00

STACK OPERATION—A REVIEW

Shown here are some pictorial representations of various stack operations such as PUSH, POP, and all of the operations performed by "MATH 16." Each box on the stacks in the drawing represents one data item or two bytes. Remember that the stack pointer is left pointing at the next available byte on the stack. For reference purposes, here are the terms involved.

Term	Meaning
LIFO Stack	The computer analogy to a pile of dishes. The last item (plate) to be placed on the stack (pile) will be the first one removed, hence the name Last In First Out Stack. Most often, the LIFO is omitted.
TOS	An acronym for Top Of Stack. This name refers to the data item that has been most recently placed on the stack.
NOS	An acronym for Next On Stack. This refers to the second data item on the stack.
Stack Pointer	The register that is used as a pointer to reference data items on the stack. Denoted RX in the 1802.
PUSH	To PUSH an item on the stack means to add another item to the stack and adjust the stack pointer so that it is pointing at the next available byte. A PUSH causes the stack to "grow" toward address 0000. STXD (73) is used in the 1802 to PUSH data.
POP	The opposite of PUSH. The IRX (60), LDXA (72) instruction sequence is used to implement this function.



sponding to the function desired. For example, the recommended calling procedure for the multiply function is shown in Table III.

At this point, it will be instructive to refer again to "Stack Operations—A Review." The illustrations show what happens when the various arithmetic operations are performed. As you can see, some of the functions operate on only one number (ABS, and NEG), while others operate on two numbers. Both types will be discussed.

The one-operand functions take their operand from TOS, perform the selected operation on that number, and return the result to TOS. With these functions, the stack neither grows nor shrinks.

The function NEG replaces TOS with the negative of itself. As an example, 0001 becomes FFFF (-1 in two's complement notation). ABS will return the absolute value of TOS. If the TOS contains FFFE (-2) before the call to ABS is made, the value after ABS has been called will be 0002.

The two-operand functions take both of their operands from the stack and return the result to the old NOS. The stack pointer is then adjusted so that the old next on-stack (NOS) becomes the new TOS (that is, the stack shrinks by 2 bytes). Care must be taken if some intermediate result on the stack needs to be saved for a later operation since the stack pointer is modified and NOS is overwritten by the new TOS. A good place to save these intermediate results is in RC because it is not modified by any of the "MATH 16" operations. Actually, the only registers that "MATH 16" deals with are: R_2, R_3, R_4, RD, RE, and RF.

As the name implies, ADD will sum TOS and NOS. As with all of the two-operand functions, the stack pointer will end up pointing two bytes higher than when it started out (SP = SP + 2).

The function SUB will subtract TOS from NOS. If you are really short on memory space, the SUB routine can be deleted. This same function can be achieved by a call to NEG, then to ADD. This saves 11 bytes.

The subroutine MUL computes the product of the *unsigned* numbers at TOS and NOS. The fact that unsigned numbers are used means that a result of FFFF does not indicate a result of -1 as might be expected. Rather, it indicates a result of 65535.

As with the multiply subroutine, DIV operates on unsigned numbers. In this case, the operand at NOS is divided by the operand at TOS. Since all of the subroutines operate on integers, no fractions can be obtained with DIV. The division routine does not check for division by zero. This condition must be avoided for DIV to produce meaningful results.

(Continued on page 66)

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1.
2

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4.

3.

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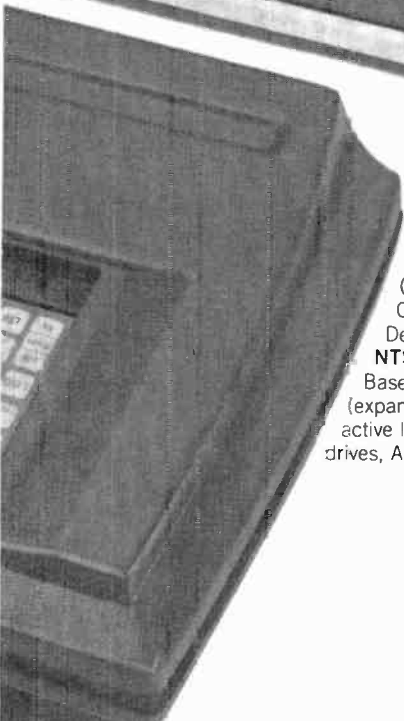

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TABLE II—ARITHMETIC FUNCTION ENTRY POINTS

Name	Function	Call Address
SUB	Subtraction	70
ADD	Addition	7B
MUL	Multiplication	98
DIV	Division	C3
ABS	Absolute Value	86
NEG	Negation	8D

TABLE III—CALLING PROCEDURE

Address	Contents	Mnemonic	Comments
N	F898	LDI A(MUL)	.SET UP SUBROUTINE
N+2	A4	PLO R4	.PROGRAM COUNTER
N+3	D4	SEP R4	.CALL MULTIPLY FUNCTION
		*	
		*	
		*	

It is interesting to note that the multiply and divide subroutines have some nice features which have not yet been mentioned. The multiply routine actually performs a 32-bit multiplication, but the stack pointer is adjusted, upon exit, to point at the least-significant 16 bits of the product. If you desire a 32-bit product, simply decrement the stack pointer twice by including two DEC R_2 instructions in your driver routine after the call to MUL.

The divide subroutine, on the other hand, only operates on 16-bit numbers. However, if the stack pointer is decremented by 2 after the division operation, the number on the TOS is two times the remainder of the previous division. The true remainder can be obtained either by shifting this number right one bit or by pushing a word of 0002 on the stack and calling the divide subroutine again.

Applied Example. The program segment in Table IV shows how to multiply two numbers using "MATH 16." Note that the least-significant byte of a 16-bit number is stored at address X, while the most-significant byte is stored at address X−1. This convention is used throughout.

After this routine is executed, the new TOS will contain 2710, which is 10000 in decimal notation.

"MATH 16" does have some limitations, such as error checking and integer-only arithmetic. But it can still provide one with a powerful tool for the 1802 system. ◇

SOFTWARE AVAILABILITY

The following are available from the Softek Co., Box 4232, Santa Fe, NM 87501: A documented source listing of "MATH 16" plus several sample applications of the package for $2.50 (item MATH 16S), and a quick-reference guide for the 1802 cpu's instructions and respective opcodes for $1 (item 1802Q).

TABLE IV—MULTIPLICATION PROGRAM

Address	Contents	Mmemonic	Comments
N	F8E8	LDI E8	.PUSH THE
N+2	73	STXD	.DECIMAL NUMBER
N+3	F803	LDI 03	.1000 ONTO
N+5	73	STXD	.THE STACK
N+6	F80A	LDI 0A	.PUSH THE
N+8	73	STXD	.DECIMAL NUMBER
N+9	F800	LDI 00	.10 ONTO
N+11	73	STXD	.THE STACK
N+12	F898	LDI A(MUL)	.SET R4 EQUAL TO
N+14	A4	PLO R4	.MUL ENTRY POINT
N+15	D4	SEP R4	.CALL MULTIPLY
N+16	00	IDL	.HALT

PROGRAMMING EPROM's WITH A SMALL COMPUTER

BY JOHN DOOLITTLE AND SLOBODAN TKALCEVIC

Part 2

IN Part 1 of this article, we discussed how EPROMs can be put to good use in expanding your digital design work. We then presented a circuit that can be used as an interface with a small computer such as the TRS-80 to program EPROMs. We are ready to proceed now with constructing the circuit.

Construction. The EPROM Programmer is designed so that all components except for the ac power supply are mounted on a double-sided printed circuit board such as that shown in Fig. 7. The four lines from the transformer secondary (color-coded blue, yellow, red, and green) are soldered to the corresponding points on the printed circuit board marked B, Y, R, and G. Connection to the computer is done through a 40-pin card-edge connector that is compatible with the expansion bus of the TRS-80 CPU or Expansion Interface unit. All components are mounted on the bottom side of the board—except the zero insertion force EPROM socket, the personality module socket, and the indicator LEDs. These parts mount on top of the board. The printed circuit can be neatly mounted in a 7″ by 6″ by 3″ aluminum enclosure using ¼-inch spacers and allowing the topside components to protrude through the top panel. Access to the board's edge connector is made through a notch in the rear panel.

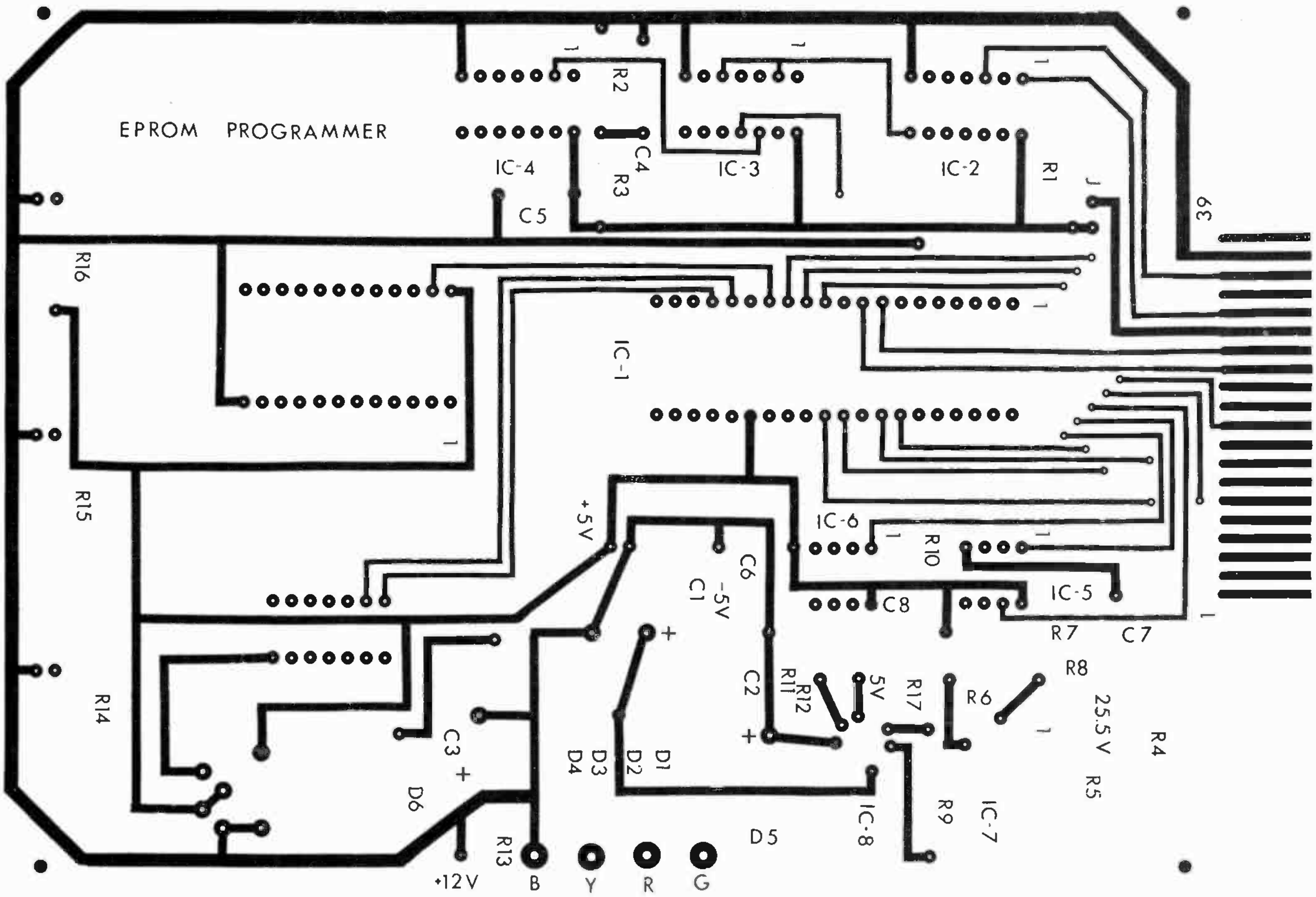
With all components soldered in place, switchable voltage regulators *IC7* and *IC8* should be adjusted (*R8* and *R12*) to develop 25.5 V and 5.0 V, respectively, before connecting the EPROM Programmer to the computer. The personality module socket is a convenient test point for the constant −5-V (pin 1) and 12-V (pin 4) supplies as well as for the switchable 5-V (pin 2) and 25.5-V (pin 3) supplies. The constant 5-V supply can be measured at pin 24 of the EPROM socket.

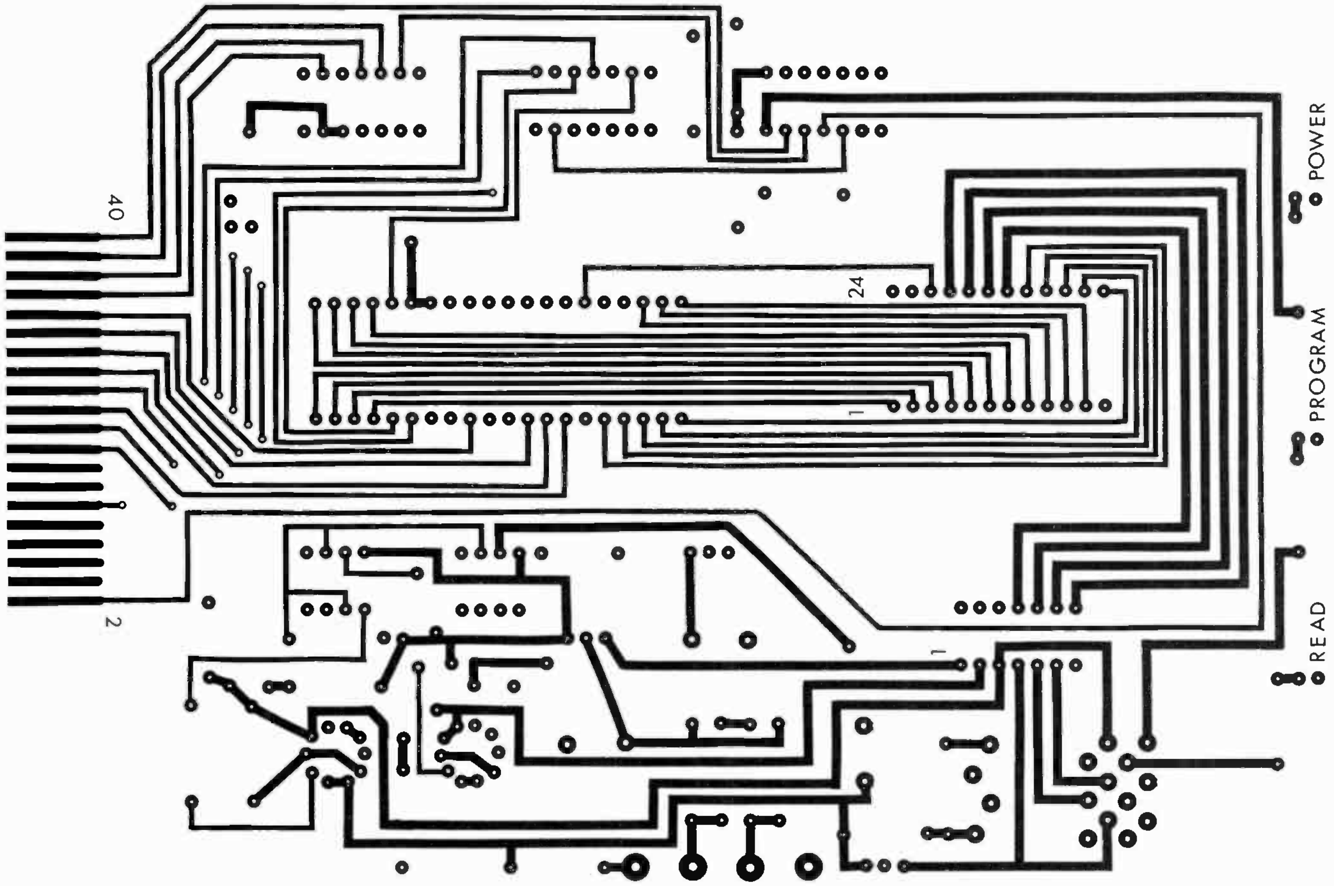
To use the EPROM Programmer with computers other than the TRS-80 Model I, a simple adapter card can be designed to interconnect the appropriate data, address, and control lines. Since ribbon cables terminated by identical connectors have the property of interchanging the lines top to bottom (but not right to left), care must be used to see that the routing is correct. In some applications, additional logic may be necessary to meet the I/O requirements of the host computer. If so, 5 V can be made available at the card edge to power external logic by simply inserting a jumper at point "J" on the printed circuit. Of course, this jumper should *not* be connected for use with the TRS-80.

Software. To accommodate up to 4K by 8-bit EPROMs, two 4K-byte buffers should be reserved in the TRS-80 memory. The first is a listing buffer which is used by the List, Verify, Copy, and Erasure verification routines to store data read in from an EPROM. The second is a programming buffer which contains data to be programmed into an EPROM. While the same memory space could be used for each task at different times, it is easiest to use separate buffers.

The software driver for the EPROM Programmer could be written in BASIC where the port-addressed I/O is handled by INP and OUT statements. Using a BASIC program for such a large task would require a large amount of memory and would operate slowly because of interpreter overhead. A better approach is to write the driver in assembly language. (The software driver written by the authors easily fits into 4K bytes of memory space.) See the Parts List in Part 1 of this article for information on ordering the software.

Sequential EPROM addresses are generated in software simply by incrementing a 12-bit counter and output-


EPROM PROGRAMMER
IC-4
IC-3
IC-2
IC-1
IC-5
IC-6
IC-7
IC-8
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
C1
C2
C3
C4
C5
C6
C7
C8
D1
D2
D3
D4
D5
D6
+5V
-5V
5V
25.5V
+12V
B
Y
R
G
39


40
24
2
POWER
PROGRAM
READ

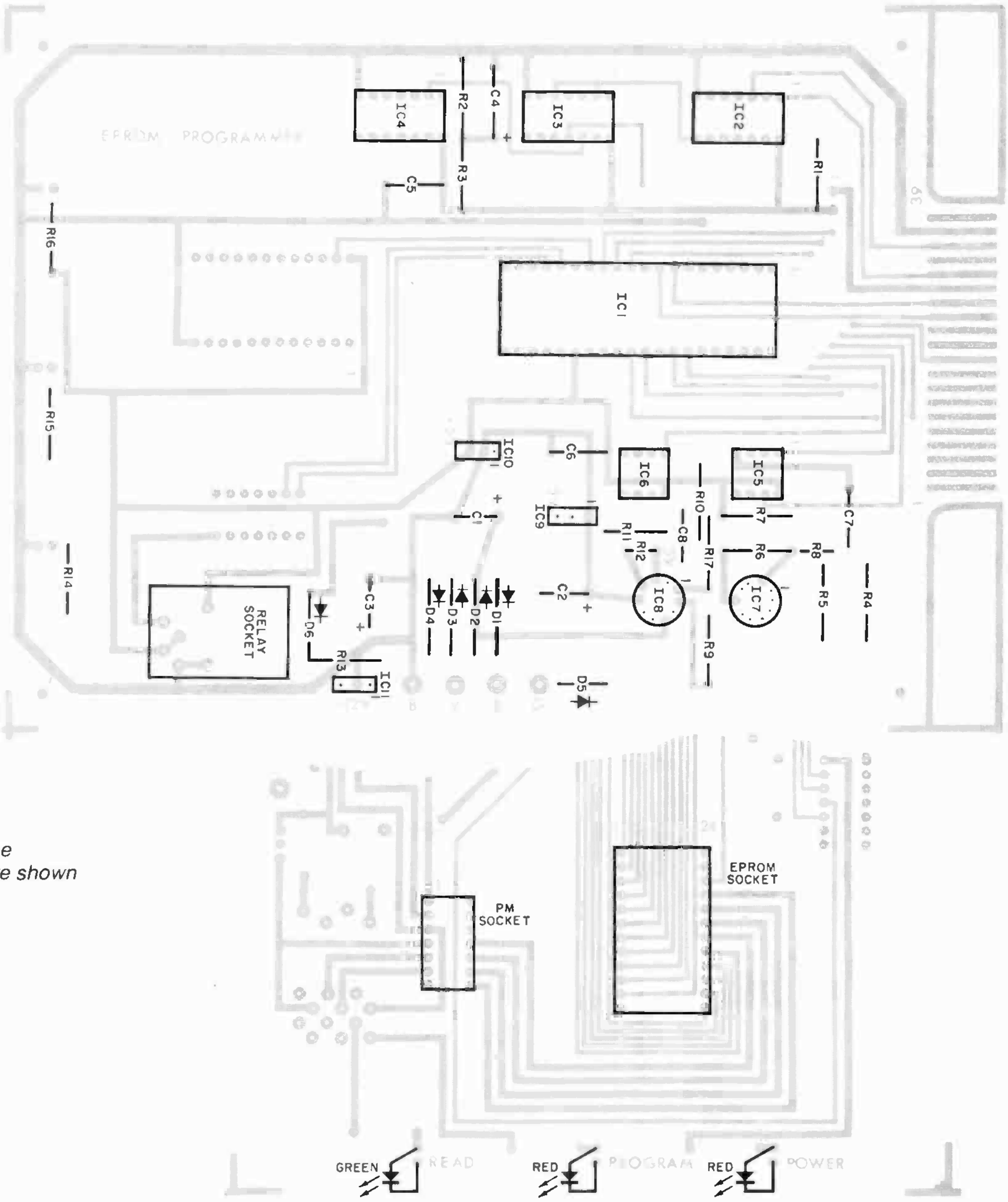


Fig. 7. Foil patterns for the double-sided pc board are shown on opposite page, while component layout is above and at right.

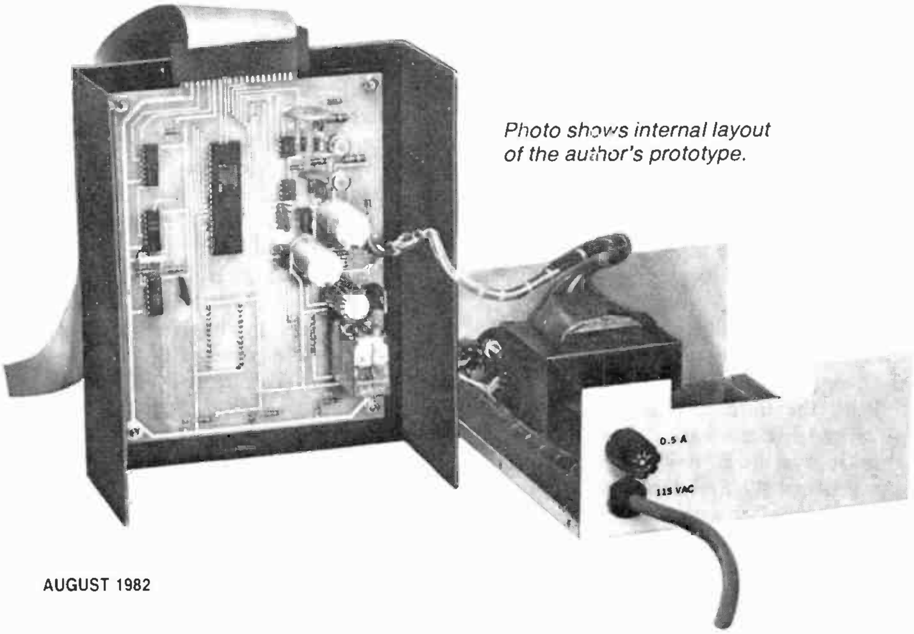


Photo shows internal layout of the author's prototype.

ting the low-order eight-bits to the 8255A's port A while the remaining high-order four-bits determine whether the port C bits (PC0-PC3) are set or reset. Address pointers to the corresponding buffer locations in the computer memory can be determined by adding the buffer starting address to the counter value. Table II shows the appropriate control bytes which must be sent to the 8255A's control port to set or reset the various lines of port C. Also shown in Table II are the control bytes which configure the 8255A for Read or Program modes.

Table III shows how to program and read data for a single location of a 2716 EPROM using Z80 assembly language. (The CPU I/O port addresses and control bytes used are those listed in Tables

TABLE III—PROGRAM AND READ SEQUENCE

```
; PROGRAMMING SEQUENCE
; Assuming that EPROM address 537H contains FF program it
; to 0E9H
        LD      A,82H       ;control byte for PROGRAM mode
        OUT     (0FBH),A    ;output it to 8255 CONTROL port
;  Set EPROM address 537H:
        LD      A,37H       ;output 8 LSBs of EPROM address
        OUT     (0F8H),A    ;to 8255 Port A
; Set 4 MSBs of address by setting proper 8255 I/O lines
;(PC0-PC3)
; In this example 4 MSBs = 0101 (5 from EPROM address)
        LD      A,01H       ;set EPROM address A8
        OUT     (0FBH),A    ;by setting 8255 I/O line PC0
        LD      A,02H       ;reset EPROM address A9
        OUT     (0FBH),A    ;by reseting 8255 I/O line PC1
        LD      A,05H       ;set EPROM address A10
        OUT     (0FBH),A    ;by setting 8255 I/O line PC2
        LD      A,06H       ;reset EPROM address A11
        OUT     (0FBH),A    ;by reseting 8255 I/O line PC3
;
; Switch relay into PROGRAM mode
        LD      A,0CH       ;reset 8255 I/O line PC6 to
        OUT     (0FBH),A    ;switch relay to PROGRAM mode
;
; Enable EPROM programming
        LD      A,09H       ;set 8255 I/O line PC4 to
        OUT     (0FBH),A    ;turn on switchable 25.5V
;
; Output byte (e.g. E9H) of programming data to EPROM
        LD      A,0E9H      ;data output to 8255 Port B
        OUT     (0F9H),A
;
; Apply 5V programming pulse of 50 msec duration
        LD      A,0BH       ;set 8255 I/O line PC5 to
        OUT     (0FBH),A    ;turn on switchable 5V
;
; Enter 50 msec delay loop (not shown here) and turn off
; programming pulse after loop falls thru
        LD      A,0AH       ;reset 8255 I/O line PC5 to
        OUT     (0FBH),A    ;turn off switchable 5V
;
; Disable EPROM programming mode
        LD      A,08H       ;reset 8255 I/O line PC4 to
        OUT     (0FBH),A    ;turn off switchable 25.5V
;
; Switch relay to READ mode
        LD      A,0DH       ;set 8255 I/O line PC6 to
        OUT     (0FBH),A    ;return relay to READ mode
;
; READ SEQUENCE
;  Set up 8255 for READ operation
        LD      A,80H       ;control byte for READ mode
        OUT     (0FBH),A    ;output it to 8255 CONTROL port
; Set EPROM address as shown above
;
; Read data from that EPROM address into register A:
        IN      A,(0F9H)    ;read data from 8255 Port B
```

I and II.) This example shows exactly how the 8255A is configured for Read and Program operations and how to specify a particular EPROM address.

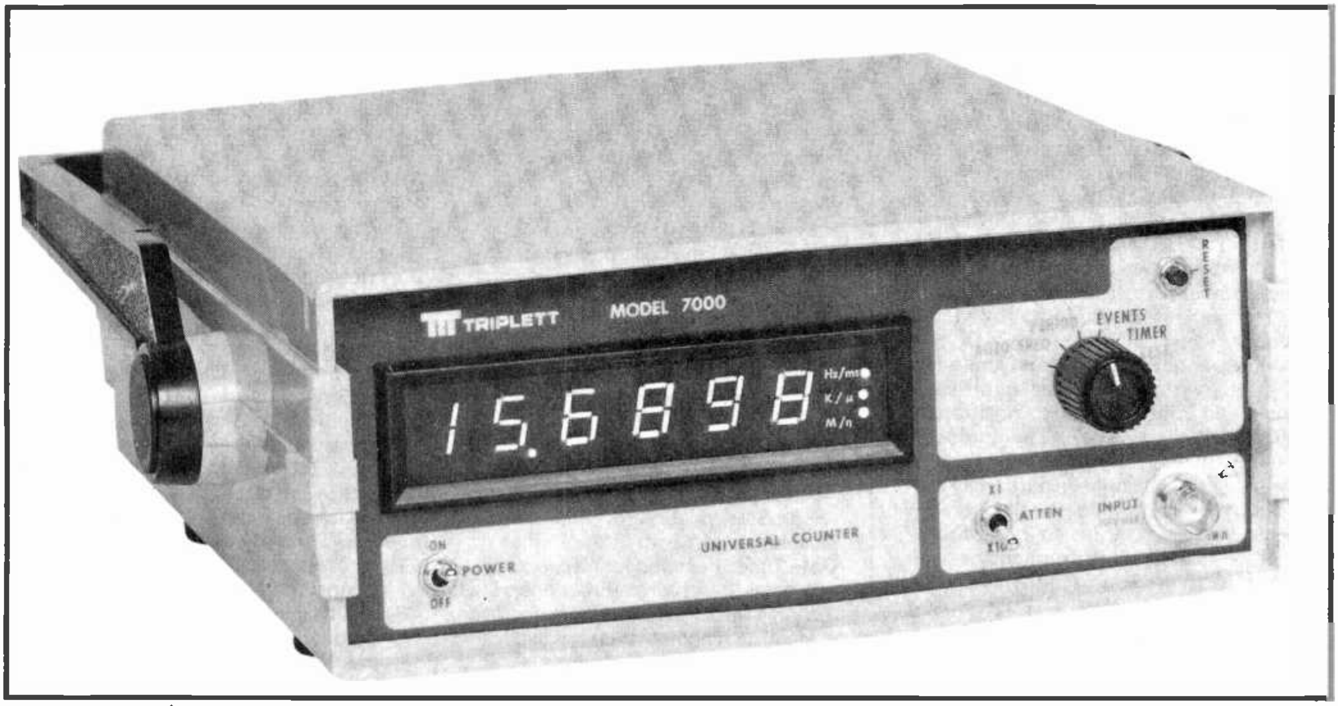
In the Program mode the relay and switchable voltage regulators are activated by the software. The programming pulse is held on for the required programming time using a software delay loop. The programming sequence for other EPROM types is similar (except for the delay loop period). And in some cases, the 5-V and 25.5-V switchable supplies exchange roles as sources for the programming enable signal and the programming pulse.

With the hardware assembly complete and the software driver written, check-out of the EPROM Programmer can proceed by first loading the programming buffer with data destined to reside in the EPROM. Often this data will be a binary file generated by an assembler, where care has been used to assure that the origin address corresponds to the starting address of the programming buffer. A more direct, although laborious, loading method is to type data from the keyboard into programming buffer locations using system software such as the TRS-80 TBUG (cassette systems) or DEBUG (disk systems).

Next, verify that the EPROM is completely erased (check that every bit location is initially in the 1 state), and then program the contents of the programming buffer into the EPROM. The programmed EPROM can be verified against the original programming buffer contents. If no errors are found, your EPROM Programmer is checked out and ready for its next programming assignment. ◇

Popular Electronics Tests

The Triplett Model 7000 Universal Counter



The Triplett Model 7000 Universal Counter is a microprocessor-based 5-Hz to 80-MHz autoranging counter having six-digit resolution. It also has two accumulating-type functions—EVENTS, which can total to one-billion at rates to 80 MHz, and TIMER, which can display elapsed time in hours, minutes, and seconds for 100 hours with up to 100 µs resolution. A built-in TEST function verifies proper operation.

Provisions are made for full external control The six functions—HZ, AUTO FREQ, PERIOD, EVENTS, TIMER and TEST—are selected by a single rotary switch while LED annunciators indicate the function. Suggested retail is $300.

General Description. The "heart" of the instrument is a 2650A 8-bit NMOS microprocessor that receives its operating instructions from a 2616 2K by 8 static MOS ROM, with temporary data stored within a 6810 128 by 8 MOS static RAM.

Other than the function selector rotary switch, the front panel contains the POWER on/off switch, an ATTENuator switch that can select either X1 or X10 attenuation of the selected input signal, a BNC INPUT connector, and a RESET switch that sets the display to zero when using the TIMER or EVENTS function. This latter control has no effect on other functions.

The display consists of six digits of 0.43"-high, red, seven-segment LEDs, and three red LED function annunciators. These annunciators include Hz/ms, used for the AUTO FREQ and PERIOD functions to indicate that the display is Hz or milliseconds repectively; the K/µ annunciator (also used in AUTO FREQ and PERIOD functions), indicating that the display is kHz or microseconds respectively; and the M/n annunciator that, when used in the AUTO FREQ mode, indicates that the display is in MHz, and when in the PERIOD mode, indicates that the display is in nanoseconds. The M/n annunciator is also used as an overflow indicator in the Hz mode (indicating that the frequency is higher than 1 MHz). When operating in the EVENTS mode, the M indicator shows that the total number of events accumulated is the displayed number multiplied by one-million.


CERTIFICATE OF CALIBRATION
LOCKHEED ELECTRONICS COMPANY, INC.
Plainfield, New Jersey

INSTRUMENT: COUNTER TRIPLETT ELECTRICAL MODEL 7000 — SERIAL NO. 18

PROPERTY OF: POPULAR ELECTRONICS — WORK ORDER NO. 74-6200-9320

The above instrument has been checked and calibrated against our working standards which are traceable to the National Bureau of Standards. All specifications were found to meet those set forth by the manufacturer. The metrology procedures utilized conform to and satisfy the requirements set forth in MIL-STD-45662.

NBS REPORT NUMBER: CESIUM BEAM FREQUENCY STANDARD, HP 5062C, [illegible], Dated 3/24/81

LOCKHEED ELECTRONICS COMPANY, INC. by: [signature] R. E. CORRIGAN, JR.

TEST PERFORMED BY: Rocco Carrea — DATE OF TEST: 9-11-81

TEMPERATURE: 74°F — HUMIDITY: 56%

The counter's rear apron supports the EXTernal INPUT that requires a contact closure to ground or a TTL logical zero to stop the count accumulation in the EVENTS or TIMER modes, and does not affect the other functions. A time-base INT/EXT selector switch on the apron allows either the internal time base or an external 10-MHz time base to be employed. If used, the external time base is coupled via a BNC connector.

Physically, the instrument is $8\frac{1}{2}$"W by $9\frac{9}{32}$"D by $3\frac{7}{16}$"H, and weighs $4\frac{1}{2}$ pounds. Four rubber feet make the Model 7000 skidproof when resting on a flat bench, and a variable-position tilt stand/carrying handle enables positioning the display as required. A small pair of rubber feet are used to skidproof the counter when it is used in the tilted position. Complete electrical specifications are shown in the Table.

Comments. The Triplett Model 7000 Universal Counter was checked by the Instrumentation Measurement Laboratories of Lockheed Electronics Corporation (Plainfield, NJ) against standards traceable to the National Bureau of Standards. After the tests, Lockheed issued a certificate that the Model 7000 met or exceeded its published specification in all respects—in fact, it did better than advertised.

In the three weeks that we had the opportunity to use the Model 7000, we found it to be very handy. Besides being an excellent 80-MHz frequency counter with great readability and accuracy, we very much like the Hz function because it allowed us to make accurate measurements to 1 MHz with a resolution of 1 Hz. The frequency is displayed as a whole number with leading-zero blanking. Overrange is indicated by the M annunciator (red LED) glowing. In the AUTO FREQ mode, the range is from 5 Hz to 80 MHz, with the six most significant figures and automatically positioned decimal point displayed. The units of measurement (kilohertz or megahertz) are indicated by the appropriate LED annunciators. In this mode, the display update ranges from 200 ms to 1.1 seconds (dependent on the input frequency.)

The PERIOD mode is used to make very accurate measurements (it is a reciprocal) with the range from 12.5 ns (80 MHz) to 200 ms (5 Hz). The resolution is 1 part/million. Again, the units of measurement are indicated by appropriate LED annunciators.

We really had no use for the EVENTS mode. However, if you do have a need for this function, the Model 7000 can "count" to 999,999,000 events. When less than a million counts are registered, leading zeroes are blanked. A front-panel RESET pushbutton allows resetting to zero.

The TIMER mode was used to confirm the operation, and in several cases, enabled us to accurately recalibrate several mechanical, clockwork, and electronic timer circuits. Its range is from 100 μs to 100 hours, so most timers can be directly calibrated and checked. The rear-apron gate control enabled us to check out TTL timers. (The manual spells out how this can be done.) In the TIMER mode, the display uses the six digits for hours, minutes,seconds, and fractional seconds with automatically positioned colons and decimal point.

We have used many frequency counters over the years, and the Model 7000 rates very high on our list. This is an excellent general-purpose instrument that will find wide favor with the hobbyist, technician, or engineer. With its broad range of uses, it would be a great addition to any test bench. —*Les Solomon*

CIRCLE NO. 104 ON FREE INFORMATION CARD

MANUFACTURER'S SPECIFICATIONS

Input Characteristics
- Impedance: 1 megohm shunted by 20 pF
- Connector: BNC
- Coupling: ac
- Sine-wave Sensitivity: 30 mV rms from 5 Hz to 40 MHz, 50 mV rms max. at 80 MHz
- Maximum Input: 200 V (peak ac + dc) to 500 Hz, derate linearly to 100 V (peak ac + dc) at 1 kHz, 100 V (peak ac + dc) from 1 kHz to 5 MHz, derate linearly to 30 V (peak ac + dc) at 80 MHz
- Attenuator: X1 or X10, switch selectable

Characteristics of the Six Counter Functions

Hz Position:
- Range: 5 Hz to 80 MHz
- Accuracy: ± time base accuracy ±1 count
- Resolution: 1 Hz
- Gate Time: 1 second
- Display: Frequency displayed as a whole number with leading zero blanking
- Overrange: M annunciator glows when input exceeds 1 MHz

AUTO FREQ Position:
- Range: 5 Hz to 80 MHz
- Accuracy: ±time base accuracy ±1 LSD ±trigger error
- Resolution: to 1 ppm
- Gate Time: 1 second for frequencies greater than 1 MHz. (Frequencies less than 1 MHz measured by period averaging with numbers automatically selected such that gate time is between 0.1 and 1 second. Internal frequency counted is 10 MHz.)
- Display: six most-significant digits, automatically positioned decimal point; units of measurement automatically annunciated
- Display Update: 200 ms to 1.1 s dependent on input frequency

PERIOD Position:
- Range: 12.5 ns to 200 ms (5 Hz to 80 MHz)
- Accuracy: ± time base accuracy ±1 LSD ± trigger error
- Resolution: to 1 ppm
- Gate Time: periods less than 1 μs (1 MHz) uses 1-s gate; periods greater than 1 μs are averaged, with the averaged number sufficient for a gate time of 0.1 to 1 second. Internal frequency counted is 10 MHz.
- Display: six most significant digits with automatically positioned decimal point; units automatically annunciated
- Display Update: 200 ms to 1.1 s dependent on period
- No Input: series of dashes are displayed

EVENTS Position:
- Range: 5 Hz to 80 MHz
- Capacity: 0 to 999.999 megaevents (999,999,000)
- Reset: front-panel RESET pushbutton, rear-panel connector
- Display: less than one-million events—whole number with leading zero blanking; greater than one-million events—six most-significant digits with automatically positioned decimal point. M annunciator indicates a multiplier of one million (X1,000,000). Overrange (greater than one billion events) is shown by series of dashes.
- Gate Control: rear-panel connector with TTL or contact closure compatibility

TIMER Position:
- Range: 100 μs to 100 h (99:59:59)
- Accuracy: ±time base accuracy ±1 LSD
- Reset: front-panel RESET pushbutton, rear-panel connector
- Display: six most-significant digits indicating hours, minutes, seconds, and fractional seconds in floating format with automatically positioned colons and decimal point. Overflow is displayed as a dashed line.
- Gate Control: rear-panel connector with TTL or contact closure compatibility

TEST Position:
- Microcomputer board circuitry is tested to give the operator assurance that the control and display sections of the counter are functioning properly.

Internal Time-Base Characteristics
- Type: crystal oscillator
- Frequency: 10 MHz
- Setability: ±0.1 ppm (±1 Hz)
- Line-Voltage Stability: less than ±1 ppm for ±10% line-voltage variation
- Temperature Stability: less than ±10 ppm (±-0.001%) from 0°C to 40°C ambient
- Maximum Aging Rate: ±10 ppm/year (±1 ppm/month)
- External Input: TTL level 50-ohm, 2.5-V peak-to-peak, switch selectable

TCXO Option
- Frequency: 10 MHz
- Temperature Stability: less than ±1 ppm (±0.0001%) from 0°C to 40°C ambient
- Maximum Aging Rate: ±1 ppm/year
- Warm-Up Time: none
- External Output: 10 MHz, TTL level from TCXO available at rear-panel BNC

Display Characteristics
- Visual: six digits (high-efficiency LED) 0.43" high, with decimal points and colons; three LED annunciators
- Test: exercises the electronics and displays to verify correct operation (one of six counter functions)

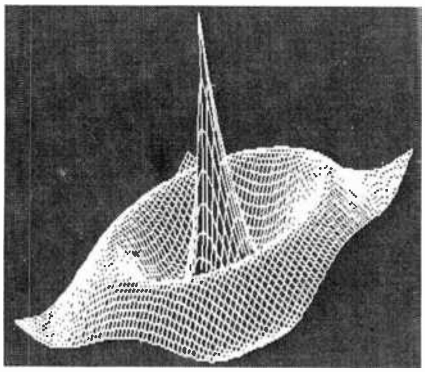
General
- Power: 105 to 130 V or 210 to 260 V, 50-60 Hz
- Fuse: 1/4 A 3AG slo-blo for 120-V operation; 1/8 A 3AG slo-blo for 240-V operation
- Power Cord: detachable three-wire
- Handle: variable position and tilt stand
- Lead Assemblies: coax cable, BNC at one end, alligator clips at the other, 36 in. long

COMPUTER SOURCES

By Leslie Solomon
Technical Director

Hardware

TRS-80 Graphics. The Model II Graphics Option (26-4104) organizes the Model II display into 640 horizontal by 240 vertical pixels. Graphics BASIC adds eleven new commands to program lines, circles, arcs, and ellipses, "paint" selected screen areas, rotate, animate, store, and retrieve screen graphics. Since it adds an additional 32K character of independent memory, graphics can overlay text in the video memory. Automatic text reversal is provided when needed. $499. **Address:** Radio Shack Computer Centers and stores.



Sinclair Expansion. Designed for the ZX80/ZX81/MicroAce, the Expansion Board is a "motherboard" that provides four 44-pin card connectors, room for Wire Wrap, gold-plated "fingers", voltage regulator for 5-volts at 3 amperes, while the ZX 16K RAM responds to its presence via RAM CS signals. Eight chips are needed, five for buffers, and three for decoding to determine direction of bi-directional data bus buffers. The board connects to the Sinclair via gold-plated fingers. Bare board is $33 (California residents please add $1.95 tax). Kit is $60 less voltage regulator. **Address:** Computer Continuum, 301 16th Ave., San Francisco, CA 94118 (Tel: 415-752-6294).

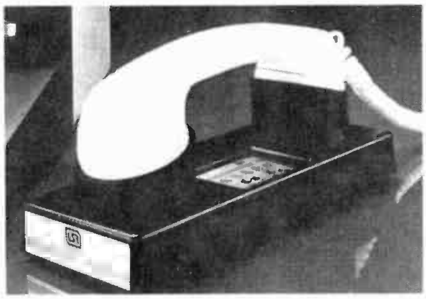
Cable Helper. The Match-Box Programmable Computer Cable System is a two-component cable system that can be used to fulfill up to 10,000 cable needs. Component A is a connector with a one-foot section of cable and Match Box attached, while Component B has a complementary Match Box that can be attached to a cable 100 feet long. The composite is programmed by moving pins within the Match Box to the correct sockets. For example, you can mate an RS232 with a 6-pin connector, or whatever. Depending on the number of conductors in the cable, prices range from $19 to $53. **Address:** ICO-Rally Corp., 2578 East Bayshore Rd., Palo Alto, CA 94303 (Tel: 415-856-9900).

Software Switching. The ASCI switch allows software controllable switching between any two peripherals using a single computer port, or allows two computers to share the same peripheral by software switching. 128 user-selectable ASCII codes can be used and the switch is controlled from DTE or DCE without the need for a null modem. Model A10 switches 10 lines, and Model A25 switches 24 lines of the RS232 interface. A10 is $295, A25 is $345. **Address:** Advanced Systems Concepts, Inc., POB Q, Altadena, CA 91001 (Tel: 213-684-5461 or 794-2308).

Apple to IBM. The 88CARD features a 8088 CPU and 64K-bytes of RAM, and when plugged into an Apple slot, makes the Apple "look" like an IBM Personal Computer. It is fully compatible with all Apple peripherals and allows selection between Apple and IBM operation. The coprocessor 88CARD uses the operating system designed for the IBM and this is included on the board. No external supplies or connections are required. $899. **Address:** Coprocessors Inc., 50 West Brokaw Rd., Suite 64, San Jose, CA 95110 (Tel: 408-947-4616).

Data Encryption. DATALOK for the Apple II uses the powerful WD2001 DES (Data Encryption Standard) chip that uses a 56-bit key to create 72 quadrillion codes. No programming skill is required, just answering a couple of on-screen questions. Even an entire diskette can be protected, and unbootable. It requires an Apple II, 48K, one disk drive, DOS 3.2/3.3, and Applesoft BASIC. The Model ACS-1A costs $349. **Address:** Atlantis Computers, 31-14 Broadway, Astoria, NY 11106 (Tel: 212-728-6700).

Acoustic Modem. The Phone Link Acoustic Modem is a low profile 300-baud instrument that operates in both the answer and originate mode. It inter-



faces to the host computer via a conventional RS-232 port. LEDs are provided for receive/send data, power on, carrier detect, and self test. $129. **Address:** U.S. Robotics Inc., 203 N. Wabash, Suite 1718, Chicago, IL 60601 (Tel: 312-346-5650).

IBM PC Hard Disks. The SCS Mini-Mega offers 5 and 10 megabyte configurations on a 5¼" disk subsystem with an optional one-megabyte 5¼" floppy for backup. The SCS Sabrina Series is a removable Winchester that offers 10 megabytes on an 8" removable Winchester cartridge along with a fixed disk capacity from 10 to 40 megabytes. CP/M-86 is used. **Address:** Sante Clara Systems, 560 Division St., Campbell, CA 95008 (Tel: 408-374-6972).

Software

School Utility. The Grading Systems Program accommodates a variety of different grade calculations for schools and colleges to maintain grade and credit information. It allows preparation of report cards, file folder labels, synoptic records, grade labels, class rosters, and honor rolls. It comes with a light pen for easy entry by para-professionals. Requires an Apple II with 48K, single disk drive, and 80-column printer. $299.95. **Address:** Chas. Mann and Associates, Microcomputer Div., 55722 Santa Fe Trail, Yucca Valley, CA 92284 (Tel: 714-365-9718).

Apple Display. Apple Flasher locates and displays Apple hi-res graphic files from DOS 3.3 disks, as pictures in about 1.5 seconds each. Display modes include single-key selection of any file on disk, continuous scan of all files on disk with new picture on screen each 1.5 seconds, carousel projector simulation to display screens from one or two drives with instant access to both next and previous, and continuous display of all screens on one or two drives (30 pictures) with individual control of timing. Unlabelled disks may be searched for presence and names of hi-res screen files. Requires Apple II with ROM or Language Card, one or two drives, and DOS 3.3. $34.50 plus $1 handling. **Address:** Crow Ridge Associates, P.O. Box 90, New Scotland, NY 12127 (Tel: 518-765-3620).

ZX81 Utility. The Cassette I/O for ZX81 is a set of utility programs to selectively read or write strings and arrays to a cassette from the ZX81. The routines occupy approximately 500 bytes and require at least a 2K RAM. $20. A memory modification to increase ZX81 memory to 2K bytes is also available for $20. **Address:** Cosmonics, Box 10358, San Jose, CA 95157.

Crosswords. The Crossword Puzzle Maker for the Apple II uses hi-res graphics and automatically connects words, prints hard copy, is menu driven, stores 40 puzzles, and is very easy to use. Words can be supplied on any subject and the program will interconnect them (or save them if they cannot fit for the moment). Clues can be inserted as desired. Creates puzzles to 20 × 20 boxes. Requires Apple II, 48K, DOS 3.3 and can use any of 24 available printers for hard copy. $49.95. **Address:** L&S Computerware, 1589 Fraser Drive, Sunnyvale, CA 94087 (Tel: 408-738-3416).

IBM Word Processor. WORD-11 for the IBM Personal Computer accepts lines of text interspersed with lines of format control information and formats the text into a document. It also contains file/merge, auto insertion of date and user-specified constants, repeat printing compatability with all DOS commands, and can send control characters to the printer. Requires IBM DOS, single disk drive, and printer. $88. **Address:** Micro Architect Inc., 96 Dothan St., Arlington, MA 02174 (Tel: 617-643-4713).

Adventure Game. Available for the Heath/Zenith, Osborne, and other CP/M machines, this expanded version of the original adventure game explores the dangers, seeks the treasures, and solves the puzzles of the Colossal Cave. It is written in machine language and is enhanced. $19.95 plus $2 shipping ($3 for 8") diskette. **Address:** Software Toolworks, 14478 Glorietta Drive, Sherman Oaks, CA 91423 (Tel: 213-986-4885).

Program Generator. Pearl III for CP/M and the Zenith Z89 and Z90 creates an application program in CBASIC with custom menus, data verified by type and length, custom reports, computational capabilities, file sorting ability, and the ability to post journal files to a master file. It is menu driven, and the output can be modified at the source code level. Comes on both 4¼" and 8" diskettes. $650. **Address:** Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025 (Tel: 312-391-8181).

Apple Graphics. The GPS (graphics processing system) for the Apple computer creates, manipulates, and edits graphics similar to a word processor with text. It features a grid that allows work to

be done to scale, and dimensions altered in proportion. It has six primary colors which can be mixed, two zoom features, 2D rotation to 360°, text capabilities, overlays which can be printed in different colors and graphics editing capability. It will work with paddles, joysticks, graphics tablets, and light pens. It will also access a 16K RAM card and is compatible with hi-res graphics. $99.95 for professional, and $59.95 for standard version. **Address:** Stoneware, Inc., 50 Belvedere St., San Francisco, CA 94901 (Tel: 415-454-6500).

Sinclair Disassembler. The ZX80 1K Disassembler for the 4K ROM ZX80, and the ZX81 and 8K ROM ZX80, require 1K of RAM and also includes a RAM memory test where the addresses of the failed bytes are displayed on the screen. $9.95. **Address:** Lamo-Lem Laboratories, Box 2382, La Jolla, CA 92038.

TRS-80 Reference. Printed on 80-lb Beckett cover stock featuring eight folds and 16 panels, these handy 8½" by 3¾" pocket reference cards cover memory map, eyeball graphics, math instructions, BASIC commands/functions/statements/special characters, move instructions, special keys, exchange instructions, BASIC and assembler messages and codes, branch instructions, data alteration, reserved words, I/O, ROM routines, complete character chart with graphics and space-compression codes, hex-dec chart, control code cross reference, complete assembler details, screen layout, and several more useful items. In essence, a heavy manual has been compressed to a few handy pages. Current issues cover all versions of the TRS-80 and color BASIC. Upcoming versions will cover Apple, Commodore, Heath, Sinclair, Atari, and the Z80 machines. **Address:** Nanos Systems Corp., POB 24344, Speedway, IN 46224 (Tel: 317-244-4078).

ZX81 Games. A number of games for the Sinclair ZX80/ZX81 including Super Invasion, Wallbusters, Cyborg Wars, Chess, Trek, etc., a Sinclair ZX81 BASIC Course, plus a number of programming and machine language guides are now available. **Address:** Softsync, Inc., POB 480, Murray Hill Stn, New York, NY 10156 (Tel: 212-685-2080).

SOLID-STATE DEVELOPMENTS

By Forrest M. Mims

PICs: Photonic Integrated Circuits

OPTOELECTRONICS and electro-optics are traditional terms for those areas of electronics that involve the emission and detection of light. Recently, the term *photonics* has emerged. Just as *electron*ics is derived from electron, *photon*ics is derived from photon.

Photonics actually had its origin in the final quarter of the last century with the invention in 1873 of the selenium light detector. By 1880, Alexander Graham Bell and Sumner Tainter had used selenium cells of their own design and construction to become the first people to send their voices over a modulated beam of light. In 1907, the light-emitting properties of silicon carbide were discovered by Captain H.J. Round.

Optocouplers and optoisolators made by mounting an LED chip and photodetector within a common package have been available for nearly twenty years. In the early 1960's, Texas Instruments introduced an optically coupled amplifier consisting of an LED mounted atop a silicon chip that included an integrated photodiode and amplifier.

Photonics today has received enormous stimulus from advances in optical-fiber communications, video-data storage and retrieval, and the prospect of computers that depend on photons rather than electrons for their operation. These and other applications for photonics have generated considerable interest in the fabrication of miniature photonic circuits on semiconductor chips.

Though integrated photonic circuits are in an early stage of development when compared to integrated electronic circuits, several important advances have been made in new and exotic semiconductor light sources and detectors, thin film waveguides and optical components, and various kinds of light-wave switches and deflectors. The ultimate goal of photonic researchers is to combine devices such as these to provide circuits that process photons much like conventional circuits process electrons. In this column we'll refer to such circuits as *photonic integrated circuits* or simply PICs.

Light Sources for Photonic IC's. Various kinds of miniature modules containing an LED or diode laser together with appropriate drive circuitry have been available for more than a decade. Like optoisolators, they are *hybrid* photonic circuits wherein the light source and the driver chip are attached separately to a common substrate.

Several kinds of laser and LED chips with on-chip driver circuits have been developed in recent years. However, monolithic integration of a source and its drive circuits on the same chip is not nearly so far along as the development of chips that contain both detectors and amplifiers.

Probably the most important PIC light sources are injection lasers that do *not* re-

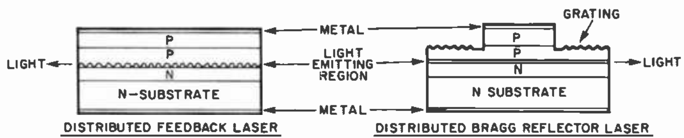


Fig. 1. Two kinds of semiconductor lasers suitable for photonic integrated circuits.

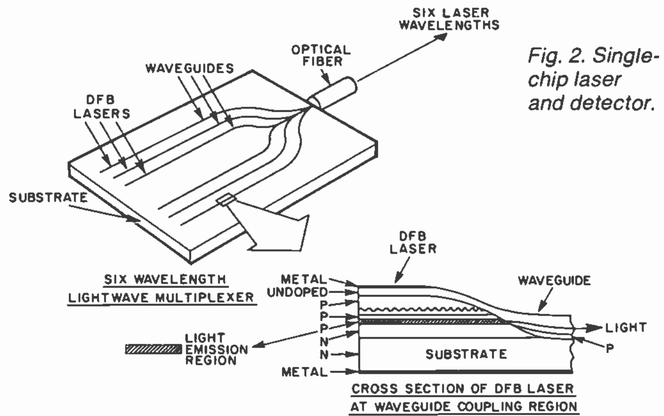


Fig. 2. Single-chip laser and detector.

quire the two end mirrors of conventional lasers. Normally the end mirrors are produced by cleaving the semiconductor from which the laser is made along its crystalline planes to produce perfectly flat and parallel reflecting facets. This procedure is not always possible when attempting to integrate a laser onto a chip along with other components.

One solution is a laser whose junction region curves back toward one side of the

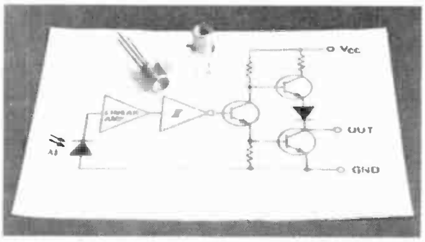


Fig. 3. TRW-Optron single-chip receivers.

chip to form a semi-circle. Cleaving a single side of the chip allows each end of the curved junction to share the same reflector. Although some light can be extracted from the central portion of this strange laser, most exits through the single end mirror and is unavailable for use inside the chip.

A better solution is to eliminate the end mirrors entirely and obtain the optical feedback necessary to sustain laser action by means of periodic grooves transverse to the plane of the junction. The corrugated grooves are formed by chemical etching or ion milling prior to the deposition of the crystal layers that complete the laser. At this stage, the laser chip resembles a microscopic old-fashioned washboard when viewed from above.

This light emitter, which is shown in Fig. 1, is called a *distributed feedback* (DFB) laser. In operation, each groove reflects back along the plane of the junction a small portion of the light emitted in the junction region. A large number of grooves insures sufficient feedback to sustain laser action.

A modification of the DFB laser is the *distributed Bragg reflector* (DBR) laser, also shown in Fig. 1. In this laser the corrugations are at either end of the central portion of the chip. Like the DFB laser, the DBR laser provides a very narrow spectral output and a structure that can be monolithically integrated onto the same substrate as other components and microscopic waveguides.

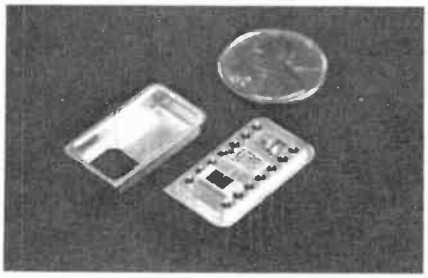


Fig. 4. Hybrid receiver made by Meret, Inc.

A remarkable example of the integration of multiple DFB lasers onto the same substrate is the six-laser multiplexer PIC shown in Fig. 2. Developed by scientists at Hitachi Laboratories in Japan, this PIC pairs six lasers with six waveguides that merge into a common exit port for coupling into an optical fiber. All lasers and their matching waveguides are formed from gallium arsenide (GaAs) and gallium aluminum arsenide (GaAlAs) layers deposited over a common GaAs substrate.

The frequency of the lightwaves emitted by a DFB laser is a function of the distance between grooves in the corrugations along the junction region. Therefore, by altering slightly the dimensions between the corrugations of the individual lasers, it was possible for the Hitachi scientists to precisely tune the lasers to six separate wavelengths between about 891 and 905 nanometers.

Other kinds of multiple wavelength sources suitable for PIC's have also been developed. Bell Labs, for example, has devised a multi-layered chip that simultaneously emits from its four stacked junctions radiation at 828, 853, 879 and 903 nanometers. Unlike the Hitachi laser multiplexer PIC, all the junctions in the Bell Labs device are driven by the same signal. A more complex chip design, however, should permit the individual junctions to be driven independently of one another.

Photonic Light-Detection Circuits. Since silicon can be used to detect light (from about 350 to 1000 nanometers) *and* to make electronic circuits, single-chip monolithic photonic receivers are well developed. Figure 3, for example, shows a low-cost light-wave receiver that includes an on-chip detector, preamplifier, Schmitt trigger and output buffer. Figure 4 shows a sophisticated light receiver employing hybrid construction.

Since silicon is a very inefficient material for light-emitting diodes, it is not possible to integrate effective light sources and sensors on a silicon substrate. However, materials like GaAs, GaAlAs, indium phosphide (InP) and indium gallium arsenide phosphide (InGaAsP) can be formed into diodes that both emit *and* detect light. Furthermore, conventional electronic circuits can be integrated upon such semiconductors together with emitters and detectors.

Figure 5 is a dual-junction detector made from InP and InGaAsP that can simultaneously detect radiation at two separate wavelengths. Also shown in Fig. 5 is a pair of spectral response curves for this diode showing peaks at 1.08 and 1.17 micrometers.

The diode in Fig. 5, which was developed at Bell Labs, can be used to detect two data channels being simultaneously transmitted through an optical fiber at two wavelengths. Similar diodes having multiple junctions or miniature diffraction grating filters that resemble the corrugations in DFB and DBR lasers may allow three or more wavelengths to be detected simultaneously.

Dual-Function Lasers and Detectors. A decade ago comparatively few scientists and engineers recognized that a single semiconductor junction could double as an efficient light source *and* detector. In a formal review prompted by

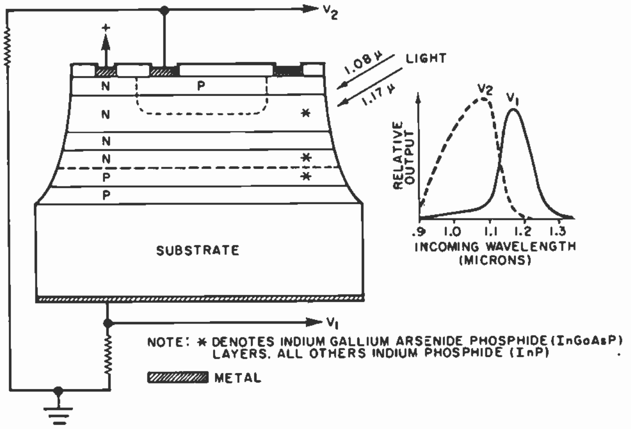


Fig. 5. Dual-wavelength demultiplexing photodiode.

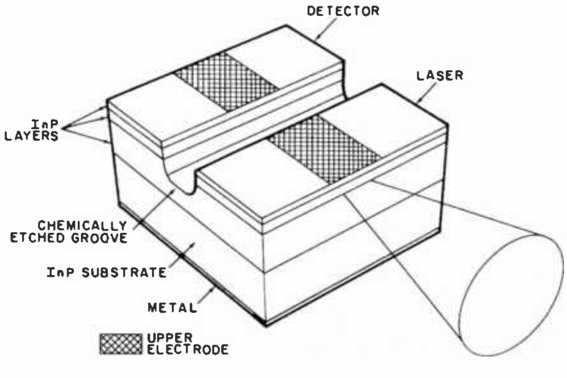


Fig. 6. Single-chip laser and detector.

an invention suggestion I had submitted in 1973, scientists and patent attorneys at Bell Labs concluded such devices "usually cannot be designed" and it is "extremely unlikely that systems considerations would permit a single device to operate as both source and detector."

Several years ago Bell Labs took another look at this technology, reversed its earlier conclusions and began applying it in experimental photonic systems. They have since made remarkable progress in developing dual-function photonic devices.

One example is the single-chip laser and detector in Fig. 6. The most unique aspect of this device is the chemically etched groove that physically separates the upper portion of the chip into two separate regions.

The etching process causes the walls of the groove to be very smooth and flat. Since the external faces of the chip are cleaved, each side has the potential ability to operate as a laser. Bell Labs has instead used one side as a laser and the other as a detector that monitors the output from the grooved face of the laser.

Another example is a 4-layer LED that functions as a single-chip optical repeater or regenerator. A weak incoming pulse of light switches on the LED and causes it to emit a much stronger pulse. Though Bell Labs scientists devised and patented a 4-layer diode for this application, standard 4-layer LEDs made by Sharp Corporation of Japan since 1974 will also operate as optical repeaters.

Other Photonic Devices. The eventual integration of sources, detectors, waveguides and electronic circuits onto single chips will require micro-miniature optical components. Already, several laboratories have made two-dimensional lenses and prisms in the form of specially shaped layers and films deposited on a substrate using integrated circuit technology. These tiny optical components can readily focus and bend ultra-thin beams of light.

Also required will be optical switches, shutters, modulators, polarizers, and other devices and components that can modify or switch an existing beam of light or deflect it from one fiber to another. Many experimental devices capable of performing these functions have already been developed. Some use piezoelectric materials to deflect beams of light. Surface acoustic waves on a piezoelectric substrate can even act as a tunable diffraction grating that selectively reflects, and hence filters, incoming wavelengths.

You can find out much more about PIC devices by spending a few hours at a good library. You might begin with a three-part series on the subject that appeared in the *Bell Labs Record* (Dec. 1980, Jan. 1981, and Feb. 1981). For a more detailed treatment, see "Components for Optical Communications Systems: A Review," *Proceedings of the IEEE* (June 1980). For a complete overview, see "Future Looks Bright for Guided Wave Optics," *High Technology* (Nov./Dec. 1981). ◇

EXPERIMENTER'S CORNER

By Forrest M. Mims

Experimenting with Piezoelectric Devices

Part 2. Piezo-Alerters and Crystal Oscillators

WE experimented with piezoelectric spark generators, microphones, and filters in Part 1 of this two-part series on piezoelectric devices. This month, we'll discuss using piezoelectric alerters and quartz-crystal oscillators.

Piezoelectric Alerters. Crystal microphones and speakers are designed to operate across a wide band of audio frequencies. Piezoelectric alerters, however, are generally designed to operate at a fixed or relatively narrow audio-frequency band. They are true solid-state sound sources.

As far as I know, the first commercial piezo-alerter was the Mallory Sonalert®. Sonalerts are available in various kinds of housings having a range of audio outputs. Most include self-contained drive circuitry.

I first purchased a Sonalert in 1966 and a few years later used it to measure the velocity of a model rocket in flight. The Sonalert, a Model SC628 emitting a tone of 2.9 kHz, was installed in the base of a model rocket. The rocket's engines were installed in pods attached to its center tube. The sound from the Sonalert was tape recorded from the ground during the rocket's flight. By measuring the doppler shift, it was possible to determine the rocket's velocity.

Alerter Construction and Operation. Thanks to their miniature size, low current consumption, and penetrating sound, piezoelectric alerters are commonly used in digital watches, clocks, smoke alarms, pagers, appliances, calculators and games. A typical alerter is a metal disc from 25 to 40 mm in diameter upon which is bonded a smaller disc of piezoceramic material. A conductive film is deposited over the ceramic layer, and electrodes are attached to it and the metal disc.

Often alerter discs include a *feedback electrode* made by isolating a small section of the metal film on the back of the piezoceramic material. The feedback electrode, which is shown in Fig. 1, simplifies the design of driver circuits and stabilizes the alerter's oscillation frequency. Piezo-alerter discs can be purchased alone or installed in plastic holders complete with connection leads. Versions with self-contained driver circuits much like the Mallory Sonalert are now available from several companies.

It is essential to properly mount an alerter disk for maximum sound output. If the vibrating portion of the disk is cemented or otherwise attached to a mount, severe attenuation of the device's sound output will occur.

Figure 2 shows three acceptable ways to mount an alerter disc. The *center mount* permits the outer rim of the disc to vibrate, while the *edge mount* permits the entire disc to vibrate. Both of these methods permit the disc to vibrate across a range of audio frequencies.

The *nodal mount*, also shown in Fig. 2, is best for a very-loud, single-frequency tone. The node of a piezo-alerter disc is a concentric ring around the center of the disc at which vibration at a fixed frequency is at a minimum (or even non-existent). Ideally, the diameter of the nodal ring is 0.55 times the diameter of the metal disc. The actual diameter, however, varies from the predicted value due to the presence of the piezoceramic disc and nonuniformities in the metal disc.

One way to find the actual location of the nodal ring is to sprinkle fine sand or powder on a piezo-alerter disc being driven at a desired frequency by a suitable oscillator. The powder particles will gradually bounce into the nodal region and form a thin, circular ring around the center of the disc.

Piezo-Alerter Driver Circuits. A piezo-alerter can be driven directly by a variable-frequency signal generator. Even alerters having nodal-mounted discs can be operated across the audio spectrum, although edge- and center-mounted discs work best across a wide band of audio frequencies.

Figure 3 shows a simple, single-transistor driver for a piezo-alerter having a feedback terminal such as the model PKM11-6A0 from muRata Corporation of America (1148 Franklin Rd., SE, Mariette. GA 30067). This alerter is also available from Radio Shack (catalog number 273-064).

The PKM11-6A0 can be operated over a specified range of 3 to 15 V (mine works down to 1 V) and has a current consumption over this range of 2 to 12 mA. Its output sound-pressure level ranges from more than 80 dB at 3 V to more than 90 dB at 15 V. Its resonant frequency is within 700 Hz of 6.5 kHz. It has an operating temperature range of − 20° to + 60° C and weighs only 1.5 grams.

A test version of the circuit in Fig. 3 drove the alerter at a frequency of 6772 Hz when V_{CC} was 3 V. This frequency is controlled by the dimensions of the feedback tab on the alerter disc and not the components of the oscillator. For example, changing *R1* over a range of 100 to 330 kilohms altered the shape of the waveform but not the frequency. The frequency is nearly independent of changes in V_{CC}.

Figure 4 shows a simple, single-chip, CMOS oscillator suitable for driving a piezo-alerter. This circuit is adapted from one in a Gulton Industries application note. Notice how the 4049

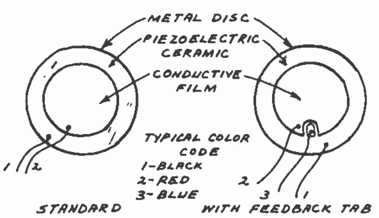


Fig. 1. Piezoelectric alerter elements.

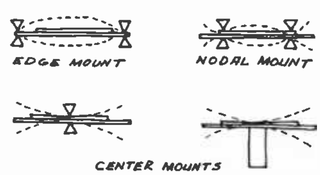


Fig. 2. Three mounting arrangements for piezoelectric alerter elements.

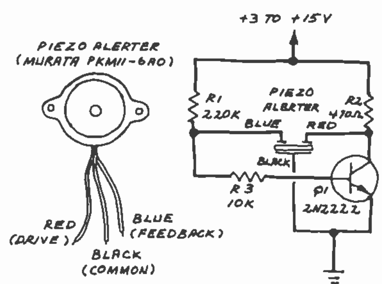
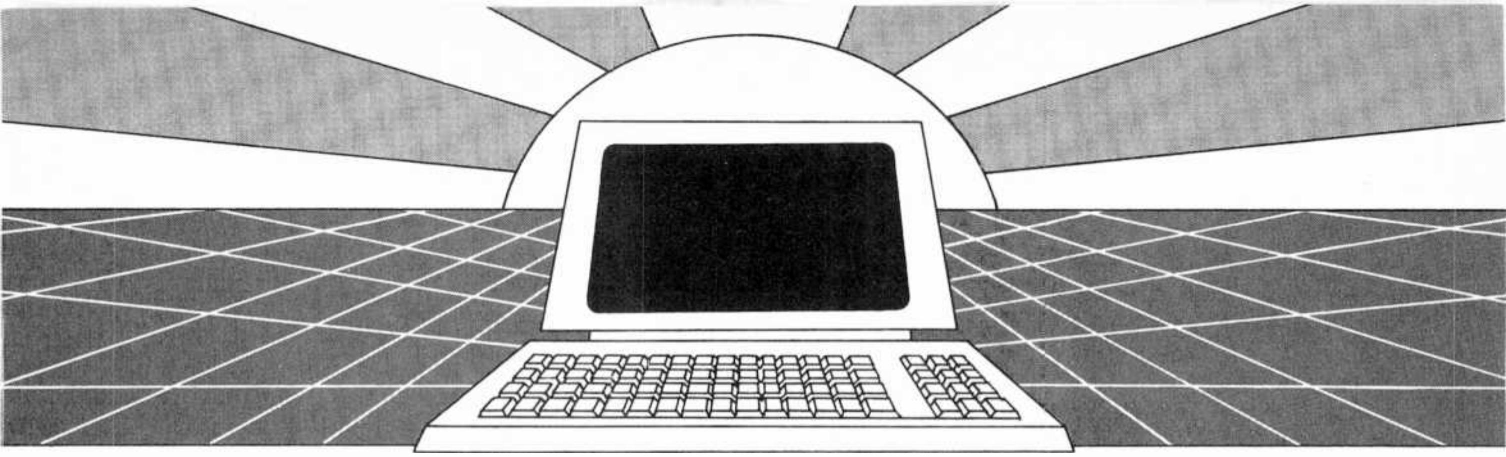
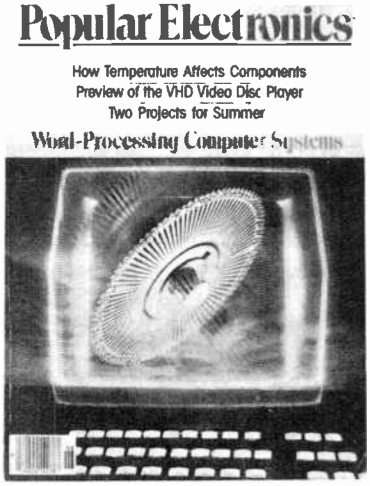


Fig. 3. Piezoelectric alerter driver circuit.



DISCOVER THE MAGAZINE THAT LAUNCHED THE MICROCOMPUTER INDUSTRY



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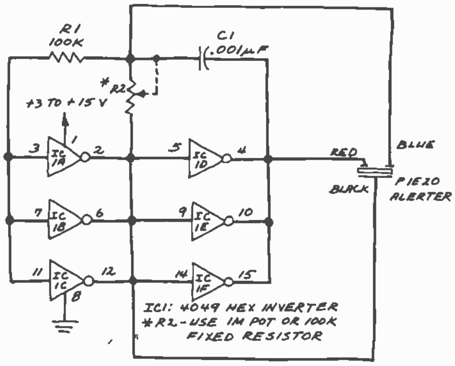


Fig. 4. An IC alerter driver circuit.

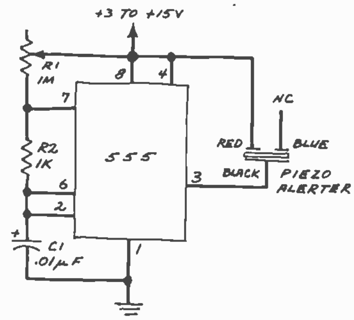


Fig. 5. Adjustable-frequency driver circuit.

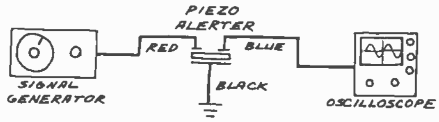


Fig. 6. Using a piezoelectric alerter as a signal filter.

gates are connected in parallel to permit higher drive current.

The circuit in Fig. 4 has the advantage of having an adjustable frequency. A breadboard version I built operated over a range of about 185 Hz to 7 kHz. The frequency change, however, was not gradual but occurred in steps. When the piezo-alerter reached its resonant frequency of around 7 kHz, changing *R2*'s resistance had no effect.

The circuit in Fig. 5 will drive piezo-alerters with and without feedback terminals at a variable frequency. Unlike the circuit in Fig. 4, this circuit provides a gradual, nonstepped output tone. A slow *pock . . . pock . . . pock* sequence can be produced by using a 0.47-μF capacitor for *C1*.

The operation of a piezo-alerter's feedback electrode can be graphically demonstrated by connecting the anode of a red LED to the blue lead of the alerter in Fig. 5. Connect the LED's cathode to ground. The output from the blue lead easily exceeds a few volts, more than enough to forward-bias the LED and cause it to emit a dim glow.

Keep in mind that there is no electrical connection between the feedback electrode and the main electrode on the piezoelectric ceramic disk. The voltage at the feedback terminal is true piezoelectricity. It is generated in response to the pressure wave that appears in the piezoelectric ceramic disk. (The pressure wave is generated in response to the drive signal.) The LED demonstration shows how a piezoelectric device can function as a solid-state transformer or isolator.

Using an Alerter as a Filter. Figure 6 shows how to demonstrate the use of a piezo-alerter as a ceramic filter. The model PKM11-6A0 exhibited frequency-response peaks at 2.3 kHz, 7.0 kHz, 18 kHz, 27 kHz and 45 kHz. While a scope is helpful, it's possible to monitor the filter's operation by simply listening to the change in amplitude of the filter's sound output as the signal generator's frequency is varied. Of course this method only works at audio frequencies.

Incidentally, I attempted to measure the delay introduced by the piezoelectric ceramic with the help of a dual-trace 100-MHz oscilloscope. The speed of sound in the ceramic is around 5000 m/s according to *Reference Data for Radio Engineers* (ITT, Howard W. Sams & Co., 1975, p. 4-44). Since the gap between the main and feedback electrodes on the piezo-alerter disc is 0.5 mm, the expected delay is 100 nanoseconds.

Though the driver circuit for the test, the 555 oscillator in Fig. 5, provided clean leading- and trailing-pulse edges, the signal elicited from the feedback terminal had too much ringing for an accurate measurement of the delay. While I *think* I monitored a 100-ns delay, I cannot be certain due to the sloppy appearance of the feedback pulse. Perhaps you will have better results.

Other Alerter Ideas. The very narrow audio spectrum produced by piezo-alerters makes them ideal for use in experiments with sound. With the help of a microphone and an oscilloscope, you can easily demonstrate constructive and destructive interference of sound waves. Try pointing the microphone at the alerter while moving the microphone back and fourth. Or point both the alerter and the microphone at a flat metal or plastic panel which you can move back and forth. The proper arrangement will reveal a periodic amplitude fluctuation in the received signal, which you can view on the scope.

Note that, in an enclosed room, the sound of an alerter can vary dramatically in intensity. This is a result of the way the single-frequency acoustical waves from the alerter form complex interference patterns. Negative interference causes the formation of *dead spots* where the sound is virtually imperceptible. Constructive interference forms regions where the sound is uncomfortably shrill.

Sounds from radios, televisions, phonographs and people span a wide range of audio frequencies. Therefore, the effects of interference are not nearly as noticeable.

The effects of the acoustical interference caused by the pure tone emitted by an alerter may or may not be desirable. It is certainly attention getting to walk by an alerter and notice the changes in sound intensity. But it can also be confusing, particularly if you are trying to find the source of the sound in an enclosed room having many flat, hard reflecting surfaces! The resultant interference problems can be avoided by using multiple or swept tone alerters.

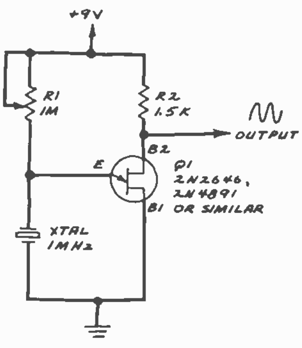


Fig. 7. UJT oscillator.

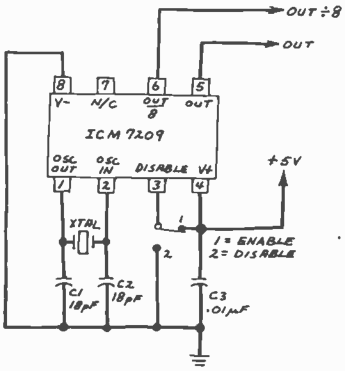


Fig. 8. Clock-pulse generator.

If you enjoy experimenting, try using a piezo-alerter as a microphone. You'll find that alerters with nodal mounting function as *frequency selective* sound detectors. Also, try adding a tube or reflector to an alerter to form a directional sound source. You can try operation at resonant ultrasonic frequencies. You can even develop various kinds of sonic radar circuits or try operating an alerter under water.

Alerter Precautions. Data sheets for piezo-alerters note that mechanical shock can cause them to generate high-voltage spikes that can damage their drive circuit and perhaps other associated circuits. This problem can be alleviated by installing an appropriately rated protection diode directly across the alerter.

Another precaution concerns the placement of an alerter on a circuit board. Be sure to mount the alerter on a rigid, fixed portion of the board. If the alerter is mounted on a cantilevered portion of a circuit board, it may set up vibrations in the board, substantially reducing its sound output.

Finally, a precaution I've *not* seen in the data sheets concerns the shrill sound which can be produced by some alerters. I've found that the sound can easily produce a piercing headache. While experimenting with the circuits described above, I eventually resorted to covering the aperture of the alerter with clay or tape to muffle the sound output.

Quartz-Crystal Oscillators. The final piezoelectric device we will consider is the quartz-crystal oscillator. Precision-cut wafers of quartz are used to make piezoelectric resonators having exceptional frequency stability. Figure 7 shows an ultra-simple, crystal-controlled, unijunction-transistor oscillator that uses only four components. The quartz crystal replaces a capacitor normally used in this circuit. The oscillation frequency can be tuned from about 50 kHz to exactly 1 MHz when the crystal has a resonant frequency of 1 MHz. Tuning is accomplished by altering the resistance of *R1*.

If you monitor the output of the oscillator in Fig. 7 with an oscilloscope, you will notice that the oscillation frequency tends to change in jumps as *R1* is adjusted. This is a result of the crystal's oscillating at various harmonics of its 1-MHz resonant frequency. Near 1 MHz, the oscillator quickly locks onto the crystal's resonant frequency.

The circuit in Fig. 7 is useful for understanding the operation of a simple quartz-crystal-controlled oscillator. It can also be used to supply a marker frequency to calibrate oscilloscopes, signal generators, and shortwave receivers.

Figure 8 shows a very useful crystal-controlled, clock-pulse generator. The circuit is designed around Intersil's ICM7209, a CMOS general-purpose timer chip. The crystal can be any quartz crystal having a resonant frequency of 10 kHz to 10 MHz. The circuit consumes only about 11 mA when powered by a 5-V supply and requires only four external components.◇

PROGRAMMER'S NOTEBOOK

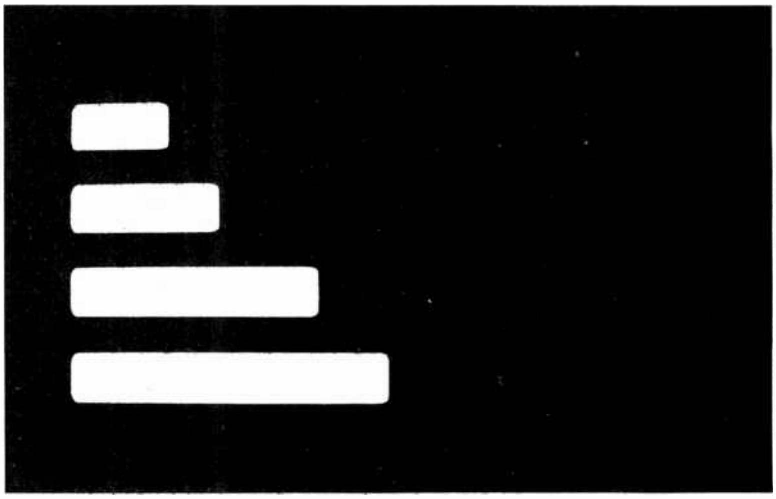
By Jim Keogh

Drawing Bar Graphs

ONE of the more common methods of showing data in graph form on a video monitor is by extending bars from a predetermined base line to a plotted data point.

Let's take a close look at how such a bar-graph routine can be incorporated in a program. We will give programs for the TRS-80 and the Apple II, but they can be modified to run with almost any BASIC in a machine having memory-mapped video or a terminal having cursor control.

To modify these programs, compare the functions of each portion of the program which are defined in the REM statements with similar functions found in your BASIC. For example, consider a bar-graph program that "draws" a bar graph from left to right on the screen (Table I). Throughout this program, the REM statements will explain what is tak-



Horizontal bar graph drawn with program in Table I.

TABLE I—PROGRAM FOR HORIZONTAL GRAPH

TRS-80

```
10  REM CLEAR THE SCREEN
20  CLS
30  REM ASK FOR FOUR DATA POINTS
40  INPUT "FOUR VALUES"; A, B, C, D
41  REM CLEAR THE SCREEN
42  CLS
50  REM ADD THE FOUR DATA POINTS
60  F = A + B + C + D
70  REM DETERMINE THE DECIMAL
    EACH DATA POINT IS OF THE
    TOTAL.
80  AA = A/F
90  BB = B/F
100 CC = C/F
110 DD = D/F
120 REM DETERMINE THE ROUNDED
    OFF PORTION OF THE BAR GRAPH
    TO BE DISPLAYED. THE NUMBER IN
    THE BRACKETS REPRESENTS THE
    POKE POSITIONS OF THE DISPLAY
    SCREEN.
130 AW% = AA * (15742 – 15680)
140 BW% = BB * (15780 – 15728)
150 CW% = CC * (15998 – 15936)
160 DW% = DD * (16126 – 16064)
170 REM THE FOLLOWING DRAWS THE
    BAR GRAPH THAT WILL START AT
    THE FIRST POKE POSITION AND
    STOP AT THE FIRST POKE POSI-
    TION PLUS THE PERCENTAGE VAL-
    UE OF THE DATA POINT.
180 FOR AS = 15680 TO
    (15680 + AW%)
190 POKE AS, 191
200 NEXT AS
210 FOR BS = 15808 TO
    (15808 + BW%)
220 POKE BS, 191
230 NEXT BS
240 FOR CS = 15936 TO
    (15936 + CW%)
250 POKE CS, 191
260 NEXT CS
270 FOR DS = 16064 TO
    (16064 + DW%)
280 POKE DS, 191
290 NEXT DS
300 REM THE NEXT STATEMENT PRE-
    VENTS THE COMPUTER FROM DIS-
    PLAYING THE WORD 'READY'.
310 GOTO 310
```

APPLE II

```
10  REM CLEAR THE SCREEN
20  CALL –936
30  REM ASK FOR FOUR DATA POINTS
40  INPUT "FOUR VALUES"; A, B, C, D
41  REM CLEAR THE SCREEN
42  CALL - 936
50  REM ADD THE FOUR DATA POINTS
60  F = A + B + C + D
70  REM DETERMINE THE DECIMAL
    EACH DATA POINT IS OF THE
    TOTAL.
80  AA = A/F
90  BB = B/F
100 CC = C/F
110 DD = D/F
120 REM DETERMINE THE ROUNDED
    OFF PORTION OF THE BAR GRAPH
    TO BE DISPLAYED. THE NUMBER 30
    REPRESENTS THE VALUE OF 100%
    OF THE BAR GRAPH
130 AW = INT (AA * 30)
140 BW = INT (BB * 30)
150 CW = INT (CC * 30)
160 DW = INT (DD * 30)
161 REM TURN ON THE GRAPHIC FUNC-
    TION AND DRAW RED BARS.
162 GR: COLOR = 1
170 REM DRAW THE BAR GRAPH
180 HLIN 0, (AW) AT 10
190 HLIN 0, (BW) AT 15
200 HLIN 0, (CW) AT 20
210 HLIN 0, (DW) AT 25
300 REM THE NEXT STATEMENT PRE-
    VENTS THE COMPUTER FROM DIS-
    PLAYING THE 'READY' STATE-
    MENT.
310 GOTO 310
```

TABLE II—PROGRAM FOR VERTICAL GRAPH

TRS-80

```
10  REM CLEAR THE SCREEN
20  CLS
30  REM ASK FOR FOUR DATA POINTS
40  INPUT "FOUR VALUES"; A, B, C, D
41  REM CLEAR THE SCREEN
42  CLS
50  REM ADD THE FOUR DATA POINTS
60  F = A + B + C + D
70  REM DETERMINE THE DECIMAL
    EACH DATA POINT IS OF THE
    TOTAL
80  AA = A/F
90  BB = B/F
100 CC = C/F
110 DD = D/F
120 REM DETERMINE THE ROUNDED
    OFF PORTION OF THE BAR GRAPH
    TO BE DISPLAYED. THE NUMBER IN
    THE BRACKETS REPRESENTS THE
    POKE POSITIONS OF THE DISPLAY
    SCREEN.
130 AW% = AA * (16336 - 15663)
140 BW% = BB * (16346 - 15673)
150 CW% = CC * (16356 - 15683)
160 DW% = DD * (16366 - 15693)
170 REM THIS DRAWS THE BAR GRAPH.
    IT WILL START AT THE FIRST POKE
    POSITION AND STOP AT THE FIRST
    POKE POSITION MINUS THE PER-
    CENTAGE VALUE OF THE DATA
    POINT.
180 FOR AS = 16336 TO
    (16336 - AW%) STEP - 64
190 POKE AS, 191
200 NEXT AS
210 FOR BS = 16346 TO
    (16346 - BW%) STEP - 64
220 POKE BS, 191
230 NEXT BS
240 FOR CS = 16356 TO
    (16356 - CW%) STEP - 64
250 POKE CS, 191
260 NEXT CS
270 FOR DS = 16366 TO
    (16366 - DW%) STEP - 64
280 POKE DS, 191
290 NEXT DS
300 REM THE NEXT STATEMENT PRE-
    VENTS THE COMPUTER FROM DIS-
    PLAYING THE WORD 'READY'.
310 GOTO 310
```

APPLE II

```
10  REM CLEAR THE SCREEN
20  CALL -936
30  REM ASK FOR FOUR DATA POINTS
40  INPUT "FOUR VALUES"; A, B, C, D
41  REM CLEAR THE SCREEN
42  CALL - 936
50  REM ADD THE FOUR DATA POINTS
60  F = A + B + C + D
70  REM DETERMINE THE DECIMAL
    EACH DATA POINT IS OF THE
    TOTAL.
80  AA = A/F
90  BB = B/F
100 CC = C/F
110 DD = D/F
120 REM DETERMINE THE ROUNDED
    OFF PORTION OF THE BAR GRAPH
    TO BE DISPLAYED., THE NUMBER
    35 REPRESENTS THE VALUE OF
    100% OF THE BAR GRAPH.
130 AW = INT (AA * 35)
140 BW = INT (BB * 35)
150 CW = INT (CC * 35)
160 DW = INT (DD * 35)
161 REM TURN ON THE GRAPHIC FUNC-
    TION AND DRAW RED BARS.
162 GR: COLOR = 1
170 REM DRAW THE BAR GRAPH.
180 VLIN (AW), 35 AT 10
190 VLIN (BW), 35 AT 15
200 VLIN (CW), 35 AT 20
210 VLIN (DW), 35 AT 25
300 REM THE NEXT STATEMENT PRE-
    VENTS THE COMPUTER FROM DIS-
    PLAYING THE WORD 'READY'.
310 GOTO 310
```

ing place at that particular point in the program. To get things started, the computer will request that you INPUT four values representing the data points to be plotted. Once the last piece of data is keyed in, the video display will "draw" four bar graphs, each bar representing one piece of data.

You can easily expand the number of data points as required. However, before you begin to make any modifications, you should understand the programming approach.

The program starts by causing the computer to set aside a certain area on the screen for each bar graph. This is done without knowing the values of the data points. The computer "assumes" that the amount of space set aside is equal to a bar graph of maximum amplitude (100%).

When the final INPUT data point is ENTERed, the computer adds the values of the data points, with the numeric sum of all data points becoming the "100%" value. This establishes what percentage each data point represents of the total.

Finally, the computer illuminates that portion of the bar graph which represents the percentage the data point is of the total. The computer is able to represent all the data in a neatly prepared bar graph since the program operates on a percentage basis and not directly with the actual value of each data point.

The second program (Table II) example is very similar, except that the bar graphs are "drawn" from bottom to top, rather than from left to right on the screen. (Table II). As before, the program calls for four data points.

These bar-graph programs can be used as a subroutine (with appropriate line-number changes) in your own software. For example, the results of an analysis can be displayed in several ways, such as in a table or a bar graph. The routines illustrated in this column use data points INPUT from the main program and display them as a bar graph. ◇

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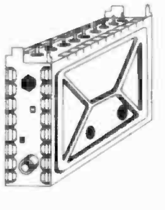

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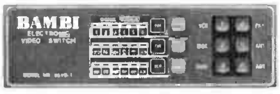

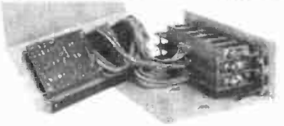

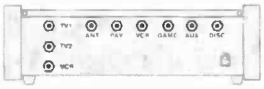

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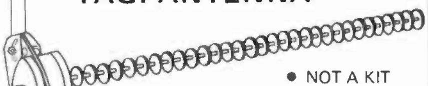

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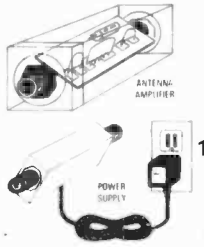

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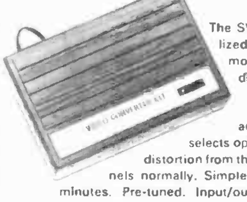

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able. Donald R. Fonville, 1025 Valleydale Dr., Burlington, NC 27215.

Acrosound Model 120 stereo ultralinear amplifier. Need original owners manual. Steven Bender, Box 28360, Queens Village, NY 11428.

Galaxie III SSB amateur transceiver. Need circuit diagram. John DeVine, 127 Los Angeles Ave., Stratford, CT 06497.

Pioneer Model SX-600T AM/FM stereo receiver. Need schematic, parts list and layout. Torsten Isaacson, 65 Dellbrook Ct., Ofallon, MO 63366.

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Incoterm Corporation 055-13-02-70 keyboard assembly. Need schematic or any information available. Graham Mott, 2 London Bridge, London SE1 9RB, England.

Currier Smith Model 10478-G01-001 telephone answerer. Need schematic and service literature. Frank B. McCorrison, 72 Antwerp St., Brighton, MA 02135.

Stark Model 9-11 tube tester. Need instruction manual and tube charts. Jack Marsden, 25 Springbrook Rd., Cobourg, Ontario K9A 4HB.

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Supreme Model 599 set tester. Need schematic, operations manual, tube list and any other information. Erick Gulbrand, 1500 Woodland Terrace, Lake Oswego, OR 97034.

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Collins Model R390 receiver. Need technical manual L11-856. P. Spanu, 20 Dickinson Rd., Darien, CT 06820.

Hallicrafters Model S-38 receiver. Need instruction and service manuals. D.R. Wilson, 15075 Aster, Allen Park, MI 48101.

Hickok Model 670 oscilloscope. Need schematic and instruction manual. Gayne Jones, 10071 N.E. South Beach Dr., Bainbridge Island, WA 98110.

LFE Model 832 oscillator and sweeper. Need schematic and manual. John Leary, 100 Dorman Rd., Oxford, CT 06483.

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PROJECT OF THE MONTH

By Forrest M. Mims

A Tunable Notch Filter

SOMETIMES signals within a narrow frequency range interfere with the operation of an electronic circuit. The best known of these interfering signals is 60-Hz line noise. Shortwave radio listeners often find that a broadcast they are attempting to monitor is partially masked by an annoying tone.

Figure 1 shows a passive filter that can be tuned to reject or block a narrow band of audio frequencies. Such a circuit is called a *band-rejection filter*, *band-stop filter*, or *notch filter*. The particular filter in Fig. 1 is called a *bridged differentiator* tunable notch filter. It is easier to adjust than the better known twin-tee (or twin-T) notch filter.

The filter in Fig. 1 uniformly attenuates frequencies outside its band-stop region by about 4.1 dB (i.e about 48% of a non-band-stop frequency is blocked). This loss can be virtually eliminated by following the filter with an op amp to form an *active* notch filter as shown in Fig. 2. This circuit has a uniform attenuation outside its stop band of only 0.4 dB (i.e. about 5% attenuation).

I measured this attenuation with the help of a signal generator, oscilloscope, and a breadboard version of the active filter. When potentiometer *R1*, *R2* was adjusted so that $R1 = R2 = 50$ kilohms, then the notch frequency was 1431 Hz. The signal from the filter at points outside the stop band had an amplitude of 2.75 V. At the bottom of the notch the signal's amplitude was 0.15 V. This represents an attenuation of 0.15/2.75 or 94.5%.

Many engineers prefer to express such relationships in terms of decibels. In this case, the attenuation in decibels is $20\log(V_{out}/V_{in})$. Therefore, the attenuation is 20log(0.055) or −25.27 decibels.

Figure 3 is a plot of the frequency response of the circuit in Fig. 2 when it has been adjusted for a stop-band centered at 1431 Hz. Note that the slope of the notch is much sharper on the low-frequency side. Also note that the amplitude axis of the graph has a linear scale. Often such frequency-response curves are plotted on a logarithmic scale.

The notch frequency of the circuit in Fig. 2 can be easily tuned across much of the audio spectrum. According to various texts about filters (e.g. H. Berlin's "The Design of Active Filters," E&L Instruments, 1977), the notch frequency is given by

$$F_{notch} = 1/2\pi C\sqrt{3R1R2}$$

However, inserting the values for the circuit in Fig. 2 when $R1 = R2 = 50$ kilohms gives a predicted notch frequency of 1838 Hz. Recall from above that the actual notch frequency I measured was 1431 Hz.

Similarly, when *R1* is 10 kilohms and *R2* is 90 kilohms, the equation predicts a notch frequency of 3063 Hz. However, I measured an actual notch frequency of 2334 Hz.

These discrepancies are likely due to tolerance variations in all three capacitors, and *R3* in the test circuit. For optimum results, *C1*, *C2* and *C3* should have exactly equal values. Likewise, the resistance of *R3* should be exactly six times the resistance of *R1* + *R2*.

The attenuation at higher frequencies is not as sharp. At 10 kHz, for example, the amplitude at the notch frequency was 13.4 dB below the out-of-notch frequencies.

Incidentally, I connected the circuit in Fig. 2 between my shortwave receiver and an external power amplifier in an effort to tune out annoying interference tones. If the frequency of the interfering tone was steady, the filter did indeed greatly reduce its amplitude. I also found that the filter is ideal for attenuating the shrill tone from a piezoelectric alerter being operated in a room monitored by an intercom. This permits the intercom to be comfortably monitored without the annoyance of the alerter's tone. ◇

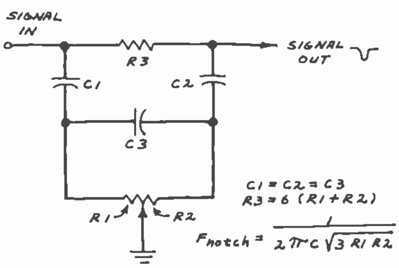

Fig. 1. A passive bridged, differentiator tunable notch filter.

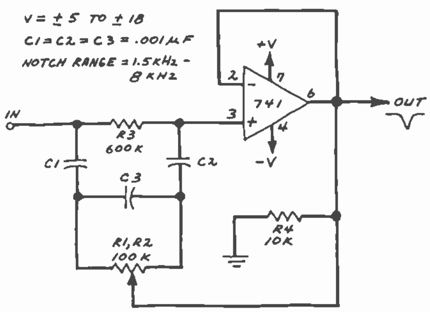

Fig. 2. Circuit for an active tunable notch filter.

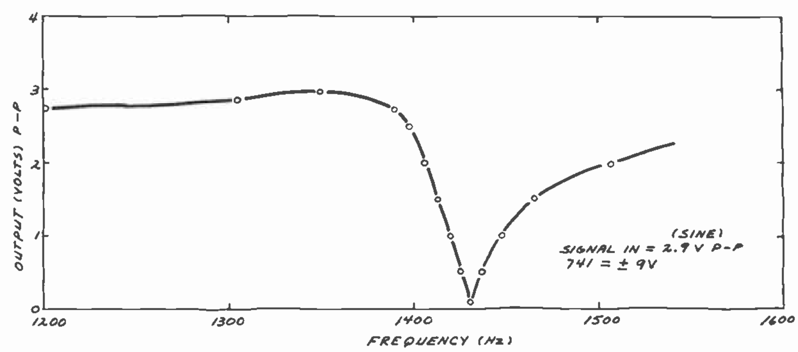

Fig. 3. A plot of the notch for circuit shown in Fig. 2.

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8T97	.99
8T98	.99
DM8131	2.95
DP8304	2.29

MISC

3341	4.95
76477	3.95
AY3-8910	12.95
MC3340	1.49
95H90	7.99
11C90	13.95
8202A	34.95
3242	7.95
MC3480	9.00
MC4024	3.95
MC4044	4.50
3205	3.50

BIT-RATE GENERATORS

14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
MM5307	10.95

UARTS

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

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95
74C922	5.25
74C923	5.50

CLOCK CIRCUITS

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

6800

68000	call
6800	4.95
6802	10.95
6808	13.90
6809E	19.95
6809	19.95
6810	2.95
6820	4.95
6821	4.95
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	16.95
6847	12.25
6850	3.45
6852	5.75
6860	10.95
6862	11.95
6875	6.95
6880	2.95
6883	24.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	7.95
68B21	12.95
68B45	35.95
68B50	12.95

68B00 = 2 MHZ

6500

1 MHZ

6502	6.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	8.75
6532	11.25
6545	22.50
6551	11.85

2 MHZ

6502A	9.95
6522A	11.70
6532A	12.40
6545A	28.50
6551A	12.95

3 MHZ

6502B	14.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.0	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

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1791	29.95	MSM5832	6.95
1793	38.95	32.768 CRYSTAL .	1.95

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.01uf DISC ...	100/ 6.00	MC1330 ..	1.49
.1uf DISC	100/ 8.00	MC1350 ..	1.19
.1uf MONO ...	100/15.00	MC1358 ..	1.39
		LM1800 ..	1.99

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2732 32K EPROMS 8/$7.95 EACH

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74LS00

74LS00	.25	74LS85	1.15	74LS168	1.75	74LS295	1.05
74LS01	.25	74LS86	.40	74LS169	1.75	74LS298	1.20
74LS02	.25	74LS90	.65	74LS170	1.75	74LS324	1.75
74LS03	.25	74LS91	.89	74LS173	.80	74LS352	1.55
74LS04	.25	74LS92	.70	74LS174	.95	74LS353	1.55
74LS05	.25	74LS93	.65	74LS175	.95	74LS363	1.35
74LS08	.35	74LS95	.85	74LS181	2.15	74LS364	1.95
74LS09	.35	74LS96	.95	74LS189	9.95	74LS365	.95
74LS10	.25	74LS107	.40	74LS190	1.00	74LS366	.95
74LS11	.35	74LS109	.40	74LS191	1.00	74LS367	.70
74LS12	.35	74LS112	.45	74LS192	.85	74LS368	.70
74LS13	.45	74LS113	.45	74LS193	.95	74LS373	1.75
74LS14	1.00	74LS114	.50	74LS194	1.00	74LS374	1.75
74LS15	.35	74LS122	.45	74LS195	.95	74LS377	1.45
74LS20	.25	74LS123	.95	74LS196	.85	74LS378	1.18
74LS21	.35	74LS124	2.99	74LS197	.85	74LS379	1.35
74LS22	.25	74LS125	.95	74LS221	1.20	74LS385	1.90
74LS26	.35	74LS126	.85	74LS240	1.29	74LS386	.65
74LS27	.35	74LS132	.75	74LS241	1.29	74LS390	1.90
74LS28	.35	74LS136	.55	74LS242	1.85	74LS393	1.90
74LS30	.25	74LS137	.99	74LS243	1.85	74LS395	1.65
74LS32	.35	74LS138	.75	74LS244	1.29	74LS399	1.70
74LS33	.55	74LS139	.75	74LS245	1.90	74LS424	2.95
74LS37	.55	74LS145	1.20	74LS247	.75	74LS447	.37
74LS38	.35	74LS147	2.49	74LS248	1.25	74LS490	1.95
74LS40	.35	74LS148	1.35	74LS249	.99	74LS624	3.99
74LS42	.55	74LS151	.75	74LS251	1.30	74LS668	1.69
74LS47	.75	74LS153	.75	74LS253	.85	74LS669	1.89
74LS48	.75	74LS154	2.35	74LS257	.85	74LS670	2.20
74LS49	.75	74LS155	1.15	74LS258	.85	74LS674	9.65
74LS51	.25	74LS156	.95	74LS259	2.85	74LS682	3.20
74LS54	.35	74LS157	.75	74LS260	.65	74LS683	2.30
74LS55	.35	74LS158	.75	74LS266	.55	74LS684	2.40
74LS63	1.25	74LS160	.90	74LS273	1.65	74LS685	2.40
74LS73	.40	74LS161	.95	74LS275	3.35	74LS688	2.40
74LS74	.45	74LS162	.95	74LS279	.55	74LS689	2.40
74LS75	.50	74LS163	.95	74LS280	1.98	74LS783	24.95
74LS76	.40	74LS164	.95	74LS283	1.00	81LS95	1.69
74LS78	.50	74LS165	.95	74LS290	1.25	81LS96	1.69
74LS83	.75	74LS166	2.40	74LS293	1.85	81LS97	1.69
						81LS98	1.69

LINEAR

LM301V	.34	LM1800	2.99
LM308V	.98	LM1889	2.49
LM309K	1.49	LM3900	.59
LM311	.64	LM3909V	.98
LM317T	1.95	LM3914	3.95
LM317K	3.95	LM3915	3.95
LM318	1.49	LM3916	3.95
LM323K	4.95	75451V	.39
LM324	.59	75452V	.39
LM337K	3.95	75453V	.39
LM339	.99		
LM377	2.29	**BI FET**	
LM380	1.29	TL071	.79
LM386V	1.50	TL072	1.19
LM555V	.39	TL074	2.19
LM556	.69	TL081	.79
LM565	.99	TL082	1.19
LM566V	1.49	TL083	1.19
LM567V	1.29	TL084	2.19
LM723	.49	LF347	2.19
LM733	.98	LF351	.60
LM741V	.29	LF353	1.00
LM747	.79	LF355	1.10
LM748V	.59	LF356	1.10
LM1310	2.90	LF357	1.40
MC1330V	1.89	**EXAR**	
MC1350V	1.29		
MC1358	1.79	XR 2206	3.75
LM1414	1.59	XR 2207	3.85
LM1458V	.69	XR 2208	3.90
LM1488	.99	XR 2211	5.25
LM1489	.99	XR 2240	3.25

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80

WW = WIREWRAP

CONNECTORS

RS232 MALE	3.25
RS232 FEMALE	3.75
RS232 HOOD	1.25
S-100 ST	3.95
S-100 WW	4.95

DIP SWITCHES

4 POSITION	.85
5 POSITION	.90
6 POSITION	.90
7 POSITION	.95
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LED LAMPS

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

CMOS

4000	.35	4071	.30
4001	.35	4072	.30
4002	.25	4073	.30
4006	.95	4075	.30
4007	.29	4076	.95
4008	.95	4078	.30
4009	.45	4081	.30
4010	.45	4082	.30
4011	.35	4085	.95
4012	.25	4086	.95
4013	.45	4093	.95
4014	.95	4098	2.49
4015	.95	4099	1.95
4016	.45	14409	12.95
4017	1.15	14410	12.95
4018	.95	14411	11.95
4019	.45	14412	12.95
4020	.95	14419	4.95
4021	.95	4502	.95
4022	1.15	4503	.65
4023	.35	4508	1.95
4024	.75	4510	.95
4025	.35	4511	.95
4026	1.65	4512	.95
4027	.65	4514	1.25
4028	.80	4515	2.25
4029	.95	4516	1.55
4030	.45	4518	1.25
4034	2.95	4519	1.25
4035	.85	4520	1.25
4040	.95	4522	1.25
4041	1.25	4526	1.25
4042	.75	4527	1.95
4043	.85	4528	1.25
4044	.85	4531	.95
4046	.95	4532	1.95
4047	.95	4538	1.95
4049	.55	4539	1.95
4050	.55	4543	2.70
4051	.95	4555	.95
4053	.95	4556	.95
4060	1.45	4581	1.95
4066	.75	4582	1.95
4068	.40	4584	.95
4069	.35	4584	.95
4070	.35	4702	12.95

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VOLTAGE REGULATORS

7805T	.89	7905T	.99
7808T	.89	7908T	.99
7812T	.89	7912T	.99
7815T	.89	7915T	.99
7824T	.89	7924T	.99
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79

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

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- ★ 35 Tracks/single side
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- ★ Available as bare board, kit, or assembled and bested board.

BARE BOARD	$40.00
KIT	69.96
ASSEMBLED & TESTED	74.95

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7400

SN7400N	.20	SN7472N	.29	SN74156N	.79
SN7401N	.20	SN7473N	.35	SN74157N	.69
SN7402N	.25	SN7474N	.35	SN74160N	.89
SN7403N	.25	SN7475N	.49	SN74161N	.89
SN7404N	.25	SN7476N	.35	SN74162N	.89
SN7405N	.29	SN7479N	5.00	SN74163N	.89
SN7406N	.35	SN7480N	.50	SN74164N	.89
SN7407N	.35	SN7482N	.99	SN74165N	.89
SN7408N	.29	SN7483N	.69	SN74166N	1.25
SN7409N	.29	SN7485N	.89	SN74167N	2.79
SN7410N	.25	SN7486N	.35	SN74170N	1.95
SN7411N	.29	SN7489N	1.75	SN74172N	4.95
SN7412N	.35	SN7490N	.49	SN74173N	1.39
SN7413N	.40	SN7491N	.59	SN74174N	.99
SN7414N	.69	SN7492N	.45	SN74175N	.89
SN7416N	.29	SN7493N	.45	SN74176N	.79
SN7417N	.29	SN7494N	.69	SN74177N	.79
SN7420N	.25	SN7495N	.69	SN74179N	1.49
SN7421N	.29	SN7496N	.69	SN74180N	.79
SN7422N	.45	SN7497N	3.00	SN74181N	2.25
SN7423N	.29	SN74100N	1.49	SN74182N	.79
SN7425N	.29	SN74104N	.89	SN74184N	2.49
SN7426N	.29	SN74105N	.89	SN74185N	2.49
SN7427N	.25	SN74107N	.35	SN74190N	1.25
SN7428N	.49	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	.35	74LS107	.45	74LS240	1.49
74LS09	.35	74LS109	.45	74LS241	1.49
74LS10	.35	74LS112	.45	74LS242	1.49
74LS11	.39	74LS113	.49	74LS243	1.49
74LS12	.35	74LS114	.49	74LS244	1.49
74LS13	.59	74LS122	.89	74LS245	2.95
74LS14	.99	74LS123	1.25	74LS247	1.19
74LS15	.35	74LS125	.59	74LS248	1.19
74LS20	.35	74LS126	.59	74LS249	1.19
74LS21	.35	74LS132	.99	74LS251	.99
74LS22	.35	74LS133	.89	74LS253	.99
74LS26	.35	74LS136	.49	74LS257	.89
74LS27	.35	74LS138	.89	74LS258	.69
74LS28	.35	74LS139	.89	74LS260	.69
74LS30	.35	74LS151	.89	74LS266	.69
74LS32	.35	74LS153	.89	74LS273	1.95
74LS33	.59	74LS154	1.75	74LS279	.89
74LS37	.45	74LS155	.89	74LS283	.89
74LS38	.39	74LS156	.89	74LS290	.99
74LS40	.35	74LS157	.89	74LS293	.99
74LS42	.89	74LS158	.89	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	.69
74LS51	.35	74LS163	1.15	74LS366	.69
74LS54	.35	74LS164	1.15	74LS367	.69
74LS55	.35	74LS165	1.15	74LS368	.69
74LS73	.45	74LS168	1.19	74LS373	1.95
74LS74	.45	74LS169	1.19	74LS374	1.95
74LS75	.59	74LS170	1.95	74LS375	.89
74LS76	.45	74LS173	.99	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	.49	74LS190	1.25	81LS95	1.95
74LS90	.69	74LS191	1.25	81LS97	1.95

74S/PROMS*

74S00	.35			74S243	2.25
74S02	.35			74S244	2.25
74S03	.35	74S124	2.95	74S251	.99
74S04	.45	74S133	.45	74S253	.99
74S05	.45	74S134	.50	74S257	.99
74S08	.40	74S135	.89	74S258	.99
74S09	.40	74S136	1.39	74S260	.79
74S10	.35	74S138	.99	74S280	2.25
74S11	.35	74S139	.99	74S287*	1.95
74S15	.35	74S140	.55	74S288*	1.95
74S20	.35	74S151	.99	74S373	2.49
74S22	.35	74S153	.99	74S374	2.49
74S30	.35	74S157	.99	74S387*	1.95
74S32	.45	74S158	.99	74S471*	5.95
74S38	.89	74S160	2.49	74S472*	5.95
74S40	.40	74S174	1.25	74S473*	5.95
74S51	.35	74S175	1.25	74S474*	7.95
74S64	.40	74S188*	1.95	74S475*	7.95
74S65	.40	74S194	1.49	74S570*	4.49
74S74	.55	74S195	1.49	74S571*	4.49
74S86	.55	74S196	1.49	74S572*	5.95
74S112	.55	74S240	2.25	74S573*	5.95
74S113	.55	74S241	2.25	74S940	1.95
74S114	.55	74S242	2.25	74S941	1.95

CA—LINEAR

CA3010H	.99			CA3089N	3.75
CA3013H	2.15	CA3060N	3.25	CA3096N	3.95
CA3023H	3.25	CA3080H	1.25	CA3130H	1.39
CA3035H	2.49	CA3081N	2.00	CA3140H	1.25
CA3039H	1.35	CA3082N	2.00	CA3160H	1.25
CA3046N	1.30	CA3083N	1.60	CA3401N	.59
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CD4010	.49	CD4044	.89	CD4512	1.49
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CD4015	1.19	CD4050	.69	CD4519	.89
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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	1-99	100-499	500+	Radial	1-99	100-499	500+
.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

CIRCLE NO. 26 ON FREE INFORMATION CARD

UTIC Mini Stereo AM/FM Receiver

WITH HEADPHONES — For Joggers, Cyclists, Skaters & Sports Events

FEATURES: Lightweight headphones. Left/right balance control. Full fidelity stereo sound. Additional black soft carrying case & shoulder strap. Belt clip (hands free). Operates on 3 AA cell batteries (not incl.). Compact size: 3⅛" x 4⅞" x 1". Wt. 6 oz.

Model 2830 List Price $89.95 .... **$34.95**

SPEAKERS

2¼" Round — 8 Ohm
.25 Watt (4" Leads)
Size: 2¼" x ¾"

Part No.	Price
A0201	$1.25 or 2/1.98

2½" Square — 16 Ohm
.25 Watt (4 mount. holes)
Large Ceramic Magnet
Size: 2⅝" x 2⅝" x ¾"

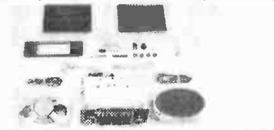
Part No.	Price
SF-25016	$1.39 or 2/2.98

MOTOROLA

AM/FM Stereo Push Button CAR RADIO

FOR VOLKSWAGEN SCIROCCO, RABBIT, AUDI 5000 AND FOX

(with minor adjustments, can be used in any automobile)



Includes bezel trim and everything pictured. Two each 4x6 speakers and grille (1½" deep). All cables and leads for hook-up. Includes all instruction Manuals for easy installation. Cut-out dimensions: 7"W x 1¾"H x 6½"L.

Model 5VW3901 .... **$49.95**

UV-EPROM Eraser

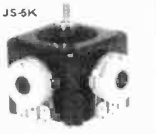
Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

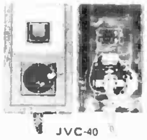
UVS-11EL Replacement Bulb **$16.95**

DE-4 UV-EPROM Eraser **$79.95**

JOYSTICKS

JS-5K





JVC-40

JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JS-150K	150K Linear Taper Pots	$4.75
JVC-40	40K (2) Video Controller In case	$4.95

5¼" Mini-Floppy Disc Drive

Pertec Computer Corp.

FOR TRS-80 MODEL I, III (Industry Standard)

Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.6V) 1.6 amps max., 5VDC (±0.25V) 0.8 amps max. Unit as pictured at left (does not incl. case, power supply or cables). 30-page data book included. Weighs 3½ pounds. Size: 5¾"W x 8"D x 3¼"H

Limited Quantity!

Part No.	Price
FD200	$179.95

Single-sided, 40 tracks, 250K bytes capacity

FD250	$199.95

Double-sided, 35 tracks, 438K bytes capacity

JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA
- Two, 3-terminal adj. IC regulators with thermal overload protection
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2"w x 5-1/16"L x 2"H

JE215 Adj. Dual Power Supply Kit (as shown) .. **$24.95**

(Picture not shown but similar in construction to above)

JE200	Reg. Power Supply Kit (5VDC, 1 amp)	$14.95
JE205	Adapter Brd. (to JE200) ±5, ±9 & ±12V	$12.95
JE210	Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp	$19.95

KEYBOARDS — POWER SUPPLIES

JE610 ASCII Encoded Keyboard Kit

The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with 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 @ 10mA for operation. Features: 60 keys generate the 126 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. Size: 3½"H x 14½"W x 8¾"D.

JE610/DTE-AK (After assembly as pictured above) **$124.95**

JE610 Kit 62-Key Keyboard, PC Board & Components (no case) .... **$ 79.95**
K62 62-Key Keyboard (Keyboard only) .... **$ 34.95**
DTE-AK (case only — 3¼"H x 11"W x 8¾"D) .... **$ 49.95**

JE212 — Negative 12VDC Adapter Board Kit for JE610 ASCII KEYBOARD KIT
Provides —12VDC from Incoming 5VDC $9.95

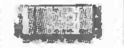
JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

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. Debounce circuit provided for all 19 keys. Nine LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3½"H x 8¼"W x 8¾"D.

JE600/DTE-HK (After assembly as pictured above) **$99.95**

JE600 Kit 19-Key Hexadecimal Keyboard, PC Board & Components (no case) **$59.95**
K19 19-Key Keyboard (Keyboard only) **$14.95**
DTE-HK (case only — 3½"H x 8¼"W x 8¾"D) **$44.95**



9½"Lx4¼"Wx1"H

ALPS 26-KEY CALCULATOR KEYBOARD
Gray Key Caps with blue, green and white back drop. Mechanical SPST Switching: 22-pin Edge Card Connection.
Part No. KB26 .... $2.95 each or 2/$4.95

16⅜"L x 5¼"W x 1⅜"H

MICRO SWITCH 69-KEY KEYBOARD
Data Entry Keyboard, Encoded Output: 8-bit Parallel EBC DIC. Switching: Hall Effect, 24-pin Edge Card Connection. Complete with Pin Connection.
Part No. KB69SD12-2 .... $19.95 each

16¾"L x 5½"W x 1⅞"H

DATANETICS 74-KEY KEYBOARD
ASCII Encoded Keyboard, Output: Even Parity ASCII. Supply voltage +5, -12 volt. Switching: Mechanical SPST — 50-pin Connection. Complete with Pin Connection.
Part No. KB354 .... $29.95 each

23"Lx5¾"Wx1-3/8"H

MICRO SWITCH 85-KEY KEYBOARD
Data Entry Keyboard. Switching: Hall Effect, 13-pin Edge Card Connection. Metal frame, dark brown key caps.
Part No. 85SD18-1 .... $29.95 each

18¼"L x 5¾"W x 1⁹⁄₁₆"H

MICRO SWITCH 88-KEY KEYBOARD
Data Entry Keyboard used in a Diablo 1640 Terminal. Supply Voltage: +5V, -12V. Switching: Hall Effect — 10-pin Edge Card Connection. Schematic included.
Part No. 88SD22 .... $69.95 each

POWER SUPPLIES

POWER SUPPLY — 5VDC @ 1 AMP REGULATED — Transaction Tech
Output +5VDC @ 1 amp (also +30VDC) reg. Input 115VAC 60Hz. Two-tone (black/beige) self-enclosed case. 6 ft., 3 cond. black power cord. Size: 6½"W x 7"D x 2¼"H. Wt. 3 lbs.
Part No. PS51194 .... $19.95 each

POWER SUPPLY — 5VDC @ 1 AMP REGULATED — B Industries
Output +5VDC @ 1 amp, +36-42VDC adj. 400mA or less, 30VAC (isol.) @ 1.5 amp. Input 115VAC 60Hz. Circ. brkr. re-set button. Blk. self-encl. case w/4 rubber feet, 6 ft., 3 cond. blk. pow. cord. On/off switch. 6¾"W x 7¼"D x 3-7/8"H - wt. 7 lbs.
Part No. PS407D .... $24.95 each

POWER SUPPLY — 5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord 11½"W x 13¼"D x 3¾"H. Wt. 6 lbs.
Part No. PS94VD .... $49.95 each

POWER PAC — Heavy Duty Multi-Voltage Power Supply — 5VDC, 12VDC, 24VDC
Output: +5VDC @ 30A, +12VDC @ 2A, -12VDC @ 4A & +24VDC @ 3A. Input: 115VAC, 7A, 220VAC, 3.5A. Reg.: ± .15% line & load comb. Ripple: 10MV peak to peak (3MV RMS). Overvolt protect.: 5V, +12V, -12V. Overcur. protect. Incl. 15½"L x 6"H x 11-7/8"D. Wt. 40 lbs.
Part No. 285-016 .... $89.95 each

★ SHIPMENT IN 24 HOURS ★

6:00 AM to 6:00 PM (PST)

Call: (415) 592-8097

JUMPER AND CABLE ASSEMBLIES

Custom Jumpers! *Custom Cables!*

STANDARD DIP JUMPERS

All jumpers use low profile dip plugs with heavy duty pins for repeated disconnect applications.

JAMECO Part No.	AP Cross Reference	No. Pins	Description	Wire Length	Price
DJ14-1	924102-12	14	single end	12"	$1.79
DJ14-2	924102-24	14	single end	24"	2.05
DJ14-3	924102-36	14	single end	36"	2.35
DJ14-1-14	924106-12	14	double end	12"	3.20
DJ14-2-14	924106-24	14	double end	24"	3.49
DJ14-3-14	924106-36	14	double end	36"	3.79
DJ16-1	924112-12	16	single end	12"	1.85
DJ16-2	924112-24	16	single end	24"	2.19
DJ16-3	924112-36	16	single end	36"	2.50
DJ16-1-16	924116-12	16	double end	12"	3.35
DJ16-2-16	924116-24	16	double end	24"	3.69
DJ16-3-16	924116-36	16	double end	36"	4.05
DJ24-1	924122-12	24	single end	12"	2.69
DJ24-2	924122-24	24	single end	24"	3.39
DJ24-3	924122-36	24	single end	36"	3.95
DJ24-1-24	924126-12	24	double end	12"	4.79
DJ24-2-24	924126-24	24	double end	24"	5.29
DJ24-3-24	924126-36	24	double end	36"	5.89

JAMECO Part No.	AP Cross Reference	No. Pins	Description	Wire Length	Price
DJ40-1	924132-12	40	single end	12"	5.89
DJ40-2	924132-24	40	single end	24"	6.79
DJ40-3	924132-36	40	single end	36"	7.69
DJ40-1-40	924136-12	40	double end	12"	10.95
DJ40-2-40	924136-24	40	double end	24"	11.89
DJ40-3-40	924136-36	40	double end	36"	12.79

STANDARD DB25 SERIES CABLES

Now you can order DB25 P or S connectors with the cable necessary to fit your application. Choose from our standard flat cable in 4 foot lengths. Call today.

STANDARD CABLES

Part No.	Cable Length	Connectors	Price
DB25P-4	4 feet	1-DB25P	$ 9.95 ea.
DB25S-4	4 feet	1-DB25S	10.95 ea.
DB25P-4-P	4 feet	2-DB25P	16.95 ea.
DB25P-4-S	4 feet	1-DB25P/1-DB25S	17.95 ea.
DB25S-4-S	4 feet	2-DB25S	18.95 ea.

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6% Sales Tax
Postage — Add 5% plus $1.50 Insurance
Send S.A.S.E. for Monthly Sale Flyer!

Spec Sheets — 25¢ each
Send 88¢ Postage for your
FREE 1982 JAMECO CATALOG
Prices Subject to Change

NEW 1982 CATALOG

Mail Order Electronics • Worldwide

Jameco ELECTRONICS

NEW! Telex Number Telex 176043

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8/82 *PHONE ORDERS WELCOME — (415) 592-8097*

BOOKS

National Semiconductor — Intersil — Intel

30001	National CMOS Data Book (640 pages) 74C, CD4000, and A/D Converters	$5.95
30002	National Interface Data Book (704 pages) DP, DS8000, DS3600, DS75000, etc.	$5.95
30003	National Linear Data Book (1376 pages) LM, LF, ADC, DAC, LH Series	$11.95
30004	National Series 80 — Board Level Computer (224 pages)	$4.95
30005	National TTL Logic Data Book (624 pages) 7400, LS, L, H, S, and DM8000 Series	$8.95

30006 Above (3) 30001,3,5 as set $24.95/lot

010400	Intel Component Data Catalog — Full data sheets for Intel's products incl. memory devices, microproc., peripherals & indust./mil. products (1328 pages)	$14.95
205610	Intel Peripheral Design Handbook — Full data sheets, appl. notes for Intel peripheral device components (644 pages)	$9.95

AC and DC Wall Transformers

Part No. DC6912

With Universal Plug and 9V Battery Snap

Selective voltages: 6,9,12VDC. Polarity selection (+/-). six-foot line from adapter to plugs — six-inch line from adapter to battery snap. 120V/60Hz. 300mA.

Part No.	Input	Output	Price
AC 250	117V/60Hz	12VAC 250mA	$3.95
AC 500	117V/60Hz	12VAC 500mA	$4.95
AC1000	117V/60Hz	12VAC 1 amp	$5.95
AC9004	117V/60Hz	9.2VAC 2.5 amp	$2.95 or 2/$4.95
DC 800	120V/60Hz	8VDC 400mA	$1.95 or 2/$2.95
DC6912 (above)	120V/60Hz	6,9,12VDC 300mA	$9.95
DV5490	117V/60Hz	9.5VDC 275mA	$2.49 or 2/$3.95
DC900	120V/60Hz	9VDC 500mA	$3.95
DC1200	120V/60Hz	12VDC 300mA	$2.95 or 2/$4.95

CONNECTORS

DB25P! DB25S Meet RS232 — Computer Users!

DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
D20418-2	Screw Lock Hdwr. (2) DB25S/P	2/$.99
DB51226	Cover for DB25P/S	$1.75
22/44SE	P.C. Edge (22/44 Pin)	$2.95
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/U	BNC Bulkhead Recp.	$1.29

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K or 32K

Kit comes complete with:
- 8 ea. MM5290 (UPD416/4116) 16K Dyn. Ram (*ns)
- Documentation for conversion

TRS-16K2	*150ns	$19.95
TRS-16K3	*200ns	$16.95
TRS-16K4	*250ns	$14.95

Mostek DC/DC Converter

+5 VOLTS TO -9 VOLTS

Input: +5V. Output: -9V (regulated) @ 30mA. Printed circuit mounting.

DC10 .... **$2.95 ea. or 2/$4.95**

Sorensen Regulated Power Supplies

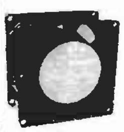
Sorensen's open construction (SOC) power supplies are series-regulated solid-state systems, designed to provide regulated DC voltages at six levels (2-28 volt range). Units are open-framed on sturdy black anodized aluminum for excellent mounting.

FEATURES: 115/208/230 VAC input @ 50-63Hz. Low Ripple: 1.5mVrms, 5mV P-P max. Adjustable current limit. Voltage adjustment control. Temperature-compensated circuitry. Optional over-voltage protection. All schematics and specifications supplied with unit. Series A, B, C, E have 3 mounting surfaces (Series F, bottom mounting only).

SPECIFICATION CHART

Part No.	Series	Output Volt. Adjust Range min.	max.	Output Current (Adc) 40°C	50°C	60°C	Size (inches)	Wt. lbs.	Price
SOC 2-6	B	1.9	2.1	6.0	4.9	3.8	5.62x4.88x2.50	4.3	19.95
SOC2-25	F	1.9	2.1	25.0	21.5	17.5	16.00x4.88x4.88	16.0	29.95
SOC5-3	A	4.75	5.25	3.0	2.4	1.8	4.00x4.88x1.62	2.0	24.95
SOC5-18	E	4.25	5.25	18.0	15.0	12.0	14.00x4.88x2.75	12.0	39.95
SOC5-25	F	4.25	5.25	25.0	21.5	17.5	16.00x4.88x4.88	16.0	49.95
SOC12-11	E	11.4	12.6	11.0	9.2	6.8	14.00x4.88x1.62	12.0	44.95
SOC12-15	F	11.4	12.6	15.0	12.75	9.5	16.00x4.88x4.88	16.0	49.95
SOC15-5	C	14.25	15.75	5.0	4.2	3.5	7.00x4.68x3.37	6.6	39.95
SOC15-9.5	E	14.25	15.75	9.5	7.6	5.6	14.00x4.88x1.62	12.0	44.95
SOC15-13	F	14.25	15.75	13.0	10.5	8.0	16.00x4.88x4.88	16.0	49.95
SOC28-0.8	A	26.6	29.4	0.8	.64	.45	4.00x4.88x1.62	2.0	24.95

Pee Wee Boxer Fan



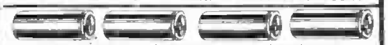
- 36cfm free air delivery
- 3.125" sq. x 1.665" depth
- 10 yrs. cont. duty at 20°C
- 115V 50/60Hz
- For Apple users

PWS2107U Cleaned & tested (used)	$ 9.95 ea.
PWS2107F New	$14.95 ea.

Muffin® Fan

- 105cfm free air delivery
- 4.68" sq. x 1.50" depth.
- 10 yrs. cont. duty at 20°C
- Impedance protected, ambients to 70°C
- 115V 50/60Hz 14W Wt. 17 oz.

MU2A1-U Cleaned & tested (used)	$9.95 ea.
MU2A1-N New	$14.95 ea.



1/2 PRICE SALE! — COMPUTER GRADE CAPACITORS

mfd	wvdc	price	mfd	wvdc	price	mfd	wvdc	price	mfd	wvdc	price
250	150	1.95	4,500	50	3.95	20,000	20	2.95	43,000	10	5.95
500	200	2.49	5,500	25	4.49	21,000	15	3.95	45,000	5	5.95
1,250	3	.99	6,100	40	2.49	22,000	15	4.95	52,000	20	5.95
1,500	25	1.95	7,000	60	4.95	23,000	7	1.95	55,000	15	5.95
1,500	50	2.95	10,000	15	2.95	23,000	10	2.95	58,000	20	5.95
2,000	10	2.95	10,000	16	3.95	23,000	20	3.95	65,000	10	7.95
2,100	200	2.85	11,000	19	4.95	24,000	20	2.95	73,800	5	7.95
2,250	100	3.95	13,000	16	2.95	27,000	10	2.95	80,000	18	9.95
2,300	33	2.95	14,000	13	2.95	32,500	10	4.95	90,000	10	8.95
2,500	15	2.95	14,000	35	3.95	40,000	25	5.95	120,000	15	10.95
3,000	25	1.95	18,000	10	3.95	42,000	10	4.95	160,000	10	8.95
3,600	40	3.95									

OVER 200 OTHER VALUES AVAILABLE

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Class Adv Contd from Page 105

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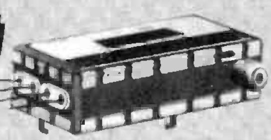

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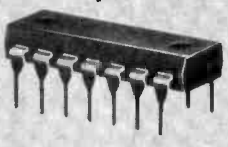

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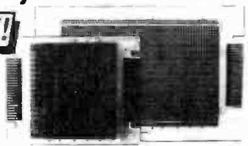

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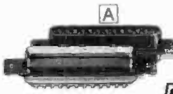

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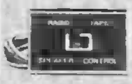

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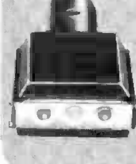

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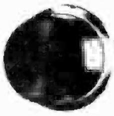

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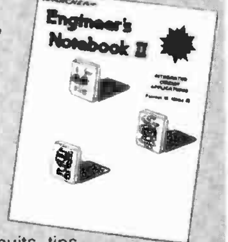

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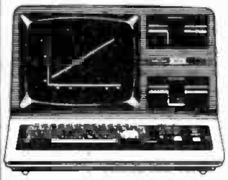

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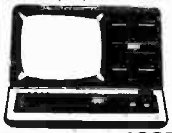

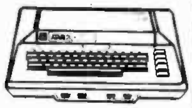

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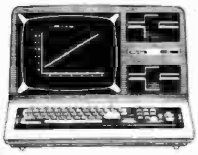

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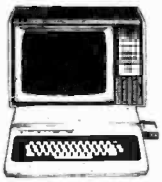

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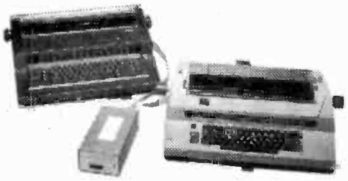

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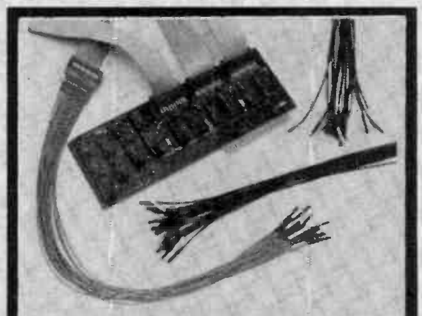

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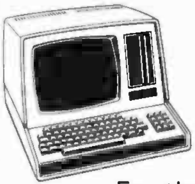

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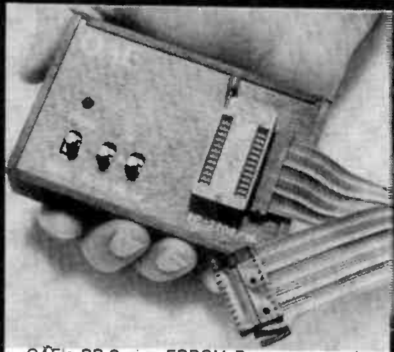

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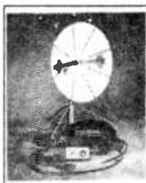

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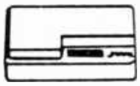

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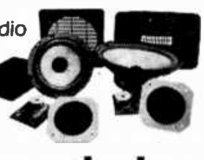

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Classified Adv Contd on Page 96

ELECTRONICS WORLD®

Personal Electronics News

HANDHELD ELECTRONIC GAMES have been forced to become more innovative in order to compete with the proliferation of arcade video games. According to Nick Underhill of Entex Industries, a major manufacturer of handheld games, players are becoming increasingly sophisticated and are now often quicker than the computer. Although the cost for a given level of game complexity has fallen with the cost of the chips that make the game work, the players are demanding more advanced games, which pushes the price back up. Entex's response has been a relatively low-priced system called AdventureVision, whose 6000 pixel dot-matrix display resembles a TV screen, and is said to be able to reproduce any graphics "from space mutants to the Mona Lisa." Players select from among Entex's game cartridges and control the action with a joystick in one- or two-player modes.

A ROBOTICS CENTER is being established at the University of Rhode Island. An outgrowth of a project supported by the National Science Foundation and more than 30 industrial firms, it is intended to be an experiment in university-industry cooperation. A four-year NSF grant to URI of $700,400 will be matched in the first year by contributions from the firms now involved in the project, with other firms expected to join later. The center should be totally supported by industry after four years.

GOLFERS IMPROVE THEIR GAME, according to Mitsubishi Electric, by using Mitsubishi's portable GL-500 base mat. The unit incorporates four sensors and a micro-computer to compute data about how you have hit the ball on the mat. Upon taking a swing, such parameters as head speed, face angle, hitting area, club-head swing, carry, ball driving direction, etc., are digitally displayed—letting you quantify your errors. All clubs, from driver to putter, can be used. The GL-500 is now on sale in Japan, with U.S. sales expected soon, either under the Mitsubishi name, or by OEM agreement. Perhaps the next development we can expect is a robot caddy, or maybe an android golfing partner who will give us tips on the stock market—electronically, of course.

"SMART CARDS", developed by Intelmatique of France, may soon replace Food Stamps, according to Richard Sprague of the U.S. Dept. of Agriculture. The cards, with microcircuits printed on them, can be interfaced to a central computer via a terminal at the point of purchase, which then records the transaction on the card itself. The Reagan administration is said to be interested in issuing "Smart Cards" to welfare recipients in order to eliminate paperwork and reduce fraud.

CUBAN RADIO INTERFERENCE was again the subject of testimony given before the House Commerce Subcommittee on Telecommunications. John B. Summers, Executive Vice President and General Manager of the National Association of Broadcasters, explained that the Reagan Administration's proposal to broadcast to Cuba on the 1040 AM frequency via Radio Marti might provoke Cuban "counter programming" on the same frequency and power level (500 kW), causing interference to stations throughout the U.S. operating on that channel. An alternative, according to Summers, would be to operate Radio Marti at 1610 or 530 kHz since Cuban AM receivers could pick up the broadcasts readily and no U.S. commercial stations currently operate on those frequencies. Of course, said Summers, the Cubans can interfere with whatever frequencies they choose to simply by turning a dial. That's why a diplomatic solution is said to be imperative.

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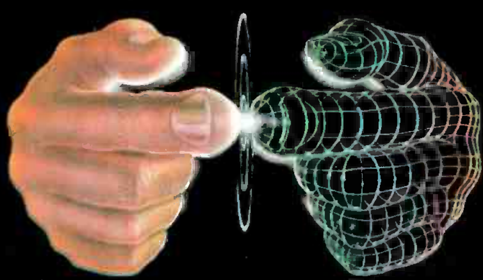

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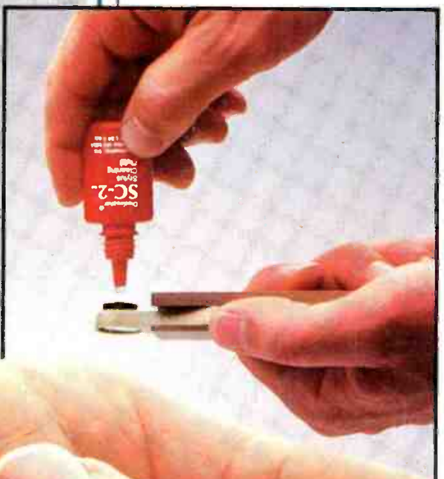

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