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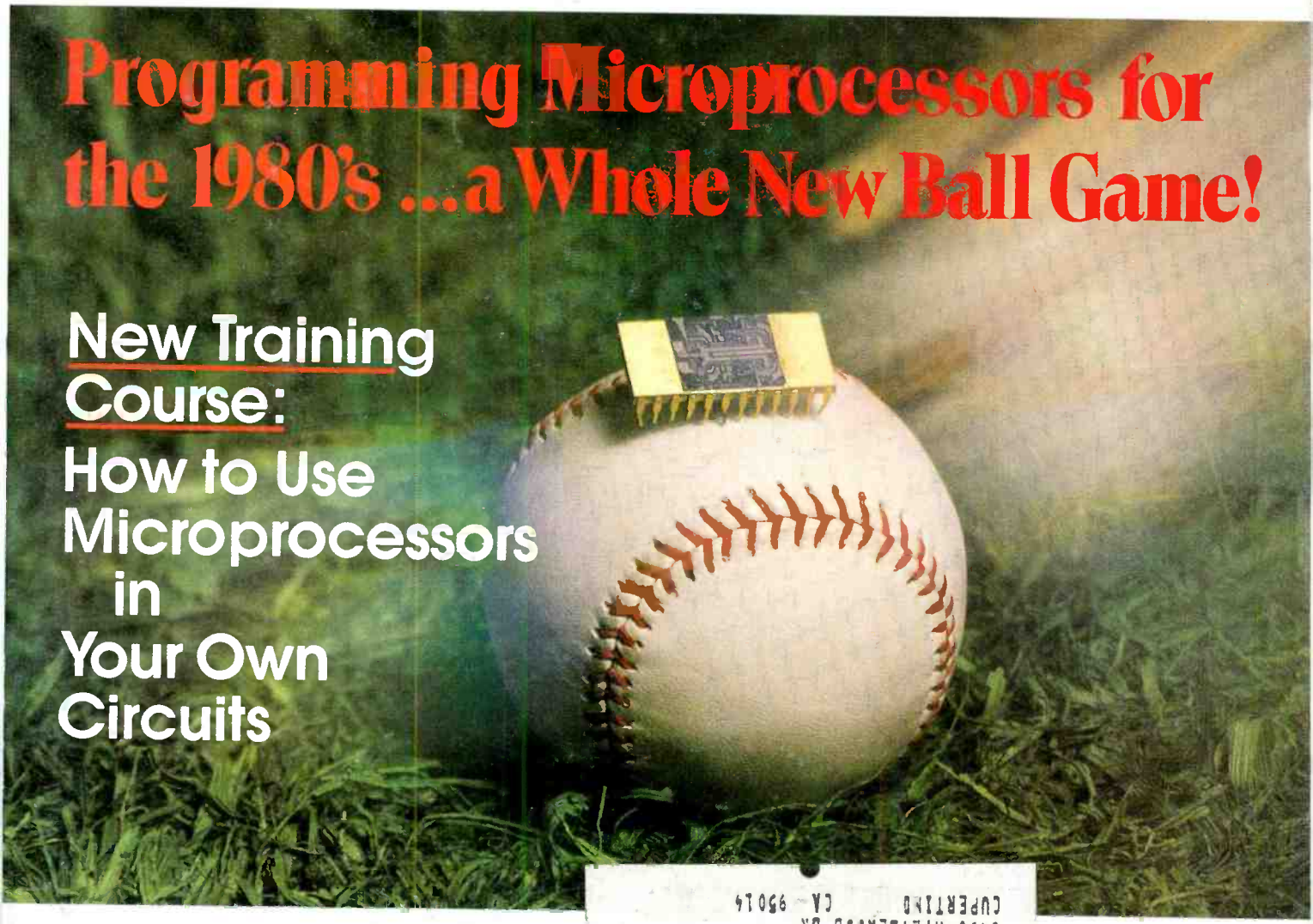

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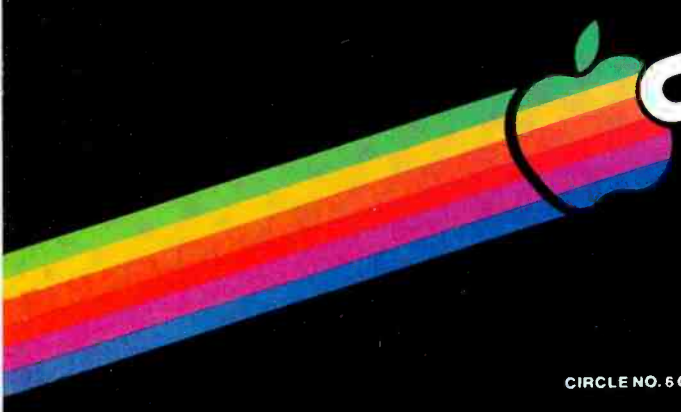

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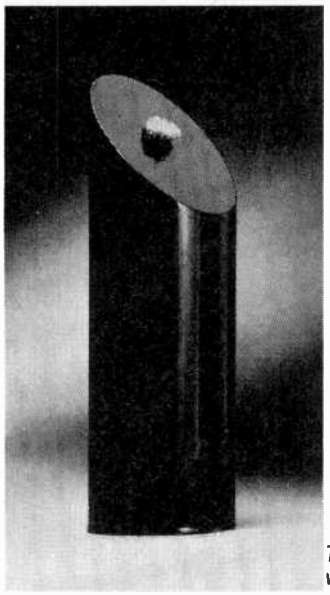

Miracle Fuzz

A new space-age invention and the same effect as lightning combine to create the world's first home oxygen regeneration system.

The new Energaire ionized oxygen generator will make a handsome addition to any desk.

You need oxygen to live. You can live without food for 60 days, without water for seven days, but without oxygen, you won't make it past two minutes.

That small piece of fuzz located on top of the cylinder shown above emits negatively-charged electrons which attach themselves to molecules of oxygen, thus creating ionized oxygen.

You are already familiar with ionized oxygen if you've smelled the air after a thunderstorm. You feel great, revitalized, and alert. The lightning from the storm adds a small negatively-charged electron to each oxygen molecule in a process called ionization.

SCIENTISTS DISCOVER

Scientists discovered that air quality can actually affect your moods, your feelings and your sense of well being. Air that is positively charged caused people to be depressed, moody and tired. Negatively-charged air made people feel good. We have all experienced air that is positively charged in air-conditioned buildings or in a polluted environment.

Scientists looking for a way to turn positively charged air into negatively charged air developed the negative ion generator—a product that produces negatively charged particles that attach themselves to air molecules and thus create the same fresh feeling you get after a thunderstorm.

The new space-age product shown above is an ionized oxygen generator called the Energaire air purifier. The copper mesh fuzz on top of the unit is one of the secrets of the system.

Although it has no moving parts, you can actually feel a wind of ionized oxygen produced from the fuzz which spreads to fill an average-sized room in one minute.

CIGARETTE SMOKE TEST

To show the dramatic effect of ionized oxygen, you can take the Energaire, blow cigarette smoke into a clear bowl, and hold the bowl inverted over the system. The smoke will vanish. The charged oxygen particles appear to dissolve the smoke particles, precipitating them from the air.

In a room, the Energaire air purifier surrounds you with these oxygen ions and cleans and purifies the air so that even in a smoke-filled room, you will be breathing cleaner, country-fresh air all day long.

WALL TEST

Take our unit and place it next to a wall. Also put a large piece of paper on the wall. Within a few days notice how black the paper gets. That black film is finite carbon particulate matter—the same pollutants you would normally breathe and that would pass through most air filters. By placing the unit in the center of a room or away from a wall, that same matter falls to the ground as dust.

A trip into the mountains exposes you to nature's freshly ionized oxygen. The Energaire produces this same effect. It will clean your room of odor-causing bacteria and stale, musty, or smoky air.

Ionized oxygen should not be confused with ozone. Ozone has a molecular formula of O_3, whereas the molecular formula for ionized oxygen is O_2 with a negatively-charged ion.

DON'T BE CONFUSED

After we announced the Energaire last year, many companies came out with their own ion generators. We purchased a unit from each company and tested them at an independent laboratory. The results are shown below:

Name	*Ions	Price
Energaire	438,000	$79.95
Omega 700	63,000	245.00
AirCare	72,000	149.95
Modulion	75,000	79.95

**Measurements indicate total number of ions per cubic centimeter per second at one meter. These figures may vary by plus or minus 10%.*

Note: One unit not mentioned above produced no ions and actually produced ozone or several times the maximum ozone concentration allowed by federal government standards.

USED IN HOSPITALS

Many hospitals are now using ionized oxygen systems in their operating rooms and burn centers. Their units not only purify the air, but they also eliminate pollen and other irritants.

Working in a clean air environment, you think clearer, are more alert, and you function better. The Energaire is actually a miniature lightning machine. The minute you plug it in, energy is converted into ionized oxygen. This efficient system uses one watt of power or less than a penny per day to operate, so you leave it plugged in continuously.

We are so impressed with the pleasant effect of Energaire that we urge you to personally test it yourself in your home or office. Order one at no obligation. Put it by your desk, or in any room where you spend a great deal of time. See if it doesn't rid your room of odor-causing bacteria and stale, musty or smoky air. Try the smoke and paper tests mentioned in this advertisement.

SLEEP FASTER

At home, use the Energaire by your bed and see how country-fresh air allows you to sleep easier, deeper, and more relaxed.

You should notice the difference within one day—especially in a work environment. But use the Energaire for a full month. Then, if you do not feel totally convinced of the positive effects of ionized oxygen, return your unit for a prompt and courteous refund.

The Energaire is manufactured by the Ion Foundation, a leading ion research and development company.

Service should never be required, but if it is, there's a prompt service-by-mail center as close as your mailbox. JS&A is America's largest single source of space-age products—further assurance that your modest investment is well protected. The Energaire measures 9" high by 3" in diameter and weighs 24 ounces.

To order your Energaire ionized oxygen generator, send **$79.95** plus $3.00 for postage and handling (Illinois residents, please add 5% sales tax) to the address shown below or credit card buyers may call our toll-free number below. We will send your Energaire ion generator complete with 90-day limited warranty on the electronics, a five-year warranty on the fuzz, and complete instructions.

Let space-age technology revitalize your life with the world's first home ionized oxygen generator. Order one at no obligation today.

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The easiest, least expensive way to generate spectacular multi-color graphics, sharp two-color alphanumerics: Your computer, a color tv set and the Percom Electric Crayon™.

Add the Electric Crayon™ to your system and your keyboard becomes a palette, the tv screen your medium.

You dab and stroke using one-key commands to create dazzling full-color drawings, eye-catching charts and diagrams.

Or you run any of innumerable programs. **Your own BASIC language programs** that generate dynamic pyrotechnic images, laugh-provoking animations.

From a combined alphanumerics-semigraphics mode to a high resolution 256- by 192-element full graphics mode, the microprocessor-controlled Electric Crayon™ is capable of generating **10 distinctly different display modes.**

Colors are brilliant and true, and up to eight are available depending on the mode.

As shipped, the Electric Crayon™ interfaces a TRS-80* computer. It may be easily adapted for interfacing to any computer or to an ordinary parallel ASCII keyboard.

But that's not all

The Electric Crayon is not just a color graphics generator/controller.

It is also **a complete self-contained control computer.** With built-in provision for 1K-byte of on-board program RAM, an EPROM chip for extending EGOS™, its on-board ROM graphics OS, and a dual bidirectional eight-bit port — over and above the computer/keyboard port — for peripherals. The applications are endless.

Shipped with EGOS™, 1K-byte of display memory and a comprehensive user's manual that includes an assembly language listing of EGOS™ and listings of BASIC demo programs, the Electric Crayon™ **costs only $249.95.**

Options include:

- LEVEL II BASIC color graphics programs on minidiskette: $17.95.
- A 34-conductor ribbon cable to interconnect the Electric Crayon™ to a TRS-80*: $24.95.
- RAM chips for adding refresh memory for higher density graphics modes: $29.95 per K-byte.
- Electric Crayon™ Sketchpad, a sketching grid of proportioned picture elements (pixels) in a tv aspect ratio. For 128 x 192 or 256 x 192 graphics modes. 11-inch by 17-inch, 25-sheet pads: $3.95 per pad.

SYSTEM REQUIREMENTS: the video circuitry of the Electric Crayon™ provides direct drive input to a video monitor or modified tv set. An internal up-modulator for rf antenna input may be constructed by adding inexpensive components to the existing video circuitry.

Prices and specifications subject to change without notice.

™ = trademark of Percom Data Company, Inc.

* = trademark of Tandy Radio Shack Corporation which has no relationship to Percom Data Company.

PERCOM

PERCOM DATA COMPANY, INC.
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Get into computer color graphics the easy, low-cost way with a Percom Electric Crayon™. Available at Percom dealers nationwide. Call toll-free, **1-800-527-1592**, for the address of your nearest dealer, or to order direct if there is no Percom dealer in your area.

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MAY 1980

Popular Electronics®

VOLUME 17, NUMBER 5

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

About the cover:

The microprocessor can be used in a myriad of applications other than for computers, which is detailed in the lead article of this issue.

Cover photo by Don Carrol

Feature Articles

Construction Articles

Columns

Julian Hirsch Audio Reports

Departments

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Editorial

WHERE ARE YOU GOING IN ELECTRONICS?

Some weeks ago I turned on my TV receiver and, surprisingly, viewed part of a program that explored the solid-state industry in that wondrous North California area called "Silicon Valley." An interview with a computer specialist revealed that there's virtually a price war going on for skilled electronics people. Times are obviously good for electronics-trained personnel, but will it continue?

All indications are that the need for skilled people in the field of electronics will grow in this new decade. For example, the U.S. Department of Labor recently indicated that computer technician jobs are expected to double in the next ten years. And an Intel executive predicts that we'll need more than one-million software engineers by 1990, while our education system is producing only tens of thousands each year.

Entry-level salaries for techs are reported to be over $20,000 per year including overtime, while some experienced techs earn $35,000. Engineers, too, are having a field day. For example, June 1979 electrical engineering graduates (bachelor's degrees) from MIT received yearly starting salaries that ranged from $17,640 to $21,780; computer science grads got $17,000 to $22,000. With a master's, the range was said to be $18,480 to $24,420. And I know an MIT grad who earned his doctorate at that time and his first job started at $30,000.

There's a minor furor going on about who's an electronics engineer. As many readers may know, there's an EE degree and a BET degree, the latter being a Bachelor of Engineering Technology. In trying to distinguish between the two, some people have suggested that the EE is really a theoretical engineer upon graduation, while the BET is an applied engineer. Moreover, it has been pointed out that the EE course is really a five-year one, though often completed in four years by handling heavy course loads, while the BET curriculum is for four years. Consequently, some EE's are battling BET's for the same jobs. There are also many techs who are doing engineering work and, indeed, are considered to be engineers and paid accordingly.

There are a lot of training avenues available to one who wishes to enter or grow in the electronics field: home study courses, seminars, technical institutes, and colleges, among others. There's also POPULAR ELECTRONICS, which in this issue presents a first-of-a-series microprocessor applications training course.

With more and more circuit designs that dedicate microprocessor IC's for noncomputer end products—telephone answering machines, electronic games, "smart" thermostats, etc.—it's imperative that readers understand how to use microprocessors to create low-cost sophisticated circuits. Moreover, this underlying knowledge will prepare you to service the ever-growing number of microprocessor-based products and provide you with a solid foundation to understand computers, computer programming, and how to make a computer interact with the outside world for, say, a super security system.

What's more, all this know-how will open new electronics vistas for the enthusiast, many of whom are involved professionally in electronics. It means that electronics can be more exciting and fulfilling than ever before.

Art Salsberg

The Personal Computer Line by OHIO SCIENTIFIC

Personal Computers

C1P: $349 A dramatic breakthrough in price and performance. Features OSI's ultra-fast BASIC-in-ROM, full graphics display capability, and large library of software on cassette and disk, including entertainment programs, personal finance, small business, and home applications. It's a complete programmable computer system ready to go. Just plug-in a video monitor or TV through an RF converter, and be up and running. 15K total memory including 8K BASIC and 4K RAM—expandable to 8K.

C1P MF: $995 First floppy disk based computer for under $1000! Same great features as the C1P plus more memory and instant program and data retrieval. Can be expanded to 32K static RAM and a second mini-floppy. It also supports a printer, modem, real time clock, and AC remote interface, as well as OS-65D V3.0 development disk operating system.

Professional Portables

C4P: $698 The professional portable that has over three times the display capability of C1Ps. Features 32 x 64 character display in up to 16 *colors*, graphics, audio output, a DAC for voice and music generation, key pad and joystick interfaces, AC remote control interface and much more. Utilizes a 4-slot BUS (2 used in base machine), 8K BASIC-in-ROM, 8K of *static* RAM and audio cassette interface. Can be directly expanded to 32K static RAM and two mini-floppy disks.

C4P MF: $1695 The ultimate portable computer has all the features of the C4P plus real time clock, home security system interface, modem interface, printer interface, 16 parallel lines and an accessory BUS. The standard machine operates at twice the speed of currently available personal computers (with GT option it runs even faster!). The C4P MF starts with 24K RAM and a single mini-floppy and can be directly expanded to 48K and two mini-floppies. Available software includes games, personal, business, educational and home control applications programs as well as a real time operating system, word processor and a data base management system.

Computers come with keyboards and floppies where specified. Other equipment shown is optional.

Home/Small Business Systems

C8P: $895 Same great features as the C4P in a tremendously expandable "mainframe package." Features over three times the expansion capability of the C4P for advanced home and demanding business applications. Can be expanded to 48K RAM, dual 8" floppies, hard (Winchester) disks and multiple I/O devices such as Voice I/O and a universal telephone interface.

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C8P DF: From $2597 The ultimate Home/Very Small Business Computer at a personal computer price. Features 32K RAM (expandable to 48K) and dual 8" floppy disks (stores eight times as much information as a mini-floppy). Has all personal computer capabilities including 32 x 64 display, color graphics, sound, DAC, joystick interfaces, home features including real time clock, AC remote interface, home security and fire detection interface and can be expanded to include voice I/O and a universal telephone system for answering and initiating calls! Its large memory capability and 8" floppies allow it to run most Ohio Scientific business system software including a compete accounting system, word processor and information management system.

For literature and the name of your local dealer, CALL 1-800-321-6850 TOLL FREE.

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Letters

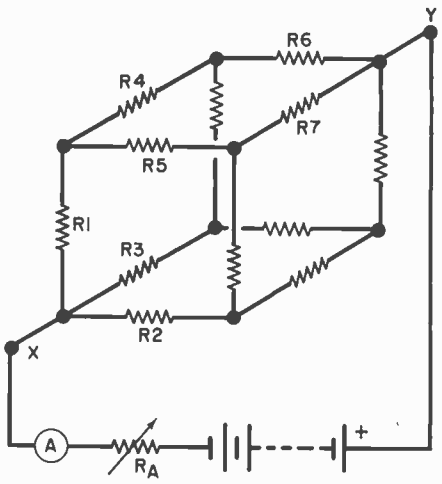
THANKS FROM SHORTWAVE FANS

As a very recent convert to the pleasures of shortwave listening, I found the use of worldwide station listings was a frustrating experience. Your listings (as in December 1979) turned the tables! I suddenly discovered I could ambush any station by referring to your listing of English broadcasts. The updating in January further improved the situation and then your February listing of selected shortwave programs came very close to giving me an adrenalin surge.—*S. F. Metz, Derry, NH.*

Someone merits a bonus for coming up with "Selected Shortwave Programs" (February 1980). The time/topic approach is imaginative, intriguing, and handy. It's like having a *TV Guide* to shortwave. Another compliment is deserved for "What's on the Air Below 500 kHz?" in the same issue. I have been waiting for something like this since I picked up a BC-453 receiver at last fall's local hamfest.—*Alan Bosch, Arlington, VA.*

A SIMPLER 3D SOLUTION

The 3D Resistor Quiz in the September 1979 issue reminded me of a problem I once gave my physics students. However, author Gary Seaver uses some parallel and series assumptions in his solution that I have trouble justifying. Below is a simpler solution using



Kirchoff's laws with no justification problems. It is not necessary to consider all the resistors—only the seven I have labelled in my diagram.

To determine resistance between X and Y, connect a battery, rheostat, and ammeter as shown. Adjust the rheostat for a 3-ampere reading on the ammeter. Now, applying Kirchoff's first law (the sum of currents arriving at a junction equals the sum of currents leaving the junction), *R1, R2,* and *R3* conduct 1 ampere each; *R4* and *R5* conduct 0.5 ampere; and *R6* and *R7* conduct 1 ampere. Using Kirchoff's second law (in any loop, the voltage rises equal the voltage drops), the drop across *R1* is 100 volts, across *R4* equals 50 volts, and across *R6* equals 100 volts. Therefore, considering *R1, R4,* and *R6* as a complete loop, the sum of the drops is 250 volts. Finally, applying Ohm's Law, we get R = E/I = 250 V/3 A = 83.3 ohms.
—*Park E. Gregory, Belleville, MI.*

COMPUTER ACCURACY

I understand the consternation on the man's face in the computer cartoon on page 87 of your March 1980 issue. A total of 3.999 from adding 2 + 2 is not 99.999% accuracy, but only 99.9975% accuracy—R. N. Tomlin, Ann Arbor, MI.

RADIATION INFORMATION

I agree with Peter L. Schestopol's letter in your March 1980 issue that there is too much misinformation being fed to the public about radiation. Unfortunately, some of his information is incorrect.

First, the rad, the unit of absorbed dose, is not 1 erg per gram but is 100 ergs per gram in the C.G.S. system. In the S. I. units, it is 0.01 joules per kilogram.

Second, the roentgen is 0.000258 cou-

lombs per kilogram of air in S. I. units. In C. G. S, it is the amount of radiation required to produce 1 electrostatic unit of charge per cubic centimeter of air.—*J. Wesley Kersey, Memphis, TN.*

SOLVING LISSAJOUS PATTERNS

In regard to the "Lissajous Pattern Quiz" (January 1980), finding the ratios can be tedious if you follow the trace and try to remember where you've been, where you're going and how many times you've gone up and down and left and right and—now where was I?

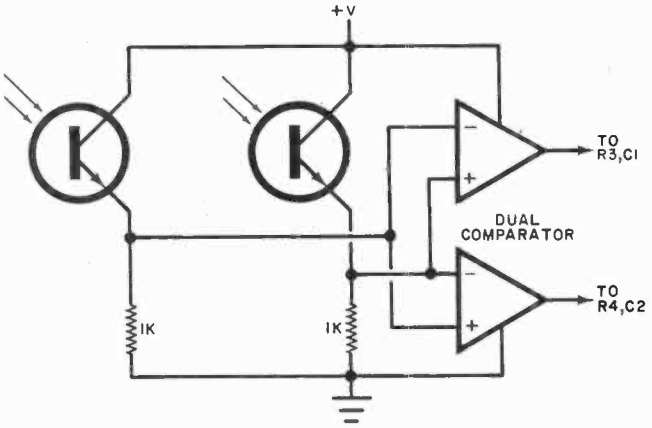
The task can be made easy by remembering that each time the trace moves from one edge of the screen to the other (half a cycle), it must cross the axis. Thus, if one draws the two major axes and counts intersections, the ratio is: vertical frequency/horizontal frequency = horizontal axis intersections/vertical axis intersections.—*D. J. Koscheka and N. D. Herbert, Palatine, IL 60067.*

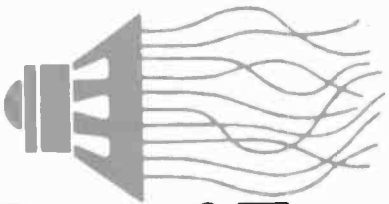
PROTECTING A LONGWAVE CONVERTER

I enjoyed the two-part article by Karl Thurber "What's on the Air Below 500 kHz?" (February and March 1980). I particularly noted the authors warning to anyone who uses a receiving converter on a transceiver to remove the mike in order not to transmit with the converter attached, thus avoiding damaging the converter. On my ham rig, I have been using a 6-meter Venus transceiver to drive a homebrew, 2-meter transverter. I broke the wire in the transceiver that runs from the receiver's antenna coil to the switching relay and installed two jacks in this line. Then, when I want to use my 2-meter transverter, I plug the output of the receiving converter section into the jack going to the antenna coil. This way I can't transmit and damage the converter. To use the transceiver on 6 meters, I simply disconnect the output of the receiving converter from the receiver input stage and run a jumper across the jacks.—*H. D. Mohr, Gahanna, OH.*

SUBSTITUTE FOR LM1890 IN SUNDIAL

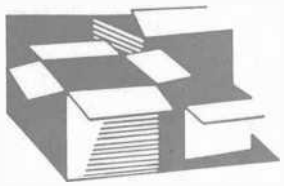
It has come to our attention that the LM1890 light-to-current converter used in the "Solar Powered Sundial" (March 1980) is in short supply since it is no longer in production. The circuit below, using conventional light-sensitive transistors and a dual comparator, can be substituted easily for the LM1890 circuit.—Ed.





Out of Tune

The schematic of the power supply for "A 3-Way Drive System for Speakers" shown as Fig. 2 on page 48 of the April 1980 issue shows the positive output of fullwave bridge *RECT1* incorrctly connected to one of its ac inputs. The etching and drilling and parts placement guides are correct.



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.

Hand-Held DMM

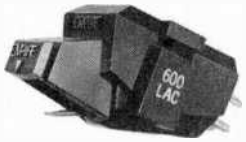
The Keithley Model 130 3½-digit LCD hand-held digital multimeter features a 0.6"-high LCD display, a 0.5% basic dc voltage accuracy, auto zero and polarity, and full overload protection. There are five

dc voltage ranges from 200 mV to 1 kV, five ac voltage ranges from 200 mV to 750 volts, five ac and dc current ranges from 2 mA to 10 amperes and five resistance ranges from 200 ohms to 20 megohms. One hundred hours of life can be expected from the internal 9-volt battery. A full line of accessories expands the Model 130 capabilities to 40 kV, 200 amperes and voltage at frequencies to 700 MHz. Dimensions are 7" × 3.1" × 1.5" (18 × 8 × 4 cm). $99.

CIRCLE NO. 87 ON FREE INFORMATION CARD

High-Technology Phono Cartridge

Heading the new Dynamic Interface series of phono cartridges from Empire Scientific is the model 600LAC. The unit uses a vapored-boron, aluminum-alloy cantilever to improve tracking and to damp unwanted resonances. In addition, the cartridge features samarium-cobalt magnets for high electrical output and lightweight construction that allows improved tracking of



warped records, as well as the ability to interface well with low-capacitance turntable wiring and preamp inputs. Frequency response is rated at 20 to 28,000 Hz ± 1¾ dB, with a recommended tracking force of 1.5 grams. Vertical tracking angle is 20°, and the unit is designed to feed an input rated at 47 kilohms in parallel with 150 pF. Price is $175.

CIRCLE NO. 88 ON FREE INFORMATION CARD

Sports Radar

Midex is now making available its Sports Radar, a handheld, lightweight (38.4 oz) radar "gun" that can be used to measure and record the speed of tennis, golf, soc-

cer and baseballs, hockey pucks, human or animal racers, RC planes, or almost anything whose speed must be known. The device will time from 20 to 150 mph. Operation is from a 12-volt dc source. Frequency is 10.525 GHz (X band) and an FCC license is not required. $149.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

CPU-Controlled Printer

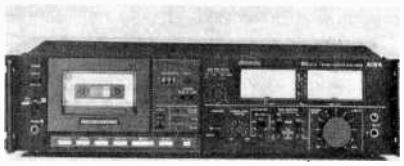
The Model 877 from Printer Terminal Communications Corp. is an 8½" roll-paper receive-only serial printer featuring bidirectional 9 × 7 dot matrix head, hardened metal chassis and a stainless-steel drive

screw. A cartridge ribbon eliminates the ribbon reversing mechanism. It prints at 120 characters per second at 80 characters per line, 10 characters per inch, and features a 95-character ASCII set. The paper roll is friction fed. The 877 includes an RS-232C interface with baud rates of 300 to 9600. Dimensions are 18" × 22" × 7.5" (45.7 × 55.9 × 19.1 cm); weight is 25 lb (11.36 kg) $999.

CIRCLE NO. 91 ON FREE INFORMATION CARD

Logic-Controlled Cassette Deck

Aiwa's AD-M700BU (black finish) and its sister unit, AD-M700U (silver finish), are designed to use metal, CrO_2, FeCr, and LH tape types. A bias fine adjustment control



allows optimum response from each. The decks have V-cut Sendust record/playback combination heads and double-gap ferrite erase heads. Other features include a Double-Dolby circuit, a logic-controlled transport with continuous repeat operation as well as start and stop memory function, and dual dc motors. Rounding out the package is a five-point LED peak indicator and a "rec-mute" function. Specifications include frequency response for metal tape at −20 VU recording level of 30 to 17,000 Hz +2, −3 dB; 25-12,500 Hz, +2,−3 dB at 0 VU; S/N 65 dB (FeCr tape, Dolby on), and wow and flutter of 0.04% (wrms).

CIRCLE NO. 92 ON FREE INFORMATION CARD

Digital Inside/Outside Vehicle Thermometer

The Heathkit CI-1525 Car Thermometer reads temperatures between −20° and +140°F (−30° and +60°C) inside and outside any vehicle (including boats) with a

12-volt dc negative-ground system. The 2½-digit fluorescent readout can be changed from Fahrenheit to Celsius and the indoor and outdoor readings can be chosen separately or automatically alternated. It uses a dual-slope analog/digital converter. Accuracy is ±3%. $89.95 kit.

CIRCLE NO. 90 ON FREE INFORMATION CARD

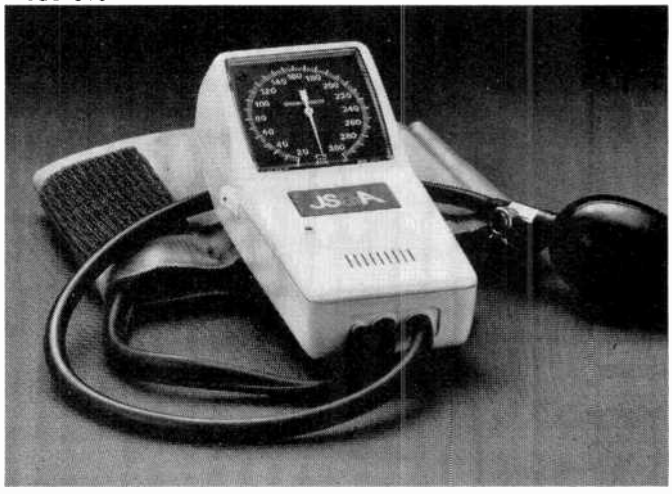
Dual-Trace, Delayed-Sweep 30-MHz Oscilloscope

B&K-Precision's dual-trace Model 1530 oscilloscope is said to have a 30-MHz vertical amplifier bandwidth, vertical sensitivity as low as 2 mV/cm, and delayed sweep over five ranges of time-base delay (1 μs to 100 ms). Other features include variable hold-off, chopped or alternate dual-trace operation, differential measurement capability, algebraic addition and subtraction of vertical input signals, X-Y display capabili-

Extended Lifespan

JS&A was destined for failure when we introduced our first electronic blood pressure unit. But then a miracle happened.

Model 310



Model 410

Advertisements were starting to appear everywhere. JS&A had just introduced the world's first home electronic blood pressure unit in a massive national advertising campaign.

But something was strange. JS&A often tests its products in its catalog first before they are nationally advertised. If they sell well, we then start a national magazine advertising campaign. The blood pressure unit sold well in our catalog, but for some strange reason, it wasn't selling well in magazines.

SHOCKING DISCOVERY

And then we found the answer. A few months earlier after our blood pressure unit appeared in our catalog, our computer manager (let us call him Ralph to protect his identity) handed us a computer printout of the catalog sales results.

Scanning the results, we discovered that the blood pressure unit was the best-selling product in our catalog—far exceeding every other product by five times.

The results were so positive that we immediately placed hundreds of thousands of dollars in an advertising campaign launched in early 1978.

Just as the advertisements were starting to appear, Ralph walked into our president's office with some startling news. "There's been a mistake," Ralph said. "The computer printout was wrong. The blood pressure unit is actually our worst selling product but a computer error gave us the wrong information."

And so our president sat back and watched JS&A advertisements appearing everywhere, knowing full well that the campaign would cost his company almost the price of a new computer.

Then came the miracle. As if by plan, the American Medical Association came out with an advertising campaign urging consumers to take their blood pressure regularly to combat hypertension or high blood pressure. Ads appeared everywhere.

The campaign revealed that there may be as many as 25 million Americans who have high blood pressure and don't know it. Simply by taking their own blood pressure and discovering hypertension early enough, Americans could be saving their lives and reducing the chances of heart attacks. Suddenly our campaign started to sell blood pressure units by the thousands.

AWARD RECEIVED

This year JS&A's president received the Extended Lifespan award for "pioneering in the distribution of home health electronic devices" by the Committee for an Extended Lifespan. In accepting the award, our president made it very clear that the award was earned as a result of a computer error and not as a result of his brilliance.

This story is painfully true. And although it may be a slight embarrassment to us, there is one aspect that is not. JS&A was indeed the company that pioneered the electronic blood pressure units and has always selected the very best units available to offer at the very lowest prices possible.

NEWEST UNIT

Our newest unit shown above is another example. The model 310 sells for only **$69.95** plus $2.50 for postage and handling (Illinois residents, please add 6% sales tax.) You simply wrap the velcro cuff around your arm (you can even keep your shirt on) and inflate the cuff. Both an audible tone and a visible red light will indicate your systolic and diastolic readings. The system is extremely accurate, comes with a self-bleeding air valve and can be stored in a convenient carrying case that comes with each unit.

The deluxe model 410 functions similar to the first system except that the readings are displayed in digits, and the unit also displays your pulse reading. It sells for **$139.95** plus $2.50 per unit for postage, insurance and handling. If for any reason you are not completely satisfied with either unit, you may return it within 30 days for a prompt and courteous refund including your $2.50 postage and handling. To order either unit, credit card buyers may call our toll-free number, or you may send your check or money order to the address below.

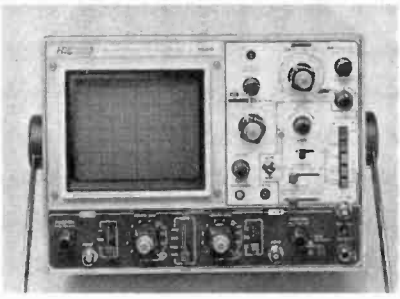
Both units use solid-state components, come complete with instructions and a one-year limited warranty, and should give you years of trouble-free service. If service should be required, we maintain a service-by-mail center as close as your mailbox. JS&A is America's largest single source of space-age products—further assurance that your modest investment is well protected.

If you are concerned about your blood pressure or know somebody who is concerned about monitoring his or hers, we recommend JS&A's latest units.

Incidentally, Ralph left JS&A on his own accord and bought a farm in another state. There were no hard feelings when he left. How could there be? Order your blood pressure unit at no obligation, today.

JS&A® PRODUCTS THAT THINK®

Dept. PE One JS&A Plaza
Northbrook, Ill. 60062 (312) 564-7000
Call TOLL-FREE 800 323-6400
In Illinois Call ..... (312) 564-7000

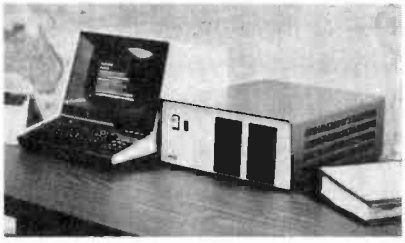


ty, built-in video sync separator, ac or direct coupling, intensity modulation provisions, range of triggering choices (channel A, channel B, alternate A and B, and ac power line, and an external source), and ×5 sweep magnification. Sweep rate can be varied from 0.2 μs/cm to 0.5 s/cm. $1340.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Desk-Top Microcomputer

The iPEX 8085 is a desk-top computer consisting of a combined microcomputer-CRT terminal and a separate dual floppy-disk storage. The CPU is an 8085A. An



automatic start-up routine, called by a single key, locks onto any CRT baud rate from 110 to 9600 and quick-tests each RAM location; a sign-on message displays installed memory size and indicates that the operating system is loading. After about four seconds, the operator has access to any programs on disk. The standard system includes 32K bytes of RAM (expandable to 56K directly) and 600K bytes of on-line disk storage (expandable to 1.2 megabytes). Supplied with Disk Extended BASIC, a Disk Operating System, debug package, utilities software, and 3K byte PROM resident system monitor. $3695.

CIRCLE NO. 94 ON FREE INFORMATION CARD

3rd Hand Circuit-Board Holder

Studio 3 has introduced a new version of "the 3rd Hand" circuit board holder. It employs a brass spring, retaining tabs, and a PVC gasket to hold a board without thumbscrews. The 3rd Hand clamps to the edge of the workbench and holds the board at an angle for the placement of components. It can then be flipped over so that solder or wrapped-wire connections can be made. The 3rd Hand is available in three sizes, each of which can be used with an optional Extension Bench Clamp that holds the 3rd Hand 2" (5.1 cm) above the workbench and 6" (15.3 cm) in from its edge. The Mini Model 3 B/C ($9.95) is 4" (10.2 cm) wide, holds boards from 1" (2.5 cm) wide to 6½" × 4½" (16.6 × 11.5 cm). Standard Model 3 A/C ($12.50) is 5¾" (14.6 cm) wide, holds boards up to S-100 buss size. Maxi Model 3 C/C ($14.95) is 7 5/16" (18.5 cm) wide, holds boards such as those employed in single-board computers. The Extension Bench Clamp, two of which are required for use with the Maxi Model 3 C/C, is $4.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Digitally Synthesized FM/AM Tuner

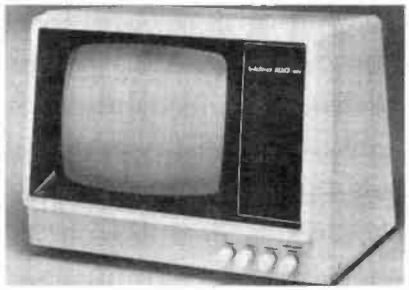
In addition to its automatic and manual tuning modes, the new Akai AT-V04 low-profile stereo FM/AM tuner, with digital readout, has seven memory presets that

can be selected at the touch of a button. Automatic tuning advances the tuner to the next strong station with equal convenience, and manual control allows weaker stations to be chosen. Minimum usable sensitivity (noise and distortion suppressed by 30 dB) is given as 1.6 μV (equivalent to 9.3 dBf), with a capture ratio of 1.2 dB. Alternate-channel selectivity is rated at better than 75 dB, image rejection at more than 95 dB, harmonic distortion (100% modulation) at less than 0.08% in mono and less than 0.1% in stereo. Other features include FM muting and tuning and signal-strength indicators.

CIRCLE NO. 96 ON FREE INFORMATION CARD

Twelve-Inch Video Monitor

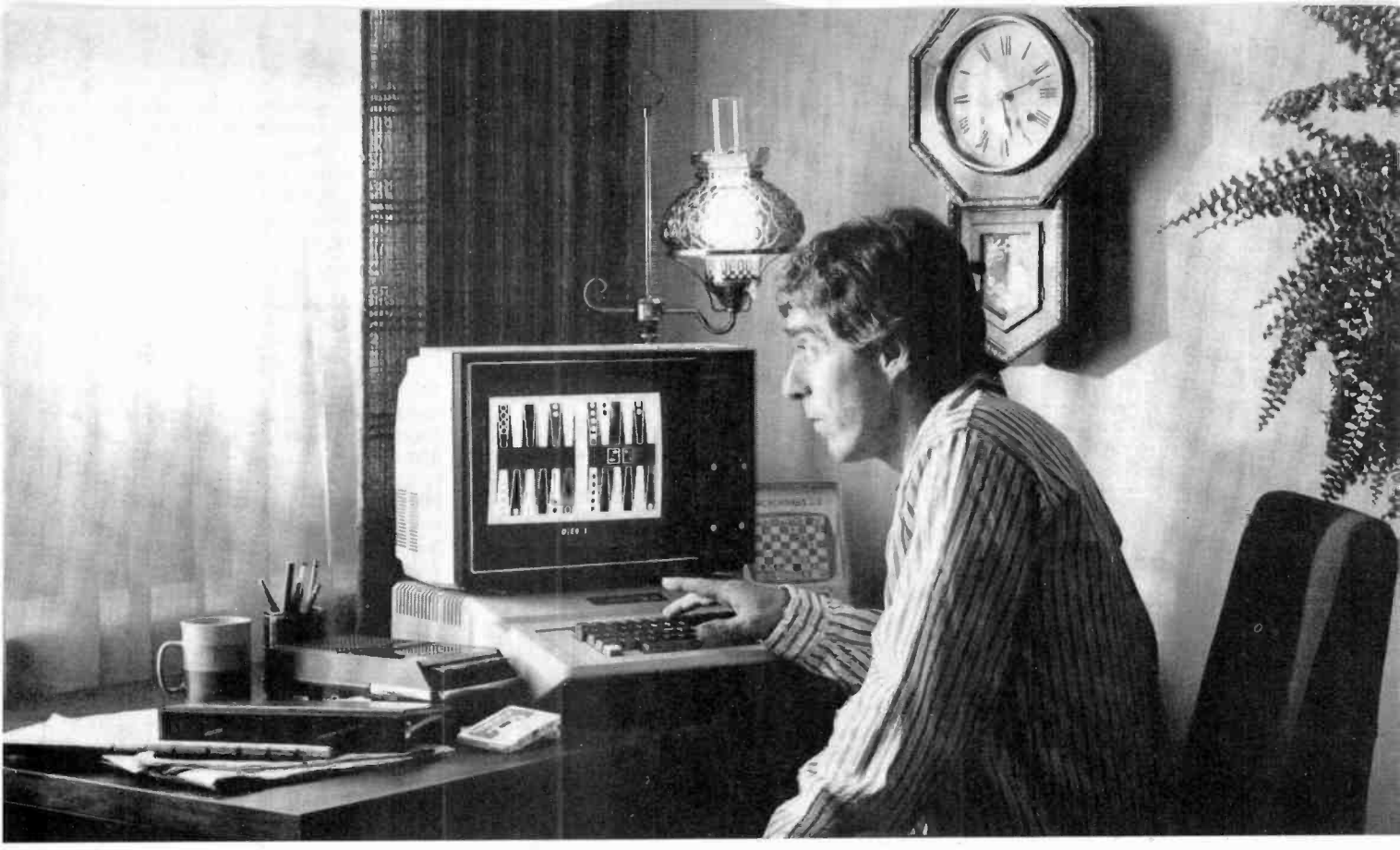
The Leedex Video 100-80 12" black-and-white monitor for home and commercial use is plug-in compatible with Apple, Atari, Radio Shack, O.S.I., Microterm, and Exidy computers. The removable face plate pro-



vides mounting space for a mini-floppy disk and there is also space inside for an 11" by 14" pc board. The 90° deflection tube allows an 80-character by 24-line display with a 12-MHz bandwidth.

CIRCLE NO. 97 ON FREE INFORMATION CARD

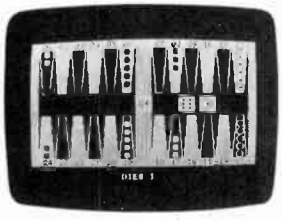
(Continued on page 12)



Even at 5:12 a.m., it's hard to quit playing Personal Software™ strategy games.

A quick game before turning in can become an all-night session when you load any of the Personal Software™ strategy games into your Apple,* PET* or TRS-80.* They'll challenge, teach and entertain you. And now there are two new games—Gammon Gambler™ and Checker King™—joining Bridge Partner,™ Time Trek™ and the best-selling Microchess.™

Gammon Gambler is a sure bet. With ten levels of skill, you can begin a novice and become an expert. Whichever level you play, the computer moves so quickly you don't have to wait. The program follows U.S. tournament rules, and includes the doubling cube to spice up the game. Written for the Apple and PET by Willy Chaplin. $19.95.



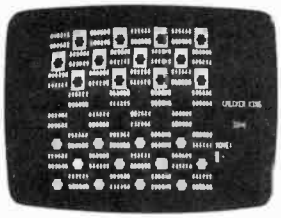
Gammon Gambler

Checker King—you probably forgot how much fun it is! If you move and change your mind, take it back and move again—without a peep from the computer. Play eight skill levels. Add and remove pieces. Save three board positions for later play. And solve three challenging checker puzzles. Written by Michael Marks for the Apple, PET and TRS-80. $19.95.

Microchess, the most widely used personal computer chess program, is a nearly perfect chess opponent for the total novice or the advanced enthusiast. Written by Peter Jennings for the Apple, PET and TRS-80. $19.95.

Bridge Partner. You against the computer in over 10 million different hands of contract bridge. You can even specify the hands' high card points. Written by George Duisman for the Apple, PET and Level II TRS-80. $19.95.

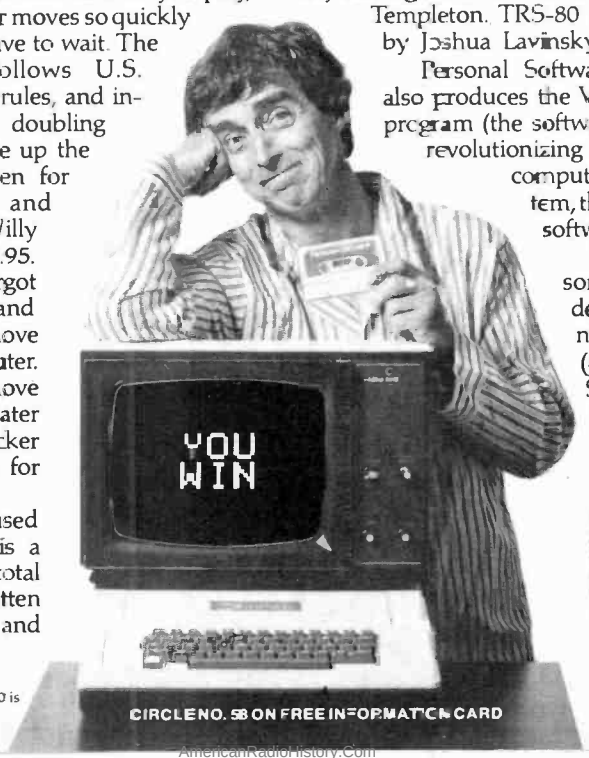
Time Trek is easy to learn, difficult to master and impossible to forget. Take command of a starship in real-time action to make the galaxy safe again. PET version by Brad Templeton. TRS-80 program by Joshua Lavinsky. $19.95.



Checker King

Personal Software, Inc., also produces the VisiCalc™ program (the software that's revolutionizing personal computing), CCA Data Management System, the Vitafacts series and other exciting software for the Apple, PET and TRS-80.

Now that you've read about the Personal Software programs, go see a demonstration. For the name of your nearest Personal Software dealer, call (408) 745-7841 or write to Personal Software, Inc., 592 Weddell Drive., Sunnyvale, CA 94086.



PERSONAL SOFTWARE

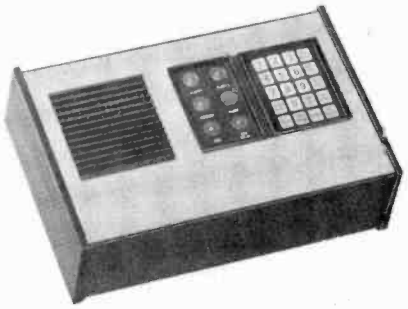
STRATEGY GAMES SERIES

*Apple is a trademark of Apple Computer, Inc.; PET is a trademark of Commodore Business Machines, Inc.; TRS-80 is a trademark of the Radio Shack Division of Tandy Corp.

CIRCLE NO. 58 ON FREE INFORMATION CARD

Microprocessor-Controlled Wireless Alarm System

Universal Security Instruments announces the availability of its Perim-A-Tron microprocessor-based programmable wireless alarm system. Using a built-in keypad, the user can select entry/exit delay times over a range of 5 to 45 seconds and a 3-digit disarm code and perform system tests. Ultrasonic transmitters mounted at various locations in the premises to be protected can be set to operate on either of two alarm channels, as well as to observe or disregard the programmed entry/exit delay. The user can employ both delayed and nondelayed transmitters on the same channel. An automatic timer silences the alarm after it has sounded for 10 minutes and then resets the system. Perim-A-Tron has an audio output stage that can drive an external PA horn speaker. Basic system of one transmitter and one receiver/supervisory module, $149.95.



CIRCLE NO. 98 ON FREE INFORMATION CARD

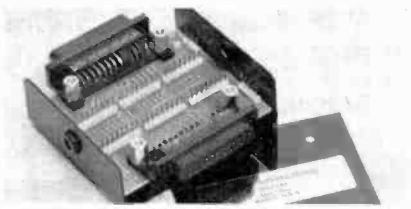
Low-Cost "Superamp"

The Adcom GFA-1 stereo power amplifier, using two amplifiers per channel in a bridged configuration, is rated to deliver 200 watts per channel to 8-ohm loads, 20 to 20,000 Hz at no more than 0.05% THD and 0.1% IM, into a 4-ohm load, the unit is said to be capable of delivering 350 watts. Rated S/N, A-weighted, at 1-watt output is 90 dB, with slew rate (80 V/s) high enough to give negligible transient IM distortion. IHF headroom is given as 2.2 dB and input sensitivity for full power output at 1.5 V into 50 kilohms. The power supply is built around a toroidal transformer, and a built-in fan is provided to assure cool operation at high power. Automatic thermal protection for the output transistors is also incorporated. $400.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Customized RS-232 Interface

The Remark Model 54 Stunt Box allows the user to create a customized interconnection between two different RS-232 computer interfaces. The box contains a pc board carrying two DB-25 connectors whose pins are terminated at 0.025" square pins and



plated-through holes. This arrangement allows the use of Wire-Wrap or jumper pins to interconnect the signal paths. To facilitate common bussing of particular signals, one 3-point, two 4-point and one 5-point areas are provided. Dimensions are 3.25" × 3.25" × 1" (8 × 8 × 2.5 cm). $52. Address: Remark International, 4 Sycamore Drive, Woodbury, NY 11797.

Vaco Five-Piece Screwdriver Set

Vaco Products' new Model 70600 is a five-piece set of Bull Driver screwdrivers in sizes: 3/16", 1/4", and 5/16" slotted; and 3/16" and 1/4" Phillips. The drivers have handles said to be 35% larger than usual and are fluted with chamfered edges. Tempered, nickel-chrome plated, chrome vanadium steel is machined and ground to form the drivers' shafts and tips.

CIRCLE NO. 100 ON FREE INFORMATION CARD

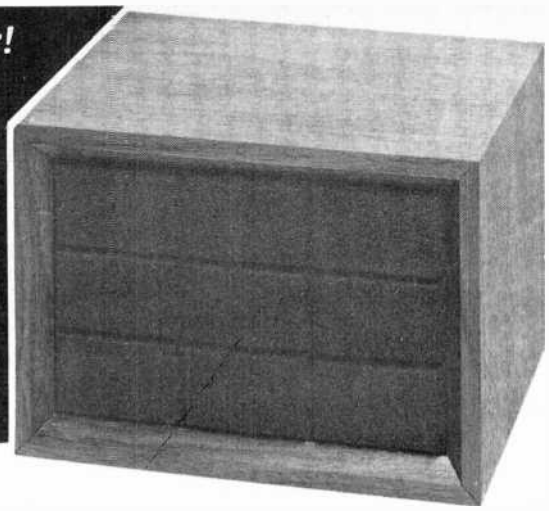
Not Just Another Limited Area Motion Detector!

guardex™

Protects Every Square Inch Of Your Building

Turns On Lights Automatically

Powerful Electronic Siren



Low Cost Computerized Burglar Alarm System Home - Office - Business

The Guardex 8000 Alarm System is walnut grained and disguised to look like a small stereo speaker (6¾" × 9¾" × 8") and weighs less than 6½ pounds.

NO INSTALLATION

Just plug the Guardex 8000 alarm system in, make several simple control adjustments to suit your particular building and it works! There are no other wires to run. This totally self-contained burglar alarm can completely seal off every square inch of the surface of your building. It protects doors, windows, and what most alarms miss... your roof, walls and floors.

HOW CAN ONE SMALL COMPUTER PROTECT MY WHOLE BUILDING?

Guardex 8000 Alarm System works on the principle of audio discrimination. This, put simply, is the process of electronically separating normal everyday sounds, such as voices, telephones, etc. from break-in type noises such as breaking glass, prying metal, or forcing a door open. The Guardex 8000 protects one story homes and offices up to 2000 square feet and open commercial buildings up to 10,000 square feet. The Guardex 9300 with wireless remote sensor capability is available for multi-story homes and offices or single story with more than 2000 square feet. Call the factory for more detailed information.

TURNS ON LIGHTS AUTOMATICALLY

When the first break-in type sound is detected, the system will instantly turn on lights, radio, or other electronic equipment that you have plugged into the back of the alarm. These lights or other equipment will remain on for a period of five minutes, then automatically turn off.

POWERFUL ELECTRONIC SIREN

The Guardex 8000 alarm is equipped with a loud built-in siren. If during the five minute period the lights or other electronic equipment has been activated, a second break-in sound is detected, (it can be only a second or two after the first break-in sound) the built-in siren will start blasting for 90 seconds. At the end of approximately 90 seconds the siren will shut off and the alarm listens again. If another break-in sound is heard, the siren will come on for another 90 seconds. If no other break-in sound is detected, the siren will stay off and at the end of the five minute period the lights will shut off and the alarm instantly resets.

The rear control panel contains two standard AC plug receptacles for a table lamp, spot lights, radio, etc.; terminals for connecting optional outside siren and back-up battery (not included); entry delay time control and sensitity control.

EXIT AND ENTRY DELAY

The Guardex 8000 alarm has a built-in exit delay allowing you approximately one minute to lock up and leave the building before the alarm is armed. When you enter your building you may find that just your normal entering sounds activate the siren. You may delay it from starting for up to 30 seconds by turning up the siren entry delay control.

BATTERY BACK-UP

Burglars rarely cut power. However, to give you total protection from a burglar and possible power failure, our alarm has provisions for a battery back-up. (Batteries not included). 12 volt lantern batteries are available at most hardware stores.

THE BURGLARY PROBLEM

The F.B.I. statistics show that at the present rate, one out of every four Americans are going to be burglarized. That is not a very pleasant fact, but it is true. You have a greater chance of being burglarized than being a victim of a fire or automobile accident. The time is now to help protect yourself and your valuables with a Guardex 8000 alarm system.

OUTSIDE SIREN

The Guardex 8000 alarm is equipped with a loud, built-in siren, but if you desire an additional siren to mount outside or in an area away from the main alarm, they are available with 50 feet of wire for $24.95. (Connecting terminals are provided on the back of the alarm).

30 DAY NO RISK TRIAL

This is your opportunity to purchase an alarm system directly from the factory for only $199.95. Try it in your home or business for thirty days without risking one cent. Put our Guardex 8000 alarm to your own test. See for yourself! It will protect every window and door from break-in. If you are not completely satisfied, return the alarm within 30 days for a complete refund. To order your Guardex 8000 alarm, CALL TOLL FREE to charge your credit card or send your check to Guardian Electronics, Inc. in the amount of $199.95. If you want the optional outside siren, add $24.94. (California residents add 6% sales tax.)

(If you require more information, call during California business hours, Monday - Friday)

VISA

master charge

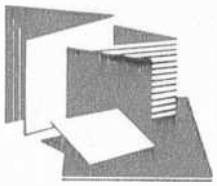
Dealer Inquiries Invited

CALL TOLL FREE
(800) 423-5499

California residents:
(213) 889-1414 collect.

GE GUARDIAN ELECTRONICS, INC.

31133 Via Colinas, Dept. PE. Westlake Village, Calif. 91361



New Literature

EMPLOYMENT OPPORTUNITIES BROCHURE

"Career Opportunities in Telecommunications" describes jobs available for experienced engineers in technologies such as fiber optics, digital ICs, complex MOS memories, bubble memories, and codecs at GTE Automatic Electric Laboratories. Address: J. Douglas Allen, GTE Automatic Electric Laboratories Inc., 400 N. Wolf Rd., Northlake, IL 60164.

SECURITY SYSTEMS BOOKLET

Security systems for commercial, industrial, institutional and residential applications are described and illustrated in "ADT High Technology Security for People, Premises and Profits." Basic operations and benefits are outlined for automated central stations, direct police and fire response, and on-site computerized security using microwave, ultrasonic, card-access, and closed-circuit TV techniques. Ask for Form 948-00 from: ADT, One World Trade Center, 92nd Floor, New York, NY 10048.

BECKMAN PORTABLE MULTIMETERS

The new TECH 300 and TECH 310 3½-digit portable multimeters are described in a bulletin from Beckman Instruments. Features on the new instruments include 2000-hour typical battery life, a semiconductor test function and overload protection on all ranges. The TECH 300 ($110) features 0.5% of reading accuracy of five dc voltage ranges, with five ac voltage ranges, and ac and dc current measurements on five ranges. The TECH 310 ($140) is similar with 0.25% accuracy and an electrical continuity checking feature. Address: Advanced Electro-Products Div., Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, CA 92634.

PORTABLE SCOPE BULLETIN

Gould's new OS1200 portable, 25-MHz, dual-trace oscilloscope is described in Bulletin 449-12. The OS1200 features of 5-inch rectangular CRT operating with 6-kV accelerating potential. It has a 14-ns rise time and signal delay facility for digital work with narrow pulses and low repetition rates. Address: Gould Inc., Instruments Div., 3631 Perkins Ave., Cleveland, OH 44114.

SCANNER FREQUENCY DIRECTORY

Electra has introduced a new "Betty Bearcat Frequency Directory" which groups frequency listings of police, fire, ambulance, public utilities, railroads, and other services by listening areas. In this way, the directory is intended to eliminate hunting through statewide alphabetical listings. The directory also has a section with a fold-out FCC frequency allocation chart, 10-code data, antenna tips, and other reference information. A cross-reference section listing users by frequency is included to help identify signals. The directory ($12.95) is published in editions for the Eastern and the Western U.S.A. Available from Bearcat scanner suppliers or Electra Co., P.O. Box 29243, Cumberland, IN 46229.

SPARKOMATIC SOUND CATALOG

A new 44-page catalog describes Sparkomatic's line of car stereos, speakers, graphic equalizers and amplifiers and power boosters. Included is the 100-watt high-fidelity SPX series, which includes the GE 1000 graphic equalizer and amplifier rated at 100 watts and the SK 6950 and SK 650 4-way 100-watt stereo speaker sets. Address: Sparkomatic Corp., Milford, PA 18337.

ANTIQUE RADIO SERVICING PUBLICATIONS

Antique Radio Services sells individually or in sets servicing materials for many early models of radios and TV receivers. These include Rider's manuals, Sams' "Photofacts," and early Supreme Publications, among others. A complete list of materials and sets available is obtainable. Address: Antique Radio Services, 646 Kenilworth Terrace, Kenilworth, IL 60043.

INCREDIBLE CASSETTE OFFER!

a $5 LCD digital WATCH

Try 10 DAK high energy cassettes risk free for only $2.19 each and get a beautiful $69 value LCD digital watch for only $5.

It's your choice. Think about the kind of music you like. You don't want to think about cassettes jamming, loss of high frequency response or tape hiss.

DAK manufactures a cassette that you can really forget about. Great sound, and no problems. And, for only $5 we hope you will think a lot about your new LCD digital quartz watch.

YOUR TIME IS PRECIOUS

Imagine yourself just finishing recording the second side of a 90 minute cassette and horrors, the cassette jams. Tape is wound around the capstan, your recorder may be damaged and you've just wasted 90 minutes of your time and perhaps lost a great recording off FM.

Enter DAK. We manufacture over one million units of cassette tape each month in our North Hollywood factory. Many of our tapes are used for high speed duplication where they are recorded at speeds up to 8 times normal. This is the ultimate stress for cassettes and causes more failures than any other use.

MOLYSULFIDE

We developed polyester slip sheets with raised spring loaded ridges to guide each layer of tape as it winds. We coat them with a unique formulation of Graphite and a new chemical, molysulfide.

Molysulfide reduces friction several times better than graphite and allows the tape to move more freely within the cassette. The molysulfide is tougher and makes the liner more resistant to wear. Evidently 3M and TDK were hot on our heels, because they have now also come out with new liners.

Hi frequency protection! Tape is basically plastic, and as it moves within the cassette friction causes the build up of static electricity, much as rubbing a balloon against your hair, or scuffing your shoes on a carpet in dry weather.

Static electricity within the cassette is drastically reduced by the low friction of the molysulfide so that its tendency to erase very high frequencies is drastically reduced. A very important consideration for often played tapes.

MAXELL IS BETTER

Yes, honestly, if you own a $1000 cassette deck like a Nakamichi, the frequency responses of Maxell UDXL or TDK SA are superior and you just might be able to hear the difference.

DAK ML has a frequency response that is flat from 40cps to 14,500cps ±3db Virtually all cassette recorders priced under $600 are flat ±3db from 40cps to about 12,500cps, so we have over 2000cps to spare, and you'll probably never notice the difference.

No apology. We feel that we have equaled or exceeded the mechanical reliability of virtually all cassettes and offer one of the best frequency responses in the industry. Maxell UDXL is truly the Rolls Royce of the industry, and DAK is comparable to the 100% US made Cadillac or Corvette!

Price DAK manufactures the tape we sell. You avoid paying the wholesaler and retailer profits. While Maxell UDXL 90s may sell for $3.50 to $4.50 each at retail, DAK ML90s sell factory direct to you for only $2.19 each complete with deluxe boxes and index insert cards.

A $5 LCD WATCH?

Of course not! This is an incredible offer. Countless stores throughout the country sell LCD quartz crystal watches like this for up to $69.

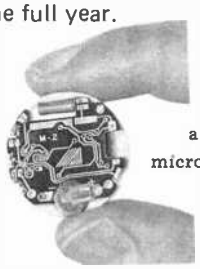
This beautifully styled slim silvertone watch is loaded with features. LCD means that the time in hours and minutes always shows without having to push buttons. Push the button once, and you'll see the date in months and days, and push the button again and the watch shows seconds.

Night light. Usually only found in the most expensive watches. Simply push a button and the entire time section lights up for convenient night viewing.

Quartz crystal accuracy means constant time within 1 minute per month. Crystals use little electricity, so the battery should last up to a year, and may be easily changed by any jewler.

Stainless steel band for long life and comfort. No cheap imitation, a first rate locking adjustable band.

It's guaranteed. This fine watch comes with a manufacturer's limited warranty for one full year.



a rugged micro-computer

DAK TAKES A RISK

Obviously giving away quality watches is not going to make DAK rich. Even giving away cheap watches wouldn't help. We are betting that you will buy our cassettes again, and we are putting our money where our mouth is!

Customers like you are very valuable in the form of future business. We anticipate receiving over 6000 orders and 4500 repeat customers from this advertisement to add to our list of over 57,000 actives.

TRY DAK ML90 CASSETTES FREE

Try these high energy cassettes on your own recorder without obligation for 30 days. If you aren't 100% satisfied for any reason, simply return the tapes and the watch to DAK for a full refund.

To order your 10 DAK ML 90 minute high energy cassettes at $2.19 each and the $69 value watch with your credit card, simply call the toll free number below, or send your check for **$21.90** plus **$5** for the watch and $3 for postage and handling for each group of 10 cassettes and each watch to DAK. (Calif. residents add 6% sales tax)

DAK unconditionally guarantees all DAK cassettes for one year against any defects in material or workmanship.

Why not order an extra group of 10 DAK ML90 cassettes for yourself or a friend? We will add one free ML90 cassette to each 10 you buy and of course you can buy one $69 value watch for $5 with each group you buy.

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INCORPORATED

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CIRCLE NO. 16 ON FREE INFORMATION CARD

Everybody's making money selling microcomputers. Somebody's going to make money servicing them.

New NRI Home Study Course Shows You How to Make Money Servicing, Repairing, and Programming Personal and Small Business Computers

Seems like every time you turn around, somebody comes along with a new computer for home or business use. And what's made it all possible is the amazing microprocessor, the tiny little chip that's a computer in itself.

Using this new technology, the industry is offering compact, affordable computers that will handle things like payrolls, billing, inventory, and other jobs for businesses of every size... perform household functions including budgeting, environmental systems control, indexing recipes, and more. And thousands of hobbyists are already owners, experimenting and developing their own programs.

Growing Demand for Computer Technicians

This is only one of the growth factors influencing the increasing opportunities for qualified computer technicians. The U.S. Department of Labor projects over a 100% increase in job openings for the decade through 1985. Most of them *new* jobs created by the expanding world of the computer.

Learn at Home in Your Spare Time

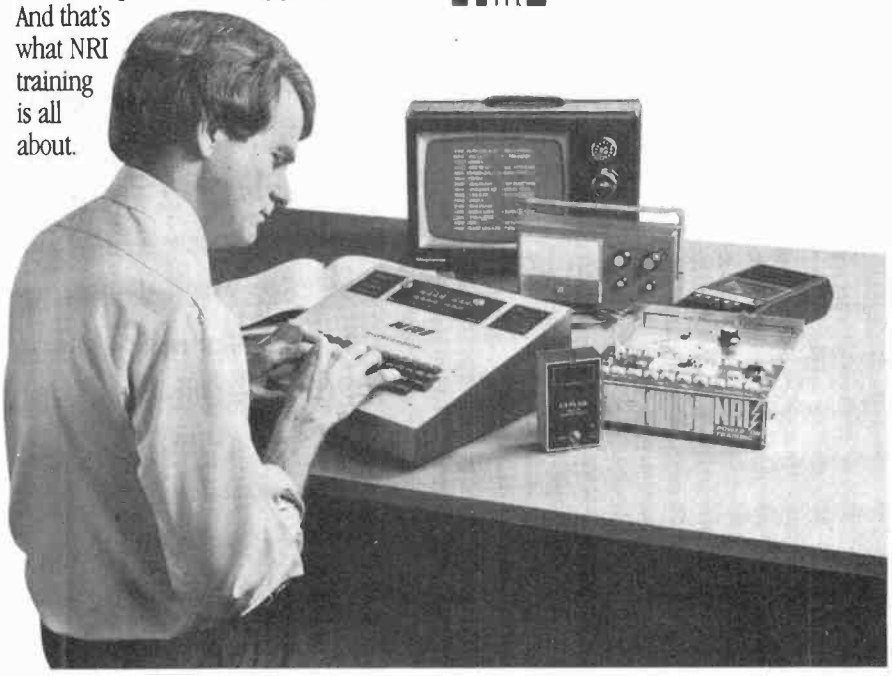
NRI can train you for this exciting, rewarding field. Train you at home to service not only microcomputers, but their larger brothers, too. Train you at your convenience, with clearly written "bite-size" lessons that you do evenings or weekends, without going to classes or quitting your present job.

Assemble Your Own Microcomputer

NRI training goes far beyond theory. It includes practical experience, too. As you progress, you perform meaningful experiments building and studying electronic circuits on the NRI Discovery Lab.® You assemble test instruments that include a transistorized volt-ohm meter and a CMOS digital frequency counter... instruments you learn on, use later in your work.

And you build your own microcomputer. Each step of construction advances your knowledge, gives you deeper insights into this amazing world that's upon us.

This is the only microcomputer designed for learning. It looks, operates, and performs just like the finest of its kind... actually does more than many commercial units. But NRI engineers have designed components and planned the assembly procedure so it demonstrates important principles, gives you working experience in detecting and correcting problems. And that's what NRI training is all about.



Other Opportunities in Electronics

Since 1914, before commercial radio was even on the air, NRI has been the way to learn new electronics skills. Today's modern offerings include, in addition to three different computer courses, TV/Audio/Video Systems Servicing, with training on the only designed-for-learning 25" diagonal color TV, with state-of-the-art computer programming. Or, check out our Complete Communications Course, preparing you to enter this booming field servicing, installing, and repairing equipment like microwave, broadcast, CB, shortwave radio, paging, radar, and more.

Mail Postage-Paid Card for Free Catalog No Salesman Will Call

Send today for your free copy of our 100-page, full-color catalog. It describes all of our electronics courses in detail, showing kits, equipment, and lesson plans. Look it over at your convenience, then decide how NRI can help you make the most of your talents. There's no obligation and no salesman will ever call or bother you. With more than a million students and unmatched experience in home training, NRI gives you the most in training for new opportunity! If card has been removed, write to:

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DISCWASHER®

DiscFoot™

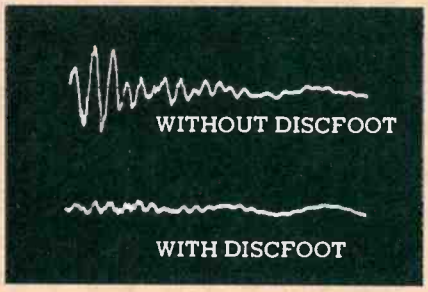
Hi-Technology Turntable Isolation System

- **Works in combination with existing feet for dramatic reduction of feedback.**
- **Isolates better than original or "replacement" feet.**

Home environments can "upset" a turntable by feeding back both speaker and footfall vibrations. Acoustic isolation of a turntable involves the complex variables of turntable weight, room/floor conditions and audio system placement. The Discwasher DiscFoot has been specifically designed to successfully isolate most turntables in the home environment.

The "Material" Solution

The major components of the Discwasher DiscFoot System are new, "totally engineered" chemical complexes that behave radically different than other plastic, rubber or spring systems. These proprietary compounds are durable and precise in behavior, although difficult and expensive to synthesize. Laboratory and real-world tests justify the use of these unusual materials in the DiscFoot System.



The Telling Test

The oscilloscope photo shows the output of two identical audio systems on the same shelf with their styli contacting the platters. The shelf is being struck by a rubber mallet. The top trace shows a turntable with absorptive "replacement" feet. The lower trace shows a DiscFoot System operating in conjunction with the existing turntable feet. Note the dramatic (tenfold) improvement in shock and feedback isolation.

The DiscFoot System contains four isolation feet, four platform caps, four furniture-protecting sheets and four special damping pads (to adapt DiscFoot units to certain turntables.) Additional single DiscFoot units are available for turntables weighing over 22 lbs. The system costs $22.

DiscFoot™

Discwasher DiscFoot can be found at audio dealers interested in preserving your music.

discwasher, inc.
1407 N. Providence Rd.
Columbia, Missouri 65201

CIRCLE NO. 19 ON FREE INFORMATION CARD

Stereo Scene

By Harold A. Rodgers
Executive Editor

DOMESTIC HARMONY

ONE OF THE oldest "truisms" that infect audio retail circles has it that the man of the house chooses equipment on the basis of its performance and the "little lady" exercises her traditional veto power on the basis of cosmetic appeal. Further, in this scenario, the female half of the partnership, through some unstated form of terrorism, dictates the placement of the equipment exclusively according to principles of interior decorating, regardless of whether or not they make any acoustic or electronic sense.

Enlightened thinking, one would hope, will recognize this view as sexist and slanderous to all concerned. On one hand it depicts men as insensitive to the visual aspects of their surroundings and likely to be dominated by the unreasonable demands of their spouses. Women, on the other hand, are seen as single-minded, irrational, and totally devoid of concern about the place of music in the household.

If audio equipment is to be introduced into a home setting, both its acoustic and visual effects will have to be given their due or the job will not be done sensibly. In fact, one would expect an aware salesperson to note this from the outset and proceed accordingly, especially if his prospective customers are a couple. To behave otherwise could easily leave one partner or the other with a reason *not* to buy.

Myth: Audio Equipment is Ugly. First, let's establish that audio equipment is not without visual appeal. Actually, it would be surprising indeed to find that the large amounts of money that manufacturers invest in cosmetics do not produce at least some positive effects. The problem is that the equipment is seldom shown, in advertisements or store displays, in conjunction with other furniture. Thus we have little information as to how the designer envisioned them positioned in the home. Interior decorators have contributed to the difficulty as well. How often does one see a model room—or its photographic rendition—into which an audio system has been integrated?

Such a state of affairs places great demands on the imagination of anyone who wants an audio system to make constructive counterpoint with the rest of his environment. For example, it is often said that loudspeaker systems are boxes and no matter what is done to them they stand their ground in pristine, unmollified boxiness. But to take this point of view is to blind oneself to distinctions, subtle though they may seem at first, that may allow one model to fit in where another might clash intensely. Tables, after all, don't really look all that different from each other either; it is simply that through experience and training most of us are capable of appreciating many of the differences.

The Role of Audio Furniture. Equipment racks and loudspeaker stands are aids to harmonizing equipment with its surroundings. In addition to the beneficial acoustic effects often contributed by the latter, they can usually put what might be dismissed as "just another box" in a visually more advantageous perspective. Stands that tip the loudspeaker a few degrees backward from vertical can (provided the speaker's acoustic design permits) do particularly well with respect to both of these criteria.

Racks have been offered by stereo component manufacturers for some time now, though often as an inducement to buy equipment all of the same make rather than "mixing and matching" as many people do. Most often, therefore, racks are displayed with equipment of the chosen brand installed and are designed, if possible, to make that equipment look better than its competitors. This should not dissuade the prospective purchaser from asking that alternative units be positioned in the rack, if they will physically fit (they won't always). In addition, there are rack suppliers, such as Gusdorf and Recoton, whose products are designed to accept any equipment with reasonable grace.

Making the Right Decisions. Generally, it will be easier to blend a music system into your home in an optimum way if you are redecorating at the same time. Then everything—audio equipment, furniture, carpeting, draperies, etc.—can be chosen to work together. There are a few principles to bear in mind while making one's choices:

1. Try to position any equipment that has controls (preamp, tuner, tape deck, etc.) where they can be reached from the listening position. Few things are as frustrating as getting up to adjust a tone control, going back to the listening position to check the sound, finding that it is not quite what you want, and having to repeat the entire procedure several times.

2. Give up outmoded ideas about positioning loudspeakers in odd corners or places where they can be hidden. To do this will hide their sound as well—or make you wish that you could hide it. Plan on speakers having a positive role in the decor, and position where they will give good sound. (Some acoustically based hints on speaker position were given in the September 1979 installment of this column.) If you absolutely must conceal speakers, consider the use of acoustically transparent curtains that will fit with other room accessories.

3. Plan on using some sound-absorbent material in the room. This can be in the form of stuffed furniture, carpeting, draperies, etc. These need not be applied over whole surfaces. In fact, some studies have shown that quasi-random application of damping material gives more efficient results. In general, surfaces near either the speakers or the listening position are the ones from which the most troublesome reflections arise.

4. Position the turntable as far away from the speakers as is practical; this will tend to avoid acoustic feedback. On the other hand, you may want it near the listening position for maximum convenience. To the extent that these desiderata conflict (some preferred listening positions are quite close to the speakers), trial-and-error may be the best guide. But don't put the turntable so close that you will continually bump it.

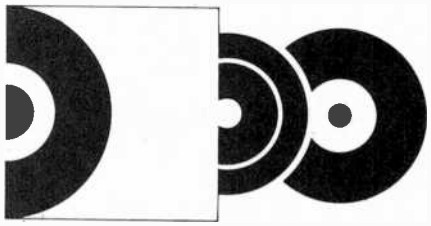
5. Do not run wires where they will be trod upon. This can easily cause disasters. If you must conceal wires under a carpet, make sure that they run under a couch or within an inch or two of a baseboard, where no one walks. (Electric power lines should not, however, be covered by carpets.)

6. Don't be afraid to experiment with unusual furniture configurations. For example, sofas are usually placed so that the long dimension parallels one of the walls of the room. Placing one a few degrees out of such parallelism may add an individual touch to the room and make the formation of standing waves less likely or prominent.

7. Be realistic in your choice of equipment. Trying to make a pair of large, electrostatic panel speakers fit and function well in a small apartment can be an exercise in futility. On the other hand, don't let the unobtrusiveness of minispeakers tempt you into putting them in a situation where they will be over their heads trying to fill a large room with sound. You may get by, but overdriven speakers and distortion are more likely results.

If you are trying to fit an audio system into an existing decor, the problem is harder. Most often, if you are serious about hearing music reproduced with high fidelity, you will have to make changes. (Light under a bushel basket or speaker behind an overstuffed chair, it's all the same.) But if you do your advance planning and have some idea of how you will integrate the system into the design, you can usually work out some solution.

If all of this suggests to you that purchasing an audio system is not something to be done on impulse, you are beginning to get the point. I don't suggest that you make so rigid a plan that nothing on earth will move you, for there are many good reasons for making revisions. One possibility is that a salesperson may be able to offer you a substantially better price on a component other than one you had preselected. By all means, consider attractive deals when they are available, but remember why you chose the model you did in the first place, what you expected it to do, and how you will fit it into your environment. If it all checks out, go for the deal. That way good listening can fit harmoniously into your home and lifestyle. ◇



Audiophile Recordings

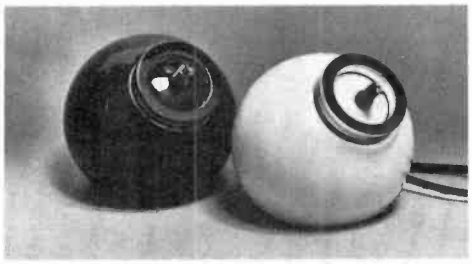
DIGITAL RECORDING VOL. III: BIZET, CARMEN PRELUDE; BERLIOZ, RAKOCZI MARCH FROM DAMNATION OF FAUST; BRAHMS, HUNGARIAN DANCE NO. 5; GINASTERA, PANAMBI SUITE; RIMSKY-KORSAKOV, PROCESSION OF THE NOBLES FROM MLADA. **Zoltan Rozsnyai conducting the Philharmonica Hungarica.** M & K Realtime Records (dbx encoded) PS-1002. Well, dbx has done it at last. This and several other records released at the same time by M & K are the first dbx-encoded, digitally mastered discs—and this one, at least, is a sonic standout. The sound is so clean (the background hiss that the dbx compander pumps up and down on normal recordings is now, for practical purposes, out of the picture) that it actually takes a bit of getting used to at first. I was able to hear a playback of the master tape of the Ginastera—probably the most interesting work on the disc—and as far as I can tell its quality is transferred virtually intact to the disc. Rozsnyai and the Philharmonica Hungarica do an especially fine job with this early work of the Argentinian composer, capturing the drive and incisiveness of the music—in the second movement, for example—while losing none of the tender, subtle moments. The more limited scope of the other works keeps them from being as inspiring, but they are well played and outstandingly recorded.

VIVALDI: THE FOUR SEASONS. **Gunars Larsens, solo violin; Rudolf Baumgartner conducting the Festival Strings Lucerne.** Denon PCM Recording OX-7174-ND. This is a very well made and recorded disc that really lets the inner voices (second violins, violas, and harpsichord) project and demonstrates that Vivaldi is not just melody and bass. The one technical shortcoming I noticed is that the solo violin is placed so far to the left that its sound often gets mixed up with the massed solo violins. As the liner notes candidly admit, the interpretation is not an exercise in Baroque purism. This is not an unreasonable approach when modern instruments are used, and the result is certainly enjoyable. Soloist and orchestra play with spirit and brilliance that Baumgartner keeps under sufficient control to prevent the effect from being heavy-handed or overdone.

Now you can create country fresh air in your home or office. And also watch cigarette smoke, pollen, dust, and other airborne particles disappear from your environment, for less than three cents a week.

All it takes is a small 2½ pound pollution fighter named Ionosphere™. Which, we're convinced, is the most superbly engineered under $200 air ionizer on the market today. Bar none.

The Sharper Image is offering Ionosphere through the mail for just $89.



Power use: approximately 3 watts. Total ion output: 3.8×10^{13} ions/sec. Ion density: 10,000 ions/cubic centimeter at 8'. Ozone production: less than .03 ppm. N_2O production: not measurable.

Ionosphere purifies the air you breathe more efficiently than any fan, exhaust unit or conventional filter system by creating a negative electrical field. One 4-inch unit will ionize up to 250 square feet or an average 12' × 20' room. This negative charge acts on floating particles—even invisible ones—causing them to cluster, fall to the floor or adhere to nearby surfaces. The air becomes pure, feels almost "washed." And Ionosphere is so efficient it requires no fan or other moving parts to disperse these ions.

You probably have experienced this fresh-air feeling before. In nature, negative ions are continually recreated by the dynamic action of the sun, rain and lightning. It's why air smells sweet and invigorating after a thunderstorm, or deep in a forest.

Born in academia.

Major ion research has been conducted at the University of California, Berkeley. Ion Systems, Inc.. a private company, was founded to manufacture ionizers to the rigorous standards of this research community. Headed by senior engineer D.A. Gehlke (formerly with the government's Polaris Project), I.S.I. has built almost every hospital ion system in the U.S. Their new portable Ionosphere is constructed with this same level of integrity.

Ionosphere's electronics are both superb and unique. It is the only ionizer that uses "passive multi-stage" circuitry for its noiseless and noninterfering output (many units are known to affect radio reception). Most other units use a "vibration" mechanism, which causes clicks, pops or an annoying high-pitched whine.

The circuitry is embedded in epoxy resin, then encapsulated in an impact-resistant sphere—a solid seamless ball of fine ceramic tile. Hermetically sealed, it is protected from the moisture that inevitably reduces the performance of competitive units. We know of no other company that takes such pains in producing their product.

Other significant differences? For one, a vastly superior ion emitter than you'll find elsewhere. This easily removable element is made from surgical stainless steel bristle, not the more commonly used copper "fuzz" or nickel-plated points. (These have short life spans, do not clean easily, and in short time lower their output.) The Ionosphere's emitter will last a lifetime, and cleans easily under hot water.

On other units, you'll also find inexpensive plastic cases. When exposed to a high voltage field, these petrochemicals can be converted to a harmful gas. But Ionosphere's tile case is completely safe.

More ions aren't necessarily better.

One 4" Ionosphere generates approximately 3.8 trillion ions every second. Unlike other units which produce an excessively high output (at the source only), the Ionosphere creates a more *naturally* balanced ion environment. You should also avoid units without stated levels of ozone production (Ionosphere is among the lowest).

Why do we need ionizers at all?

Urban life has upset the natural electrical balance of the air. Modern conveniences like heating, air conditioning, telephones and televisions greatly deplete negative ion levels, robbing the air of its natural cleansers. This is also why we feel uncomfortable under fluorescent lights.

Ionsphere restores this balance in just minutes. The air smells good again, even after smoking.

And, as a result of its work, you may need to clean your walls in a year or so. But be glad that same soot was kept out of your lungs.

Try one, or order a system.

The $89 Ionosphere comes in white (#946) or black ceramic (#945). Or you may expand your fresh air environment at an $18 savings—with three units at $249; 2 white, one black, (#947). Either way, you can experience the freshest air you've probably ever breathed, without obligation. Ionosphere comes with full instructions and a one year warranty. And if you're not delighted, simply return your order within two weeks for a prompt and courteous refund.

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Credit card holders may call the toll-free ordering number, seven days a week, anytime. Please have the product number ready. Or send your check, adding sales tax in CA (5.34 for one, 14.94 for three). Plus $3.50 delivery. Please order now to insure early delivery.

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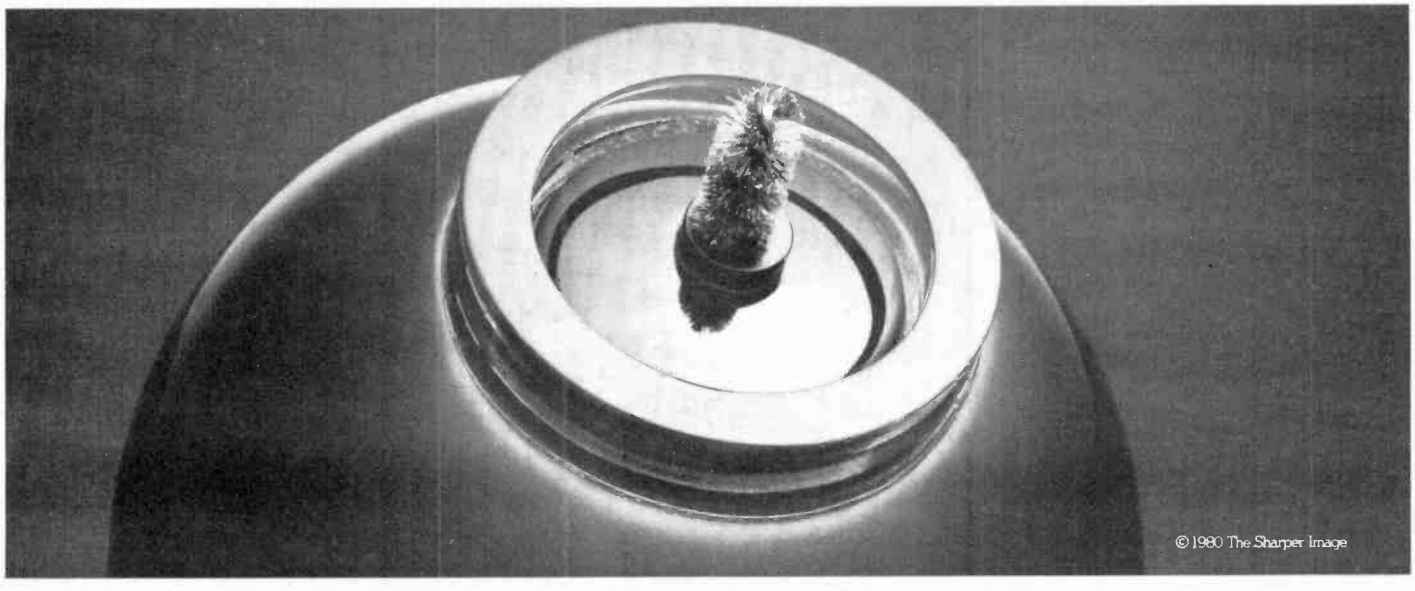
THE AIR IONIZER WITH THE SCIENTIFIC EDGE.



HEAR WHAT YOU'VE BEEN MISSING!

Listen with an 801 Omnisonic Imager,™ a quantum leap forward in stereo reproduction!

OMNISONIC IMAGERY™ IS HERE!
Our innovative state-of-the-art electronics create a totally unique sound environment never before possible. With an 801 Omnisonic Imager™, you can now experience the physiological sensation of what amounts to three-dimensional sound reproduction — what we call omnisonic imagery™ — from just *two* speakers! Sound appears to come from many sources in the listening area, depending on the quality of the signal source. A common reaction is to look about for other speakers. *And you don't have to sit rigidly fixed at a focal point between the speakers to enjoy omnisonic imagery™!*

RETROFITS TO MOST STEREO SYSTEMS!
Any unit with a tape monitor facility (internal tape loop) can mate with an 801 Omnisonic Imager™. It also has a built-in tape monitor button so you don't lose your existing tape monitor facility.

The 801 Omnisonic Imager™ works on any stereo source — FM, tapes, and records. You can record selections via the 801 Omnisonic Imager™ and replay them on conventional home-use stereo equipment.

THREE DIMENSIONS IN SOUND!
Stereo without an 801 Omnisonic Imager™ produces sound from two distinct sources. Music from the speakers arrives at your ear, but most of it falls to the floor. The result is often "muddiness" and loss of presence. Only two dimensions result — volume level and stereo separation.

Stereo with an 801 Omnisonic Imager™ creates omnisonic imagery™ never before possible. Sound seems to come from the near and far. At times, it surrounds you, and appears to come from behind you and below you. The sound never has a chance to fall to the floor. It is so alive with movement that it envelopes you. Three dimensions — volume level, stereo separation, and omnisonic imagery™ are apparent with an 801 Omnisonic Imager™.

LIFETIME WARRANTY!
You get a **lifetime warranty** on the active circuitry, and one year on all other components (excluding case and line cord), provided your 801 Omnisonic Imager™ is used as specified.

Now that you've read all about our 801 Omnisonic Imager™, don't you think it's time to hear one? If we have stimulated your interest in seeking the finest sound reproduction in the purest sense, please ask your dealer for a live demonstration. If you have any questions, or need to know the name of the dealer nearest you, call or write to:

OMNISONIX, LTD.
P.O. Box 307
Wallingford CT U.S.A. 06492
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Dealers — join our rapidly-growing network. Write to our Sales Dept. for details. Visit our booth at the June C.E.S., Chicago. D-26 Lobby Level

CIRCLE NO. 51 ON FREE INFORMATION CARD

PRODUCT GALLERY

A. MIX-IN! This new Salton Drink Mixer gives you the latitude of a bartender or soda fountain specialist. It means business with a high speed commercial quality motor. Very simple and safe. Operates on AC. #51549 $19.95 (2.65)†

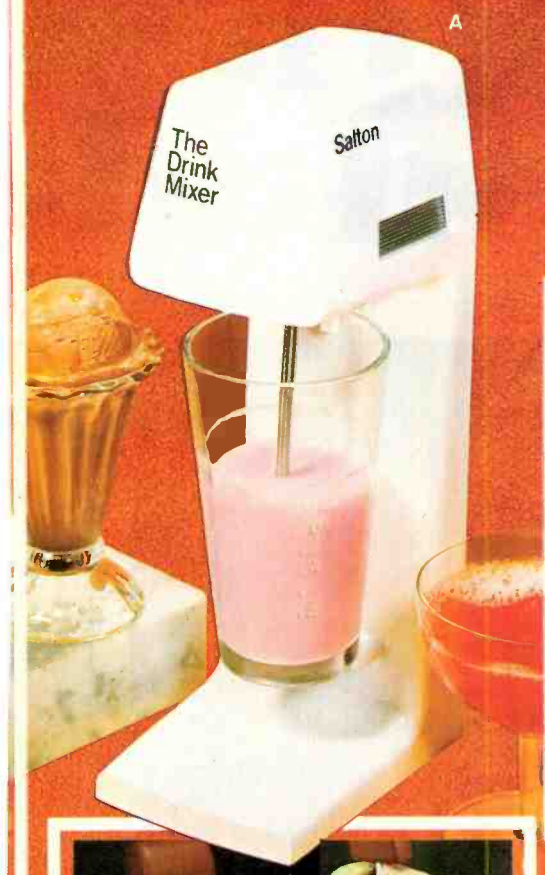
B. SHEEPSKIN THROW for your car seat. Choose beige or dark brown plush. Each measures approximately 27" x 40," has straps and loops to keep it from slipping.
Beige #51561 $49.95 (3.50)
Brown Plush #51557 $49.95 (3.50)

C. MUSICAL CHRONOGRAPH plays "Oh, Susannah" when you set the alarm. It's a watch, a stopwatch, a calendar and an alarm. Chimes every hour on the hour if you wish. Shows time, date and features a 6 digit stopwatch function. By Marcel. LCD display, dial light.
#51568 $79.95 (2.40)†

D. COMPRESSOR PUMP. Could be quite a lifesaver if you have a low tire, or it could be a breath-saver for inflatable boats, toys, pools, etc. All packed inside a molded plastic carrying case. Features include a pressure gauge for accurate air filling. Just plug it into your car lighter!
#45094 $49.95 (3.05)†

E. SAFETY COMBINATION. A smoke and burglar alarm in one portable unit. Just hang the unit over the door, and activate the on/off switch. Separate alarms distinguish smoke from intrusion. Low battery signal, loud 85 decibel horn. 4" x 3" x 6." By Wells Fargo.
#45092 $39.95 (1.95)†

F. CAR VACUUM plugs into the cigarette lighter of your car. From that point you'll be able to reach front and back seats and floors! The unit is 17½" long and the set includes 3 attachments.
#51555 $21.95 (3.30)†



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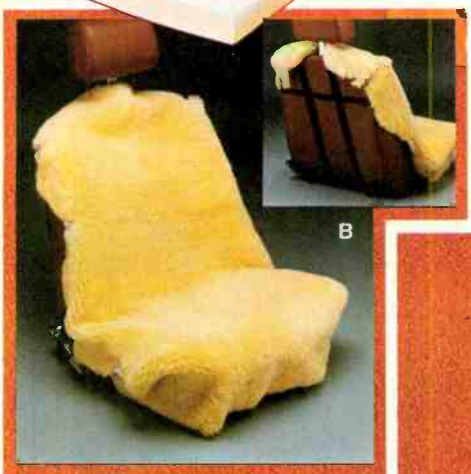

B

F

C

( ) Price in parenthesis indicates shipping charge. Please add to unit cost of item.

†Warranty available

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Sub Total $ _____
Add appropriate state sales tax $ _____
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Make check payable to Giftmaster, Inc.
Credit card orders without your signature and expiration date cannot be processed.
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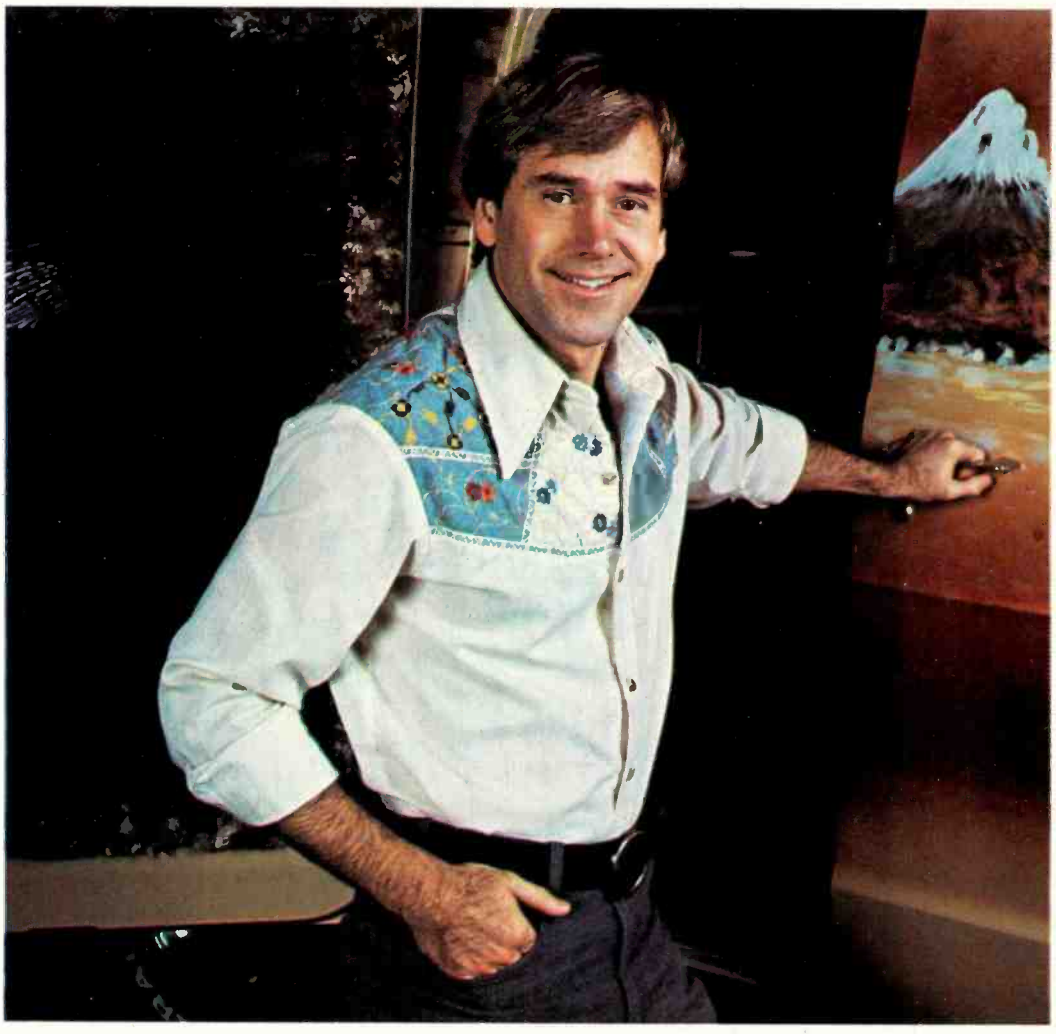

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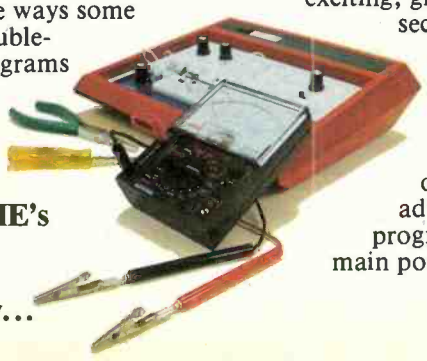

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5600A-Kit	$169.95	50Hz-550MHz	Proportional Oven .2 PPM 10° - 40°C	10-25mv	10-15mv	15-50mv	9	*115 VAC or 8.2-14.5 VDC	3¼" x 9½" x 9
5600A-Wired	$199.95								
5612Kit	$199.95	50Hz-1.2 GHz	Proportional Oven .2 PPM 10° - 40°C	10-25mv	10-15mv	15-50mv	9	*115 VAC or 8.2-14.5 VDC	3¼" x 9½" x 9"
5612 Wired	$239.95								
5500 Wired	$109.95	50Hz-512MHz	TCXO 1 PPM 17° - 40°C	10-25mv	15-25mv	25-75mv	8	115 VAC or 8.2-14.5 VDC or NICAD PAK.	1½" x 5" x 5½"
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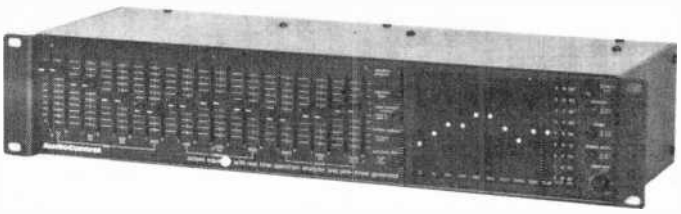
Julian Hirsch Audio Reports



Audio Control Model C-101 graphic equalizer and spectrum analyzer

HIRSCH-HOUCK LABS REPORT

The Audio Control Model C-101 combines a ten-band graphic equalizer with a real-time spectrum analyzer, whose filter bands correspond to the adjustable frequency segments of the equalizer. The two parts of the instrument are functionally separate, but their use can be coordinated by appropriate settings of the various controls.

Usefulness of the C-101 as a tool for adjusting a home music system is greatly enhanced by its built-in pink-noise generator and inclusion of a separate high-quality condenser microphone whose output can be displayed on the spectrum analyzer. It also converts the C-101 into an audio sound pressure level, or SPL, meter.

The compact Model C-101 measures 19"W × 6½"D × 3½"H (438 × 165 × 89 mm) and weighs 6¾ lb (3.1 kg). The panel is slotted for mounting in a standard EIA rack. Suggested retail price is $549.

General Description. About two thirds of the front panel is devoted to the graphic equalizer sliders. Left and right channel controls for each band are adjacent, with detents at the center (flat) positions and a nominal range of ± 12 to 15 dB. Each control has a scale calibrated from + 15 to − 15 dB in 3-dB intervals. Center frequencies of the equalizer bands are at 32, 60, 120, 240, 480, 960, 1920, 3840, 7680, and 15,500 Hz.

Two small pushbutton switches, labeled EQUALIZER PROGRAM and EQUALIZER TAPE, connect the equalizer circuits in the signal path or in the outgoing signal path to a tape recorder connected to jacks on the rear of the C-101. The buttons are mechanically interlocked so that either one must be released before the other can be pressed. The ability to equalize a program before it is recorded is a useful feature that is rarely found in today's graphic equalizers.

Near the equalizer switches is a TAPE MONITOR button that replaces the one on the amplifier to which the C-101 is connected. Included in the unit are two rumble-reducing features that are effective even when the equalizer circuits are bypassed. The SUBSONIC FILTER cuts off below 20 Hz at an 18 dB/octave rate, and the RUMBLE REDUCER suppresses vertical (out-of-phase) rumble by summing the two channels at frequencies below 200 Hz. This has virtually no effect on stereo directionality or total bass energy, since most bass program content is common to both channels.

The right third of the front panel is devoted to the real-time spectrum analyzer (RTA), whose display contains 90 red LEDs in a rectangular grid pattern (10 columns of nine LEDs). Each vertical column is labeled to correspond to one of the equalizer bands, from 32 to 15,500 Hz. Intervals between the level-indicator diodes can be set to either 2 or 4 dB by the RANGE switch. The center horizontal row of LEDs is calibrated at 0 dB, and the display range about that line is either ± 8 or ± 16 dB. In the RTA mode, a row of green LEDs appears at the 0-dB level that separates the octave bands.

Below the POWER switch is a FUNCTION button that engages the real-time analyzer when pushed in (RTA). When it is out, the display indicates total level across the audio band, appearing as a horizontal line of red LEDs whose vertical position varies with program level. A third amplitude scale, at the right of the display, labeled SPL and calibrated from 60 to 92 dB at 4-dB intervals, is used when the microphone (supplied with the C-101) is plugged into a rear-panel jack to convert the C-101 into a sound level meter (SLM) that indicates in dBA (A-weighted) levels. The RANGE switch must be set to 4 dB for SPL readings.

With the DISPLAY ACTION button in its OUT position, response of the LED indicators is slow, which is convenient for making measurements with the pink-noise test signal and for some program material. The IN position gives fast response, so that the display can follow brief program peaks. Finally, there is a small INPUT LEVEL knob, with a center detented CAL position. The CAL detent lets the C-101 display actual SPL readings from the microphone. This control is calibrated at 5-dB intervals over a ± 20-dB range and can be used to extend the range of sound-level meter readings to cover 40 to 132 dBA. It also serves as an input-level control for the spectrum-analyzer and program-level indicator functions.

There are phono jacks for the line inputs and outputs, and a second set of jacks for the tape recorder inputs and outputs on the rear apron. Two phono jacks carry the pink-noise test signal, whose 100-millivolt level is suitable for driving high-level inputs of an amplifier. Below them is a standard ¼" (6.4-mm) jack into which the microphone plugs for making acoustic SPL measurements and adjusting room equalization. The RTA display automatically switches from the electrical program to the microphone output when the mike is plugged in.

The microphone is a miniature condenser type with built-in active circuits powered by a 5-volt supply that reaches it through the signal cable. A typical calibration curve supplied with the microphone reveals a response within ± 1.5 dB from 30 to 20,000 Hz and a ± 3-dB tolerance on its sensitivity rating. This caliber of performance is more than adequate for the intended use of the instrument, although professional SLMs typically have closer tolerances. It appears that the Audio Control microphone (or a pair of them) should make a fine adjunct to a tape recorder, but the manufacturer cautions against trying to use it with anything but the C-101, or to plug any other kind of microphone into the C-101. Audio Control's microphone requires a + 5-volt power supply; and since that voltage is present at the C-101 jack, another microphone plugged into it might be damaged.

Laboratory Measurements. We measured the equalizer's frequency-response contours with the controls at their extreme settings. Each filter has a Q of 2.5, which minimizes the interactions between adjacent controls, although some still occurs. The "flat" frequency response of the equalizer section was excellent, producing virtually no alteration of the shape of a 1-kHz square-wave signal. With the equalizer bypassed, the frequency response was down only 0.1 dB at 5 and 50,000 Hz and down 0.3 dB at 100,000 Hz. (The manufacturer's rating is ± 0.75 dB from 3 to 100,000 Hz.)

The SUBSONIC filter reduced the output by 3 dB at 20 Hz, below which we did not measure the slope. The RUMBLE REDUCER had the claimed effect, although the amount of reduction depends on the source of the rumble (lateral rumble is not affected). Oscilloscope photos (Figs. 1A and 1B) reveal the outputs of the C-101's left and right channels, with only the left

(Continued on page 32)

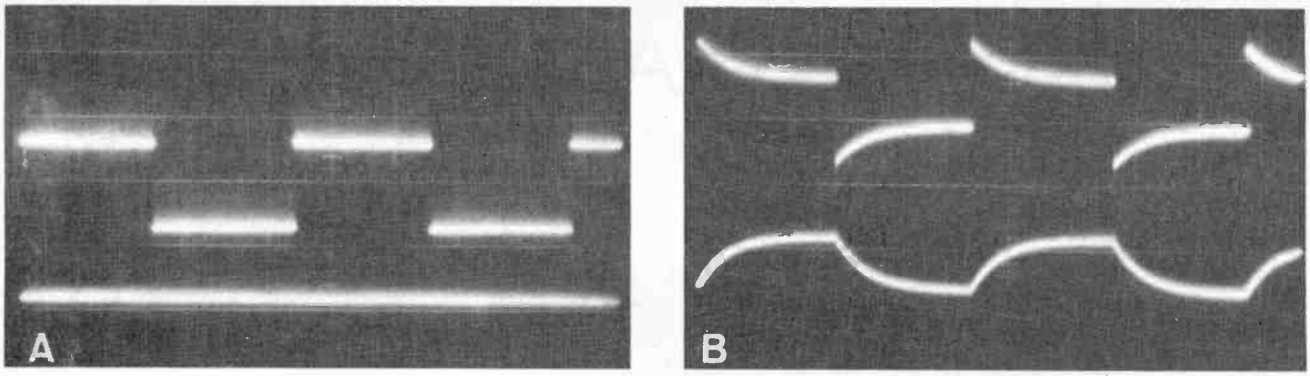


Fig. 1. Oscilloscope photos of equalizer output with square-wave input and Rumble Reducer out (A) and in (B).

channel driven by a 100Hz square wave. In Fig. 1A, the RUMBLE REDUCER is not engaged. With it engaged (Fig. 1B), the signal is present at equal levels in both channels because of the summing action of the circuit. Alterations of the square-wave shapes in the two channels result from the fact that summing begins at about 200 Hz and produces some phase shift that is not identical between channels. As phase errors are complementary, the audible program (sum of the channels) has the same waveform as the original signal.

Harmonic distortion is rated at no more than 0.025% at a 1-volt output from 20 to 20,000 Hz. We measured it at 1000 Hz and obtained readings of 0.003% to 0.0045% for all output levels from 0.1 to 5 volts and 0.006% at 7 volts. (The output of this unity-gain system clipped at 7.3 volts when driving the IHF standard load of 10 kilohms in parallel with 1000 picofarads.) Output noise level was below our minimum measurement capability of 80 microvolts (unweighted), or −82 dB relative to 1 volt. The published spec is 90 dB below 1 volt in a 10-kHz bandwidth.

Center frequencies of the 10 octave-band equalizer filters were typically within 5% of the nominal values. Amplitude calibration of the LED display was good, although intervals of 2 or 4 dB between steps resulted in some ambiguity in the readings. However, for their intended purpose, reading precision and accuracy was satisfactory.

Calibration of the SLM display, using the microphone, was checked with the pink-noise test signal through several speaker systems in a side-by-side comparison against our Scott 450B SLM. When the INPUT LEVEL control was set to CAL, the C-101's SPL readings were high by 4 to 10 dB (typically about 6 dB). When the INPUT LEVEL control was used to match the C-101 reading to that of the Scott meter at the 0-dB level of 76 dBA, the indications were accurate across the full display range. (This required a −5-dB setting of the knob on our test unit.)

We analyzed the spectrum of the pink-noise test signal on our H-P 3580A spectrum analyzer, using a logarithmic frequency sweep from 20 to 43,000 Hz. Figure 2 shows that the energy spectrum slopes downward with increasing frequency at a rate of 10 dB per decade (3 dB/octave) in accordance with the defined spectrum of pink noise.

Sensitivity of the LEVEL display to an electrical input signal from the associated amplifier was 0.575 volt for a 0-dB (center) reading using the CAL position of the INPUT LEVEL control. At its maximum setting, this control enabled a 15.6-millivolt input to give a 0-dB reading, while at its CCW limit, it was able to turn off the display completely.

User Comment. We have used many graphic equalizers that were normally adjusted only by ear, using musical program material or a pink-noise test record played through a phono system. Neither scheme gives assurance of a properly balanced system, since the human ear is simply not an accurate enough sensing device. Hence, it is reassuring to know that an equalizer/SLM system like the Audio Control C-101 is available and can eliminate guesswork.

The C-101 is the first equalizer we have seen that permits a simple, accurate equalization of one's speaker systems and listening room. Adjacent placement of left and right channel sliders simplifies operation, and the calibrated microphone makes it a matter of a few minutes' easy work to flatten out the response of a music system better than one might have thought possible. The spectrum analyzer then provides continuous display of program level or spectral content and serves as a means of comparing records, phono cartridges, tape recorders, etc. Numerous other applications, such as the use of the C-101 to set up the bias on a cassette recorder, are described in the very complete user's manual. Although the C-101 is less precise than professional instruments usually employed for making equalizing adjustments, it is quite adequate for the job.

We experimented with equalizing several very different speaker systems with the microphone close to our normal listening position. We found that the C-101 could produce a nearly flat frequency response from any of them in less than five minutes. It did not make all the speaker systems sound alike, but certain settings of the slide controls were common to all our test speaker systems, which is clear evidence of room resonances that had colored the sound of all speaker systems heard in that room. After equalization, all the speaker systems sounded much "cleaner."

The C-101 is actually a combination of the company's Models C-22 octave-band equalizer and C-50A real-time analyzer with pink-noise generator and microphone. With the two combined in a single, very compact unit, the C-101 is more convenient to use and costs $100 less than the separates.

If you are seriously considering getting an octave band equalizer, we urge you to look closely at the C-101. With other equalizers we have used, one has little chance of getting an optimum adjustment of room or speaker-system response, but with the Audio Control C-101, it is hardly possible *not* to get a equalized system.

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(More Reports on page 34)

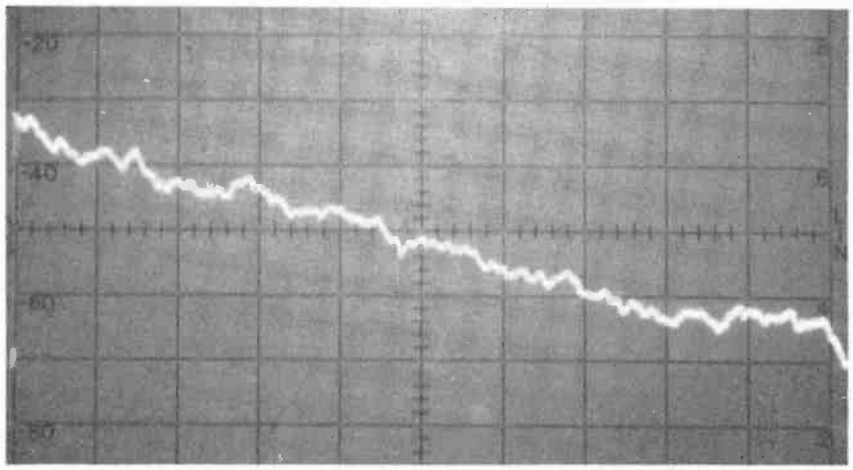

Fig. 2. Spectrum analysis of the C-101's pink-noise test signal using a logarithmic sweep from 20 to 43,000 Hz.

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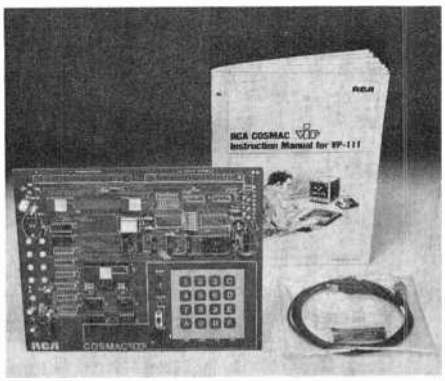

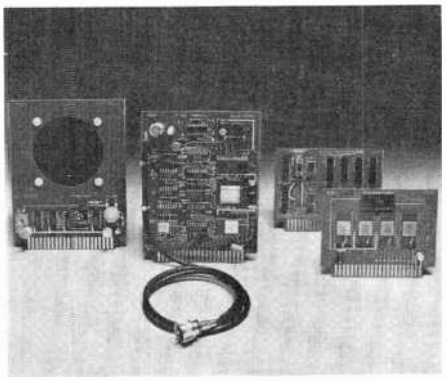

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Electro-Voice Interface:2 Series II speaker system

HIRSCH-HOUCK LABS REPORT

One of the least expensive models in the Electro-Voice "Interface" Series of speaker systems is the Interface:2 Series II. Like the rest of the line, it has been designed to make the most effective use of a small vented enclosure and compatibly designed drivers. It differs from the more expensive Interface speakers in that it does not require an equalizer. It is relatively efficient and is recommended for use with amplifiers rated between 3.6 and 250 watts per channel.

Each system weighs 25 lb (11.3 kg.) and is housed in a simulated walnut-grained vinyl cabinet, measuring 24¼" × 13¾" × 10¾" deep (616 × 350 × 273 mm). The black cloth grille is held in place by Velcro fasteners. Binding-post terminals are recessed into the rear of the cabinet. Nominal impedance of the speaker is 8 ohms, with a minimum rating of 5 ohms. Preferred operating position is close to a wall, at ear level; but, for floor mounting, a pair of 8"-high (200-mm) accessory stands is available from Electro-Voice as the Model BBR-1. Suggested retail price of the Interface:2 Series II is $160.

General Description. Interface:2 Series II is a two-way system, with an electrical crossover at 1500 Hz between a 1½" (37 mm) dome tweeter and an 8" (200 mm) woofer/midrange driver. Because of the small size of the enclosure, the "vent" takes the form of a passive radiator, a 12" (305 mm) passive cone. Acoustic crossover between the driven and passive cones occurs at 66 Hz. Tweeter level is continuously variable over a 6-dB range. (Maximum output is in the "flat" position of the control.)

The rated anechoic frequency response of the Electro-Voice Interface:2 Series II is ±3 dB from 47 to 18,000 Hz. Its total acoustic power output is rated at ±3.5 dB from 47 to 12,500 Hz. The rated sensitivity is 92 dB SPL at 1 meter when driven by 1 watt into its nominal 8-ohm impedance.

Laboratory Measurements. When we spliced our reverberant field response measurements to a close-miked woofer response curve, correcting for room absorption, we found the overall composite frequency response to be remarkably close to the specifications in the instruction booklet—actually better in many respects! The composite curve was within ±3.5 dB from 55 to 20,000 Hz with the tweeter control at maximum and within ±3.5 dB from 40 to 20,000 Hz with the control at minimum. Response at middle and high frequencies was very uniform. A slight rise of about 2.5 dB was found at 13,000 Hz, but limits of ±1 dB applied from 800 to 10,000 Hz. Reducing the tweeter level control setting tipped the curve downward above 1000 Hz.

Woofer response was impressively flat, except for a small rise at 1000 Hz that may have been due to speaker placement. From 800 Hz to 55 Hz, total amplitude variation was only 1.5 dB. Output fell off smoothly below 55 Hz.

The impedance curve of the Interface:2 Series II had the "double humped" shape typical of vented enclosures, with maxima of 30 ohms at 34 Hz and 22 ohms at 75 Hz, and a minimum of 5 ohms between 100 and 400 Hz. It rose smoothly to between 8 and 12 ohms at all frequencies above 1000 Hz. Sensitivity was almost exactly as rated, although our measurement used an octave bandwidth (about 700-1400 Hz) to E-V's 300 to 10,000 Hz. With 1 watt of drive (2.83 volts), the SPL at 1 meter was 91 dB, which is relatively high for a small vented system.

Bass distortion was very low. At 1 watt input it was between 0.5% and 1% from 100 Hz down to below 50 Hz, rising to 2% at 40 Hz and 6% at 30 Hz. Increasing the drive to 10 watts had only a moderate effect down to 55 Hz, where distortion remained under 2%. However, it was greater at lower frequencies—8.5% at 40 Hz and 14% at 35 Hz.

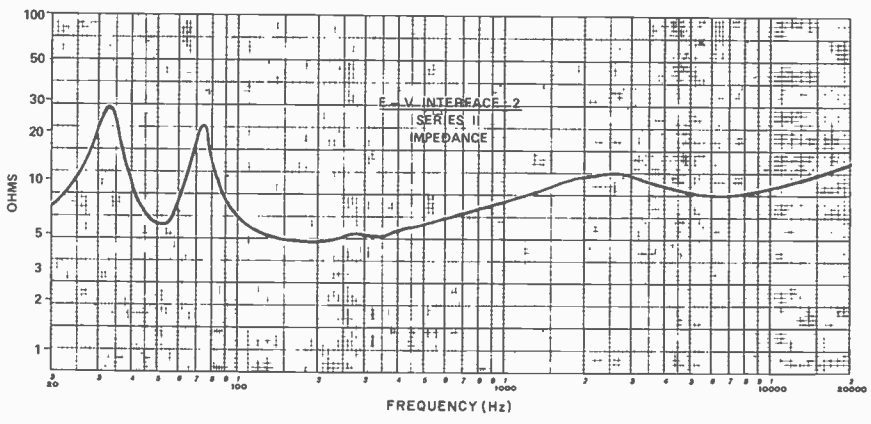
User Comment. We preferred the sound of the E-V Interface:2 Series II, with the tweeter level maximum, although a "more reflective" listening room might have changed our opinion. Initially, we installed the speakers on 7" high stands and placed them on a carpeted floor about a foot from the wall. The result was a heavy quality that did not correlate at all with the measured bass response. Placed on a shelf against the wall and at ear level, the speakers sounded vastly better. Deep bass was evident in amounts that were hard to credit to such a small box, without overemphasis of the upper bass. Balance between midrange and high frequencies was excellent.

E-V devotes considerable space in the instruction booklet to the criteria for positioning these speakers. We suspect that some care and experimentation in this area will pay dividends, as the speakers may be more sensitive to placement than most others.

Overall, the Interface:2 Series II speakers sounded smooth and uncolored. There was no trace of stridency, boom, or artificial midrange coloration. Only after we had decided that this was a *good* speaker on its merits, did we look up the list price—and received our second surprise of the day. Even a few years ago a pair of these would have been a bargain at twice the present price. Allowance for 1980's inflated currency shows them to be an excellent value indeed.

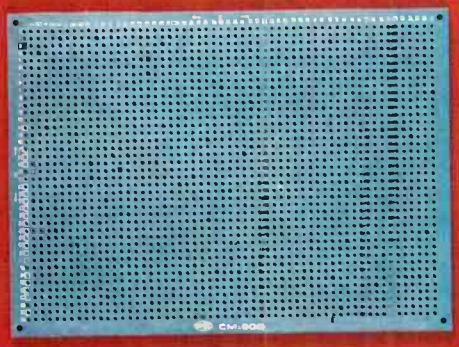
CIRCLE NO. 102 ON FREE INFORMATION CARD

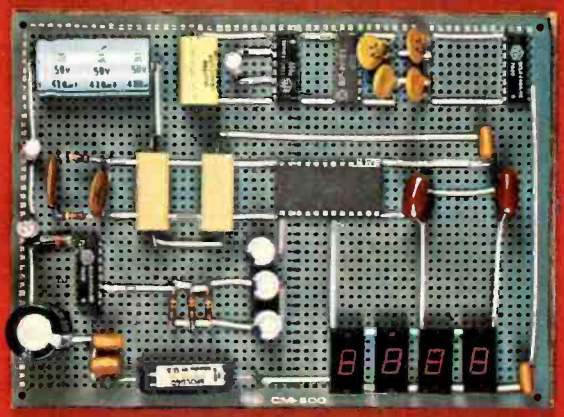
(More Reports on page 36)



Impedance curve shows rated minimum of 5 ohms.

CM-600 Circuit Mount





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Nagatronics Model 350E stereo phono cartridge

HIRSCH-HOUCK LABS REPORT

The Nagatron 350E is one of a series of induced magnet stereo phono cartridges that share a common body and differ only in their stylus systems. The user-replaceable stylus assembly of the Nagatron 350E uses a 0.3 × 0.7 mil (76 × 178 micrometers) elliptical diamond, nude mounted to a cantilever made of highly rigid aluminum alloy. The molded plastic case has been designed to minimize internal resonances, avoiding coloration of the reproduced sound from that source, and has a super-permalloy shield to minimize hum induction by external fields. Weighing 6.1 grams, the Model 350E has standard ½-inch (12.7-mm) mounting centers. Its suggested retail price is $95.

General Description. The fixed samarium-cobalt magnet of the Nagatron 350E cartridge is located outside its permalloy shielded structure, isolating the coils from its magnetic field except for the component modulated by the ferrite armature coupled to the stylus cantilever. According to Nagatron, samarium-cobalt magnets have better long-term stability than other types. As a result, the output of the cartridge does not vary after extended use.

The pivot of the stylus cantilever, supported by a block of elastomer, is very close to the armature. When the stylus assembly is inserted into the cartridge body, the armature bridges the gap between the exposed pole of the fixed magnet and the two internal pole pieces that channel the flux through the fixed coils in the body.

Rated effective tip mass of the Nagatron 350E is 0.65 milligrams. Intended tracking force is from 1.5 to 2.0 grams (1.8 grams optimum). Output at 1 kHz for a 5 cm/s velocity is rated at 4 millivolts, and channel levels are said to be balanced within 1 dB. Frequency response is stated as 10 to 25,000 Hz with no tolerance given, and rated channel separation exceeds 25 dB at 1 kHz. Recommended load is 50,000 ohms in parallel with a capacitance of 200 to 400 picofarads.

Laboratory Measurements. We installed the Nagatron 350E in a moderately low-mass tonearm (less than 15 grams) for testing. Preliminary frequency-response measurements with different values of load capacitance indicated that it was not critical. There was less than 1 dB change in high-frequency response (between 3,000 and 15,000 Hz) over a capacitance range from 175 to 375 picofarads. The latter value was used for the subsequent tests.

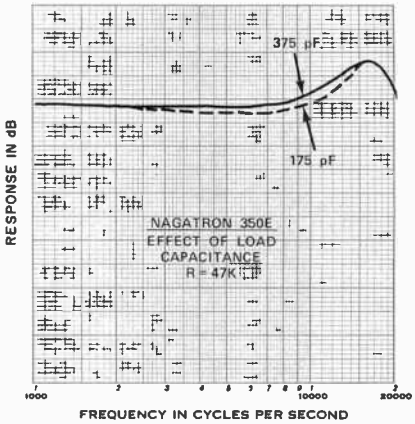
With the CBS STR100 test record, the frequency response was flat within ± 1 dB from 40 to 10,000 Hz, rising to a maximum of about +3 dB at 16,000 Hz before returning to the midrange level at 20,000 Hz. Channel separation was symmetrical between channels and measured typically 23 to 25 dB at all frequencies up to 15,000 Hz, remaining strong up to 20,000 Hz.

Low-frequency resonance in the test arm was at 9 Hz, with an amplitude of 9 dB. Square-wave response from the CBS STR112 record showed a single overshoot and well-damped low-level ringing at the 16,000-Hz stylus resonance frequency. Tracking our high-velocity test records was good at 1.8 grams—and, in most cases, at 1.5 grams. The cartridge was able to play the 60-micron level of the 300-Hz tones on the German Hi-Fi Test Record at 1.8 grams and the 70-micron level at 2 grams. Output voltage was about 3.1 millivolts at 3.54 cm/s velocity, with the channels balanced within 0.4 dB.

The Nagatron 350E did an excellent job in tracking distortion tests using the Shure TTR102 and TTR103 records. High-frequency tone bursts of the TTR103 were tracked with a distortion level not exceeding 1% even at the record's maximum level of 30 cm/s. At 15 cm/s, it was 0.6%. On the IM bands of the TTR102, the reading was 2 to 3%. (Few cartridges can track the 27-cm/s maximum level on this record.)

In the subjective tracking tests using the Shure "Audio Obstacle Course" records, the 350E was competent though not outstanding. On the ERA III record, we heard a trace of mistracking on the highest level of the sibilance and bass drum sections. On the ERA IV record, there was definite mistracking on the maximum level (#5) of all bands except the solo harp, and traces of mistracking on level 4 of most bands.

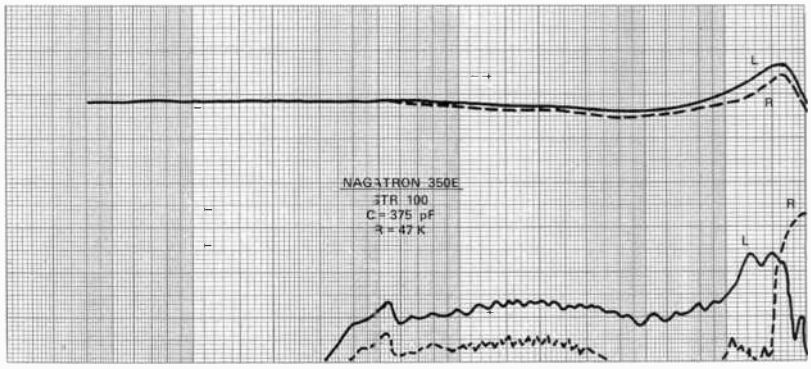
User Comment. In our listening tests, the Nagatron 350E held up very well. It gave no signs of mistracking on any music record. There were no audible signs of the 16,000-Hz stylus resonance, which was quite small in amplitude and higher in frequency than most of the music. Specific sound character that could distinguish this from many other fine cartridges was absent. In fact, the Nagatron and a number of other cartridges (all considerably higher in price) were as a rule indistinguishable by sound and generally showed no intrinsic quality differences.



Response between 3 and 15 kHz changes less than 1 dB with capacitance variation of 175 to 375 pF.

Though not everyone will see it this way, the relatively low compliance of the 350E is an advantage that makes it a good match for any of the numbers of tonearms having medium to high effective mass. The 9-Hz resonance frequency we measured in our 15-gram test arm underscores the benefit of this compatibility—it is close to the optimum frequency for tracking record warps without affecting the low bass response. In most arms, this cartridge would not resonate below about 8 Hz, nor above 11 or 12 Hz. In other words, the Nagatron 350E can be depended upon to function well in nonexotic tonearms and with almost any amplifier's input capacitance. These characteristics, with its fine sound and moderate price make it a strong mainstream contender.

CIRCLE NO. 103 ON FREE INFORMATION CARD



Frequency response and crosstalk for left and right channels.

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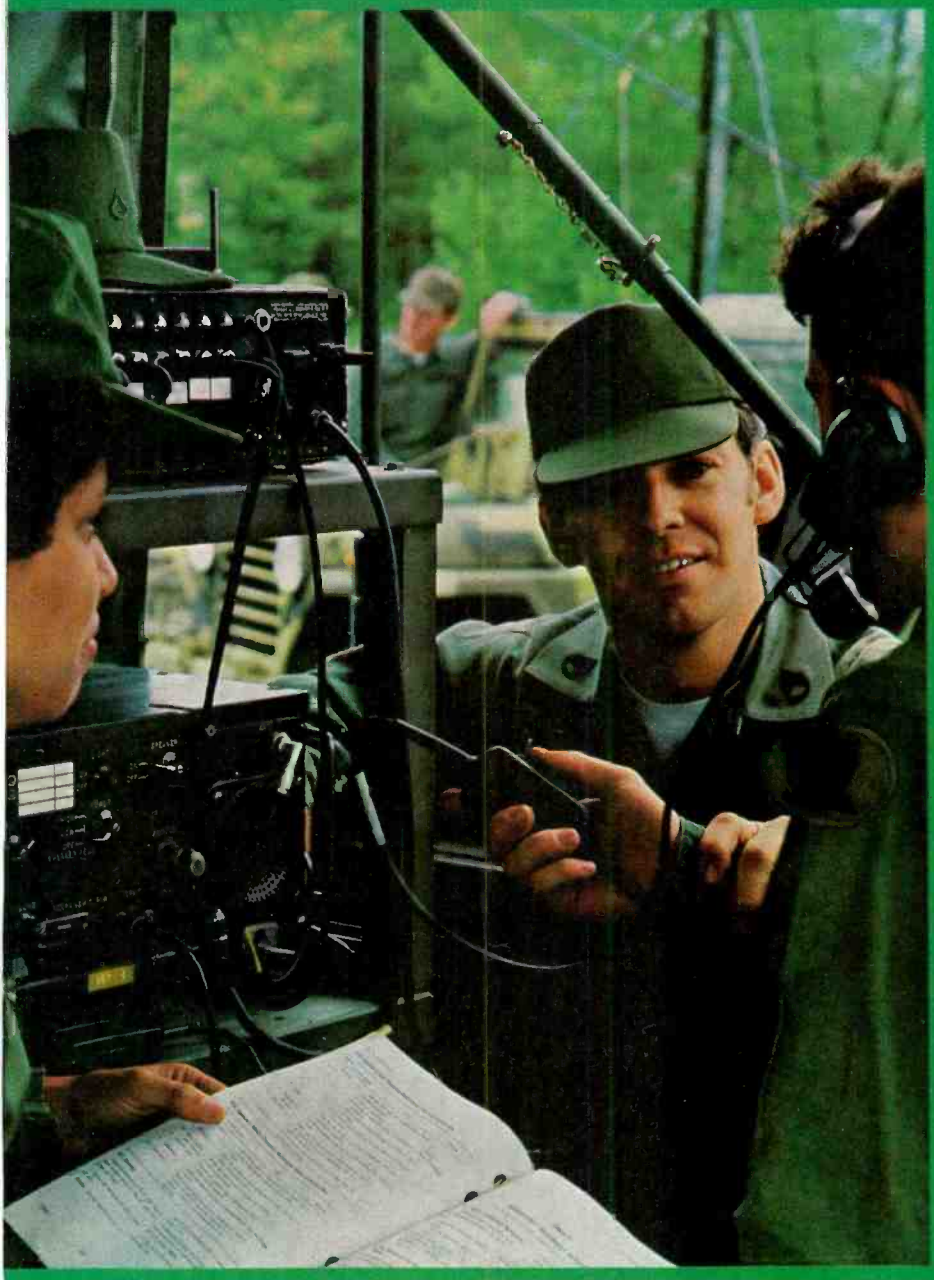

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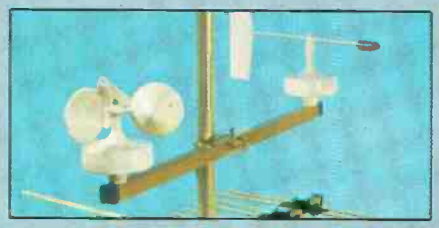

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Popular Electronics
MAY 1980

by George Meyerle

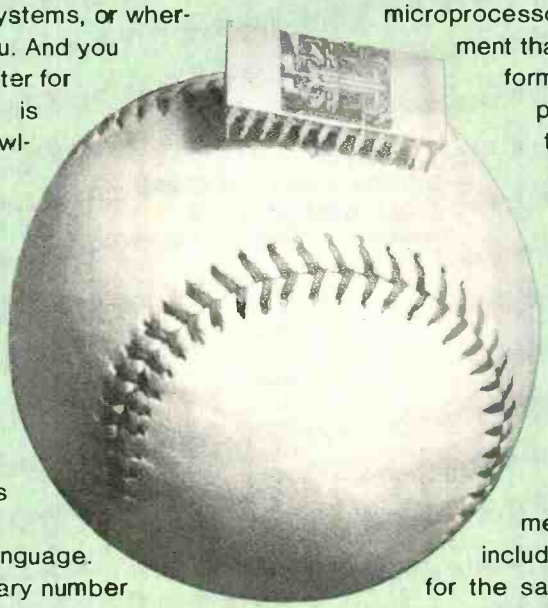
Part 1 of a series devoted to the use of inexpensive microprocessors in custom applications

Microprocessor Applications for the 1980's...

It's a Whole New Ballgame!

THE MICROPROCESSOR (central processing unit or CPU), a powerful and versatile integrated circuit, was born only in the last decade. We have witnessed its startling price decline and reveled in the result—modestly priced computers.

With $10 microprocessors available now, it's clear that the devices can be used economically for *non-computer* purposes—electronic games, telephone dialers, photographic timers, robots, "smart" thermostats, sophisticated security systems, or wherever your imagination leads you. And you need not tie up a $1000 computer for these applications. All that is required is a reasonable knowledge of microprocessors, which will also give you a better understanding of computer hardware and software.



To use a microprocessor for any of a host of applications, you need only become familiar with:

- The way the processor functions and relates to its inputs and outputs.
- The processor's program language.
- The fundamentals of the binary number system.

The foregoing doesn't require much more effort than learning about 100 words or so of a foreign language and some simple grammar. Mastering this, you can use inexpensive microprocessors where discrete parts would be awkward at best and often prohibitively costly and bulky.

Clearly, using microprocessors in the 1980's will be a whole new ballgame for electronics enthusiasts. To be certain that readers of POPULAR ELECTRONICS will be able to keep up with what we plan to present to you as time unfolds, we're launching this first-in-a-series microprocessor training course for the new decade.

What Is a Microprocessor? In its simplest terms, a microprocessor IC can be considered an element that can read data from inputs, perform computations, and control outputs. What makes it special is that it can be *programmed*. That is, it can be made to perform its various functions in any desired sequence. This flexibility is the key characteristic that lets a microprocessor and external circuitry perform such a wide variety of electronic tasks.

A microprocessor-based system is shown in Fig. 1. Note that there are four main elements. These elements can be included in the microprocessor IC, but for the sake of simplicity we will assume that they are all separate components. We will deal with the microprocessor itself separately.

The microprocessor is connected to all of the other components via the data bus by which information is passed back and forth. Control signals from the microprocessor along with the memory address signals determine which elements communicate with

the processor at any one time.

The block labelled Program is the storage area for the sequential instructions to be executed by the microprocessor. On reset or power on, the microprocessor will automatically obtain the first instruction from this memory via the data bus. After executing the first instruction it will signal for the next instruction, etc. To generate this series of instructions, better known as the program, is called "programming."

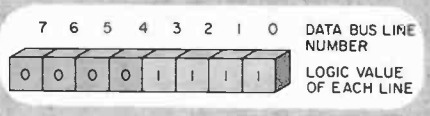
The input port section is the communication link between the microprocessor and data from keyboards, sensor switches, or the like. An input port usually can signal the microprocessor via the control bus when data is available. Output ports are used to transfer data from the microprocessor or memory components to output devices.

As an example, let's consider this system to be the controller for a simple robot and follow some theoretical steps which might occur in its operation. On reset or power on, the processor will signal the program memory to put the first instruction on the data bus. The processor reads and executes that instruction. Let's assume that the instruction tells the microprocessor to read the contents of the input port and store that data in one of its internal registers. The processor now requests the next instruction, which could be to have the microprocessor test the data from the input port. Subsequent instructions, called on the basis of the data analysis, would have the microprocessor issue to the output port data that would cause the robot to take a specific action.

While the robot is performing its mission, the processor will request its next instruction, which might be to reread the input port that monitors the progress of the robot. Each reading of the input port would similarly be tested, with the microprocessor issuing commands to control the course of action. This general system could just as easily operate as a telephone dialer or other product.

Signal Lines. Before we tackle the microprocessor functions, let's review the types of signals you might find on the signal lines. These lines carry voltages that represent binary numbers. The microprocessor, the I/O ports, and memory also respond only to these electrically coded binary numbers. It would be a great asset, therefore, to have an understanding of binary numbers and their decimal and hexadecimal (base 16) equivalents.

In an 8-bit microprocessor, the data bus will consist of 8 lines. The status of each of these lines can either be a logic 1 or a logic 0, each represented by one of a pair of voltage levels (high and low, positive and negative, etc.). If the microprocessor is reading from the data bus, and lines 0, 1, 2, and 3 are logic 1, and lines 4, 5, 6, and 7 are at logic 0, you can write that input as 00001111 as shown.



Writing long lists of these inputs in binary form would be very tedious and cumbersome. It is convenient to convert this binary representation of the 8 bits into a hexidecimal form. Thus, 00001111 can be represented by 0F (hex). Writing a 16-bit address in binary will convince you of the value of binary to hexidecimal conversion. This conversion is listed in Table I.

We cannot, however, completely forget about binary representation of these numbers because in that form they will allow easy identification of which switch is to be turned on for a given input or which light or motor will go on as a result of particular outputs. For example, if we are at an output port capable of driving low-voltage lamps and we want a certain sequence of these lamps to light at any one time, we must remember that the lamp will go on only when there is a logic 1 appearing on the data line at the output port. It will be helpful to remember that binary digit, 0 or 1, is referred to as a bit. This group of eight bits is called a byte. A 16-bit address is thus made up of two bytes. Four bits (half a byte) are sometimes referred to as a nibble.

TABLE I—DECIMAL—BINARY—HEXADECIMAL EQUIVALENTS

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

The RCA 1802. In this article we will discuss the RCA 1802. In subsequent articles, other processors will be described. Although microprocessors vary greatly in terms of their capabilities and specific language or instruction set, they are similar in many functions. Some are faster, more input/output compatible, easier to program, or more suitable for data processing, etc. But if you can understand the basic workings of the 1802 and its instruction set, evaluating any microprocessor specification sheet will be easier. (The complete 1802 specification sheet and instruction summary can be had at no charge by sending a self-addressed, stamped (30¢) envelope to Netronics R & D Limited, 333 Litchfield Road, New Milford, CT 06776.)

As our first example does not require all the elements of this processor, we will omit those that will not be used. The processor elements we will need are:

SCRATCH-PAD REGISTERS: There are 16 scratch-pad registers, each of which holds 16 bits. They are used to hold intermediate results. As the data bus can handle only 8 bits at a time, these registers are loaded and unloaded 8 bits at a time—the high-order byte in one operation, the low-order byte in another.

D-REGISTER: The D or Data register is used as an input and output to the ALU register (Arithmetic Logic Unit). Data is transferred to the D register, tested or modified by the ALU register and then returned to the data bus. The DF register is a flag used in arithmetic operations to determine if a carry or borrow occurred.

Q: This is a single-bit output line which can be set or reset by a program instruction. It is often used as an output. For example, it can turn a light on or off.

INPUT FLAGS: The 1802 has four input flags that are tested for their logic level by instructions.

Figure 2 shows a practical hook-up of an 1802 microprocessor and a simple array of peripheral equipment. Control inputs EF1,2,3, and 4 sense when any of the four pushbuttons is closed. The Q output is coupled to transistor *Q1* that, in turn, drives a solenoid. Instructions, called for from ROM via the 8-line address bus, are delivered via the 8-line data bus. This arrangement is sufficient to solve our example problem.

The Problem. For our example application, we have selected a solenoid-operated lock that will open only when four pushbutton switches are operated in the proper sequence. If any button is pressed out of sequence, the controller ignores all inputs for a period of one minute. After that time, it will respond only to the entire combination in correct sequence. To further forestall attempts to solve the combination, each button must be released before the system will register that the next one has been pushed. Finally, when the lock does open, it will remain in that condition for only five seconds.

The Instruction Set. The 91 instructions recognized by the 1802 fall into nine categories. In this introductory article, however, we will need only four. These are the Control, Short Branch, Memory Reference and Register Operations subsets. Each instruction has two identifications—one called a *mnemonic* (memory aid for humans), the other called an *op code* (the digital representation required by the processor). The mnemonic is closely allied to the specified instruction, and in many cases is an abbreviation. This is exemplified by BR for BRanch and REQ for RESET Q.

The mnemonic REQ corresponds to the binary op code 0111 1010, which can, for convenience, be written 7A (hex). Eight-bit binary numbers are often written as two groups of four (nibbles). Each nibble can be converted into a single hex digit. Binary numbers are the *only* ones the processor "understands." Instructions and binary data written in binary form or the hex equivalent are said to be in "machine language." Data is sometimes entered into a processor via a hex keypad that automatically produces a binary output.

Control Instructions. As the category name implies, these instructions are used where some general control over processor operations is required. We will use three of the 10 instructions in this subset. For each, we give the mnemonic, op code, name, and description.

NOP-C4-No Operation. This instruction performs no processor operations. It causes the processor to remain idle for three machine cycles, then fetch the next instruction. It is used mainly in timing applications to generate a delay.

REQ-7A-Reset Q. This instruction causes the processor's Q line to assume a low state (0 volt).

SEQ-7B-Set Q. This instruction causes the Q line to assume the high state (+5 volts).

Branch Instructions. Normally, a processor executes instructions in the order in which they are stored in memory—the one at the lowest-order memory location first, then the next, etc. A branch causes the processor to depart from the sequence, jump to another part of the memory, and execute one or more of the instructions stored there.

Branches are often (but not necessarily) conditional, taking place only when a defined condition arises. They require two bytes of data. The first is the op code for the branch instruction and the second is the address to which the processor will branch. For reasons of its own internal organization, the 1802 has "long" and "short" branch instructions. We will use 10 of the short ones.

BR-30__-Short Branch. Branch to the memory location specified by the byte (__) following the 30 op code.

B1-34__-Short Branch if EF1=1. If the EF1 line has a logic value of 1, the program will branch to the memory location that follows the op code. If EF1 is not 1, the processor goes to the next instruction in sequence.

B2-35__, B3-36__ and B4-37__ perform the same action on the EF2, EF3 and EF4 lines respectively.

BNZ-3A__-Short Branch if D not 0. If the D register contains other than zero, the program will branch to the specified memory location. If it contains zero, the program advances to the next instruction in sequence.

BN1-3C__-Short Branch if EF1=0. If the EF1 input line is a logic zero, the program will branch to the specified memory location. If the EF1 line is 1, the program proceeds to the next instruction in sequence.

BN2-3D__, BN3-3E__, and BN4-3F__ are used similarly to test the EF2, EF3 and EF4 lines, respectively.

Memory Reference. These instructions allow the user to load data into the temporary storage registers in the processor. We use only one of the seven provided.

LDI-F8__-Load Immediate. This instruction places the "__" data, following the F8 op code, into the D register of the processor. If the instruction were F8 55, the processor would place 55 (01010101) in the D register.

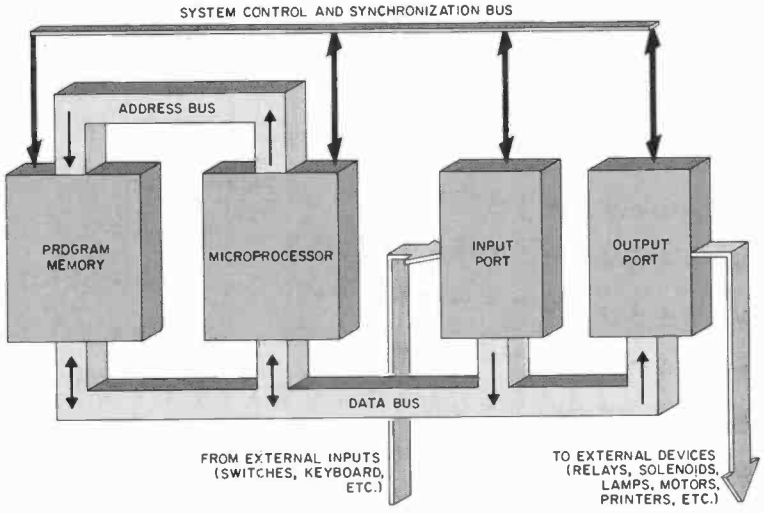


Fig. 1. Block diagram of a microprocessor-based system.

Register Operations. These instructions allow operations to be performed on the data in any of the 16 temporary storage registers of the 1802. These instructions are formed from a hex digit followed by a number to identify the register. We will use four of the available seven instructions.

PLO-AN-Put Low Reg N. Places the data byte currently in the D register into the low-order register specified by N.

PHI-BN-Put High Reg N. Places the data byte currently in the D register into the high-order register specified by N.

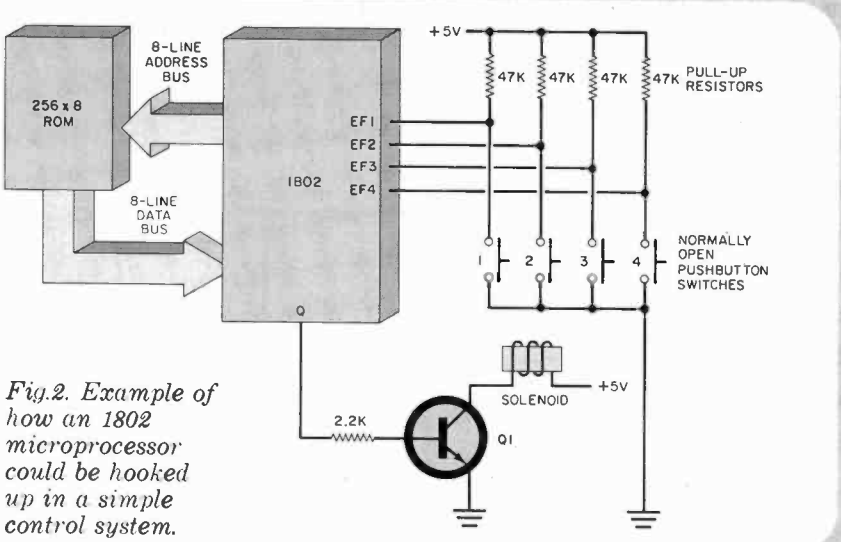


Fig.2. Example of how an 1802 microprocessor could be hooked up in a simple control system.

DEC-2N-Decrement Reg N. Decrement (reduce by 1) the digital value stored in the register specified by N.

GHI-9N-Get High Reg N. Places the data currently in the high-order register designated by N into the D register.

Programming. The example we will use was previously described. However, that description is in human terms that make no sense to the processor. Therefore the problem has to be restated in language that the processor can decode. The restatement will constitute a program.

To create a program, it is convenient to start with a diagram or flowchart that covers all the steps that need be taken by the processor to fulfill the task. The analysis of the task is necessarily very detailed, because any step omitted or misstated, no matter how minor, can cause the program to malfunction.

Creating the Flowchart. As shown in Fig. 3, begin by writing the word START in the center at the top of the page. Since this will also be a label and referred to in the program, write this word on the same line in the LABEL column. Referring to the hardware diagram in Fig. 2, we can see that when the flow starts, we want the solenoid to be de-activated to keep the door locked. Since this occurs when the Q line is low, write RESET Q=0 in a small box directly under START. A line, signifying flow direction, joins the two boxes. The four pushbutton switches must be operated in a 3-4-2-1 sequence, and if any switch is depressed out of sequence, a one-minute time delay will be invoked, after which the flow will proceed directly back to the START. We have also decided that after the correct pushbutton sequence has been entered, the solenoid will be activated for only five seconds.

At this point, some decisions regarding switch condition must be made. A decision box is diamond-shaped with the flow entering the upper corner and either of the three remaining corners used for the YES or NO answers. The first decision, labelled "1st Test," determines if any of the wrong switches (1, 2 or 4) has been closed. If the answer is YES, the flow then proceeds to the one-minute delay. At the conclusion of the delay period, the flow returns back to the START, keeping the solenoid de-activated. If the answer is NO (neither switch 1, 2 or 4 has been operated), the next decision determines if switch 3 (the correct one) has been depressed. If the answer is NO, this means that *no* switches were operated, so the flow goes back to the start of the 1st Test.

As long as *no* switches are touched, the flow "loops" around the 1st Test element, waiting for some switch activity. If switch 3 was depressed, the answer to the second decision box is YES, forcing the flow to proceed to the 1st Release that checks whether switch 3 has been released (opened). If switch 3 has not been released, the flow "loops" around this decision box until switch 3 is released.

The next nine decision boxes, down to 4th Release, ask similar questions of switches 4, 2 and 1 (the correct sequence). If during these queries, a wrong switch is depressed, the YES answer to the decision sends the flow to the 1-minute delay and back to the START. Note that in the flowchart, each pair of switch operation decisions form a labelled Test, and each Release is suitably identified.

Once the four pushbuttons have been properly depressed and released, we want the solenoid activated so that the door will be unlocked. Since the solenoid is activated when the Q line is high, the next block (labelled UNLOCK) is entitled SET Q=1. When the Q line goes high in response to this block, two simultaneous events should occur: the solenoid is activated, and a five-second delay is invoked. At the conclusion of the five-second period, the flow returns to START and de-activates the solenoid. It now scans the 1st Test, awaiting further switch action.

Creating the Program. The program that enables the 1802 to implement the flowchart is shown in Table II. The extreme left column, marked LABEL, defines the various parts of the program corresponding to the flowchart. They are very useful because the various branch addresses are usually filled in after the program has been structured. In the second column, identified as PROGRAM ADDRESS, are the memory addresses where each element of the program will reside. These too can be filled in after the program has been written. The reason for this is that a particular line in the program may consist of two or more bytes, and each byte must have an address. Programming convention is that the program address shown in this column is

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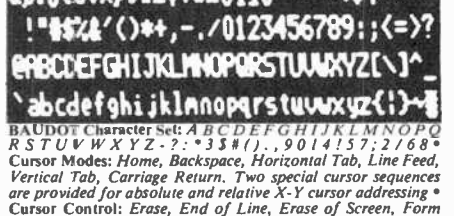

BAUDOT Character Set: *A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ? : • 3 $ # ( ) . , 9 0 1 4 ! 5 7 ; 2 / 6 8 •*

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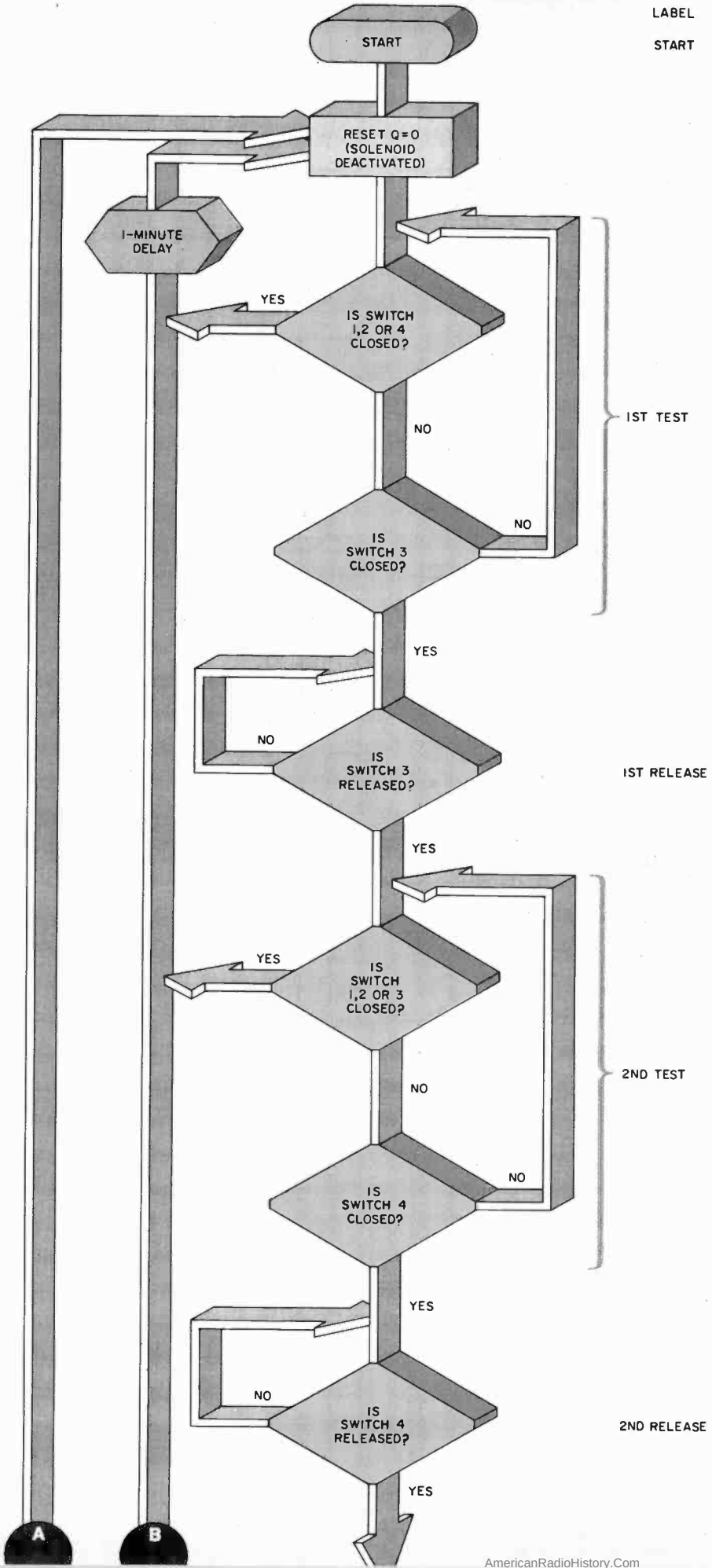


the beginning address of that set of instructions.

The third column, OP CODE, represents the hexadecimal machine code for the instruction plus any extra byte required to modfy the instruction. In most cases, the extra byte is a Branch address and is filled in after the program has been completed. The fourth column, MNEMONIC, contains the word-like version of the op code. This column, once you get used to it, makes reading a program considerably easier.

The column marked COMMENTS is strictly for the human being. At some later date, when you return to the program, reading this column will tell you in detail what is supposed to happen at each step. Trying to figure out what the program does without referring to the comments or the flowchart is difficult.

When first powered up, the processor fetches its first instruction at memory address 0000.

The label "Start" should use program address 0000. Since we have decided that, at the beginning, the solenoid should be de-activated, we use the mnemonic instruction REQ (reset Q) having the op code of 7A on the start line. The comments column then explains this action and the result.

The next step is a decision. In the flowchart, the three wrong switches were tested in one box. In the program, we force the processor to test each switch in turn for an open or closed condition. Like the flowchart, we label this 1st Test, and use the next memory address 0001. Switch 1 is tested by the mnemonic B1 having op code 34. This op code checks the status of switch 1 (actually the EF line associated with it). It is a two-part op code that requires a branch address if the switch was depressed. Since we don't know the address of the 1-minute time delay at this time, we temporarily leave the required second byte of the op code. blank. Therefore, this line of the op code column is 34__.

Since two bytes were used at address 0001, the next memory address is 0003. Here the program op code queries the status of switch 2 via op code

Fig. 3. Flowchart, at left and on opposite page, gives steps the microprocessor must perform.

35 (B2). Thus program address 0003 contains 35__. Keep in mind that, as each line is created, sufficient detail must be inserted in the COMMENTS column to explain what is going on.

Since two bytes were used as address 0003, the next address is 0005. Here, op code 37 (B4) questions the status of switch 4. Since this is still the wrong switch, we must branch to the 1-minute delay. Thus, address 0005 contains 37__.

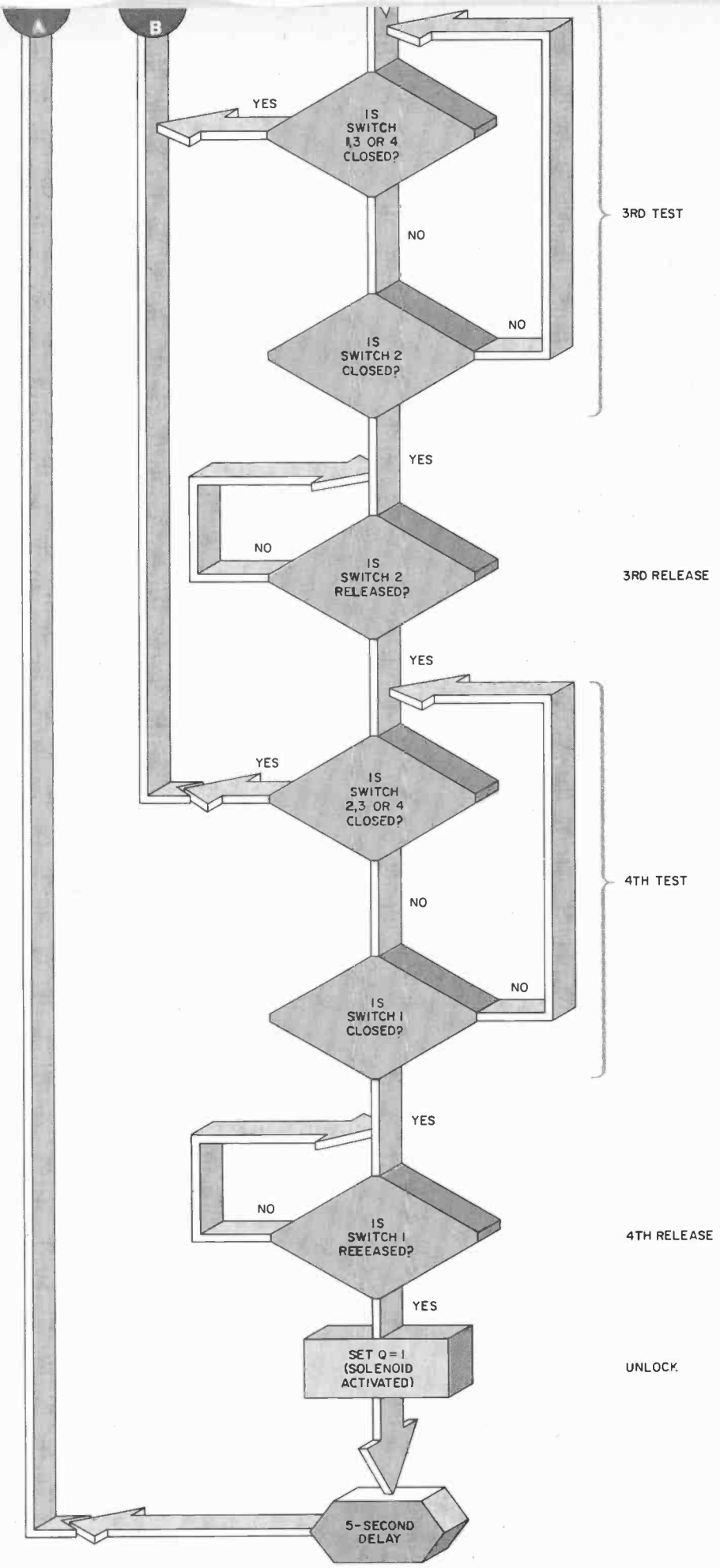
Now we are left with only one switch (switch 3, the correct one). Address 0007 checks this switch via op code 36. If this switch was depressed, the program branches to the 1st Release, whose address is as yet unknown. Thus, address 0007 contains 36__.

Now, what happens if *no* switches were touched? This is the purpose of program address 0009. If the flow gets to this point without branching, address 0009 forces the program to return to the 1st Test, which we now know is located at program address 0001. Now you see the value of the label. Since we are working with only one page of memory (256 bytes), the leading two zeroes of the address are not required, so address 0009 contains BR (branch immediately) to program address 01. Thus, if during the 1st Test no switches were operated, the program "loops" around this section, awaiting switch action.

Since we have determined that switch 3 was depressed at address 0007, we now perform the 1st Release at address 000B. The 3E instruction at address 000B says that, if the switch was released, branch the program to 0F, the start of the 2nd Test. If the switch is still depressed, the instructions at 000D force the program to return (30, Branch Immediate) back to memory address 0B, and await switch release.

The 2nd Test, switch 2 Release, 3rd Test, switch 3 Release, 4th Test and switch 4 Release, operate just as did the 1st Test and switch 1 Release. The reader can follow the program flow to make sure that the four switches must be depressed in proper sequence before the program arrives at the Unlock block at program address 0039.

The Unlock statement is one-byte instruction 7B that causes the 1802 to set its Q-output line to the high state. Since the solenoid is connected to this



output, when this instruction is carried out by the processor, the solenoid becomes activated and allows the door to be opened.

As soon as the op code at program address 0039 is executed, the flow passes to the next block having the label 5-Sec. Delay located at program address 003A.

To create a delay, we can take advantage of the fact that it takes time for the processor to execute an instruction. Therefore, we can give it a series of "busy work" instructions to let it waste the required time. Such maneuvers should of course produce no other external effects. In this case, data is passed back and forth between internal registers of the 1802 in a particular sequence. It is not really important which registers are used, but the instruction set allows us to "play" with the D register more easily than with some others.

The delay starts at program address 003A by loading FF (1111 1111) into the D register. The next step uses instruction A1 (address 003C) to load the FF from the D register into the low-order half of register-1. Then, according to address 003D, the FF is also loaded into high-order half register-1 using the B1 instruction. Next, the program contains four NOPs (No Operations), instructions during which the processor does absolutely nothing but waste clock cycles. The 1802 uses the op code C4 for NOP, each wastes 10-11 microseconds (using a 1.71-MHz timing reference oscillator or "clock"). The four instructions at address 003E "pad" the time delay so that the loop will come to five seconds.

As we now know, register-1 contains 1111 1111 (FF). Address 0042 uses op code 21 to decrement (reduce by one) the contents of register-1. After the first cycle, low-order register-1 contains 1111 1110 (FE). Address 0043 loads the high-order byte of register-1 into the D register using instruction 91. We know that the D register will contain 1111 1111 (FF). The 3A instruction at address 0044 checks the contents of the D register. If the D register is not all zeros (and we know it isn't), the program branches back to address 3E and continues decrementing the contents of register-1, moving the high-order byte into the D register, and checking the contents of the D register for all zeros, etc.

After 65,280 passes through the "loop," which should total five seconds, the contents of the D register will be 0000 0000. When this occurs, the program moves on to address 0046 and finds a BR (30) that goes back to the Start at address 00. At this point, the Q line is forced low and the solenoid is de-activated. The program then pro-

TABLE II—PROGRAM

LABEL	PROGRAM ADDRESS	OP CODE	MNEMONIC	COMMENTS
Start	0000	7A	REQ	Make Q output low (door locked)
1st Test	0001	34 48	B1	If switch #1 depressed, branch to 1-min. delay, else next instruction
	0003	35 48	B2	If switch #2 depressed, branch to 1-min. delay, else next instruction
	0005	37 48	B4	If switch #4 depressed, branch to 1-min. delay, else next instruction
	0007	36 0B	B3	If switch #3 depressed, branch to #1 Release, else next instruction
	0009	30 01	BR	If no switches depressed, branch to 1st Test.
1st Release	000B	3E 0F	BN3	If switch released, branch to 2nd Test, else next instruction
	000D	30 0B	BR	If switch not released, branch to 1st Release
2nd Test	000F	34 48	B1	If switch #1 depressed, branch to 1-min. delay, else next instruction
	0011	35 48	B2	If switch #2 depressed, branch to 1-min. delay, else next instruction
	0013	36 48	B3	If switch #3 depressed, branch to 1-min. delay, else next instruction
	0015	37 19	B4	switch #4 depressed, branch to #2 Release, else next instruction
	0017	30 0F	BR	No switches depressed, branch to 2nd Test
2nd Release	0019	3F 1D	BN4	If switch released, branch to 3rd Test, else next instruction
	001B	30 19	BR	If switch not released, branch to #2 Release
3rd Test	001D	34 48	B1	If switch #1 depressed, branch to 1-min. delay, else next instruction
	001F	36 48	B3	If switch #3 depressed, branch to 1-min. delay, else next instruction
	0021	37 48	B4	If switch #4 depressed, branch to 1-min. delay, else next instruction
	0023	35 27	B2	If switch #2 depressed, branch to #3 Release, else next instruction
	0025	30 1D	BR	If no switches depressed, branch to 3rd Test
3rd Release	0027	3D 2B	BN2	If switch released, branch to 4th Test, else next instruction
	0029	30 27	BR	If switch not released, branch to #3 Release
4th Test	002B	35 48	B2	If switch #2 depressed, branch to 1-min. delay, else next instruction
	002D	36 48	B3	If switch #3 depressed, branch to 1-min. delay, else next instruction
	002F	37 48	B4	If switch #4 depressed, branch to 1-min. delay, else next instruction
	0031	34 35	B1	If switch #1 depressed, branch to #4 Release, else next instruction
	0033	30 2B	BR	If no switches depressed, branch to 4th Test
4th Release	0035	3C 39	BN1	If switch released, branch to Unlock, else next instruction
	0037	30 35	BR	If switch not released, branch to #4 Release

ceeds to the 1st Test, and loops around it, awaiting further switch action.

The one-minute delay invoked when a wrong switch is depressed starts at program address 0048. It works by running through the 5-Sec. Delay 12 times under control of another outside loop. This action requires 5 × 12 or 60 seconds.

LABEL	PROGRAM ADDRESS	OP CODE	MNEMONIC	COMMENTS
Unlock	0039	7B	SEQ	Set Q output high (unlock door), go to next instruction
5-Sec. Delay	003A	F8 FF	LDI	Load FF (1111 1111) into the D register
	003C	A1	PLO	Loads D register into low-order half of register-1
	003D	B1	PHI	Loads D register into high-order half of register-1.
Timer	003E	C4 C4	NOP	Waste time to increase delay
	0040	C4 C4	NOP	
	0042	21	DEC	Decrement (reduce) the contents of register-1 by 1
	0043	91	GHI	Load the high-order byte of register-1 into the D register
	0044	3A 3E	BNZ	If the content of the D register is not zero, branch to Timer and continue decrementing register-1 and testing the D register. When the D register contains zero, go to next instruction.
	0046	30 00	BR	End of 5-sec. time delay, branch to Start.
1-Min. Delay	0048	F8 0C	LD1	Load the D register with 0C (0000 1100)
	004A	A2	PLO	Load 0C from the D register into the low-order half of register-2
Loop 1	004B	F8 FF	LDI	Load the D register with FF (1111 1111)
	004D	A1	PLO	Load FF from the D register into the low-order half of register-1
	004E	B1	PHI	Load FF from the D register into the high-order half of register-1
Timer Start	004F	C4 C4	NOP	Waste time to pad out the delay
	0051	C4 C4		
	0053	21	DEC	Decrement the contents of register-1 by 1
	0054	91	PHI	Load the high-order byte of register-1 into the D register
	0055	3A 4F	BNZ	If the content of the D register is not zero, branch to Timer Start. Continue decrementing register-1 and testing the D register. When the D register contains zero, next instruction
Loop 2	0057	22	DEC	Decrement the contents of register-2 by 1. (Register-2 contains 1100 from address 004A)
	0058	82	PLO	Load the contents of register-2 into the D register
	0059	3A 4B	BNZ	If the content of the D register is not zero, branch to Loop 1. Continue decrementing, then testing the D register. When the D register contains zero, next instruction
	005B	30 00	BR	End of 1-min. delay, branch to Start. This sets the Q output low to deactivate the solenoid and lock the door. The program then awaits further switch operations.

The 12-times loop starts at address 0048 by loading the D register (F8) with 0C (0000 1100) which is decimal 12. Address 004A loads this byte into register-2 (A2).

The program from address 004B to 0056 is the five-second delay as previously described. In this case, when the D register contains all zeros, the program drops to address 0057 that decrements the contents of register-2 by one (it now contains 1011 or decimal 11).

The next two instructions (address 0058 and 0059) are the remainder of the "outside" loop that decrements register-2 each time the five-second delay is executed. After the twelfth pass, register-2 will contain zero. When this occurs, the program advances to address 005B, where it is told to branch (30) back to the Start (00).

Since we now know the address of the 1-Minute Delay (0048), we can go back into program and substitute 48 for each of the blanks (depicted as __) that were used where the program had to branch to the one-minute delay.

Modifications. The basic program is easily modified even by an inexperienced programmer. For example, at each switch Release segment (identified by its program label), you might as an exercise write a small program that requires, say, that the switch be released within two seconds, otherwise the program branches to the 1-minute time delay. Such a new set of instructions can reside above program address 005C (the end of the present program) and can be invoked (called) from the switch release segment. Some branch statements can be used. If you require a longer combination, then enlarge the program accordingly. Note that you can change the combination easily by modifying the pertinent instruction in each switch Test location.

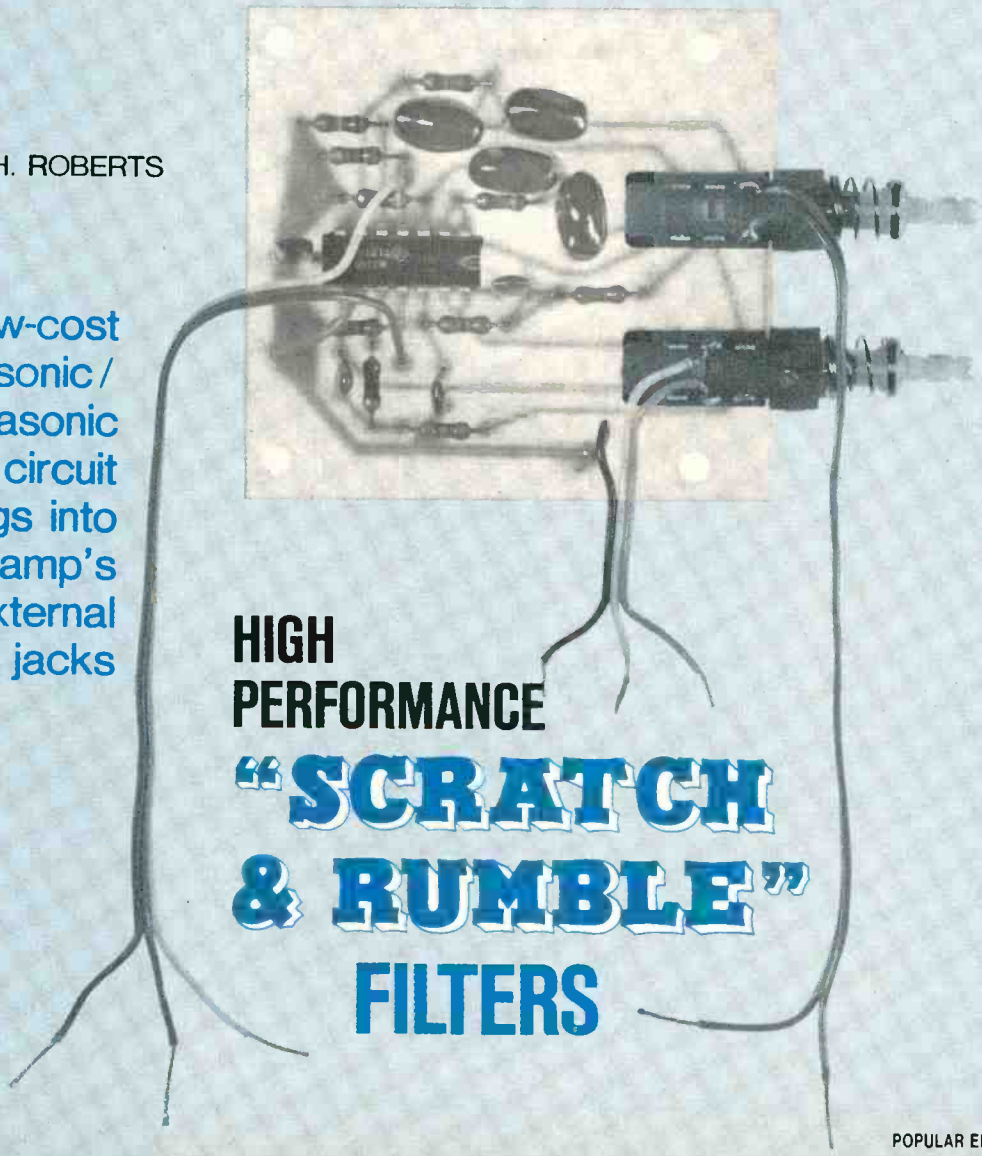
In Conclusion. We have seen how powerful an element a microprocessor can be. To realize even the simple example presented above in single-function logic gates would be impractical. Implementing the actions we wanted from the microprocessor was a task of but modest difficulty by comparison.

Succeeding articles in this series will extend the uses of microprocessors further. We will also discuss the hardware needed in more detail. ◇

BY JOHN H. ROBERTS

Low-cost ultrasonic/infrasonic circuit plugs into preamp's external jacks

HIGH PERFORMANCE "SCRATCH & RUMBLE" FILTERS



IN THEORY, "scratch" and "rumble" filters are useful additions to an audio system. In practice, however, the filters built into many components have either inappropriate cutoff frequencies or too gradual slopes (or both) to adequately perform their intended functions. If you're dissatisfied with those contained in your preamplifier, integrated amplifier, or receiver, try the quartet of high-performance active filters presented here.

These filters are designed around a quad BIFET operational amplifier IC, and can be inserted into or removed from the signal chain at the push of a switch. The project can be built at low cost, and its compact size allows it to be tucked into an existing audio component. Also, its modest power requirements can easily be satisfied by the host component.

About the Filters. One of the simplest active filter designs is based on the voltage-controlled voltage source configuration. This circuit is commonly known as the Sallen/Key design because it was described in a paper by R.P. Sallen and E.L. Key that appeared in the March 1955 issue of the *IRE Transactions on Circuit Theory*. Shown schematically in Fig. 1 are second-order, high-pass (A) and low-pass (B) active filters employing operational amplifiers. Although op amps as we know them were not available in 1955, Sallen and Key's paper is applicable to filters employing more recently developed active devices.

These filters have unity gain within their passbands, a gain that is independent of resistor values. They have second-order responses, which exhibit an attenuation of 3 dB at the cutoff frequency and an ultimate slope of 12 dB/octave. For audio applications, the most useful VCVS filter is one whose response is "maximally flat," whose Q is 0.707. This is true of the filters described in this article.

The cutoff (−3-dB) frequency of the high- or low-pass filter can be calculated from $f_c = 1/[2\pi(R1R2C1C2)^{1/2}]$. In the high-pass filter of Fig. 1A, the value of $C1$ is chosen to equal that of $C2$ and the resistance of $R1$ is chosen to be half that of $R2$. This simplifies the equation for the cutoff frequency so that it takes the form: $f_c = 1/2.828\pi C1R1$. Similarly, in the low-pass filter of Fig. 1B, the resistance of $R1$ is chosen to equal that of $R2$ and the capacitance of $C2$ is chosen to be half that of $C1$. The simplified equation for the low-pass cutoff frequency is: $f_c = 1/2.828\pi R2C2$. Note that the low-pass filter resembles the high-pass design except that the positions of the resistors and capacitors have been interchanged.

If optimal filter performance is to be achieved, the passive components used should be of high quality. For example, the resistors should be carbon- or metal-film components and the capacitors

should have mica, polystyrene or Mylar dielectrics. The criteria for choosing the operational amplifier are those that make an op amp well suited for use as a voltage follower—high input impedance, low input current, and high speed. The author's choice is the Texas Instruments TL074CN, a quad BIFET op amp that satisfies these requirements handily.

The complete schematic of the project is shown in Fig. 2. In all, four filters appear in this diagram—a low-pass and a high-pass filter for each stereo channel. The component designations not shown in parentheses pertain to the left-channel circuit. Those component numbers given parenthetically pertain to the right-channel filters.

If both selector switches (*S1* and *S2*) are in their OUT positions, the filter outputs are left floating. Placing HIGH PASS selector switch *S1* in its IN position connects the outputs of the high-pass filters (*IC1A*, *IC1B* and their associated components) to the OUT positions of LOW PASS selector switch *S2* and to the inputs of the low-pass filters (*IC1C*, *IC1D* and their associated components).

If *S2* is in its IN position, signals pass through the low-pass filters before they appear at the project's output. Otherwise, they are routed to the output terminals without being high-pass filtered. This switching arrangement allows the connection of either filter alone, both together, or neither in the signal chain.

The circuit can be powered by either a bipolar or single-ended supply. Maximum voltages are ± 15 volts for a bipolar supply and +30 volts for a single-ended one. Current demand is approximately 10 mA. Components *C9*, *R9*, and *R10* are required only if a single-ended power supply is used. They generate an artificial "circuit ground" which is designated in Fig. 2 using the conventional chassis-ground symbol. Contrast this with the system signal ground appearing at the input and output terminals of the project. An earth-ground symbol signifies system signal ground to differentiate it from the artificial "circuit ground."

A single-ended supply is represented to the right of the passive components as a battery generating voltage V_{SUPPLY}. Traditionally, the chassis on which a positive, single-ended power supply is mounted becomes the negative return and is also used as the signal ground for the circuit powered by the supply. In the case of these active filters powered by a single-ended supply, the chassis can be used as the input and output signal ground (which will be tied to system ground), but the artificial ground generated by the passive components must be kept isolated from it. The artificial ground will be at a dc level equal to one half of the supply voltage, and the chassis (system) ground will act as the −V negative supply for the quad op amp.

If a bipolar supply is used, the artificial and system grounds should be tied together. Direct coupling can be employed between the stage preceeding the filters and the project input terminals as well as between the project output terminals and the input of the next stage in the signal chain. However, if the circuit is powered by a single-end supply, capacitive coupling should be used.

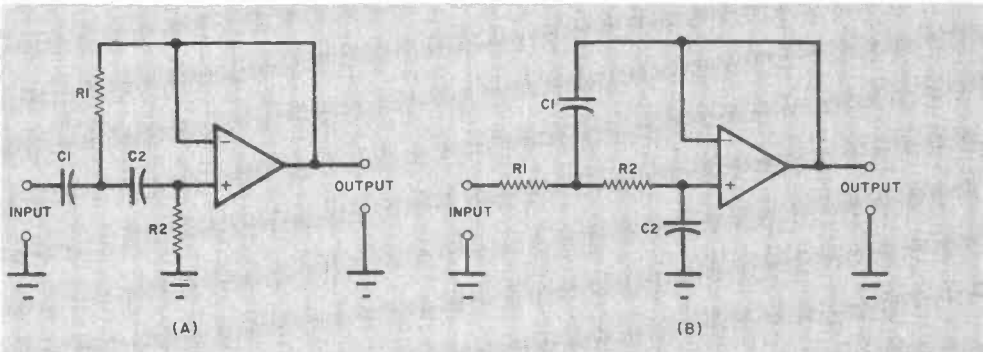


Fig. 1. Second-order high-pass (A) and low-pass (B) filters.

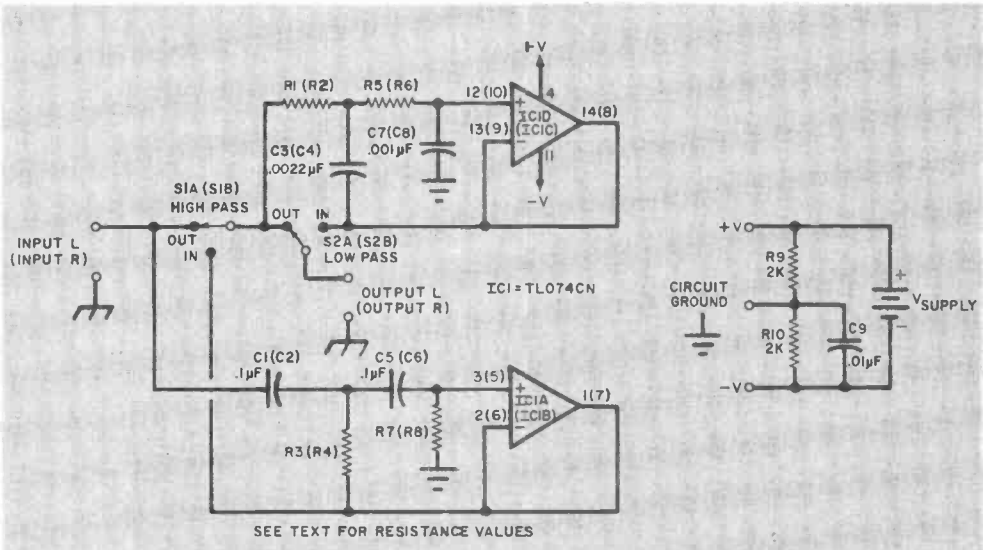


Fig. 2. Schematic diagram of the complete project.

PARTS LIST

C1,C2,C5,C6—0.1-μF 5% Mylar, mica or polystyrene
C3,C4—0.0022-μF 5% Mylar, mica or polystyrene
C7,C8—0.001-μF 5% Mylar, mica or polystyrene
C9*—0.01-μF Mylar, disc ceramic, mica or polystyrene
IC1—TL074CN quad BIFET op amp
The following are carbon-film, 1/4-watt, 5%-tolerance (or metal film, 1/4- or 1/8-watt, 1% tolerance) fixed resistors unless otherwise specified.
R1,R2,R5,R6—see text for value.
R3,R4—see text for value.
R7,R8—see text for value.
R9*,R10*—2000 ohms, 1/2-watt, 5% or 10% tolerance, carbon-composition or carbon film.
S1,S2—Dpdt switch
Misc.—Printed circuit or perforated board, IC socket or Molex Soldercons, suitable power supply and enclosure, hookup wire, shielded cable, circuit board standoffs, hardware, solder, etc.
* These components are required only if a single-ended power supply is used.

Note—The following are available from Phoenix Systems, 375 Springhill Road, Monroe, CT 06468: kit of parts including printed circuit board, IC, switches, and resistors and capacitors for two 20- or 50-Hz high-pass and two 13,000- or 19,000-Hz low-pass filters, No. P-91S for $10.00. Also available separately are: TL074CN quad BIFET op amp IC, No. P-91C, for $2.50; etched and drilled printed circuit board, No. P-91B, for $2.00; push-on/push-off dpdt switch, No. P-91SW, for $1.00 each. Connecticut residents, add 7% state sales tax. If order is less than $10.00, add $1.00 shipping and handling.

Construction. The project is relatively simple, so point-to-point, wiring, wrapped-wire, or printed-circuit assembly techniques can be used. Etching and drilling and parts placement guides for a suitable printed circuit board are shown in Fig. 3. If another assembly method is chosen, observe sound construction practices for circuits containing high gain-bandwidth devices. Keep leads short and run grounds carefully.

The use of Molex Soldercons or an IC socket is recommended. Be sure to orient the IC correctly and pay attention to polarities when making connections to the power supply. Use the minimum amount of heat and solder consistent with the formation of good connections.

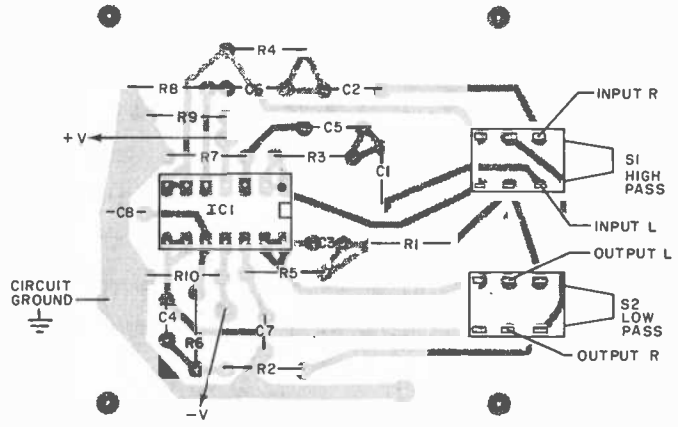
The circuit board has been laid out to accommodate pc-mount push/push switches. These switches are available from the source given at the end of the Parts List. If you want to employ another type of switch, simply interconnect the foil pads with the appropriate lugs of the remotely mounted switches with lengths of flexible hookup wire.

Mount the filter board either in the enclosure of a host audio component or in an enclosure specially selected for this purpose. The board should be installed in such a way that board-mounted switches (if used) are readily accessible. If the project is placed inside an existing audio component, the simplest way to satisfy the project's modest power requirements is to tap the host's supply. A high-voltage supply can be used to power the project by introducing zener voltage regulation.

You will note that the values of all of the *RC* components in the active filters have not been specified in the schematic or the Parts List. This has been done to allow you to choose the cutoff frequencies of the filters that you assemble. The design equations for the low- and high-pass filters were given earlier. In the high-pass design, use equal values of capacitance (0.1 μF) for *C1*, *C5*, *C2*, and *C6*. Select the resistance of *R2* so that it is double that of *R1*. The value of *R1* can be calculated using the high-pass design equation. In the low-pass filters, use equal values of resistance for *R1*, *R5*, *R2*, and *R6*. The capacitance of *C7* and *C8* should be half that of *C3* and *C4*. Recommended values are 0.0022 μF for *C3* and *C4* and 0.001 μF for *C7* and *C8*. Resistance values for any desired cutoff frequency can be calculated using the low-pass design data.

The most common application for the high-pass filter is to attenuate low-frequency turntable rumble. To be an effective rumble filter, the circuit should attenuate the low-frequency rumble without significantly altering the spectral power density of the program material. Most musical recordings contain little information in the bottom bass octave, so 50 Hz is an acceptable cutoff frequency. Component values that will produce a 50-Hz, −3-dB frequency are: *C1*, *C5*, *C2*, *C6*—0.1 μF; *R3*, *R4*—22,000 ohms; *R7*, *R8*—47,000 ohms. Those readers who want any deep bass present in their recordings to come through unattenuated will prefer a lower cutoff frequency. Component values that will result in a cutoff frequency of 20 Hz are: *C1*, *C5*, *C2*, *C6*—0.1 μF; *R3*, *R4*—56,000 ohms; *R7*, *R8*—110,000 ohms. For a cutoff frequency other than the two just given, calculate new resistance values.

Low-pass filters are frequently employed to attenuate FM hiss and disc surface noise. They are also useful to attenuate 19,000-Hz FM stereo subcarriers that can interfere with the taping of broadcasts off the air. To be an effective hiss or subcarrier filter, the circuit should attenuate high-frequency noise, etc., without the loss of program content at lower frequencies. Most musical program material contains little information in the extreme highs, so 13,000 Hz is an acceptable cutoff frequency. Component values that will produce this response are: *R1*, *R5*, *R2*, R6—8200 ohms; *C3*, *C4*—0.0022 μF; *C7*, *C8*—0.001 μF. For a higher cutoff frequency, say, 19,000 Hz, use the following component values: *R1*, *R5*, *R2*, *R6*—5600 ohms; *C3*, *C4*—0.0022 μF; *C7*, *C8*—0.001 μF. If you prefer a cutoff frequency other than the two just given, calculate new resistance values.



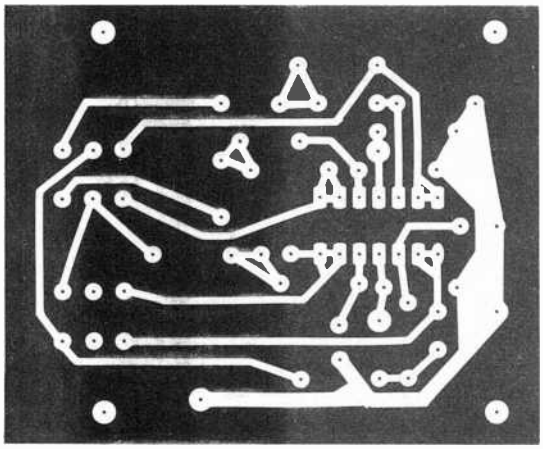


Fig. 3. Full-size etching and drilling guide for printed-circuit board is shown at left. Diagram for layout of components is above.

Installation and Use. The project can be introduced into the audio system at any point where signals are at line level. Two possibilities are at a tape monitor loop and between the preamp output and power amplifier input. It's good practice to insert a 51-ohm resistor between the "hot" output terminal of each channel's circuit and the inner conductor of the cable which carries signals to the input of the next stage. This can prevent oscillation due to the effects of cable or load capacitance.

In Conclusion. The active filters presented in this article offer a higher level of performance than those included in many audio components. A bit of experimentation will convince you how useful properly designed low- and high-pass audio filters really are. ◇

"Chess Challenger-10 Wins Microchess Tourney"
—Personal Computing Magazine
February, 1979

Genius Offspring

"Its successor, the new Chess Challenger "7", is infinitely more powerful."
—S. Samole
President, Fidelity Electronics

Chess Challenger-10 did more than win the Penrod Memorial Microchess Tournament, it literally trounced all opponents. Personal Computing Magazine, February, 1979, reports, *"Chess Challenger-10 emerged as the easy victor with ten wins, two draws and no losses."*

All Top Name Performers

There were no amateurs in the championship playoff. Every contender bore the brand of a well-known electronic chess game, and each was accompanied by its entourage of coaches, programmers, and engineers. After each contestant had played all of the opponents in round robin fashion, the brilliant Challenger-10, stood far ahead of its second place runner-up.

Nobody Knew

Unknown to the other companies, the undefeated tournament leader was being retired after the contest. Taking its place was a far more powerful chess computer, the Challenger "7". This new micro-computer had already beaten the official undefeated champ during a series of pre-tournament warm-up games at the factory. Its engineers explain that it is simply 14 months ahead in technology, in finer algorithm sophistication and in its superb performance.

Improve Your Game to Near Brilliant

Within its seven different levels of play, you can enjoy every degree of chess competition, from beginner to tournament skill. Its total flexibility lets you change games midstream or switch sides with the computer to see how it would handle your dilemna. You can add pieces to your side or take away the computer's Queen. It is a superb teacher!

Touch the PV key and the "7's" total recall memory will verify every piece position on the board. You can even set up hypothetical encounters to test its reaction at each level.

Fidelity's Challenger "7" is able to analyze over 3,024,000 board positions. It masterfully handles over one thousand book openings and will respond to any deviation. Academic openings as Sicilian, French, Ruy Lopez and Queen Gambit Declined, are just some of the challenges to keep you on your toes.

It Knows Every Rule in the Book

The Challenger "7" will permit you to castle or perform an En Passant capture or do so itself, if that is its best move. When your pawn has reached the eighth rank, it will be automatically raised to a Queen, unless you tell the computer to promote it to another piece. It will take on any player and sharpen his skills considerably...but it won't permit illegal moves.

Sound Signals

You just cannot believe the chess I.Q. of this phenomenal unit. The Challenger "7" has a beep audio feedback which sounds to acknowledge your move, and double beeps when the computer has made its response. At Level 1, its average response time is 5 seconds. At Tournament Level 7, the Challenger makes championship decisions in just 3 minutes.

Unbeatable in Price As Well As Play

Best of all, the Chess Challenger "7" is the most affordable electronic unit you can own. It is just $89.95 complete with Staunton designed pieces and UL approved 110V AC adaptor.

All pieces are magnetized, to stay where you place them on the permanent metal board. The set is mounted in a simulated wood-grained housing which measures 12⅛" x 8" x 1". Bright, one-half inch tall LED electronic digits, provide unmistakably clear readout. The unit is backed by a 90-day manufacturer's limited parts and labor warranty.

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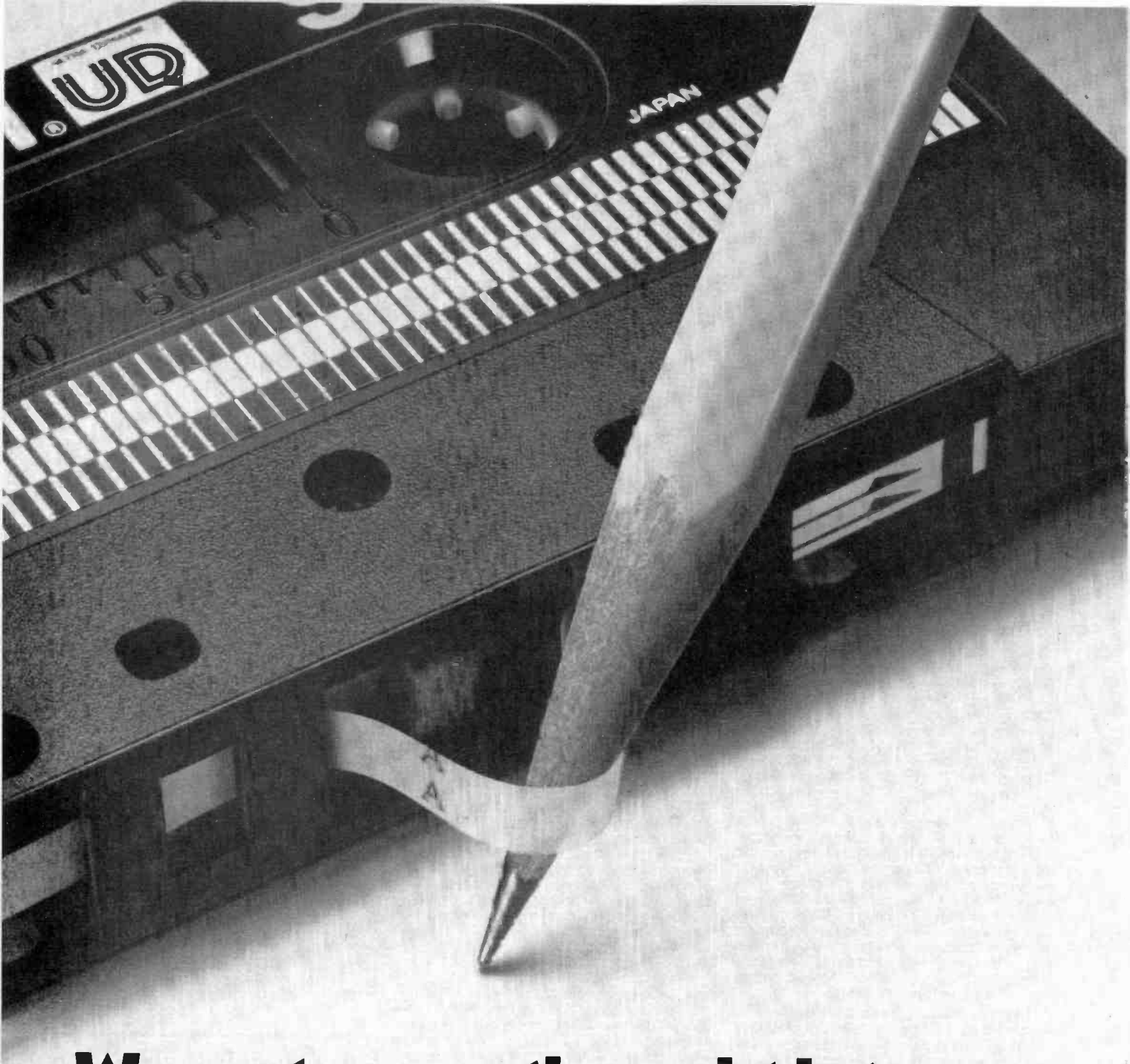
Final Results

Reprinted Courtesy of Personal Computing, February, 1979. P. 66. (Darker lines ours.)

	CONTESTANTS		OPPONENTS #1	2	3	4	5	6	7	8	9	Games Won	Games Drawn	Games Lost	FINAL SCORE	FINAL POSITION
1	MICRO-CHESS 1.0 (Heath H-8)	W			½	Ø	1	Ø	Ø	Ø			1	3	8	2½	7*
		B			½	½	Ø	Ø	Ø	Ø							
2	MICRO-CHESS 1.5 (TRS-80)	W	½		½	½	Ø	Ø	Ø				Ø	5	7	2½	6*
		B	½		Ø	Ø	Ø	½	Ø								
3	MICRO-CHESS 2.0 (PET)	W	½	1		1	Ø	Ø	½				3	4	5	5	4
		B	1	½		½	Ø	Ø	Ø								
4	CHESS CHALLENGER (3 Level)	W	1	1	½		Ø	½	½				2	5	5	4½	5
		B	Ø	½	Ø		Ø	Ø	½								
5	CHESS CHALLENGER (10 Level)	W	1	1	1	1		1	½				10	2	Ø	11	1
		B	1	1	1	1		1	½								
6	BORIS	W	1	½	1	1	Ø		1				7	2	3	8	3
		B	1	1	1	½	Ø		Ø								
7	SARGON I (TRS-80)	W	1	1	1	½	½	1					6	5	1	8½	2
		B	1	1	½	½	½	Ø									
8	ATARI *Did not play*	W															
		B															

* Note: Microchess 1.5 wins 6th place over Microchess 1.0 by virtue of the tie breaking analysis of relative strength of opponents



We put more thought into our leader than most manufacturers put into their tape.

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It has a built-in non-abrasive head cleaner designed to remove the oxide residue other tapes leave behind, without damaging your tape heads.

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It even gives you a five second cueing mark, so you can set your recording levels without wasting tape. Or time.

Obviously, all the thought that went into our leader was designed to help you get more out of our tape.

So if you think our leader sounds impressive, wait till you hear what follows it.

maxell

CIRCLE NO. 40 ON FREE INFORMATION CARD

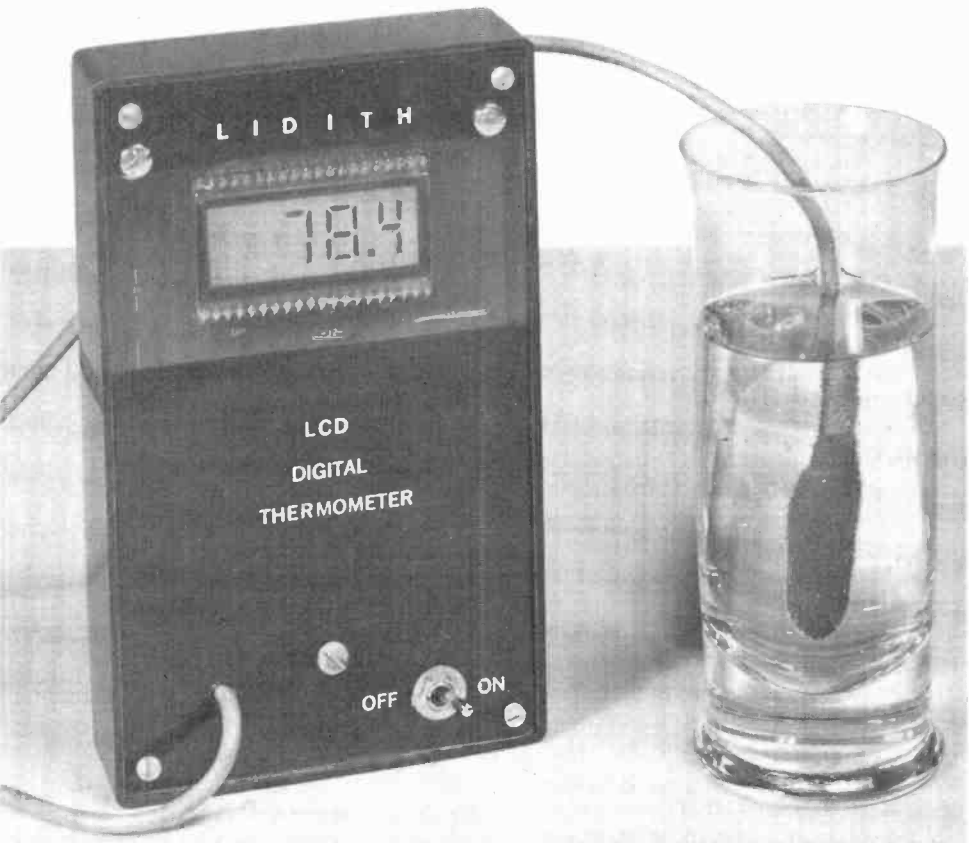
Maxell Corporation of America, 60 Oxford Drive, Moonachie, N.J. 07074

BY TOM FOX

BUILD 'LIDITH'

A 3½-Digit LCD Digital Thermometer

Measures from −30° to +199° F with 1° accuracy and 0.1° resolution



HERE IS AN easy-to-build, battery-operated 3½-digit thermometer, which we call "LIDITH" for LIquid-crystal DIgital THermometer. It can measure temperatures from −30° F to +199° F. Basic accuracy is better than ±1° over its entire range and averages better than ±0.5° from 0° to 100° F. Each degree is divided into 10 equal parts, giving Lidith a 0.1° F resolution. Readout is on a ½" (12.7-mm) liquid crystal display.

With some simple circuit modifications, Lidith can perform other functions, such as reading the temperature in °C, measuring accurately down to −67° F and displaying both indoor and outdoor temperatures.

Circuit Operation. Shown in Fig. 1 is the schematic diagram of Lidith. (See Box for details on sensors.) Resistor *R11* is the series voltage dropper for the 6.8-volt zener diode in the temperature transducer (*IC2*). The *R12/C6* network provides additional stability if the transducer is used as a remote sensor. Resistors *R9* and *R10* form a precision voltage divider to insure that the proper proportion of the transducer's output voltage goes to the digital panel meter (DPM) circuitry.

Several points should be noted about the *IC2* circuit. At room temperature (77° F), the transducer's output from pins 1 and 2 to pin 3 is nominally 2.98 volts and increases by 10 mV for every 1° C or 1.8° F increase in temperature. This potential is measured with respect to +9 volts, not ground. This means that at 77° F, pins 1 and 2 are at −2.98 volts, with respect to +9 volts.

The heart of the DPM is the Intersil ICL7106 single-chip 3½-digit MOS A/D (analog-to-digital) converter that drives the LCD. The 7106 uses dual-slope conversion, in which linearities tend to cancel out. Therefore, the circuit does not require extremely accurate or stable (and expensive) components. Also, as long as it remains unchanged for a single conversion cycle, the clock frequency does not have to be precise or extremely stable. The only real requirement is a stable current reference.

In addition to ease of use and relatively low cost, the 7106 has several other features that make it ideal for use in Lidith. Since the thermometer employs CMOS circuitry, it consumes little current (about 0.8 mA). It has true autozeroing, will directly drive LCD displays, and has a guaranteed ±1-count accuracy over its entire ±2000-count range.

The RC network for the 7106's inter-

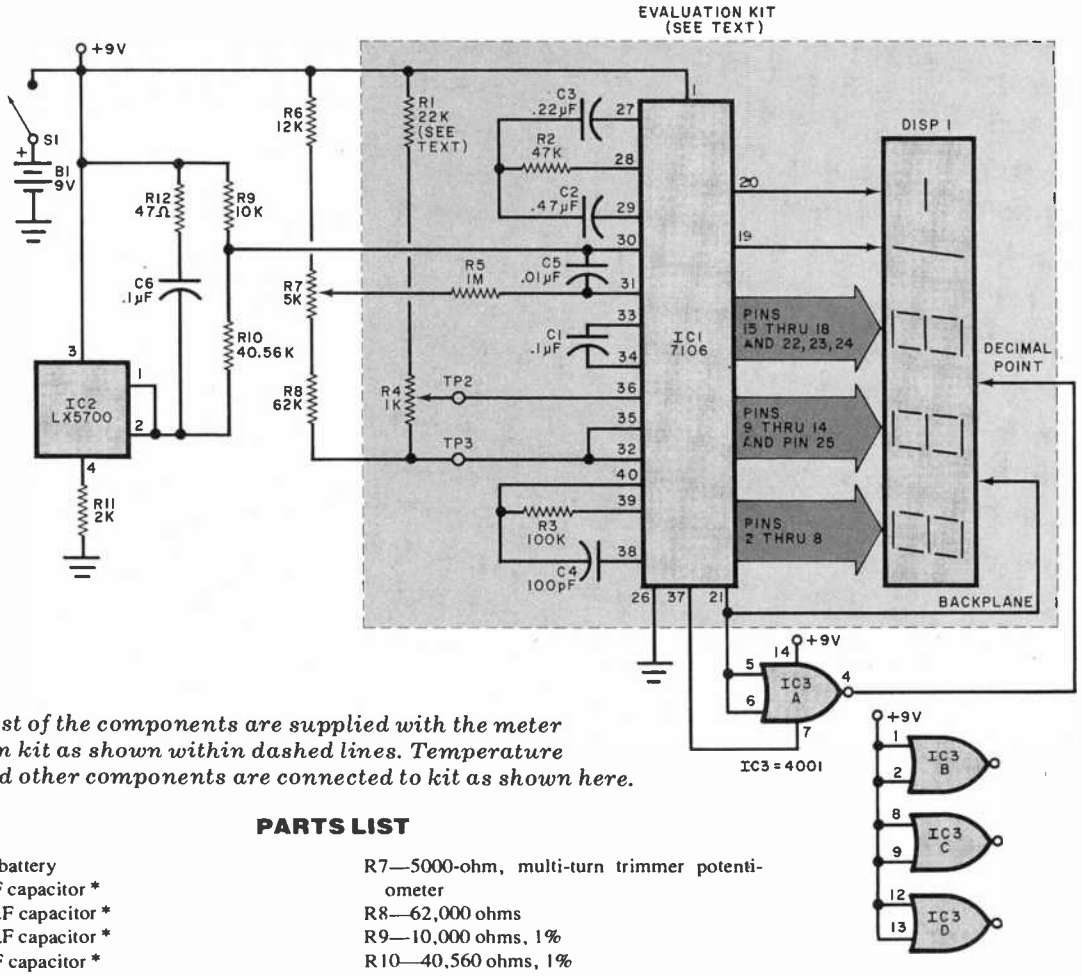


Fig. 1. Most of the components are supplied with the meter evaluation kit as shown within dashed lines. Temperature sensor and other components are connected to kit as shown here.

PARTS LIST

B1—9-volt battery
C1—0.1-μF capacitor *
C2—0.47-μF capacitor *
C3—0.22-μF capacitor *
C4—100-pF capacitor *
C5—0.01-μF capacitor *
C6—0.1-μF capacitor
DISP1—3½-digit LCD display *
IC1—7106 3½-digit A/D converter (Intersil) *
IC2—LX5700 temperature sensor (National)
IC3—4001 quad 2-input NOR gate
The following are 5%, ¼-watt resistors unless otherwise specified:
R1—22,000 ohms
R2—47,000 ohms *
R3—100,000 ohms *
R4—1000-ohm trimmer potentiometer *
R5—1 megohm *
R6—12,000 ohms
R7—5000-ohm, multi-turn trimmer potentiometer
R8—62,000 ohms
R9—10,000 ohms, 1%
R10—40,560 ohms, 1%
R11—2000-ohm, 5%
R12—47 ohms, 10%
S1—Spst switch
Misc.—Battery holder, IC socket (1), three-conductor flexible cable, 3/16" to ¼" ID thin-wall brass or copper tubing, spaghetti, E-POX-E ribbon, acrylic spray, plastic case (Radio Shack 270-627). ⅛"-thick clear plastic sheet, black spray paint, glue, mounting hardware, etc.
* These items are supplied in the Intersil Single Chip Panel Meter Evaluation Kit available for $29.95 plus $1 shipping and handling from Ancrona, Box 2208P, Culver City, CA 90230. Ancrona also sells the ICL7106 IC for $14.70.

Note: The following are available from T. R. Electronics, RR#1, Box 604, Newaygo, MI 49337: Kit containing one LX5700, R9, and R10 at $9.75 postpaid (ask for #ST2R for conventional kit, #CT2R for Celsius version, or #AT2R for "Alaskan" version). Also available separately: LX5700 temperature sensor (with data sheet) at $6.50 plus $0.50 postage and handling; a matched pair of LX5700s (±1° C or better) at $15.00; R9 and R10 at $1.75 each.

nal oscillator is made up of *R3* and *C4*. With the values shown, oscillator frequency is about 48 kHz. Capacitor *C3* and resistor *R2* are the integrating components, while *C1* is the reference capacitor and *C2* is the auto-zero capacitor. Low-pass RC filter *R5*/*C5* is used for improved noise rejection.

A stable 2.8-volt reference potential between pin 1 (V+) and pin 32 (COMMON) is provided by the 7106. Resistors *R1* and *R4* form an adjustable voltage-divider network that applies a suitable proportion of this reference voltage to pin 36 (REF HI) and pin 35 (REF LO). Adjustment of *R4* is made for a potential of 0.110 volt (110 mV) between REF HI and REF LO. In Lidith, *R4* is basically a scale-adjust trimmer potentiometer.

Another adjustable voltage-divider that uses the 7106's 2.8-volt reference is made up of *R6*, *R7*, and *R8*. Notice that temperature-adjust trimmer *R7*'s wiper is connected through filter resistor *R5* to pin 31 (IN HI) of the 7106.

Once the thermometer is calibrated, with *R7* at a fixed position, IN HI is at a fixed voltage. For the DPM to display 00.0, its IN LO (connected to the transducer's voltage-divider network) must be exactly equal to its IN HI point. Thus, after calibration, the voltage at *R7*'s wiper must be identical to that coming from the transducer's *R9*/*R10* divider network (and connected to IN LO) when the transducer's temperature is at 0°. We can conclude, then, that *R7* can be viewed as a 0° trimmer pot. However, since 0° F is not easy to achieve, *R7* will actually be set for a display of 32.1 when the transducer is immersed in ice water.

As the transducer's temperature rises, its output at pins 1 and 2 becomes more negative, with respect to +9 volts. This more-negative potential is felt at the 7106's IN LO input. When IN LO becomes more negative, with respect to IN HI (which is set at a constant voltage after calibration), the 7106 senses this as a positive voltage at its input, since IN HI is now more positive, or less negative,

than IN LO. Therefore, the DPM displays a positive number.

When the transducer's temperature goes below 0°, IN LO is less negative than IN HI and the DPM indicates a negative temperature.

The 7106 directly powers all segments of the LCD. Pin 21 goes to the display's backplane, while the frontplane segments connect to pins 2 through 25, excluding pin 21, which connects to the decimal point between the units and tenths decades in the display. Between the decimal point and pin 21 is a CMOS inverter that provides the proper ac voltage with an insignificant dc offset. It may seem wasteful to use an entire 4001 for this trivial task when a single MOS transistor would do the same job, but a 4001 is less expensive and more readily available.

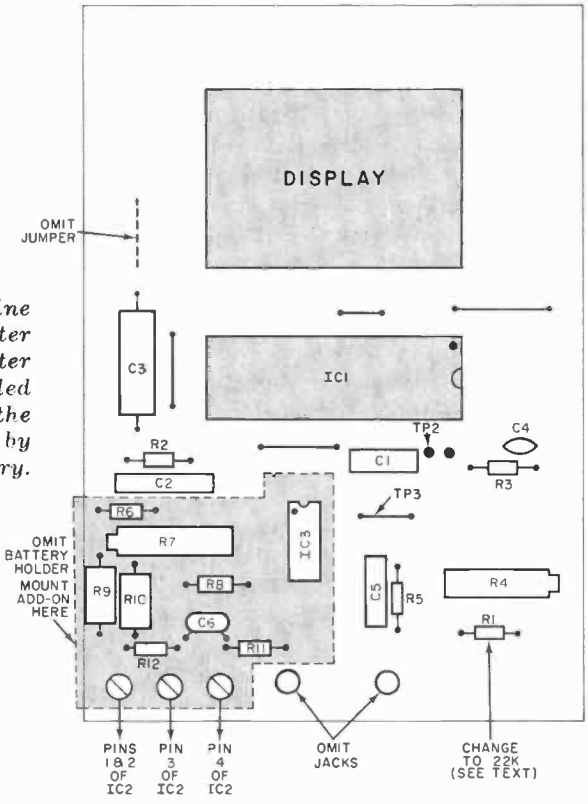


Fig. 2. The main outline here is that of the meter evaluation kit. Thermometer components can be added to the "open" area on the kit board created by taking off the battery.

Construction. Unless you can obtain a suitable 3½-digit LCD at reasonable cost, we strongly recommend Intersil's ICL7106EV/KIT Single Chip Panel Meter Evaluation Kit. It is available from Ancrona Corp. (see Parts List) and other Intersil distributors. If you are set on building your thermometer from scratch instead, follow Fig. 1 and the pin configuration guide for the LCD you buy.

Except for the remote sensing transducer, all thermometer components mount on the Evaluation Kit's circuit board. Build the Kit following the instructions supplied with it. Then, referring to Fig. 2, replace *R1* supplied with the Kit with a 22,000-ohm 5% (or better) tolerance carbon or metal-film resistor. (If you can adjust *R4* for 0.115 volt or more between *TP2* and *TP3*, *R1* need not be changed.) Eliminate the battery holder, specified jumper, and banana jacks. Drill holes for and mount the extra circuitry as shown. Refer back to Fig. 1 and interconnect all on-board components.

A 1" to 2" (25.4- to 50.8-mm) length of 3/16" to ¼" (4.8- to 6.4-mm) inner-diameter thin-walled brass or copper tubing should be used as a heat sink for the transducer if you plan to measure air temperatures. If you plan to use Lidith primarily for taking body and liquid temperatures, you can omit the tubing. Use a length of flexible three-conductor cable to interconnect transducer and circuit assembly. The cable can be up to 50' (15.2 m) long with no problems.

Referring to Fig. 3, slip the metal tubing onto the cable as shown. Then remove about 1" of the cable's outer jacket and prepare the ends of the conductors. Slip a length of plastic tubing over each

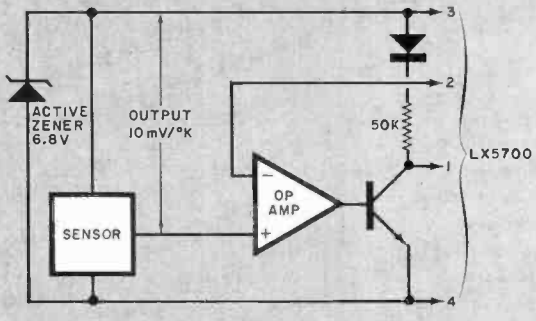
TEMPERATURE SENSOR SUPPLIERS

There are a number of manufacturers who produce temperature sensors suitable for use with Lidith. The following is a list of a few such manufacturers, followed by brief descriptions of the suitable sensors.

Precision Monolithics Inc. (1500 Space Park Dr., Santa Clara, CA 95050) produces Ultra-Matched Monolithic Dual Transistors, Series MAT-01, which, with suitable amplification, can be used in an electronic thermometer. For details, consult the company's application note No. AN-12 titled "Temperature Measurement Method Based on Matched Transistor Pair Requires No Reference."

Analog Devices (Rte. 1, Industrial Park, P.O. Box 280, Norwood, MA 02062) has recently released the AD590 Two-Terminal Temperature Transducer. It produces an output current proportional to the absolute temperature. At room temperature (77° F or 25° C), a 298.2-μA output is available. For every 1° C rise or fall, current increases or decreases by 1 μA. Premium model AD590M has a guaranteed maximum calibration error of ±0.5° C at 25° C. If you prefer to deal with voltages instead of currents, simply add a precision resistor in series with the transducer.

National Semiconductor Corp. (2900 Semiconductor Dr., Santa Clara, CA 95051) produces the LX5600/5700 series of IC temperature transducer specified in Lidith's Parts List. As shown in the diagram in this box, the transducer includes a built-in operational amplifier, internal zener diode to provide voltage regulation, and output transistor whose collector can be returned to a potential as high as 36 volts.



There are undoubtedly other semiconductor manufacturers who make sensors and transducers similar to those mentioned above, and this is not intended to be a complete list. ◇

conductor. Using a heat sink between transducer and tie points, solder the conductors of the cable to the leads on the transducer. Then spray several coats of plastic insulation (such as GC's Koloid K-29 or Clear Acrylic Plastic) over the connections and exposed wires. Alternatively, dip the entire transducer assembly in GC Liquid Tape. When the coating dries, push the plastic tubing down until it contacts the transducer's body and covers all bare wires.

Clean the transducer and metal tubing with fine steel wool or sandpaper. Referring to Fig. 4, solder the transducer to the tube, taking care to be sparing with the heat.

Finally, use epoxy putty to make a waterproof probe out of the transducer assembly. Prepare the putty according to directions and then wet your hands and form a rough cylinder around the transducer assembly. Do not be concerned if your work appears messy. Just make sure the transducer and connections are completely sealed. With damp hands, roll the rough cylinder between your hands until it is smooth and nearly perfectly cylindrical and has a blunt cone-shaped tip.

Mount the thermometer circuit inside a housing large enough to accommodate it and its battery.

Calibration. If possible, the following reference-voltage adjustment should be performed with the aid of a digital multimeter. However, a good-quality analog voltmeter can be used if its input impedance is 1 megohm or greater. If you have a laboratory thermometer, you can do away with the need for a meter altogether, but calibration will take considerably more time. (More about this later.)

Turn on the power and let the thermometer warm up for at least 2 minutes. Then, with the meter set to its lowest range, connect the negative prod to *TP3* (actually a jumper) and positive prod to *TP2*. Referring to Fig. 2, carefully adjust *R4* for a reading of 0.110 volt.

To calibrate the thermometer, you will need a plastic bucket filled about three-quarters full with compact clean snow, ice chips, or ice cubes. Pour in enough cold water to nearly fill the bucket. Place the transducer probe in the center of the ice/water mixture and wait a few minutes until the LCD stabilizes at some number.

Vigorously stir the ice mixture and adjust *R7* for a display of 32.1. This display figure is more desirable than the usual 32.0 because you will most likely be performing calibration in a warm room where ice water will be melting. In any event, what you are really measuring is the temperature of the *water*, which will not be exactly 32° F. If Lidith was calibrated exactly as described above, there are only two possible sources of error left—the transducer's slope and linearity errors. Fortunately, the transducer specified is almost perfectly linear. According to the conservative specifications, the nonlinearity of the LX5700 is less than ±0.5%. The only possible significant error left, then, is a slight slope error, the worst case of which is about ±0.4 mV/°K. With a laboratory thermometer and some patience, even this error can be removed.

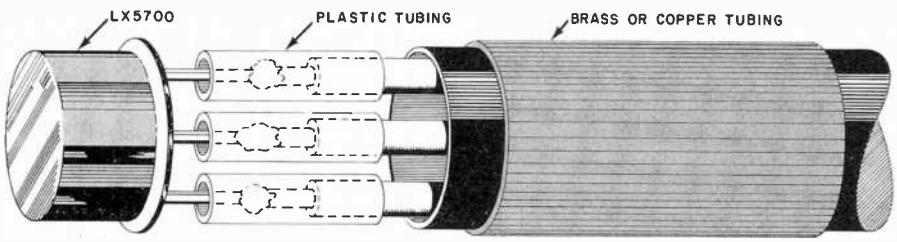


Fig. 3. Temperature probe construction. Make sure all soldered connections are well insulated. Thin metal tubing is optional.

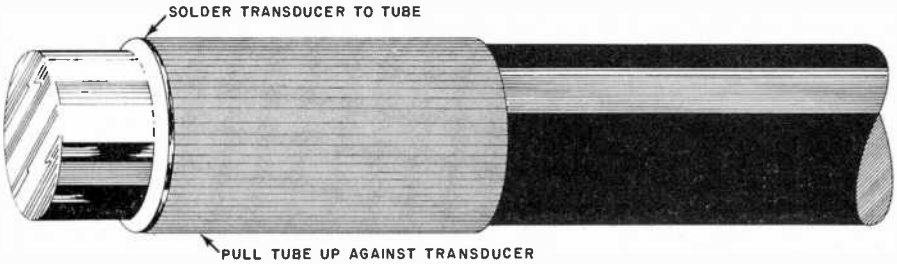


Fig. 4. Solder the optional heat sink to the heat sensor. Then use epoxy putty to form a waterproof probe out of the transducer assembly.

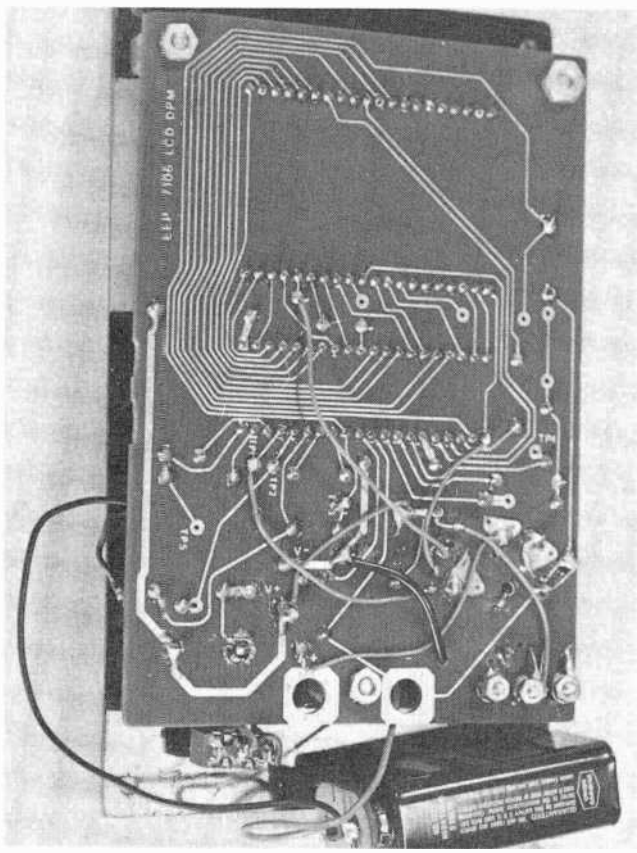


Photo showing back of meter evaluation kit board after extra holes have been drilled and components for temperature sensor have been added.

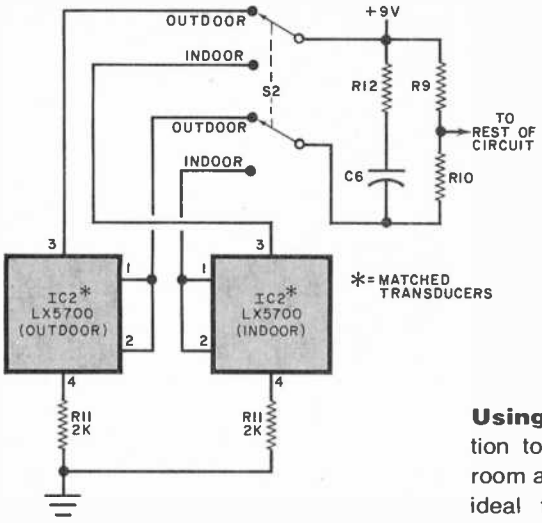


Fig. 5. Diagram shows how to connect two temperature sensors to the basic thermometer. For best results, sensors used should be matched.

To remove the slope error, adjust *R4* and *R7* exactly as described above. (If a DMM is not available, initially set *R4* to its midpoint.) Place the probe and lab thermometer in warm (about 120° F) water and, while stirring the water, adjust *R4* until Lidith's display indicates exactly the same temperature as the lab thermometer. Then place the probe in a bucket of ice/water and adjust *R7*, if necessary, for a reading of 32.1. Return the probe to the warm water and, if necessary, readjust *R4*. Repeat the immersion-and-adjustment procedure until it is no longer necessary to trim the settings of the potentiometers.

Using the Thermometer. In addition to the obvious use of measuring room and ambient temperature, Lidith is ideal for measuring temperatures in pools, for isolating excessively warm electronic components in an operating circuit, as a remote-indicating freezer or refrigerator thermometer, and as a medical thermometer. (If you calibrate accurately for 98.6° F against a good-quality oral mercury thermometer, the accuracy of Lidith can approach ±0.1° F over a 92° to 110° F range.) The Celsius version can also be used by auto hobbyists as a water-temperature monitor.

To accurately measure outside-air temperatures, you need both an accurate thermometer like Lidith and a suitable thermometer shelter. (For details on measuring outside-air temperature, see pages 23 and 25 of *Unique Electronic Weather Projects* published by Howard W. Sams & Co., or refer to some other suitable book on weather instruments.)

If you turn on Lidith only when you wish to know the temperature and leave the power off at all other times, a standard 9-volt battery should last more than a year. For a continuous display, omit *S1* and use six alkaline D cells in series instead of the 9-volt battery. In continuous use, the D cells should last about a year or more.

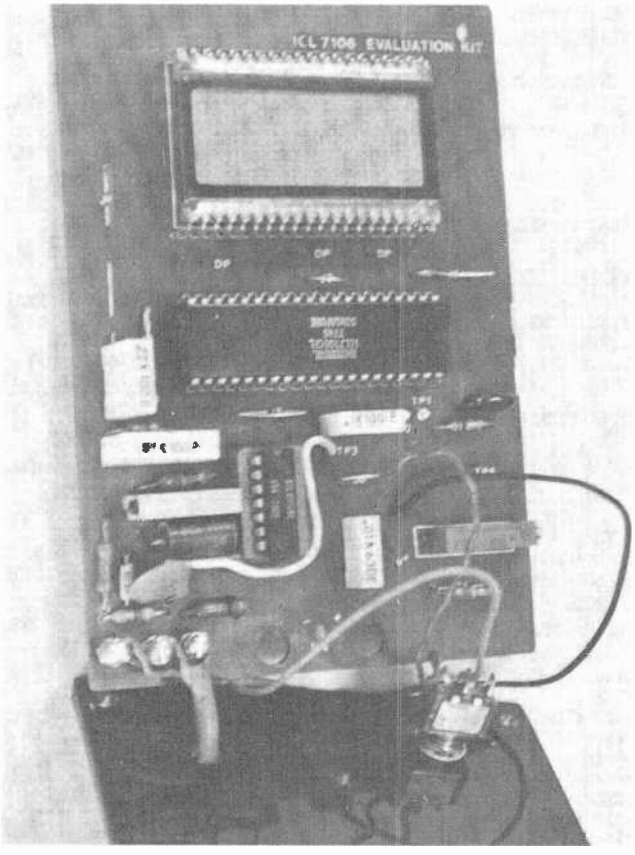
The thermometer can be used to measure temperatures in two different locations, such as indoors and outdoors, using the circuit shown in Fig. 5. Bear in mind, however, that if you select two LX5700 transducers at random, one of the temperatures measured can be off by as much as 14° F, due to the possible ±8° C maximum offset error of the device. This error can be reduced to 4° C if you use premium-quality LX5700As. Even so, your best bet would be to use a pair of custom-matched transducers (see Parts List).

With a few changes in component values, you can make Lidith measure temperatures in Celsius degrees from −55° to +125° C. You can even make an "Alaskan" version that measures down to −67° F and up to +199° F.

The following changes are required for both the Celsius and Alaskan versions. First, change *C2* to a 0.1-μF Mylar capacitor, *R2* to a 220,000-ohm, 5% tolerance carbon-film resistor, and *R4* and *R7* to 10,000-ohm, 15-turn trimmer potentiometers. Then adjust *R4* so that the potential between *TP2* and *TP3* is 0.500 volt.

For the Celsius version, change *R6* to 20,000 ohms, *R8* to 22,000 ohms, and *R10* to a 10,000-ohm 1% tolerance precision resistor. Calibrate by adjusting *R7* for a 00.1 reading on the LCD when the probe is immersed in an ice/water mixture as before.

For the Alaskan version, change *R6* to 82,000 ohms, *R8* to 15,000 ohms, and *R10* to a 1120-ohm, 1% tolerance precision resistor. Calibrate exactly the same as for the regular version, but adjust *R4* for a potential of 0.500 volt between *TP2* and *TP3*.



Front view of meter evaluation kit showing components for temperature sensor added in area where battery holder was.

Summing Up. Lidith is a truly state-of-the-art precision digital thermometer. With a few minor changes, it can be "tailored" to your needs. And, in ordinary use, it is highly energy-efficient, thanks to the use of low-power MOS circuitry and liquid-crystal display. ◇

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Ions are electrically charged atoms in the air with either a positive or negative charge. The sun and cosmic rays as well as lightning and fast-moving water (like waterfalls, surf) generate trillions of negative ions every day. The more negatively ionized the air, the fresher and more alive it is. Air pollution, artificially controlled climates (with air conditioning and heating) and electronic equipment all produce excess positive ions, depriving the air of these small negative air ions and creating dead "stuffy" air.

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Ion density:	430,000 ions per cm^3/sec. at 1 meter. 1.55 million ions per cm^3 at 50 cms.
Use:	Large room or office—9000 cu. ft.
Warranty:	1 year
Output voltage:	15KV
Ozone:	Less than 2 parts per billion
Dimensions:	5⅜" x 4¼" x 2⅜"

Executive System Four™

Ion density:	Low to maximum of 540,000 ions per cm^3 at 1 meter. 1.6 x 10^6 ions per cm^3 at 50 cms.
Output voltage:	15KV
Ozone:	Less than 2 parts per billion
Dimensions:	11" x 5" x 4"
Use:	Large room or office 10,000 cu. ft.
Warranty:	1 year

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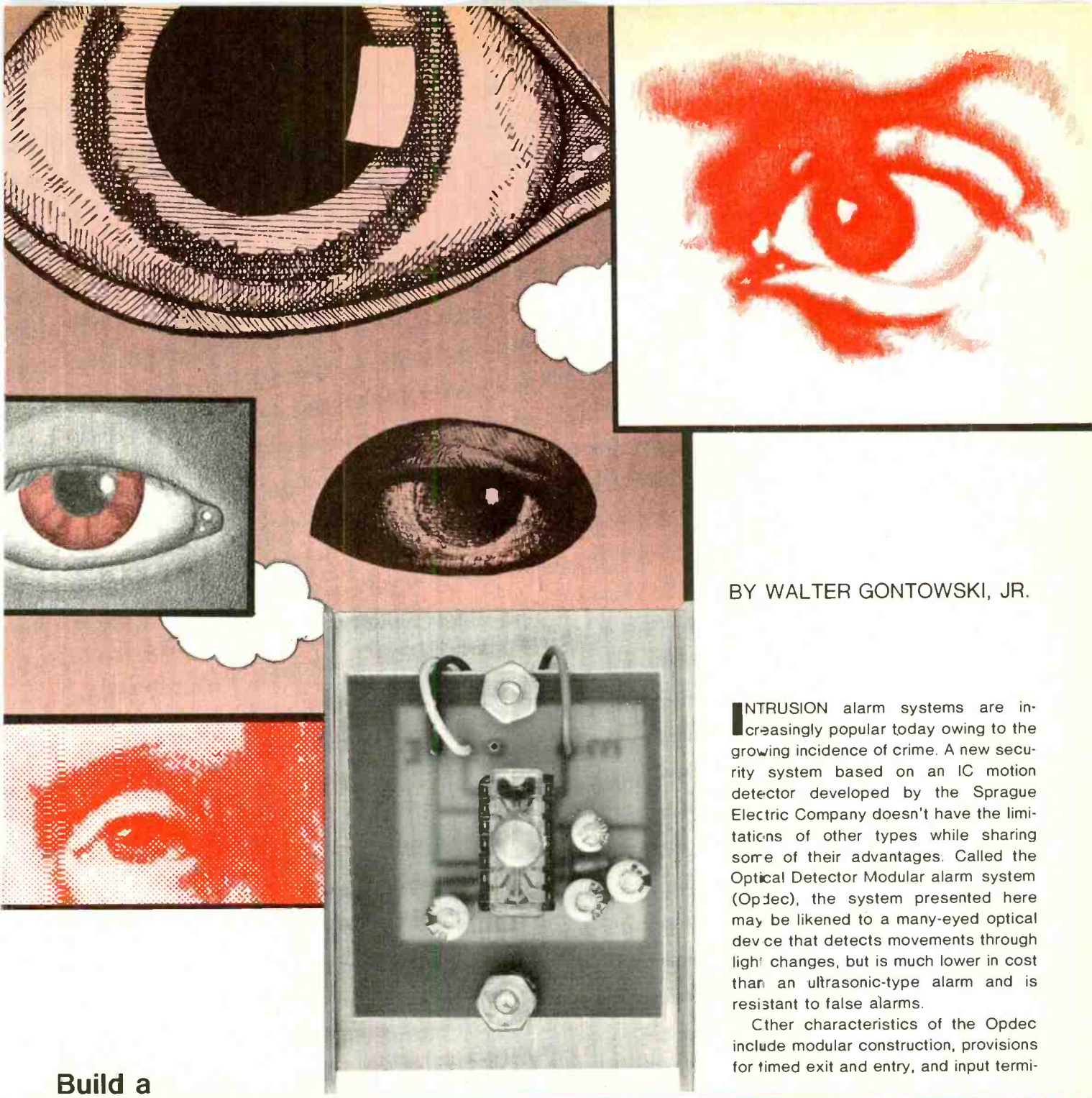


Build a

MOTION-DETECTOR ALARM

- Many-Eyed Modular System
- Low-Cost IC
- Responds to Light Changes

BY WALTER GONTOWSKI, JR.

INTRUSION alarm systems are increasingly popular today owing to the growing incidence of crime. A new security system based on an IC motion detector developed by the Sprague Electric Company doesn't have the limitations of other types while sharing some of their advantages. Called the Optical Detector Modular alarm system (Opdec), the system presented here may be likened to a many-eyed optical device that detects movements through light changes, but is much lower in cost than an ultrasonic-type alarm and is resistant to false alarms.

Other characteristics of the Opdec include modular construction, provisions for timed exit and entry, and input terminals for optional closed-loop wiring that can yield added protection. Finally, Opdec can also function as a fire/smoke detector at the same time that it is on the lookout for intruders.

The Motion Sensor. The heart of the Opdec system is Sprague's ULN-2232A Integrated Optical Motion Detector. Un-

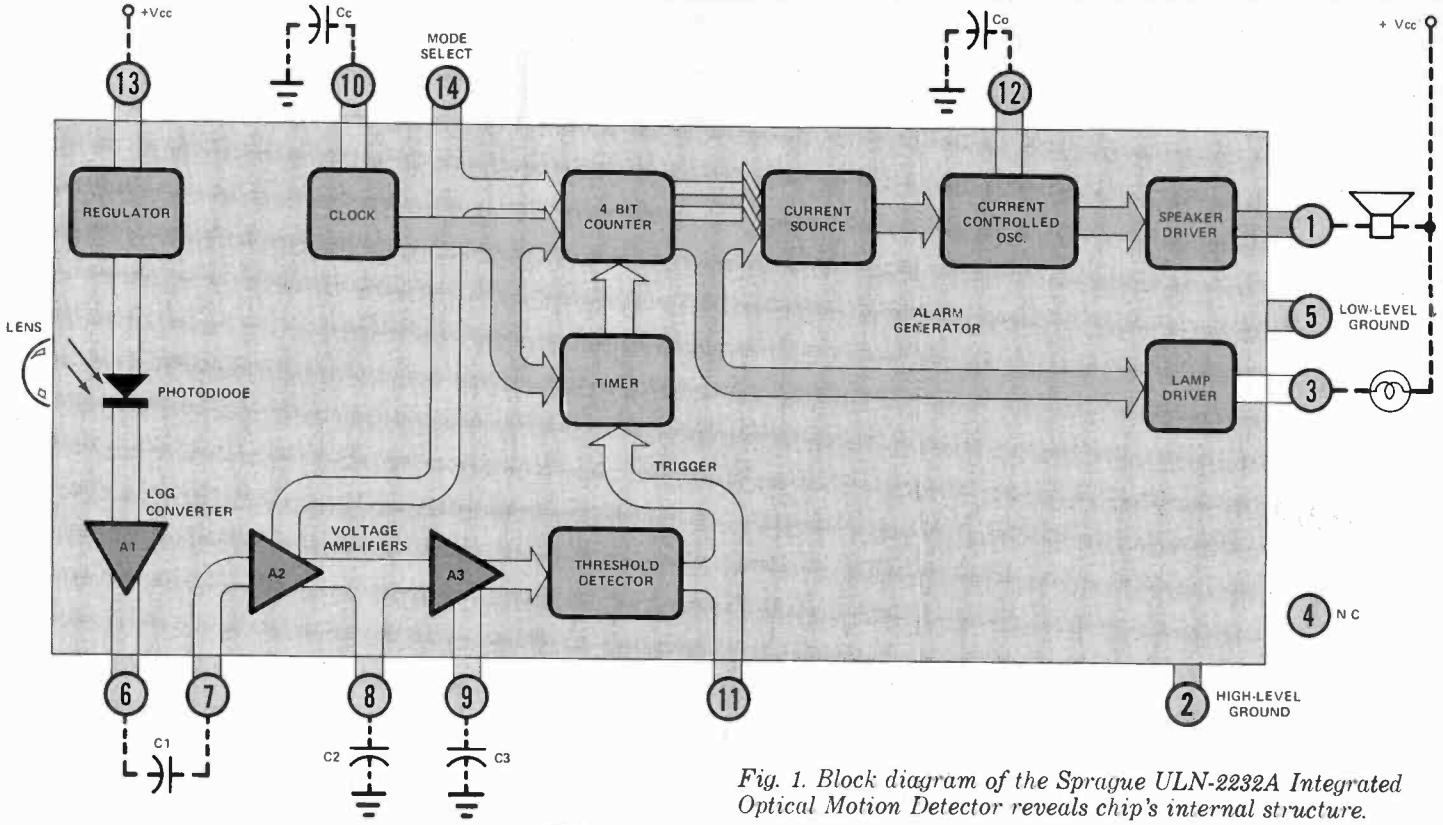


Fig. 1. Block diagram of the Sprague ULN-2232A Integrated Optical Motion Detector reveals chip's internal structure.

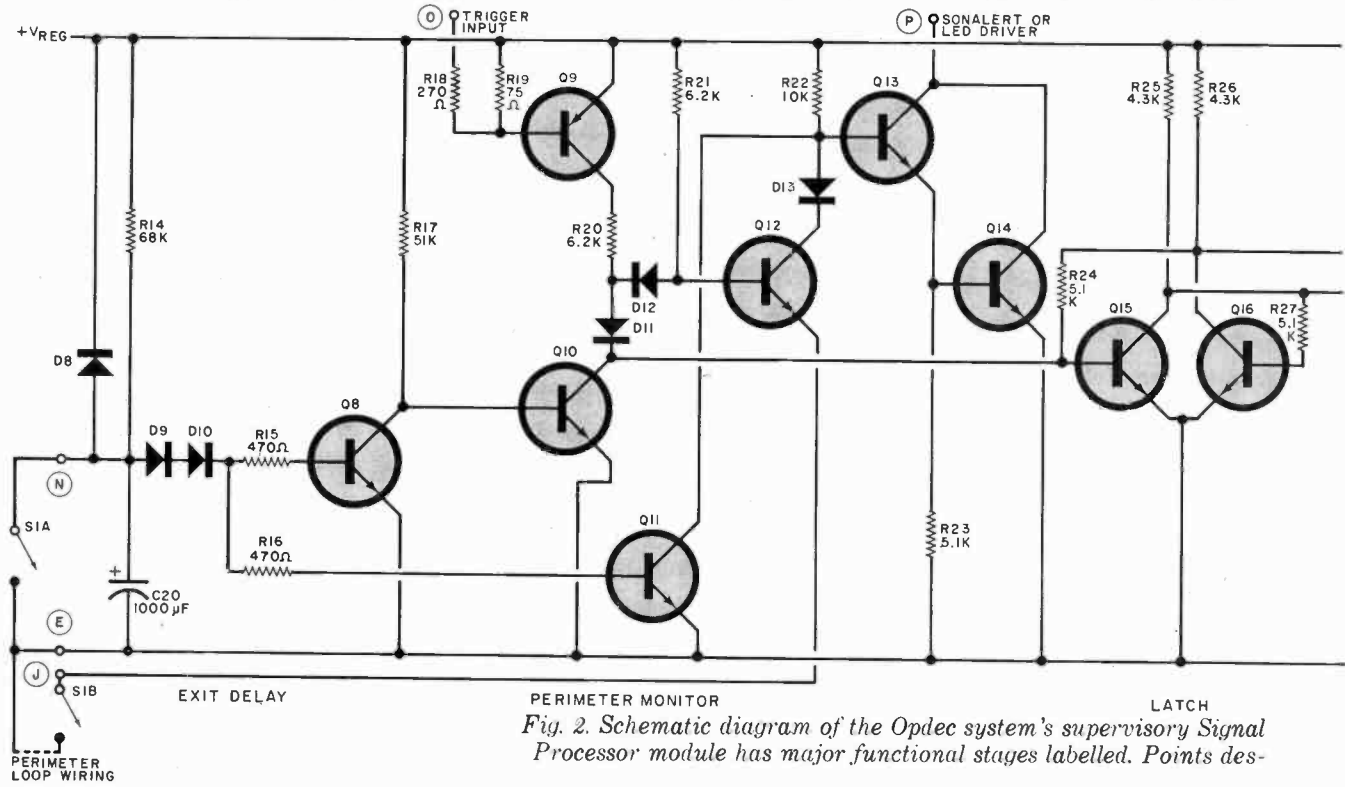


Fig. 2. Schematic diagram of the Opdec system's supervisory Signal Processor module has major functional stages labelled. Points des-

like a conventional optoelectronic alarm sensor (usually a CdS photocell) that triggers the alarm when the path between a light source and the sensor is interrupted, this novel IC senses the presence of an intruder by detecting changes in the amount of ambient light reaching it. As the intruder enters the room or moves around in it, the amount of light reflected to the sensor IC will vary. The sensor has been designed to respond to this change in light level.

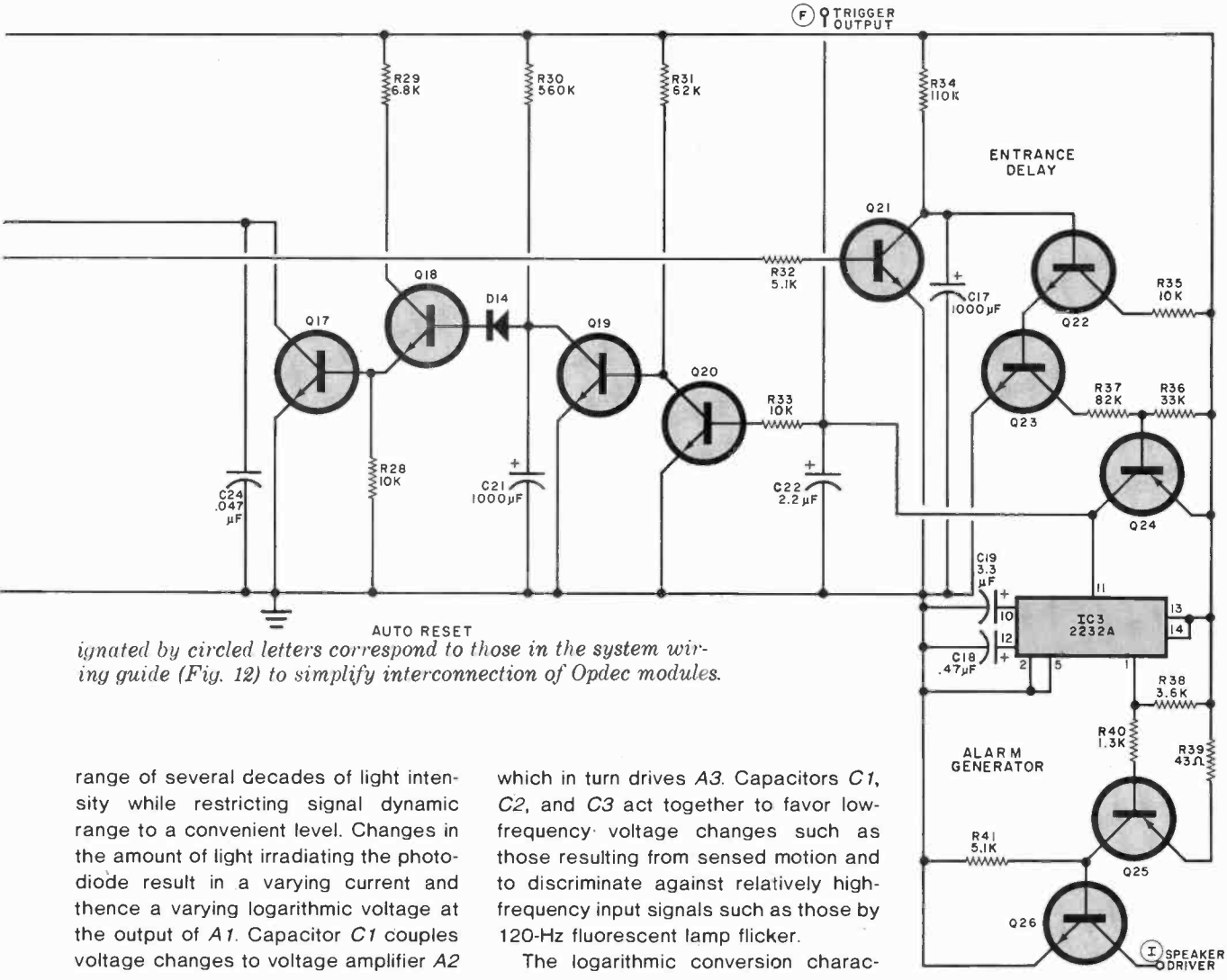
A block diagram of the ULN-2232A IC sensor is shown in Fig. 1. The chip contains, among other things, a photodiode, a logarithmic converter, a voltage amplifier, a threshold detector and an alarm generator. Sensor operation is as follows.

The photodiode generates a small electric current when it is irradiated by light energy. This photocurrent is processed into a voltage by logarithmic converter *A1*. Taking the log of the current allows sensor operation over a

PARTS LIST FOR SIGNAL PROCESSOR MODULE (including System Power Supply)

C1—10,000-μF, 25-volt electrolytic
C17,C20,C21—1000-μF, 6-volt electrolytic
C18—0.47-μF, 6-volt tantalum
C19—3.3-μF, 6-volt tantalum
C22—2.2-μF, 6-volt tantalum
C24—0.047-μF, disc ceramic
D1,D2—3-ampere, 100-PIV rectifier
D8 through D14—1N4001 rectifier
D15—4.7-volt, 1-watt zener diode (1N3825 or equivalent)
F1—½-ampere fast-blow fuse
IC3—ULN-2232A Sprague Integrated Motion Detector
Q1,Q26—2N4921 npn silicon transistor (or equivalent)
Q8,Q10 through Q23—Sprague RT108 npn silicon transistor (or equivalent)
Q9,Q24,Q25—Sprague RT106 pnp silicon transistor (or equivalent)
The following are 5%-tolerance, ¼-watt carbon-composition resistors, unless otherwise specified.
R1—100 ohms, 2 watts, 10% tolerance
R13—43 ohms, 4 watts, 10% tolerance
R14—68,000 ohms
R15,R16—470 ohms
R17—51,000 ohms
R18—270 ohms
R19—75 ohms
R20,R21—6200 ohms
R22,R28,R33,R35—10,000 ohms
R23,R24,R27,R32,R41—5100 ohms
R25,R26—4300 ohms
R29—6800 ohms
R30—560,000 ohms
R31—62,000 ohms
R34—110,000 ohms
R36—33,000 ohms
R37—82,000 ohms
R38—3600 ohms
R39—43 ohms
R40—1300 ohms
S1—Dpst switch
T1—24-volt, 2-ampere center-tapped transformer (Stancor P-8662 or similar)
Misc.—Mallory SC-628 Sonalert or LED, 8-ohm dynamic speaker (if Siren Driver module is omitted), printed circuit board, standoff insulators, snap-on heat sinks for *Q1* and *Q26* (Wakefield 291.80ABC2 or similar), silicone thermal compound, suitable enclosure measuring approximately 10" × 5" × 3¼" or 25.4 cm × 12.7 cm × 8.3 cm (Bud RC11100 or similar), barrier block terminal strip, hookup wire, solder, hardware, etc.

Note—The Sprague ULN-2232A Integrated Optical Motion Detector can be purchased for $7.85 (plus $1 postage and handling in U.S.) from Sprodco Marshall Street, North Adams, MA 01247.



ignated by circled letters correspond to those in the system wiring guide (Fig. 12) to simplify interconnection of Opdec modules.

range of several decades of light intensity while restricting signal dynamic range to a convenient level. Changes in the amount of light irradiating the photodiode result in a varying current and thence a varying logarithmic voltage at the output of *A1*. Capacitor *C1* couples voltage changes to voltage amplifier *A2* which in turn drives *A3*. Capacitors *C1*, *C2*, and *C3* act together to favor low-frequency voltage changes such as those resulting from sensed motion and to discriminate against relatively high-frequency input signals such as those by 120-Hz fluorescent lamp flicker.

The logarithmic conversion charac-

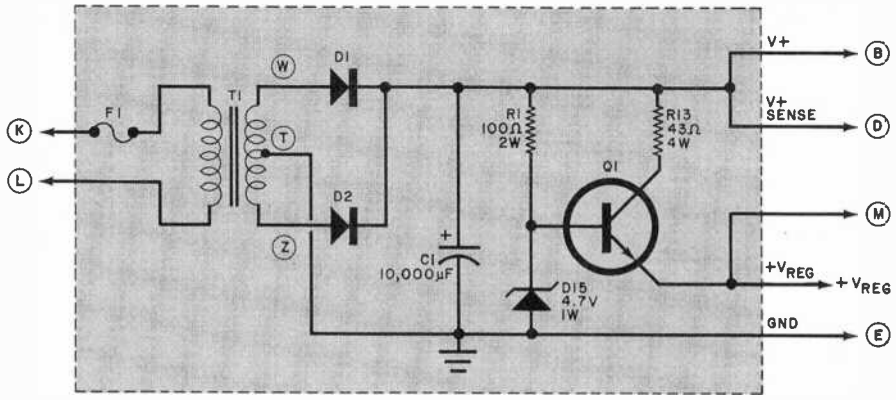


Fig. 3. This power supply can satisfy current demand of a complete Opdec system. Most of it fits on the Signal Processor's pc board.

teristic of *A1* and the gains of *A2* and *A3* are chosen so that the threshold detector is triggered when the change in light level exceeds ±5% during a relatively short period of time (about one second). When the threshold detector is triggered, a pulse is routed to pin 11 of the IC and to a four-bit counter that is part of the chip's timing and alarm-generating circuit. An on-chip transistor is capable of driving a small loudspeaker, but it is not used in the Opdec system. Rather, the pulse appearing at pin 11 of the IC sensor is applied to the Signal Processor, the central, supervisory module of the Opdec system.

The Signal Processor is shown schematically in Fig. 2. Among other things, it detects trigger signals from any of several motion sensors, decides if the sensor has in fact detected the movement of an intruder (rather than being triggered by lightning, a car passing in the night, or some similar phenomenon), generates exit and entry delays, automatically resets the system a few minutes after it has sounded the alarm, and provides optional closed-loop perimeter protection. Also included in the signal processor module is a power supply for the complete system. This supply is shown schematically in Fig. 3.

When the system is armed, *S1* is opened. This allows *C20* to charge through *R14*. In the meantime, *Q8* is cut off and allows *Q10* to conduct. Transistor *Q10* ensures that the latch consisting of *Q15*, *Q16* and their associated resistors is reset. While *C20* is charging (approximately one minute), the occupant can move about the premises freely and leave through a protected exit without setting off the alarm. Trigger pulses from the motion detectors he passes cause *Q9* to conduct, but while *C20* is charging, the pulses appearing at the collector of *Q9* are shunted to ground by *Q10*. When the voltage across *C20* increases to approximately 2.1 volts, *Q8* conducts and cuts off *Q10*. The Opdec system is now armed.

If light-level changes such as those caused by motion are detected, pulses are sent to *Q9*, which sets latch *Q15Q16*. The latch cuts off *Q21* enabling *C17* to charge through *R34*. During the interval that *C17* is charging (approximately 30 seconds), the alarm is not activated. This delay gives the occupant time to enter the house and disarm the system. When the voltage across *C17* equals approximately 1.3 volts, *Q22*, *Q23*, and *Q24* conduct and actuate the alarm generator comprising *IC3* and drivers *Q25* and *Q26*. The sound produced by *IC3* is similar to the "yelping" sound made by police sirens.

Once the alarm generator has been activated, it will continue to oscillate for 10 minutes. After that time, it turns off and the Opdec system automatically rearms itself. This feature is included in case the alarm is triggered while the occupants are away for an extended period and no one is able to turn off the alarm. This 10-minute reset function is generated in the following manner. When *Q24* begins to conduct, it provides base drive for *Q20*. This transistor cuts off *Q19*, which allows *C21* to charge through *R30*. It takes this capacitor approximately 10 minutes to charge up to a voltage which causes *Q18* and *Q17* to conduct. When *Q17* turns on, it resets the latch, which turns off the alarm. Opdec is again armed and awaits any further trigger signals.

Special precautions must be taken to prevent Opdec from generating false alarms due to lightning, passing cars with glowing headlights, etc. One specially constructed detector module (more on this later) should be mounted in a window and aimed at the sky. When a lightning flash occurs, this detector will momentarily disarm the system and then automatically rearm it. This module should not be mounted in such a way that any swaying trees, moving cars, or similar objects are in its field of view.

If you would like to incorporate the additional protection of a closed-loop system, magnetic reed door switches (normally closed) and metallic foil tape for glass can be connected to the signal processor. These items can be purchased at most electronics stores and are simple to install. The switches and tape are all wired in series and connected to point J and ground (point E). If any of the protected doors are opened or a foiled window is broken, the closed-loop circuit is opened. This cuts off *Q12*, which in turn allows the latch to be set by means of *R21*, *D11*, and *D12*. After the 30-second entry delay interval, the alarm is activated.

An additional feature of the Opdec Signal Processor module is either a visual or audible indication if any of the doors or windows are inadvertently left open upon exiting. If, for example, a window were left open, *Q12* would be cut off and *Q13* and *Q14* would conduct. Either a Mallory Sonalert or a light emitting diode can be employed to indicate that the Opdec system has been ordered to arm itself. The indicator can be connected to the collectors of *Q13* and *Q14* (point P). If you decide to use a LED, make sure you insert a 560-ohm resistor between the cathode of the LED and the collectors of the transistors (point P). Once the system has been armed, the warning circuit is disabled by *Q11*, which begins to conduct and cuts off *Q13* when *C20* has charged sufficiently.

The Siren Driver. There are several different means of signalling that the Signal Processor has been triggered. In the author's installation, the collector of *Q26* (point I) was connected to an existing intercom system and to two exterior paging horns. In addition, a 12-volt, battery-operated electronic siren was incorporated as a back-up alarm in case there was a power failure, or the power lines were cut. An 8-ohm horn speaker can be connected to the collector of *Q26*. The resulting *loud* alarm sound should be sufficient to scare away any intruder.

The electronic siren driver is shown

(Continued on page 66)

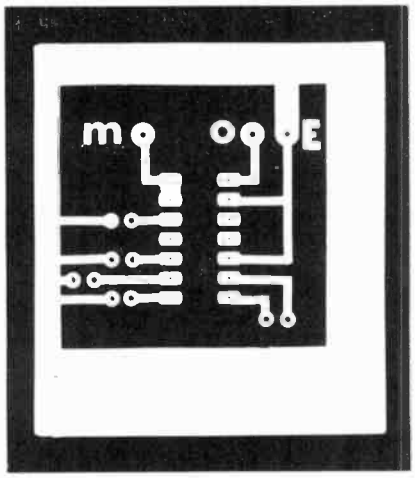


Fig. 4. Etching and drilling guide for motion and lightning sensor pc boards (shown above.)

Fig. 5. Etching and drilling guide for Signal Processor module pc board (shown below).

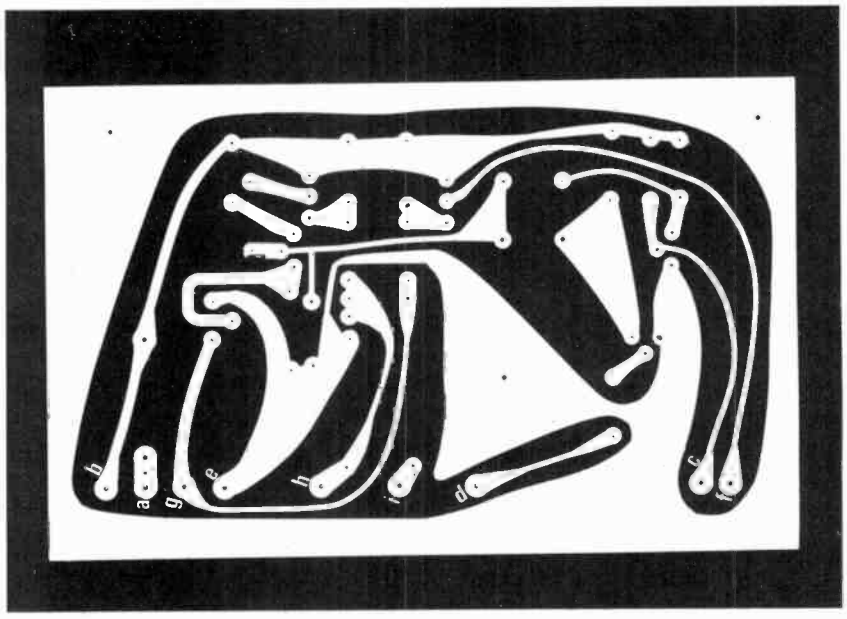
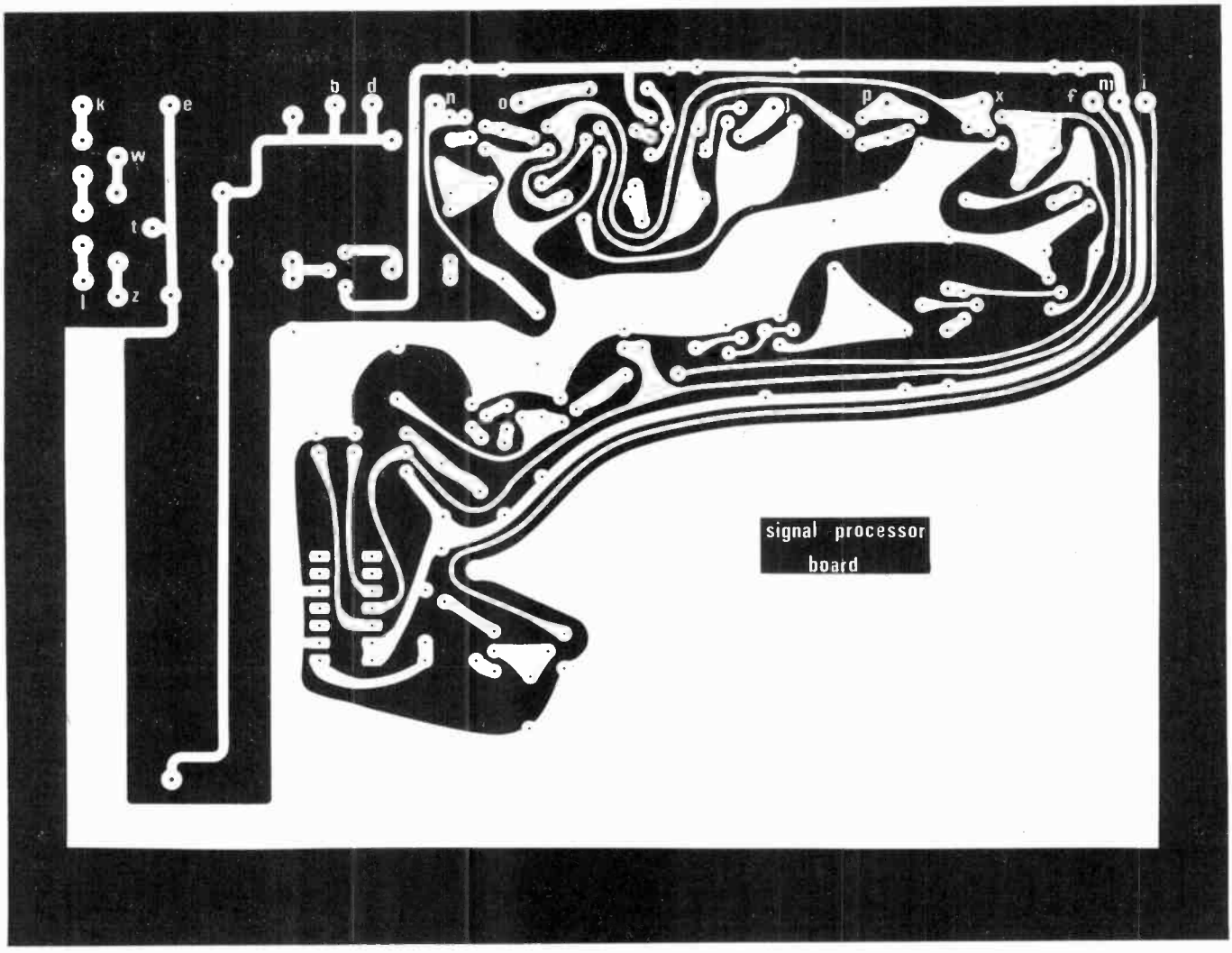


Fig. 6. Etching and drilling guide for the Siren Driver module's printed circuit board is shown above. Artwork for this and the other two pc boards on this page appears full-size.



schematically in Fig. 7. Signals appearing at the collector of *Q26* are coupled to *Q5* by means of *D6* and *R8*. Capacitor *C23* filters the pulses produced by *Q26*. Transistor *Q5* provides base current for *Q6* which in turn supplies base current to siren driver *Q7*.

If the line-derived positive supply voltage V+ is lost because of a power-line failure or intentional disabling by the intruder, the system will be powered automatically by a 12-volt lantern battery. In the event that the intruder locates the Signal Processor module and cuts all the wires leading to it, *Q3* will sense a loss of voltage and activate the siren driver by means of *R5* and *D5*.

Finally, if because of some emergency you want to instantly activate the siren, close the optional, PANIC switch, assuming that it has been installed.

Smoke and Fire Detection. Although the motion detector will detect smoke and fire (because both cause changes in ambient light), it is advisable to install one or more commercially available, self-contained smoke detectors because the Opdec system has to be armed if it is to detect smoke and fire. Thus, the occupants of the premises will be protected while they are there even though Opdec will not ordinarily be armed.

(Continued on page 68)

PARTS LIST FOR SIREN DRIVER MODULE

C23—1-μF, 25-volt electrolytic
D3—3-ampere, 100-PIV rectifier
D4 through D7—1N4001 rectifier
Q2,Q3,Q6—Sprague RT108 npn silicon transistor or equivalent
Q4,Q5—Sprague RT106 pnp silicon transistor or equivalent
Q7—Sprague RT114 npn silicon transistor or equivalent
The following are 5%-tolerance, ¼-watt, carbon-composition resistors.
R2—10,000 ohms
R3,R5,R9—20,000 ohms
R4—200,000 ohms
R6,R7—75,000 ohms
R8,R10—51,000 ohms
R11—30,000 ohms
R12—470 ohms
R42—360 ohms
Misc.—Siren (Vexon 160, Radio Shack 275-488 or equivalent), printed circuit board, standoff insulators, snap-on heat sink for Q7 (Wakefield 296040AB or similar), silicone thermal compound, suitable enclosure, 12-volt battery, barrier block terminal strip, etc.

PARTS LIST FOR MOTION SENSOR MODULE

C2,C5,C6—47-μF, 6-volt electrolytic
C3—0.22-μF, 6-volt tantalum
C4—0.01-μF, 50-volt disc ceramic
IC1—ULN-2232A Sprague Integrated Motion Detector
Misc.—Printed circuit board, standoff insulators, suitable enclosure measuring approximately 2¾" × 2⅛" × 1⅜" or 7 cm × 5.4 cm × 4.1 cm (Bud CU-2100-A or similar), barrier block terminal strip, hookup wire, solder, hardware, etc.

PARTS LIST FOR LIGHTNING SENSOR MODULE

C7,C10—47-μF, 6-volt electrolytic
C8—0.22-μF, 6-volt tantalum
C9,C11—4.7-μF, 6-volt tantalum
IC2—ULN-2232A Sprague Integrated Motion Detector
Misc.—Printed circuit board, standoff insulators, suitable enclosure measuring approximately 2¾" × 2⅛" × 1⅜" or 7 cm × 5.4 cm × 4.1 cm (Bud CU-2100-A or similar), barrier block terminal strip, hookup wire, solder, hardware, etc.

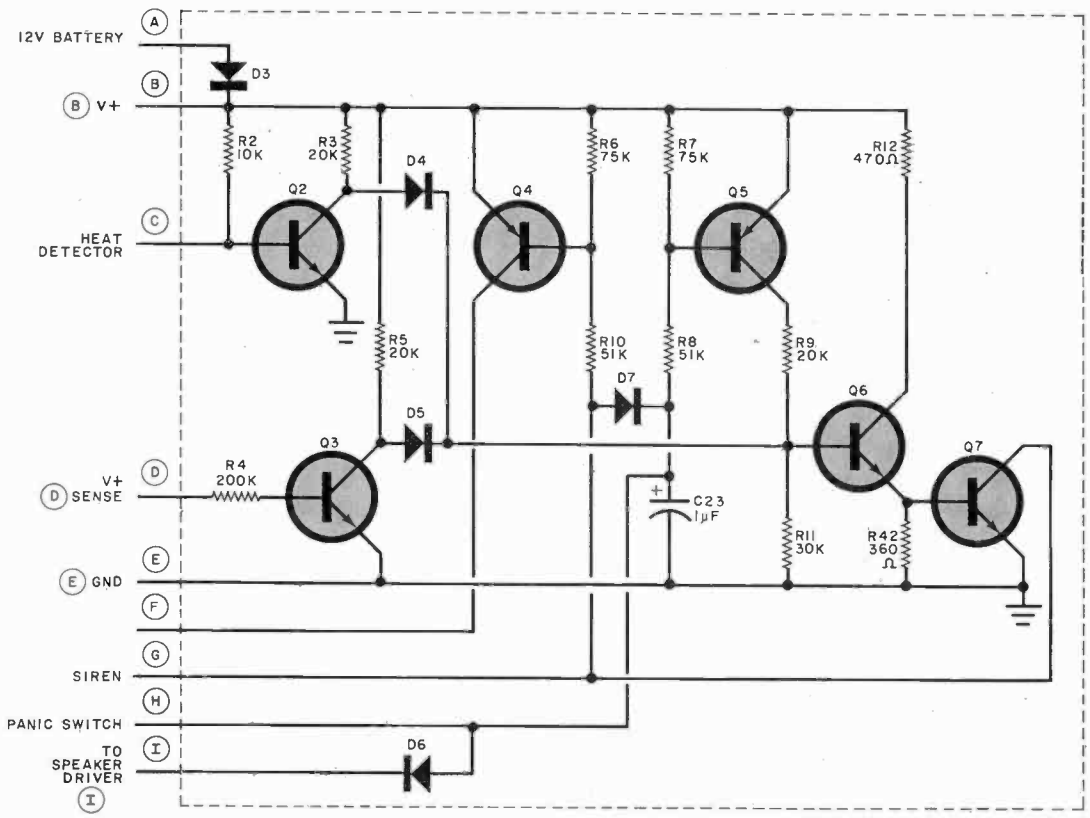
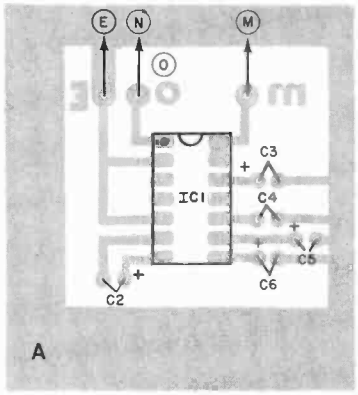


Fig. 7. Schematic diagram of Siren Driver module appears at left.



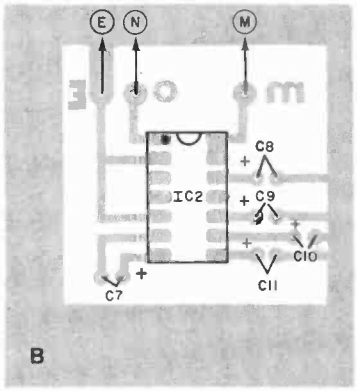


Fig. 8. Component placement guides for motion (A) and lightning sensor modules (B) appear above left. Also see Fig. 11.

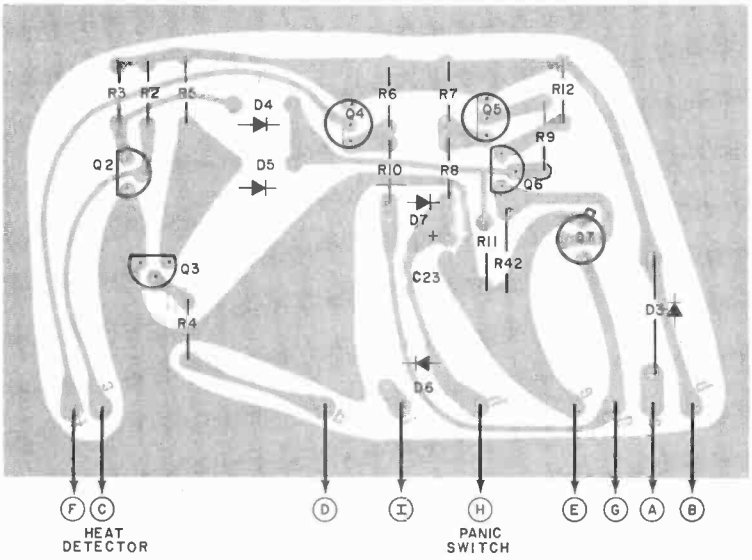
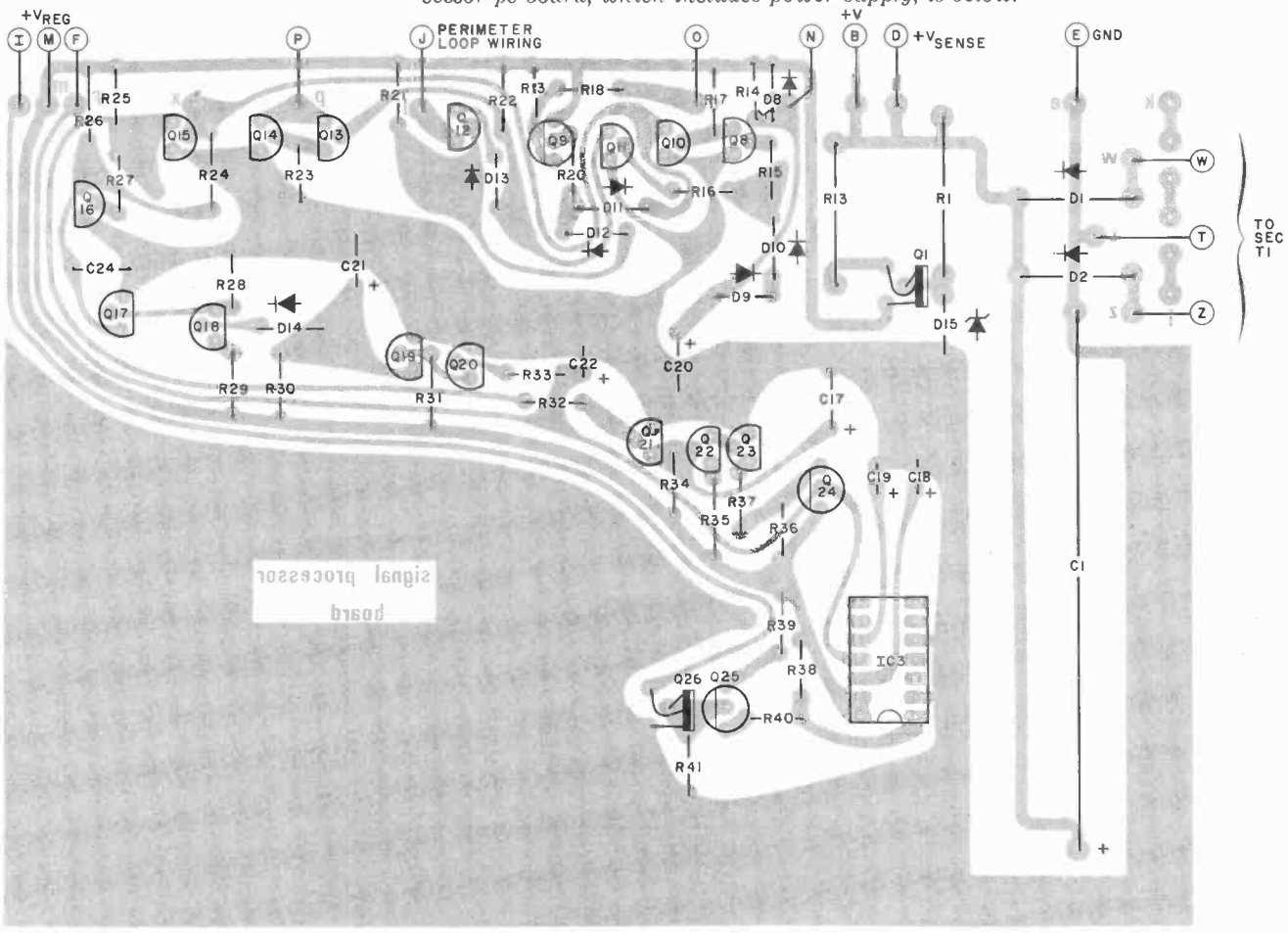


Fig. 10. Shown above is the component placement guide for Opdec system's Siren Driver module printed circuit board.

Fig. 9. Component placement guide for the Signal Processor pc board, which includes power supply, is below.



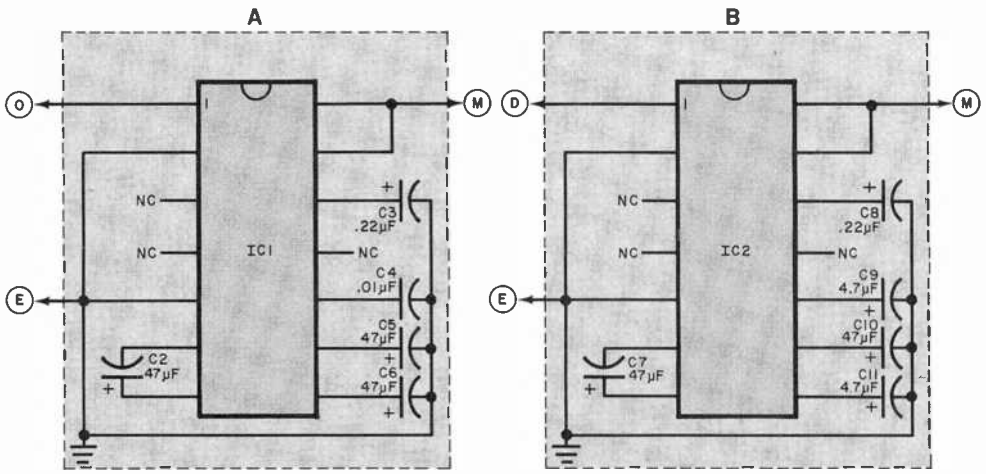


Fig. 11. Wiring diagrams for motion sensor (at far left) and special lightning sensor (left).

Because most smoke detectors do not detect fire, it is also wise to install heat detectors (available at most electrical supply houses) in areas where instant flare-ups could occur (i.e. furnace rooms, areas where paint and thinner are stored, etc.). These detectors, which behave like normally open switches, can be wired in parallel to point C of the Siren Driver module and ground. Whenever a heat detector attains a certain temperature, it behaves like a closed switch. It will then cut off *Q2*, which enables the siren driver via *R3* and *D4*. The Opdec system need *not* be armed for this to occur.

Construction. Printed circuit construction techniques are recommended for the assembly of the Motion Detector, Signal Processor, and Siren Driver modules. Full-size etching and drilling guides for printed-circuit boards for these modules are shown in Figs. 4, 5, and 6. The corresponding component placement guides appear in Figs. 8, 9, and 10. Note that there are two component placement guides in Fig. 8. The first (Fig. 8A) is the guide for the standard motion sensor, and the second (Fig. 8B) is for the lightning sensor that momentarily disarms the system and prevents false alarms.

Mount all resistors first, then the semiconductors. The capacitors should be mounted last. Take care to apply the minimum amounts of heat and solder consistent with the formation of good solder joints. Each module should be housed in a suitable enclosure. The lightning and motion detectors should be mounted in an enclosure measuring approximately 2¾" × 2⅛" × 1⅝" (7cm × 5.4cm × 4.1cm). Each printed circuit is mounted using ¼" (6.4-mm) spacers. A 5/16" (8-mm) hole should be drilled in the front of each sensor enclosure directly in line with the center of the ULN-2232A integrated circuit to allow light to reach the IC.

The circuits and circuit boards of the motion and lightning sensors are identical except for part number designations and component (capacitor) values. These are given in both the component placement guides of Fig. 8 and the wiring diagrams of Fig. 11.

A master wiring diagram for the Opdec system appears in Fig. 12. Interconnecting the modules will be greatly simplified if barrier block terminal strips are installed on the module enclosures and connected to the appropriate circuit board foil pads. The strips should be letter-coded to agree with the scheme used in Fig. 12 and the component-placement guides, and the wires used to interconnect modules should be color-coded. Because the cost of the ULN-2322A IC sensor is comparable to that

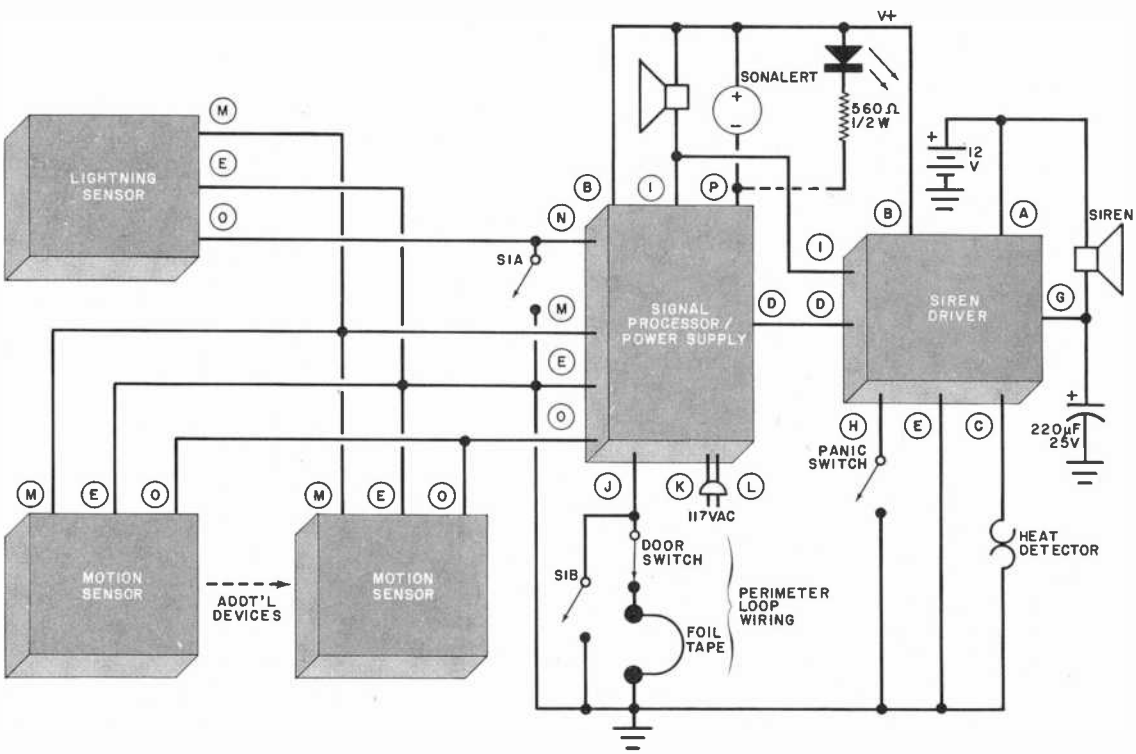


Fig. 12. Master wiring guide for complete Opdec system with optional closed loop and heat detector.

of a quality magnetic reed switch, it can be used liberally throughout the premises to be protected. Each sensor module should be connected to the Signal Processor module using three lengths of flexible, stranded hookup wire (No. 22 or larger). Heavier gauge hookup wire (No. 18 or larger) should be used for the rest of the connections.

Installation and Use. The siren and the Siren Driver module should be installed in the attic or some other area where the intruder will not be able to locate it readily. The Signal Processor module can be mounted in any convenient area such as an entrance closet. As was mentioned earlier, any attempt to tamper with the Signal Processor module will set off the siren. The ARM/DISARM switch, *S1*, should be located in a convenient spot but not easily detectable by an intruder.

DESIGN SPECIFICATIONS
ULN-2232A
SPRAGUE INTEGRATED
MOTION DETECTOR

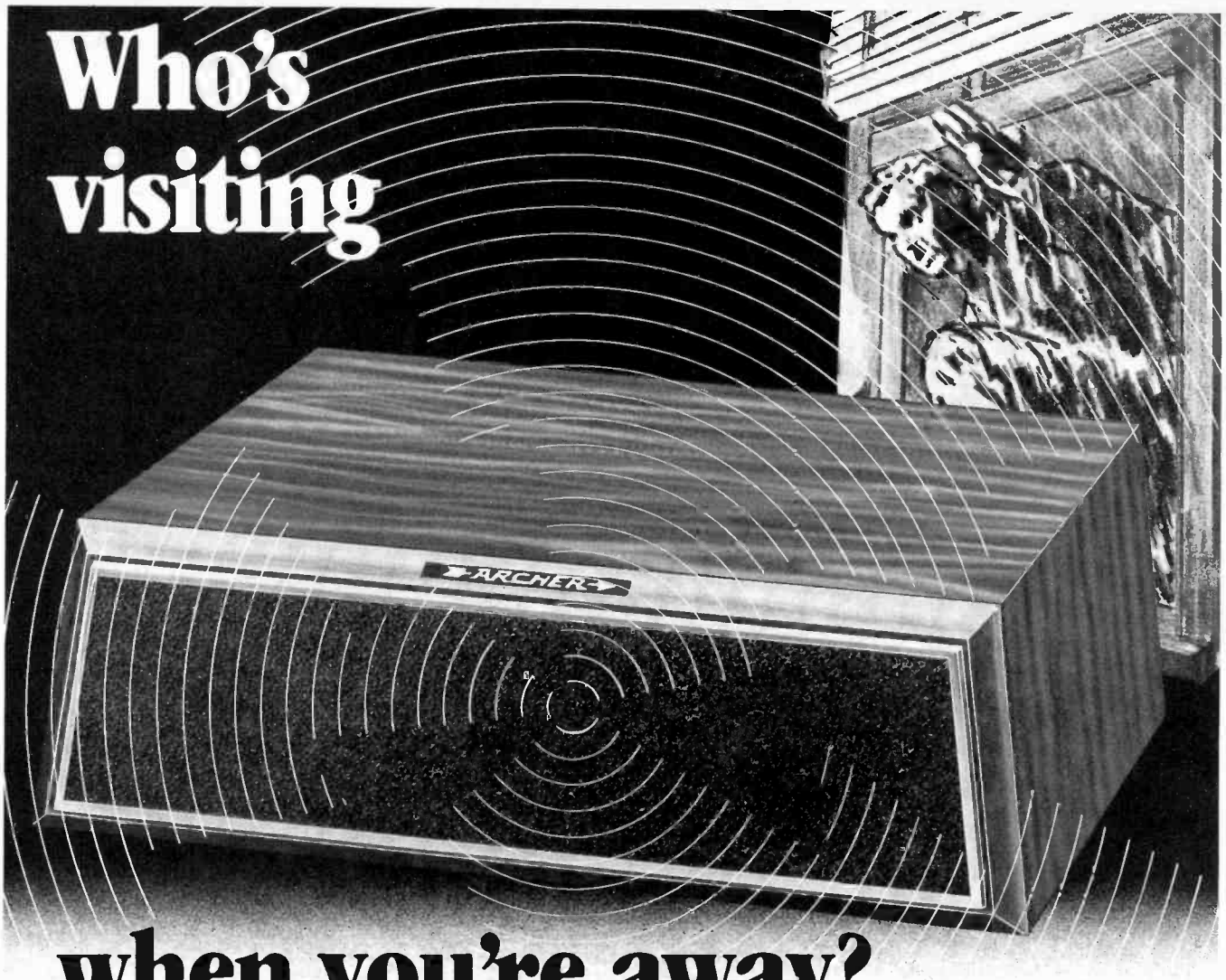
Supply voltage: +3.0 to +4.5 volts dc
Ambient temperature: +10°C to +40°C
Current demand: 20 mA maximum when V_{CC} equals +4.5 volts
Minimum sensing range: 8' (2.4 m)
Sensitivity: $\Delta L = \pm 5\%$ at 1 Hz
Ambient light: 0.1 fc to 100 fc (1.08 lux to 1076.4 lux or 1.08 lumens/m² to 1076.4 lumens/m²)
Alarm sweep: 200 to 1000 Hz
Alarm sweep rate: 5 Hz
Audio output: 100 mW continuous
Device fabrication: Monolithic IC containing linear amplifiers employing pnp and npn bipolar junction transistors; I²L gates, counters, and D/A converter; low-leakage photodiode; and bipolar junction power transistors.

The ideal number and location of Motion Sensor modules in your Opdec system depends on the size of your home or office and the number of areas that need protection. Sensor modules can be placed on kitchen counters, on TV receivers, or even mounted within a suspended ceiling into which a (5/16" or 8-mm) hole has been drilled. In deciding where modules are to be placed, keep in mind that they sense motion by detecting *changes* in light level. Therefore, do not aim a Motion Sensor module toward a window or any flashing lights. During the daytime, there should be sufficient natural illumination to permit operation of the sensors. At night, however, some source of artificial light will have to be used. Readily available photoelectric or electromechanically timed devices can be employed to automatically turn on such lights at dusk. Make sure that the artificial light sources are *simultaneously* activated and that one of them is placed near the lightning detector. This module will momentarily disarm the system, thus preventing the Motion Sensor modules from triggering the Signal Processor when power is applied to the lamps.

Options. Depending on factors peculiar to each site at which an Opdec system is to be installed, there are several optional changes that can be made. For example, if you think that lightning or some similar phenomenon is not a problem in the area to be protected, simply eliminate the lightning detector. Also, you can mount a key-operated dpst switch outside the premises to be protected for use as *S1*. If this is done, the exit and entry delays will no longer be needed. Accordingly, the following Signal Processor components can be eliminated: transistors *Q8*, *Q10*, and *Q11*; diodes *D8*, *D9* and *D10*; resistors *R14*, *R15*, and *R16*; and capacitors *C17* and *C20*. If this is done, connect the position lug of both portions of the dpst switch to point E. Connect one switch pole to the base of *Q13* and the other pole to that of *Q15*.

If you prefer to have the alarm remain on indefinitely after the system has been triggered, eliminate the automatic time-out feature. This is done by omitting the following Signal Processor components: transistors *Q17* through *Q20*; diode *D14*; resistors *R28* through *R31*, and *R33*; and capacitors *C21* and *C22*. Finally, if a back-up battery power source is not needed, the Siren Driver module, the siren, and the battery can be eliminated. If this is done, the collector of *Q26* (point I) can be used to sink current from the positive supply through a dynamic loudspeaker to ground.

In Conclusion. Opdec is an inexpensive but sophisticated alarm system that can enhance the security of business or residential premises. Its optical sensors can detect not only intruders but also smoke of fire. The system is thoughtfully designed and is readily expanded to include heat detectors, closed-loop sense wiring, and a large number of optical Motion Sensor modules. ◇



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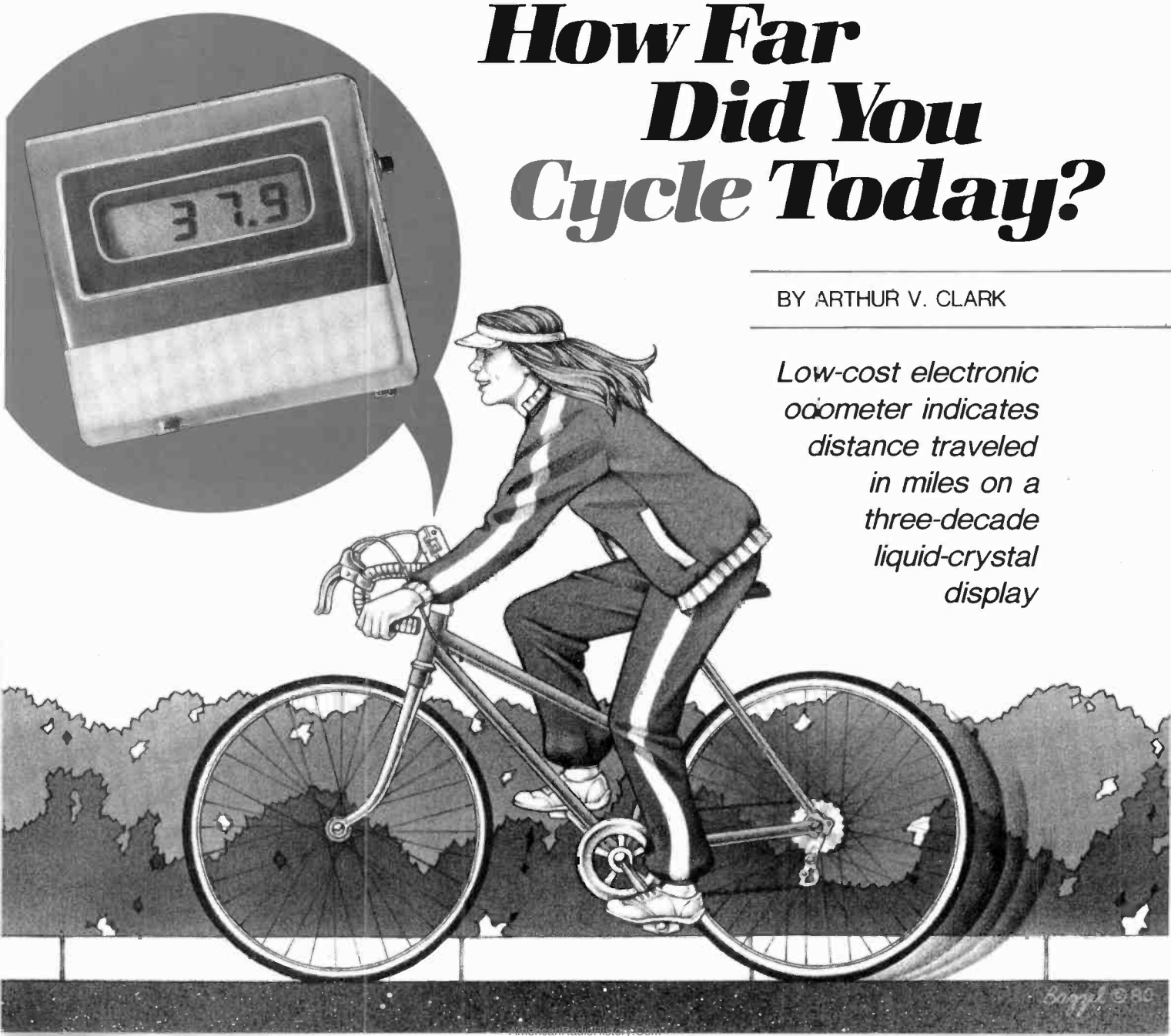
How Far Did You Cycle Today?

BY ARTHUR V. CLARK

Low-cost electronic odometer indicates distance traveled in miles on a three-decade liquid-crystal display



WHETHER you pedal according to a strict exercise regimen or just for fun, you probably want to know how far you travel on your bicycle. Presented here is an electronic odometer for cyclists that allows you to do just that. Its design provides advantages lacking in many commercially available odometers. Wheel motion is sensed magnetically, obviating drag, slippage, noise generation, and sensitivity to misalignment, one or more of which can characterize the mechanical sensing systems employed in many commercial products.

Digital counters tally the number of wheel revolutions sensed and convert this number into the total distance (in miles) travelled. The counters, which can be reset to zero at the push of a button, drive a liquid-crystal display that is highly legible in the brightest daylight. Accuracy of the odometer is limited by the tenth-of-a-mile resolution of the display. Parts count is low, and, thanks to the use of CMOS ICs and a liquid-crystal readout, the circuit draws very little current from its self-contained battery power source.

About the Circuit. The Electronic Odometer is shown schematically in Fig. 1. Travel is measured by means of *S1*, a magnetically actuated reed or LC2 mercury-film switch mounted on the bicycle frame. Each time a magnet on the rim of the front bicycle wheel passes near the switch (which occurs once each time the wheel makes a complete revolution), the switch closes. Thus, a series of momentary switch closures is generated when the bicycle is in motion.

The reed switch is connected to the rest of the project by a short length of two-conductor cable terminated with subminiature phone plug *P1*. This plug is inserted into matching jack *J1*. When *S1* is open, the CLOCK input (pin 10) of 12-stage binary counter is at V_{DD}. During the brief interval that *S1* is closed, the counter's CLOCK input is at V_{SS}. It is in this manner that the series of switch closures is converted into a train of clock pulses that counter *IC2* can process.

This counter is triggered by the negative transition of each clock pulse. When it has counted 74 of them (equalling a tenth of a mile traveled for a bike with

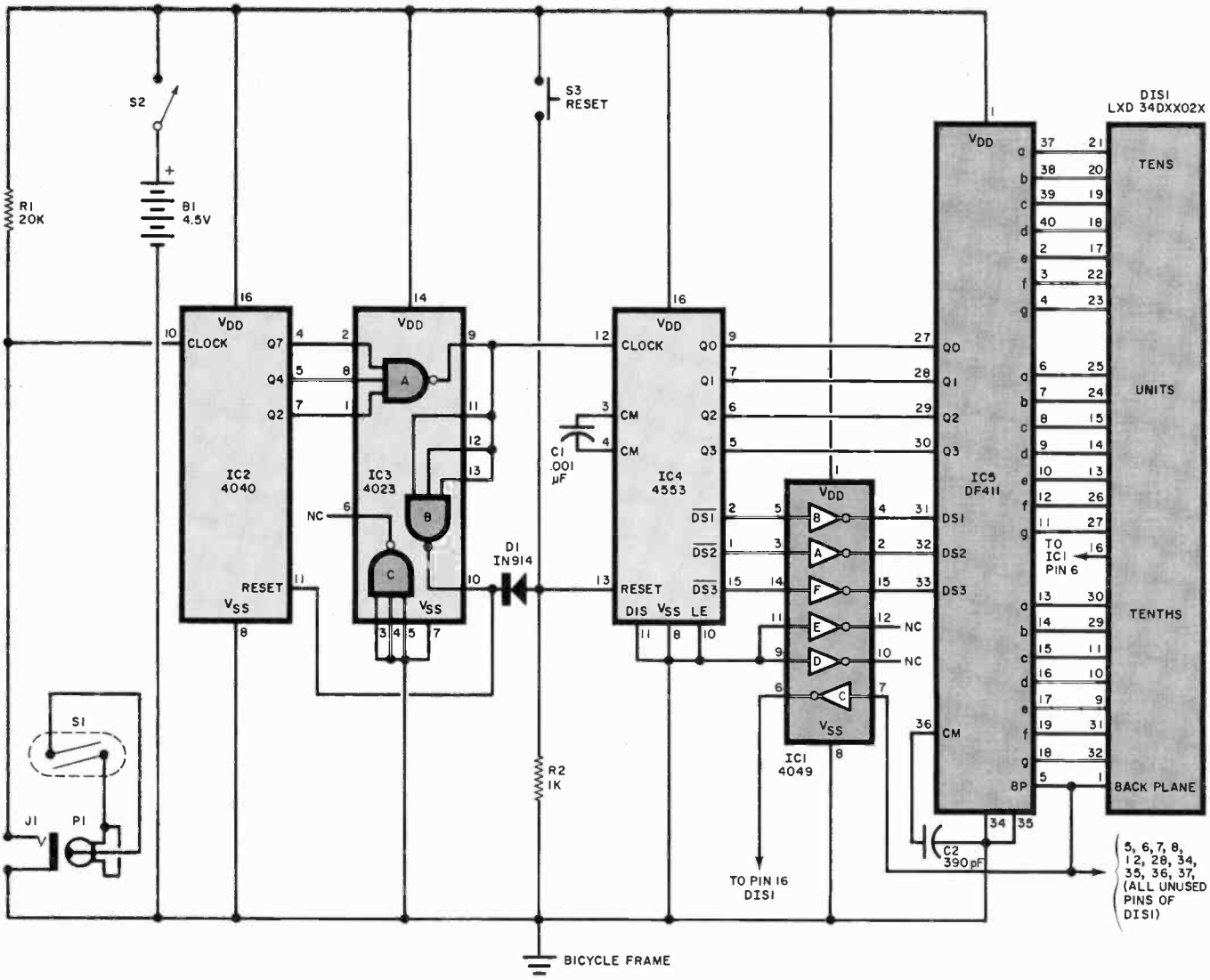


Fig. 1. Schematic diagram of the bicycle odometer. Counter IC2 converts closures of S1 into pulses representing distance traveled. These are tallied by IC3 and displayed by DIS1.

27-inch wheels), pins 4, 5, and 7 are at logic one (V_{DD}). These logic levels are applied to the three inputs (pins 1, 2, and 8) of NAND gate *IC3A* and cause its output (pin 9) to go to logic zero. This negative-going pulse clocks *IC4*, a three-decade counter/BCD decoder with multiplexed outputs. The pulse is also applied to NAND gate *IC3B*, which inverts it to provide a positive-going reset pulse for 12-stage binary counter *IC2*. The binary counter then starts to tally the clock pulses generated by *S1* during the next tenth of a mile.

Each clock pulse applied to pin 12 of *IC4* is counted and stored in the chip's latch, up to a maximum count of 999. Because each pulse corresponds to a tenth of a mile of travel, the maximum tally will signify a total distance of 99.9 miles. This stored information is time-division multiplexed and presented sequentially, one BCD digit at a time, at output pins 5, 6, 7, and 9.

PARTS LIST

B1—Three series-connected 1.5-volt alkaline or NiCd cells
C1—0.001-μF disc ceramic
C2—390-pF disc ceramic
D1—1N914 silicon switching diode
DIS1—LXD 34DXX02X liquid-crystal seven segment display
IC1—CD4049 hex inverter
IC2—CD4040 12-stage binary counter
IC3—CD4023 triple 3-input NAND gate
IC4—F4553 or MC14553 3-decade counter/BCD decoder with multiplexed outputs
IC5—DF411 multiplexed BCD-to-seven-segment decoder/liquid-crystal display driver
J1—Subminiature phone jack
P1—Subminiature phone plug
R1—20,000-ohm, ¼-watt, 10% carbon-composition resistor
R2—1000-ohm, ¼-watt, 10% carbon-composition resistor
S1—Normally open reed or LC2 mercury-film spst switch
S2—Spst toggle switch
S3—Normally open momentary pushbutton switch
Misc.—Printed circuit board, IC sockets or Molex Soldercons, suitable enclosure, No. 16 AWG brass wire, wood or aluminum block, two-conductor cable, hookup wire, battery holder, printed circuit board standoffs, solder, epoxy cement, permanent magnet, etc.

Note—The DF411 display driver is manufactured by Siliconix Inc., 2201 Laurelwood Road, Santa Clara, CA 95054. The LXD 34DXX02X liquid-crystal display is manufactured by Liquid Xtal Displays Inc., 24500 Highpoint Road, Cleveland, OH 44122. A suitable LC2 mercury-film normally open spst switch is manufactured by Fifth Dimension Inc., Box 483, Princeton, NJ 08540.

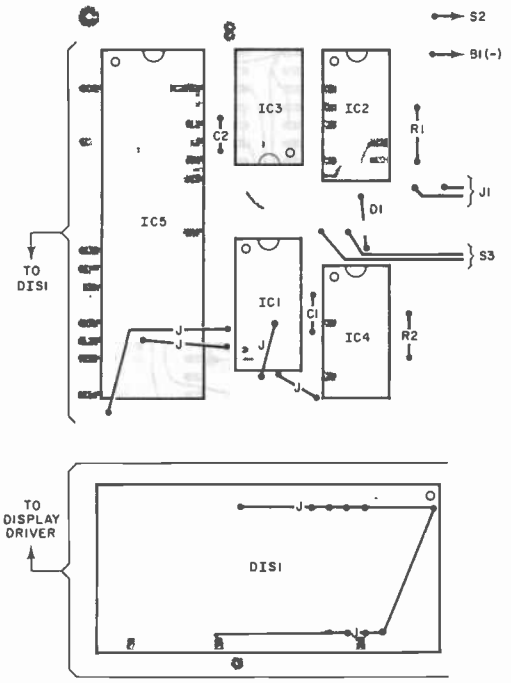


Fig. 2, Full-size etching and drilling guide for a suitable printed circuit board is at left.

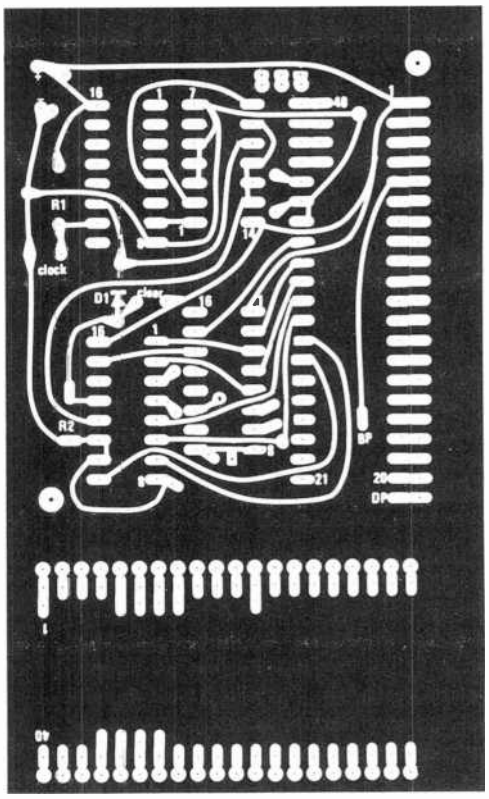


Fig. 3. Component layout for the printed circuit board is at right.

An on-chip oscillator, whose frequency is determined by the value of *C1*, governs the multiplexing of the BCD digits and provides DIGIT SELECT control pulses at pins 2, 1 and 15 of *IC4* for the multiplexed LCD driver. Logic levels appearing on these stobe lines are inverted by *IC1A, IC1B* and *IC1F* to be compatible with the levels required by *IC5*. The BCD numbers presented at pins 5, 6, 7, and 9 of *IC4* are applied to the input terminals (pins 27 through 30) of *IC5*, a BCD-to-seven-segment decoder/latch/multiplexed driver designed for use with a liquid-crystal display.

This complex chip's multiplexing function and the ac drive required by the liquid-crystal display are generated by an internal oscillator whose operating frequency is determined by the value of *C2*. The outputs of *IC5* drive directly the active segments of *DIS1*, a three-digit liquid-crystal display. At the same time, the common back plane of the display is driven by a voltage that is 180° out of phase with respect to the voltage applied to the activated segments of the display. In accord with good design practice, the unused inputs of CMOS logic chips *IC1* and *IC3* are committed to logic zero.

Power for the Odometer circuit is provided by *B1*, the series connection of three 1.5-volt alkaline or rechargeable NiCd cells. Because the circuit's current demand is very modest, long alkaline cell life (or, in the case of NiCd batteries, extended intervals between recharges) can be expected.

Construction. The use of a printed circuit board is recommended because it results in a compact, rugged assembly. A full-size etching and drilling guide for a suitable board is shown in Fig. 2. The corresponding component placement guide is shown in Fig. 3. This board calls for some close work, so be sure to use a fine-tipped soldering pencil and small-diameter solder. When soldering component leads to the board, apply the minimum amounts of heat and solder needed for good connections.

A single-sided printed circuit board is employed to simplify its fabrication. This means, however, that several insulated jumpers must be used. These jumpers must be installed first, because components will be mounted on top of them. Next, install the fixed resistors, capacitors and convenient lengths of flexible hookup wire that will be used to connect the circuit board to the battery holder, switches, and phone jack.

The last components to be installed are the semiconductors and the display. Be sure to orient each semiconductor carefully, observing its polarity and pin basing. Follow the standard procedure for handling MOS devices. The use of IC sockets or Molex Soldercons will minimize the risks posed to the chips by improper handling, the application of excessive heat during soldering, etc. Be sure to inspect your work carefully for solder bridges.

In the author's prototype, that portion of the circuit board containing the liquid-crystal display was sawed and separated from the rest of the board. It was then interconnected with the display driver using convenient lengths of flexi-

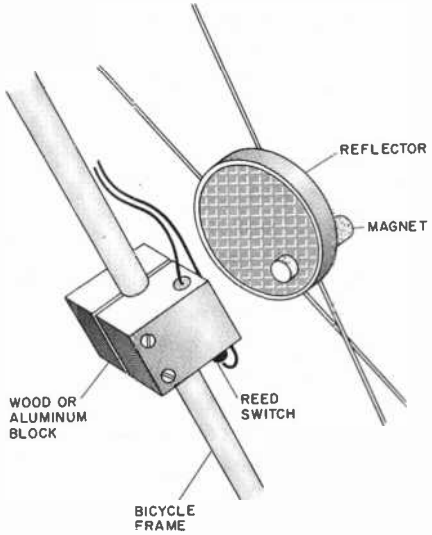


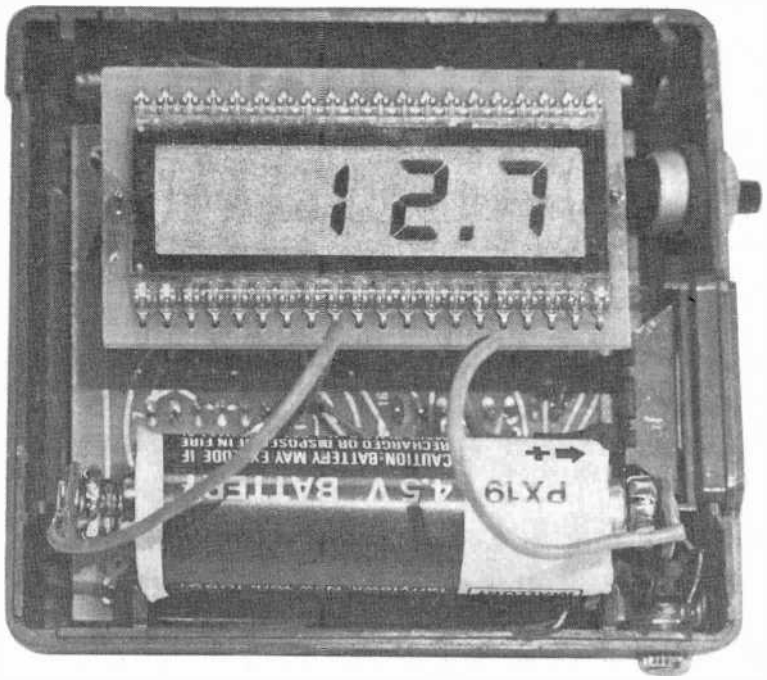
Fig. 4. Details of the author's actuating magnet/motion sensor switch assembly.

ble hookup wire (using Fig. 3 as a guide) and was stacked above the printed circuit board by two slender rods made from No. 16 AWG brass wire running through holes drilled in the board and through corresponding holes in the display board. This assembly was secured together by means of epoxy cement.

An enclosure for the project was made from the case of a defunct calculator by cutting it in half and cementing the end cap back on with epoxy. A threaded bolt was run through a hole drilled in the case and cemented to it with epoxy. This bolt and a matching wing nut permit quick, easy installation and removal of the project from the bicycle's front reflector bracket. Connection of the circuit common to the bicycle frame is accomplished by the mounting bolt, wing nut, a solder lug and the reflector bracket.

inserted into this hole and secured with epoxy cement. A drawing of the complete switch and magnet assembly devised by the author appears in Fig. 4. Note that the switch block was cut in half after drilling a hole in it corresponding to the diameter of the bicycle fork's tubing. This allows the block to be secured to the fork by means of retaining screws. Note also that the reed switch was installed in another hole drilled in the block.

Checkout and Use. Connect the probes of an ohmmeter to *P1* and lift the bicycle frame so that the wheel to which the actuating magnet has been attached can turn freely. Rotate the wheel and note the ohmmeter reading. It should indicate an open circuit until the actuating magnet passes near the reed switch, at which point a short-circuit reading



Internal view of the author's prototype odometer shows display, circuit board and battery fit in a compact plastic case.

The wheel-motion sensor switch is installed by securing a normally open reed switch to a block of wood or aluminum with epoxy. This block is then secured to one of the bicycle forks. Either the front or rear fork can be used, but installing it on the front fork permits the use of a shorter cable (terminated in subminiature phone plug *P1*) to connect the switch to the rest of the circuit.

The actuating magnet is installed by drilling a suitable hole in the plastic reflector of the appropriate wheel. A strong permanent magnet should be

should be seen. If this does not occur, adjust the position of the switch assembly until a switch closure is obtained each time the magnet passes the switch.

Now plug *P1* into *J1* and apply power to the project. The display should read 00.0. If it indicates some other number, momentarily depress *S3*. Rotate the wheel a total of 74 revolutions. The display should now register 00.1. If it does, the project is working properly, and you are now ready to take your first bicycle trip with an Electronic Odometer. ◇

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Four varying light intensities are built into the viewing display, allowing the Sunwatch to adjust automatically to any light. This means you can always read it, even in the brightest sunlight.

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The Sunwatch is capable of displaying the following information: hours • minutes • seconds • months • date • day • leap year • speed calibration • AM/PM indicator • seconds count-off.

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The workings of the watch: solar panels, energy cells, quartz crystal, computer on a chip, etc., are all permanently sealed in a Lexan module. This module is so unique it's protected by U.S. and foreign patents.

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Leave the Sunwatch in salt water for months. Dive with it in depths up to 750 feet. There are no openings — magnetic slide bars activate all functions. With Sunwatch's exclusive, permanently sealed Lexan module, there are no "O" rings or seals to leak.

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You can crash it into a rug-surfaced brick wall at 90 mph with no noticeable effect. Wear it while doing heavy work, exercise or any strenuous activity.

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Put the Sunwatch in boiling water for 30 minutes, freeze it in a block of ice for a year. Extreme temperatures will not damage your Sunwatch.

Pressure resistant
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Made in the United States
The Sunwatch, designed by Roger Riehl, was being worn by its inventor nearly a year before the first electronic digital watch was even available to the general public. Since that time constant engineering evaluations and design improvements have been made on the Sunwatch to incorporate the latest in digital microcircuit and solar power technology. Thus the Sunwatch today represents state-of-the-art electronics technology. It is built to the same rigid standards practiced by the manufacturer in creating sophisticated computer microcircuits for the U. S. Government and other major users of these components.

*** A word about other "Solar Watches"**
Roger Riehl, designer of the Sunwatch, states that there is no other completely solar powered watch on the market today. Claims of solar power by other watch manufacturers are based on the use of a small solar cell. Due to their limited size, these cells can be proven, in technical terms, to be of virtually no significant value in extending the life of a watch battery. For this reason, all other so-called "solar watches" must have replaceable batteries. The Sunwatch's power storage system, however, need never be changed and is, in fact, permanently sealed to withstand abuse and the elements.

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MERCURY 1980©

For over a year now, in magazines and newspapers the world over, there have been enthusiastic write-ups on a remarkable new device that can cut your electric bill while helping the U.S. save huge quantities of fuel.

"The NASA/Nola power saver," wrote a **Popular Science** senior editor, "was developed by Frank Nola at NASA's George C. Marshall Flight Center as an offshoot of a program to reduce power consumption in spacecraft motors. Nola calls it a PFC — power-factor controller. I prefer to call it a power saver, however, because that's what it does."

NASA TESTED IT

According to Clyde S. Jones of NASA, "The device has been tested at Marshall Center on over 40 types of motors, with power savings ranging up to 60%, depending on the loading. The motors tested were both single-phase and three-phase, ranging from ½ H.P. to 5 H.P. Most motors will show up to 40-to-50% savings when running lightly loaded or unloaded, and some will show 5-to-7% savings at rated load."

NASA's Technical Support Package showed the test results and noted that "The Power Factor Controller applies to induction type electric motors — the most commonly used type in all major home appliances and the most commonly used by industry."

HOW IT SAVES POWER

Popular Electronics explained it this way: "AC induction motors characteristically run at a nearly constant speed that's fixed by power-line frequency and independent of load and supply voltage. When heavily loaded, the motor draws line current that is nearly in phase with the applied voltage . . . Under light load conditions, the motor develops less torque by allowing more lag between the voltage and current. This reduces the power factor while leaving the current essentially the same in magnitude.

"Though the low power factor means that conversion of electricity to mechanical power is small, the large current causes considerable (heat) losses in the supply lines and motor windings. This is what reduces efficiency.

"To minimize this waste, Nola's device monitors the motor's power factor and, when it detects light load conditions, it reduces the supply voltage . . . The current, now more nearly in phase with the voltage, therefore does as much useful work as before, but it and the voltage are smaller, resulting in a net savings of electrice power."

THE SAVINGS CAN ADD UP

Like everything else, the cost of electric power keeps going up. Not only is the basic rate you pay going up, the power companies have now added on a "fuel adjustment" charge to help pay for running their generators. In 1980, 1981 and beyond, you'll pay more and more for the privilege of running your electric appliances.

Right now, the typical consumer pays about $8 per month to operate a 16.5 cu. ft. frost-free freezer . . . $10 to run a 17.5 cu. ft. frost-free refrigerator . . . $8.25 for an attic fan operating 12 hours a day . . . and about $60 for an air conditioner used during summer months. It's not hard to figure out what you're paying per year just to run **one** of these appliances. And in many parts of the country, the cost is even higher.

That's why Nola's power saver can soon pay for itself, then start reducing your electric bills — the amount of savings, of course, depending on which appliance(s) you usetit with.

There's just one catch. Until now, the device has not been **available** — except for industrial models prices at $80 or more.

INTRODUCING THE WATT WIZARD

Cynex, an American manufacturer of electrical and electronic products and a prime contractor for the U.S. Government, has been licensed by NASA to manufacture Frank Nola's power saver. Cynex calls it the Watt Wizard.

"The Watt Wizard," says Ray Beauchea, the firm's Marketing Director, "regulates the voltage fed into an induction motor, reducing or boosting power as required, when loads go up or down. Simply stated, it makes motors run more efficiently, especially when idling. It reduces motor heat, affording longer motor life and reducing the amount of air conditioning required for cooling (rooms) in summer months. It saves electric power, because kilowatt hours are greatly reduced. And it causes the motor to run quieter."

SIMPLE TO USE

Cynex makes several models of the Watt Wizard (all with solid state design), including the 110 V AC plug-in model we're offering. It's for single phase fractional H.P. motors (less than 1 H.P.) which is the type used in most made-for-the-home freezers, refrigerators, window and attic fans, swimming pool pumps,furnace fans, vacuum cleaners, sewing machines, power drills, etc.

Simply plug the Watt Wizard into any electric outlet, then plug the appliance into the Watt Wizard. There's no wiring required. Unlike some competitor's models (if and when available), the appliance does **not** have to be turned on before being plugged into the power saver. You can leave the appliance — whether on or off — plugged into the Watt Wizard all the time. Or you can move the Watt Wizard to various locations, depending on which appliance is being used. (Better yet, order several Watt Wizards.)

OTHER MODELS AVAILABLE

Air conditioners, washers and dryers require wire-in model. If you lack mechanical skill, you probably need an electrician to install it. We also offer it in 220 VAC single or three-phase.

ADVANCE FEATURES

The Watt Wizard also includes two more unique features. It's fused, so if you accidently overload the device, it won't burn out. Just change the fuse, which is available at any auto supply store.

And the Watt Wizard features an LED readout, so you can actually tell, at any moment, exactly how much power you're saving — 10%, 20%, 30%, 40% or 50%.

There's a "Power On" light, too. And the Watt Wizard comes with the manufacturer's 1-year limited warranty.

LOW COST — AND A TAX CREDIT

We're offering the Watt Wizard for only **$39.95,** with **immediate delivery.** Want two? Then it's just **$37.95** each. Or splurge and get three at **$34.95** each. Wire-in models for heavy duty motors are **$6** more for each unit. Add just **$2.50** postage/handling for each **order** (not each unit).

And next year, when you fill out your tax return, you can deduct a full 15% energy tax credit — for additional savings.

30-DAY MONEY-BACK GUARANTEE

Try the Watt Wizard for up to 30 days. If not completely satisfied, return it (insured) for a full refund.

The sooner you send for the Watt Wizard, the more you can save on your electric bills. To order, send your check or money order to the address below. Or charge it to your Visa, MasterCharge, American Express or Carte Blanche credit card. If using your charge card, you can also order via our toll-free phone number:

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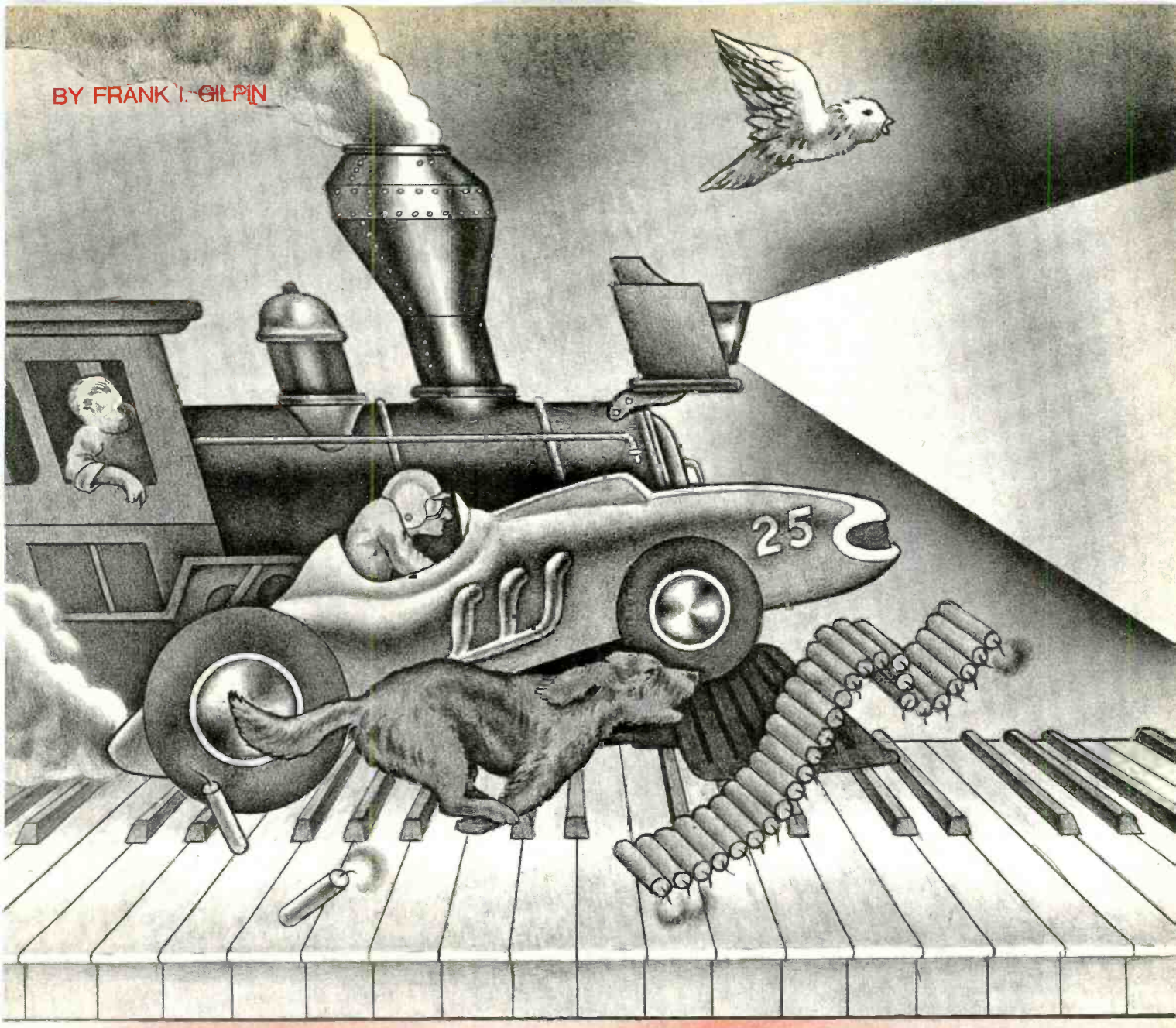


EXPERIMENTING WITH A SOUND-EFFECTS GENERATOR

UNTIL a couple of years ago, experimenting with sound-effects circuitry was difficult, requiring a large breadboard to accommodate oscillators of various descriptions, modulators, noise sources, mixers, envelope generators, etc. Now, thanks to Texas Instruments' SN76477 complex sound generator, an integrated circuit that sells nationally for about $3.00, sonic experimentation is far more convenient. What makes the 76477 unique is that it contains all the active circuitry needed to generate just about any sound imaginable. A few resistors and capacitors and a power supply are the only external components required.

Inside the IC Package. By considering its complex circuit as a series of function

With a minimum of extra components and a single Texas Instrument SN76477 IC, you can create a host of different sounds

"blocks," it is relatively easy to understand and follow the 76477's operation. In Fig. 1, the IC's function blocks are reduced to simplest form, with basic sound-generating blocks in gray shading and supplemental control blocks in color. Typical waveforms available at various points in the system and what the final output before amplification might look like are also shown.

A more complete picture of all the function blocks contained in the IC's 28-pin package is shown in Fig. 2. Fabricated from bipolar analog and I^2L digital blocks, this IC contains all the active circuitry needed for a user to create an almost unlimited range of sounds.

a nominal 0.1-to-30-Hz range, contingent on the values of resistance (*R*) and capacitance (*C*) connected from pins 20 and 21, respectively, to ground. Two outputs are available from this oscillator: a 50% duty-cycle square wave that is applied to the mixer and a triangular wave that can be routed to an external voltage-controlled oscillator (vco) via pin 16 or through the SLF's select logic block to modulate the internal vco.

Modulation of the internal vco covers a 10:1 range, with the lowest frequency determined by the *R* and *C* values connected between pins 18 and 17 to ground. This vco's output goes to the mixer and envelope-select circuits.

signal is present or absent, the system inhibit logic controls the output of the envelope generator and modulator. This signal also toggles the one-shot multivibrator that is used to generate the short-duration pulses used to simulate the sounds of gunshots, bells, and explosions. Time duration of the multivibrator's output signal is determined by the *R* and *C* values connected from pins 24 and 23 to ground. Maximum usable period is approximately 10 seconds.

The output from the one-shot multivibrator is passed through the envelope-select circuit that determines envelope shape and is used to modulate the envelope generator and modulator.

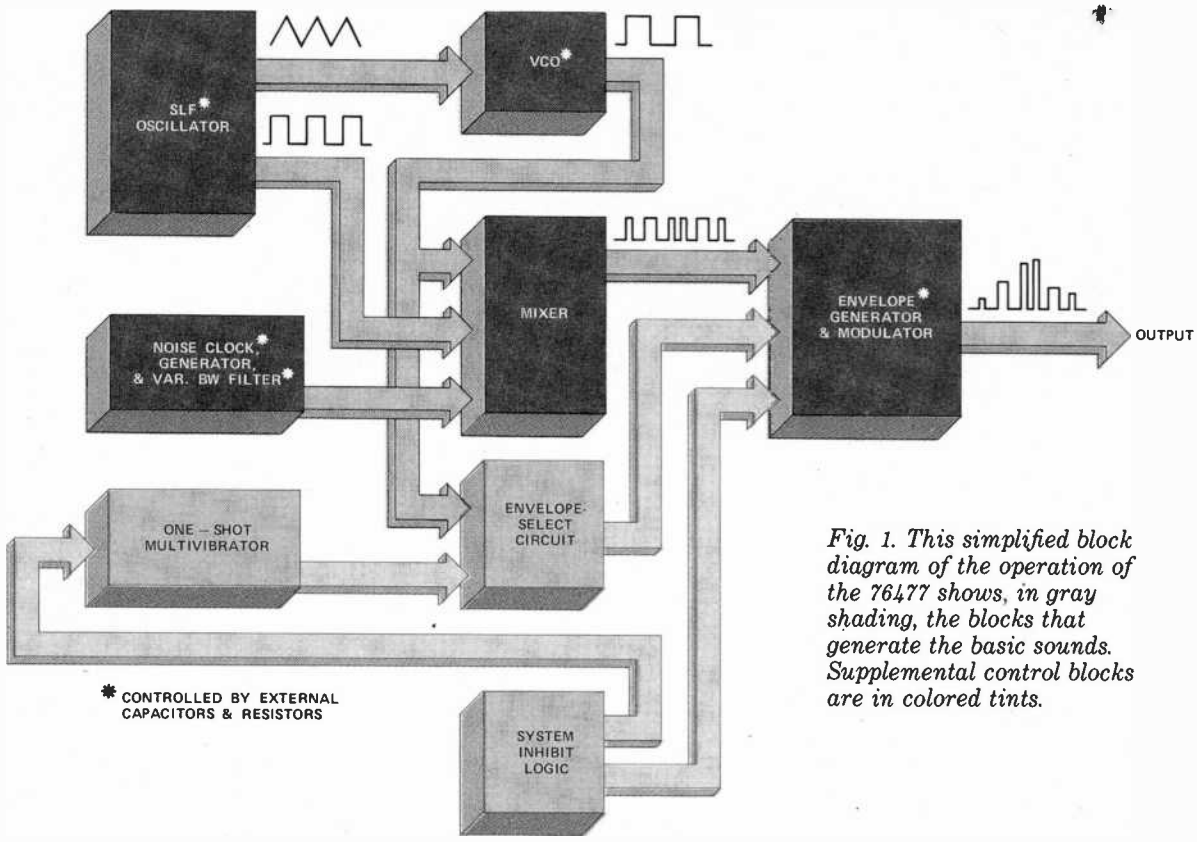


Fig. 1. This simplified block diagram of the operation of the 76477 shows, in gray shading, the blocks that generate the basic sounds. Supplemental control blocks are in colored tints.

Desired sounds are all user defined. You simply switch into and out of the IC's circuit resistor and capacitor values and set a few logic states to "tailor" the audio parameter you require. Sounds of gunshots, explosions, sirens, musical instruments, "phaser" guns, etc., can be simulated. You can even create sounds you never heard before.

An audio amplifier is built into the IC, but you can route its output to a high-quality audio amplifier to obtain a louder, richer sound.

Chip Operation. The super-low-frequency (SLF) oscillator in the 76477 has

Output pulses from the noise clock, whose frequency is determined by the resistance values connected from pins 3 and 4 to ground, are used to control the noise generator. The output from the noise generator is passed through a variable-bandwidth noise filter, controlled by the *R* and *C* values from pins 5 and 6 to ground, to the mixer.

The mixer combines the three inputs (from the noise filter, the SLF's square-wave generator, and the vco) and, contingent on the dc states of its three selector inputs, at pins 25, 26, and 27, determines type of mixer-output signal.

Depending on whether a 5-volt control

Modulator attack and decay are controlled by the *R* and *C* values connected from pins 7, 8, and 10 to ground.

The final signal is applied to the audio amplifier, which develops a 2.5-volt peak-to-peak maximum low-impedance output at pin 13. A feedback resistor can be connected between pins 12 and 13 to modify the amplifier's gain.

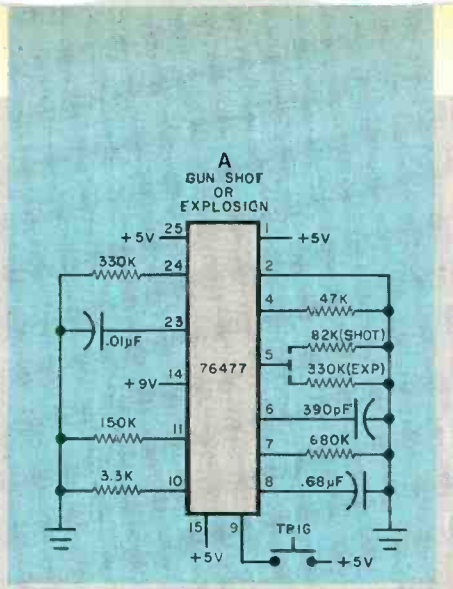
There are 23 variables under user control with the 76477 sound generator. Hence, you can be kept occupied for a considerable time exploring the effects that can be obtained with various combinations of controls.

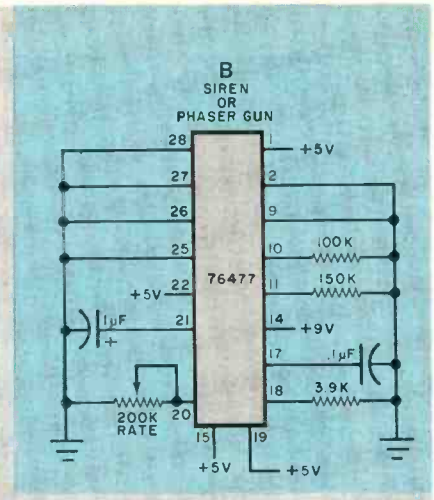
(continued on next page)

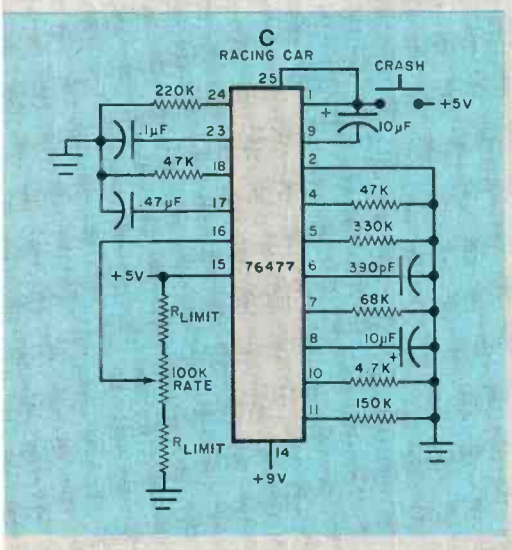
Fun Circuits You Can Build

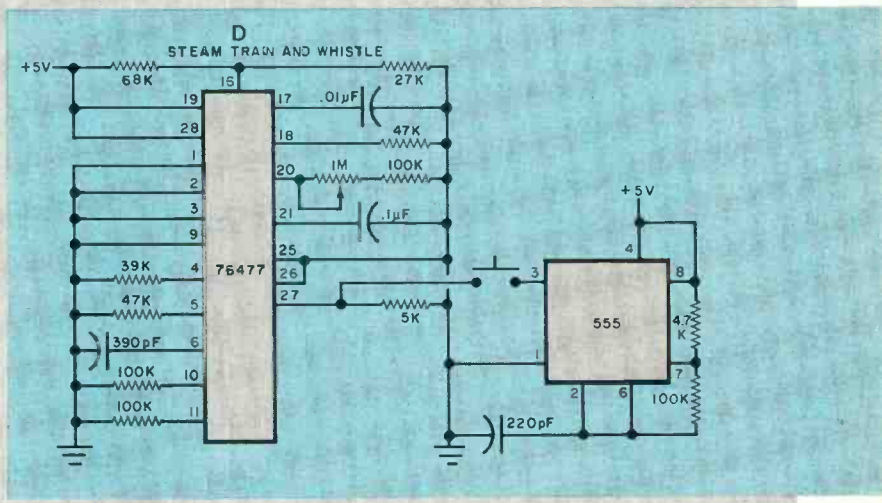
In this section, we present five fun circuits that typify some of the uses to which the SN76477 complex sound generator IC can be put. All are relatively simple and inexpensive to build, because the IC contains all the active circuitry needed.

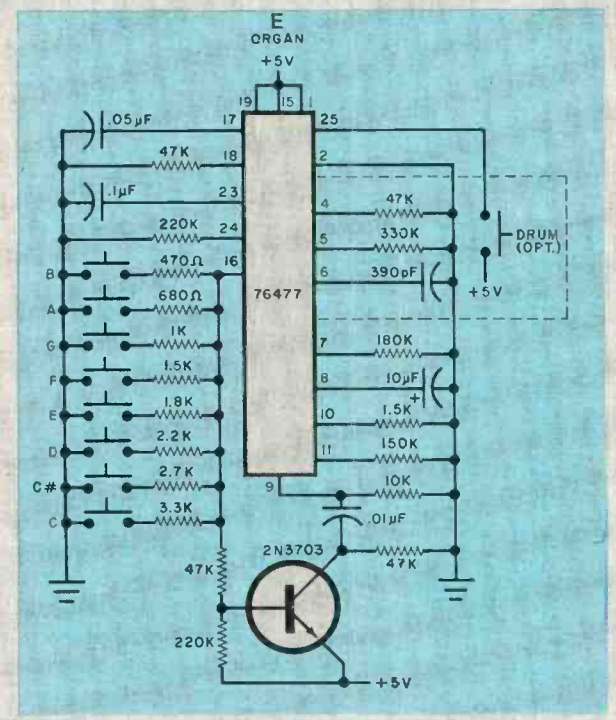
Circuits A, B, and C can be used to add realistic sound effects to the animation in video games. The model railroader will find circuit D useful, while the electronic "organ" in circuit E should appeal to all, especially children. Finally, circuit F illustrates how an outboard transistor amplifier stage can be added to increase the power delivered to the speaker.

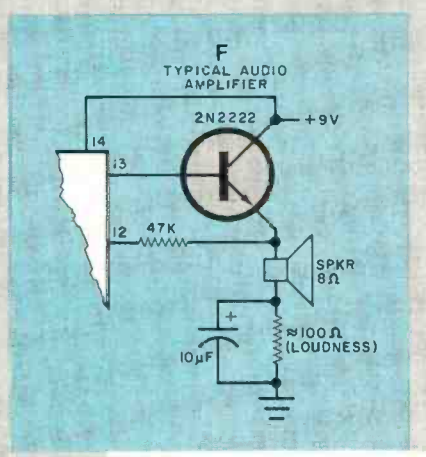












Practical Breadboard. Shown in Fig. 3 is the circuit of a practical experimenter's "breadboard." Although the circuit is really quite simple, to utilize the full capabilities of the 76477 sound generator, a rather large cabinet is required to accommodate all the switches and jacks shown.

You can use a small piece of perforated board on which to mount *IC1* (a socket is recommended) and the *Q1*/*Q2* audio amplifier circuit. Alternatively,

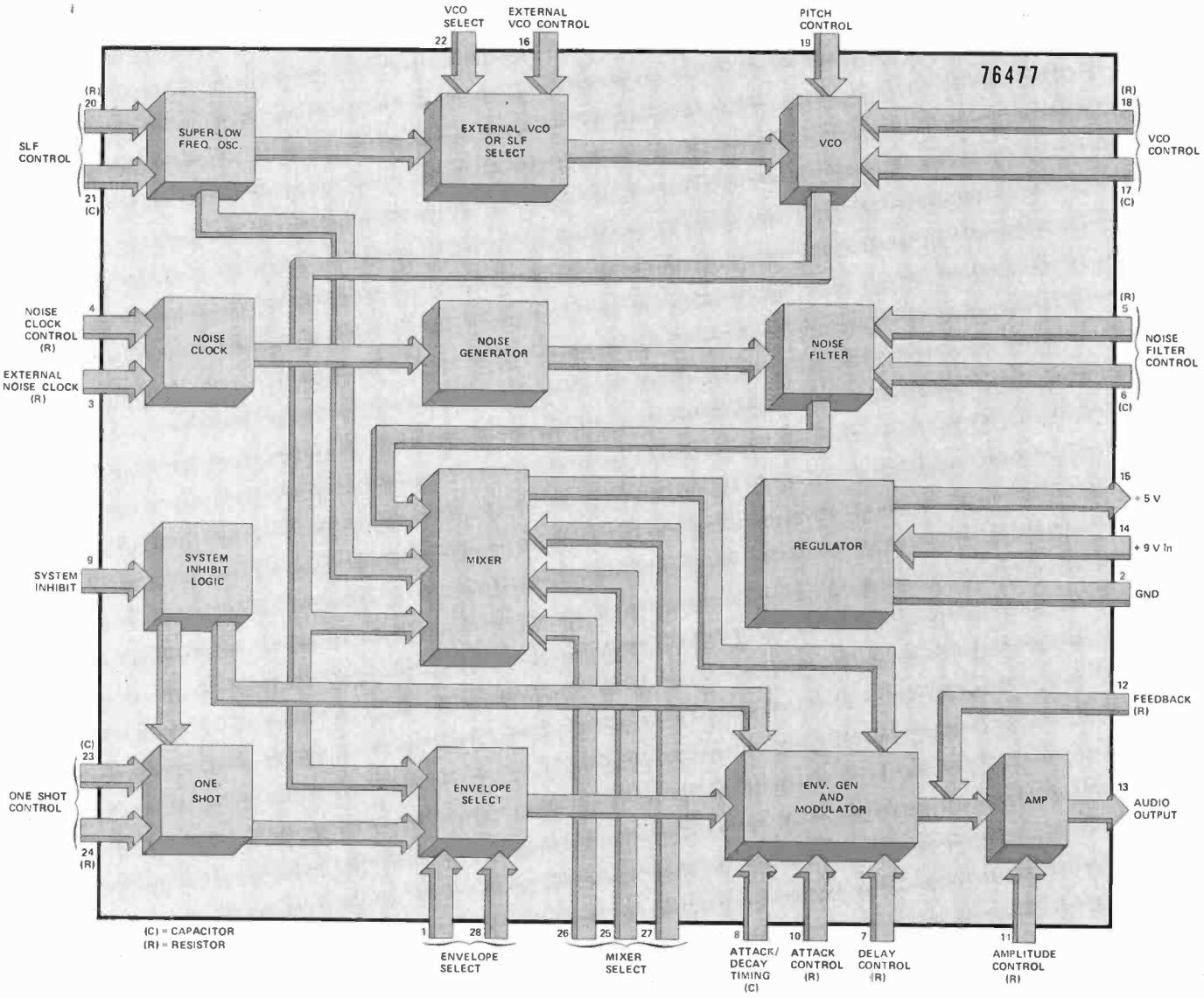


Fig. 2. The block diagram of the internal operation of a 76477 complex sound generator IC shows how it contains a complete sound-effects lab in a 28-pin package.

you can design and fabricate a printed-circuit board. If you use perforated board, you can Wire Wrap or pencil wrap the components into the circuit.

Although the system will operate from a standard 9-volt battery, you might opt for a small power supply that can deliver 7.5 to 9 volts instead, if only to free yourself from having to replace batteries periodically. Make sure, however, that the cabinet you select will accommodate all controls, jacks, and circuitry.

All 28 switches, 12 banana or tip jacks, and 8 potentiometers should be mounted on the front "control" panel and suitably identified with a dry-transfer lettering kit. To simplify experimenting, switches, jacks, and pots should be identified according to function as shown in Tables I through III. Table IV is an example of grouping according to function. Group arrangements can be outlined on the control panel with a heavily inked or painted line.

Once the various components are mounted on the front panel, refer to Fig. 3 and wire them into the circuit.

TABLE I—JACK IDENTIFICATION

J1	Input for external noise oscillator
J2	Input for external voltage-controlled oscillator
J3	Noise filter resistance measurement jack with *R4*
J4	Decay resistance measurement jack with *R6*
J5	Attack resistance measurement jack with *R8*
J6	Audio output
J7	External vco measurement jack with *R15*
J8	Vco control resistance measurement jack with *R18*
J9	Pitch control resistance measurement jack with *R23*
J10	SLF oscillator control resistance measurement jack with *R25*
J11	One-shot resistance measurement jack with *R27*
J12	Common ground

Use. Note in Fig. 3 that each IC pin that terminates in a potentiometer has both a switch and banana or tip jack in series with the pot. This permits you to use an ohmmeter to measure the resistance required for a given sound, arrived at experimentally. After obtaining the desired sound, you simply open the switch for the pot and use the ohmmeter to measure the resistance from the associated jack to ground. If you keep a log of the various resistances and capacitances required for particular sounds, they can be duplicated on demand.

(Continued on page 82)

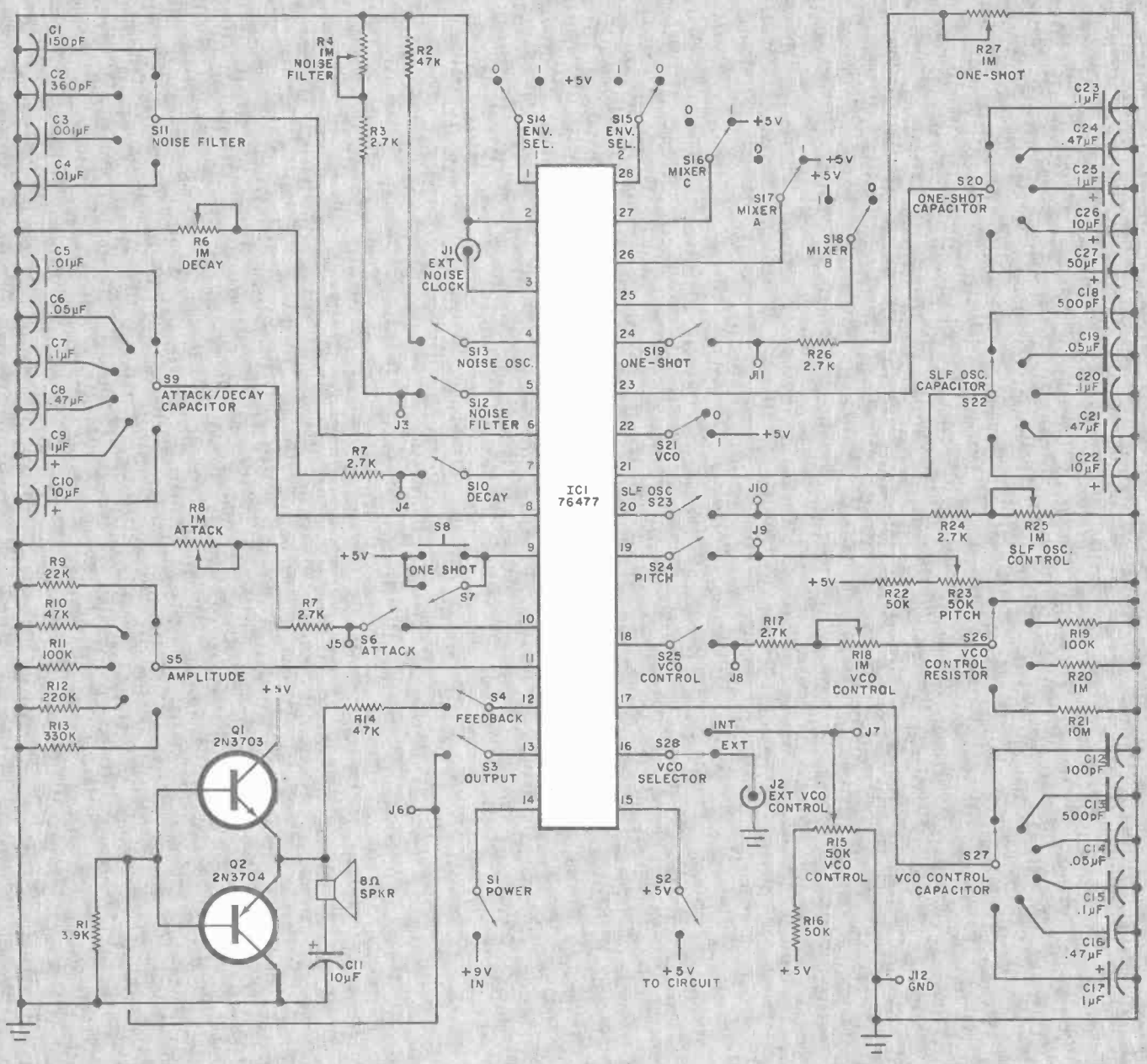


Fig. 3. The circuit for a complete sound-effects generator uses 28 switches, 12 banana (or tip) jacks and eight potentiometers to allow a broad selection of controllable parameters.

PARTS LIST

B1—9-volt battery (see text)
C1—150-pF capacitor
C2—360-pF capacitor
C3—0.001-μF capacitor
C4,C5—0.01-μF capacitor
C6,C14,C19—0.05-μF capacitor
C7,C15,C20,C23—0.1-μF capacitor
C8,C16,C21,C24—0.47-μF capacitor
C9,C17,C25—1-μF capacitor
C10,C11,C22,C26—10-μF, 15-volt electrolytic
C12—100-pF capacitor
C13,C18—500-pF capacitor
C27—50-μF, 15-volt electrolytic
IC1—SN76477N complex sound generator (Radio Shack 276-1765 or similar)
J1,J2—RCA phono jacks
J3 through J12—pin or banana jacks
Q1—2N3703 transistor
Q2—2N3704 transistor
The following are ½-watt, 10% resistors unless otherwise noted:
R1—3900 ohms
R2,R10,R14—47,000 ohms
R3,R5,R7,R17,R24,R26—2700 ohms
R4,R6,R8,R18,R25,R27—1-megohm linear-taper potentiometer
R9—22,000 ohms
R11,R19—100,000 ohms
R12—220,000 ohms
R13—330,000 ohms
R15,R23—50,000-ohm linear-taper potentiometer
R16,R22—50,000 ohms
R20—1 megohm
R21—10 megohms
S1 through S4,S6,S7,S10,S12 through S19,S21,S23 through S25—Spst slide or toggle switch
S5,S20,S22—Single-pole, 5-position nonshorting rotary switch
S8—Normally open, momentary-contact pushbutton switch
S9,S27—Single-pole, 5-position nonshorting rotary switch
S11,S26—Single-pole, 4-position nonshorting rotary switch
S28—Spdt slide or toggle switch
Misc.—Battery holder; 28-pin DIP socket for IC1; dry-transfer lettering kit; suitable enclosure; control knobs and dial plates (7); etc.

Since the circuit can generate a very wide variety of sounds, let us give an example of how you might go about "tailoring" a specific sound with the breadboard. In this example, we will use the sound of a gunshot.

First, close FEEDBACK switch *S3* and OUTPUT switch *S4* to place the audio amplifier in the circuit. Then close +5V switch *S2* to activate the +5-volt line. Main POWER switch *S1* can now be closed when you are ready to experiment with the controls.

Since a gunshot has fast attack and relatively brief decay times, close ATTACK and DECAY switches *S6* and *S10*, respectively, to permit you to adjust attack and decay times via ATTACK and DECAY pots *R8* and *R6*. As you experiment with various settings of these controls, close main POWER switch *S1* and press and release ONE SHOT switch *S8* to hear the gunshot sound for each combination of settings. Adjust *R6* and *R8* and press and release *S8* until the sound obtained is "just right." (Calibrated index scales behind each potentiometer control knob will simplify recording of settings.)

If desired, required values of attack and decay time resistances can be measured and recorded by opening the ATTACK and DECAY switches and measuring with an ohmmeter between DECAY jack *J4* and ground and between ATTACK jack *J5* and ground. ENVELOPE SELECT 1 and 2 switches *S14* and *S15* can also be preset for the required envelope.

To produce an explosion instead of a gunshot sound, close NOISE FILTER switch *S12* and adjust NOISE FILTER control *R4* for the desired effect.

In Conclusion. The sound-effects generator breadboard presented here can be used in either or both of two ways. For the designer, it is a "tool" that simplifies designing a circuit from scratch. One can "design" a circuit with the breadboard, measure resistances of the controls and read off capacitor and logic-state (+5V or 0) settings from the panel, and assemble the circuit around a separate 76477 generator chip. The other way to use the breadboard is to simply experiment with control and switch setting combinations until you hear a sound you like. Used in this manner, you can record a whole series of sound effects that can be used with home movies and slide shows, for theatrical events, etc.

Whichever way you use the breadboard, it is a good idea to log parameter values for given sounds for future reference. Then, any time you want to reproduce a sound arrived at experimentally, you can, simply by setting the controls and switches as detailed in your log. ◇

TABLE II—SWITCH IDENTIFICATION

S1	Power switch for 7.5-to-9-volt dc supply
S2	Power switch for 5-volt dc supply
S3	Output
S4	Feedback
S5	Amplitude resistance selector
S6	Attack resistance
S7	One-shot, constant when closed
S8	One-shot momentary
S9	Attack-decay timing capacitor selector
S10	Decay resistance
S11	Noise filter capacitor selector
S12	Noise filter resistance
S13	Noise oscillator resistor
S14	Envelope select 1: logic 0, logic 1
S15	Envelope select 2: logic 0, logic 1
S16	Mixer C: logic 0, logic 1
S17	Mixer A: logic 0, logic 1
S18	Mixer B: logic 0, logic 1
S19	One-shot resistance
S20	One-shot capacitor selector
S21	Voltage-controlled oscillator (vco): logic 0, logic 1
S22	SLF oscillator control capacitor selector
S23	SLF oscillator control resistance
S24	Pitch control resistance
S25	Vco control resistance
S26	Vco control resistance selector
S27	Vco control capacitor selector
S28	Internal/external vco selector

TABLE III—CONTROL IDENTIFICATION

R4	Noise filter control
R6	Decay control
R8	Attack control
R15	Vco control
R18	Vco control
R23	Pitch control
R25	SLF control
R27	One-shot multivibrator control

TABLE IV—CONTROL GROUPING

One-Shot	J11,R27,S7,S8,S19,S20
Noise Filter	J3,R4,S11,S12
VCO Control	J7,J8,J9,R15,R18,R23,S21, S24,S25,S26,S27,S28
SLF Control	J10,R25,S22,S23
Noise Clock	S13
Mixer Select	S16,S17,S18
Envelope	J4,J5,R6,R8,S6,S9,S10, S14,S15
Amplitude	S5
Audio Output	J6,S3,S4
Power On/Off	S1
+5 volts	S2
Ground	J12

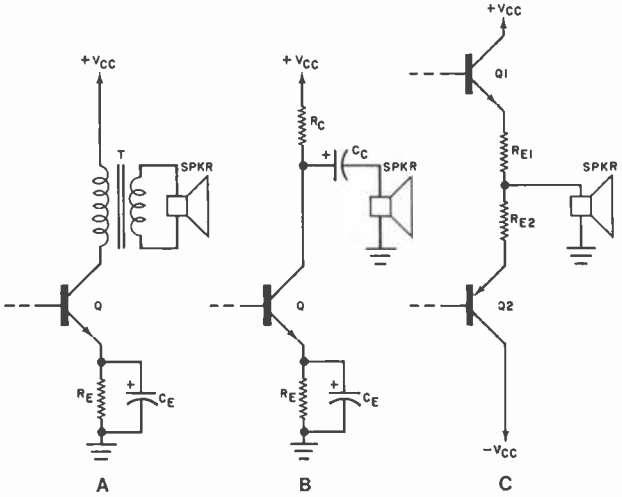
Hobby Scene

By John McVeigh, Technical Editor

AMPLIFIER/LOUDSPEAKER COUPLING

Q. Can you show examples of transformer-, capacitor-, and direct-coupled amplifier output stages? What are the advantages and disadvantages of each?—Harold Armistead, Middleton, MA.

A. The final stages of transformer-, capacitor-, and direct-coupled audio amplifiers are shown at A, B, and C, respectively. Those



shown at A and B are single-device stages, but transformer or capacitor coupling can be used with two-device (push-pull, Class B or AB) stages as well. Transformer coupling provides two benefits—dc isolation and impedance coupling. Because the amplified audio (ac) signal at the collector of *Q* is riding on a dc level, the isolation provided by the transformer is necessary. Impedance transformation (usually step-down) is less important in transistor circuits than in tube designs, which tend to have higher output impedances. Capacitive coupling reflects this by providing dc isolation but no transformation.

The direct-coupled output stage shown at *C* employs transistors *Q1* and *Q2*, which are driven out of phase, as emitter followers. A transistor operating as an emitter follower has a low output impedance, obviating the need for impedance transformation. If a bipolar power supply is employed and the transistors are correctly biased, the amplifier's "hot" output terminal (the junction of R_{E1} and R_{E2}) will have no dc offset. This is so because under quiescent conditions the V_{CE} drops of both transistors are equal in magnitude and opposite in polarity, leaving the output terminal at dc ground.

Disadvantages associated with transformer coupling include losses (eddy, hysteresis and winding-resistance), physical bulk, expense and the fact that distortion-producing core saturation occurs if the transformer is driven too hard. Coupling capacitors are not lossy, are smaller than transformers and cost less. However, both have fallen out of vogue, at least in middle-of-the-road and high-end solid-state audio equipment because of a belief that such coupling techniques cause sonic degradation. Transformer coupling can result in high-frequency rolloff, and capacitive coupling can cause low-frequency rolloff *if the design is inadequate.*

Direct coupling is attractive in that nothing gets between the final amplifying devices and the loudspeaker, but involves the added expense of a bipolar supply. Also, biasing is somewhat critical if excessive dc offsets at the output are to be avoided. Finally, if one of the devices in the output totem pole develops a collector-to-emitter short, the loudspeaker could be irreparably damaged.

TRIGGERING FLASH UNITS

Q. I recently purchashed some surplus photographic flash units that I would like to convert into blinking emergency lights. Each unit is powered by two 1.5-volt batteries and is triggered by the closure of a switch. Keeping this switch closed continuously does not cause the flash to glow or blink continuously. Rather, the flash lights upon closure of the switch and then stays dark until the switch is subsequently opened and closed once more. How can I adapt this type of flash into a blinking warning light? Any information on this subject would be greately appreciated.—Michael Wojtusiak, New York, NY.

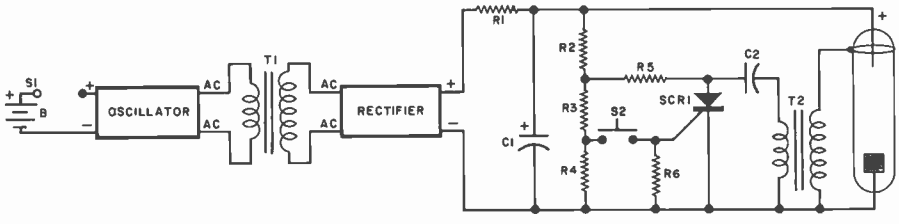
A. A typical flash unit is shown schematically in the figure. When power switch *S1* is closed, the oscillator generates square waves, usually at a rate greater than 20,000 Hz. These ac square waves are stepped up in voltage by transformer *T1* and converted into pulsating dc by the rectifier. Storage capacitor *C1* charges up through *R1* until the voltage across it reaches a few hundred volts. Similarly, *C2* charges up to about two-thirds of the ultimate voltage across *C1*.

When the capacitors are fully charged and trigger switch *S2* is closed, *SCR1* receives gate drive and begins to conduct. The charge stored in *C2* is dumped into the primary of trigger coil *T2*. A high-voltage pulse appears across the coil's secondary, which ionizes the gas in xenon flash tube *FT1*. This ionized gas provides a low-impedance path for the charge stored in *C1*. As this capacitor dumps its charge to ground through the flash tube, a large current flows through the ionized gas and a brilliant burst of light appears. It takes very little time for *C1* to completely discharge, so that even though the flash of light generated by the tube is extremely bright, it is also very brief.

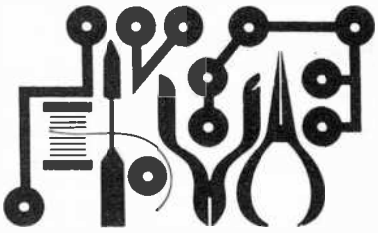
If *S2* is kept closed, the SCR will continue to conduct even though *C2* has discharged. This prevents *C2* from recharging and thus prevents further excitation of *T2* and *FT1*. For the tube to flash again, *S2* must be opened, *C1* and *C2* must fully recharge and *S2* must be closed once more. (Capacitor *C1* will start to recharge as soon as it has completely discharged and current through *FT1* drops to zero; *C2* can't recharge until *S2* opens.)

From your description of the units you purchased, it seems that they operate in essentially the same manner as the circuit just described. To make such a unit blink on and off, *S2* must effectively be closed, reopened, closed again, reopened, etc. This can be accomplished in any one of several ways. For example, an astable multivibrator can be used to drive a relay or switching transistor wired in parallel with the unit's trigger switch. The multivibrator should be designed to oscillate at the desired flash rate and to cause the output device (relay or transistor) to close the trigger loop for only a brief interval. Before building the additional circuit, measure the voltage across the trigger switch. Then select a switching component (relay, transistor, thyristor, etc.) that can withstand this voltage on a continuous basis. An IC timer, a UJT, or even a neon bulb can be employed as the nucleus of the astable multivibrator.

Remember that the interval between trigger pulses should be no shorter than the time required for recharging of the main storage capacitor. Also, running the flash unit on a continuous basis calls for the use of alkaline or rechargeable NiCd cells.



Experimenter's Corner



By Forrest M. Mims

OPTICAL FIBER COMMUNICATIONS (Part 1)

OPTICAL FIBER communications is one of the fastest growing areas of modern electronics. Here's why.

- A hair-thin glass fiber can carry more information than 900 pairs of copper wires comprising a cable as thick as your fist.
- Glass and plastic fibers are immune to electromagnetic interference and do not attract lightning strokes.
- Because fibers are insulators and not conductors, they don't generate sparks or present a shock hazard, nor can they be short-circuited.
- Some glass fibers can transmit a modulated beam of light more than ten kilometers before it is necessary to employ a repeater to strengthen the signal.
- Communications-grade fiber is already cheaper than coaxial cable, and even greater price advantages are in the offing. The raw material for glass fiber is sand, but coax is manufactured using copper (for conductors) and petroleum-derived plastic (for the dielectric).
- Fiber systems are impossible to jam and difficult to intercept.
- Glass fiber has a higher tensile strength than a steel wire of the same (small) diameter.

In this first installment of a two-part series, we'll find out how fibers transmit light and learn something about their idiosyncrasies. In Part 2, we'll put fibers to work in some practical communication systems that you can easily build.

How Fibers Transmit Light. Figure 1 shows how a ray of light travels through an optical fiber by making multiple reflections from the fiber's core/cladding boundary. The core and cladding are both transparent but the index of refraction of the core is slightly higher than that of the cladding. Just as the boundary between air and water is highly reflective, the core/cladding boundary behaves as a mirror to light waves striking it within the fiber's *acceptance angle*.

The material in Fig. 1 is known as a *step-index* fiber because of the sharply defined transition between its core and cladding. Step-index fibers are easily manufactured, but have one major disadvantage. Light waves entering one end of a fiber at the same time can arrive at the opposite end at slightly different times due to the different travel paths or modes they can follow. This causes narrow optical pulses to be stretched, and places an upper limit of a few tens of megahertz on the rate at which data can be sent through the fiber.

Graded-index fibers are manufactured to reduce the delay problem associated with step-index fibers. Instead of a well defined core/cladding interface, this type of fiber merges the core with the cladding to form a gradual change in refractive index. This causes light rays to curve through the fiber as shown in Fig. 2. Because the light near the cladding travels faster than light in the core, there is considerably less pulse broadening. Accordingly, data rates as high as hundreds of megahertz are possible.

Attenuation of Optical Fibers. The first question most people ask when they learn about optical fiber communications is, "How clear are they?" The answer is *incredibly* clear. If ocean water were as clear as typical communications-grade glass fiber, it would be possible to see clearly the bottom of the deepest depths of the sea.

The attenuation of optical fibers is given in decibels per kilometer (dB/km). Inexpensive plastic fibers such as those used to make optical art displays often have an attenuation of hundreds or thousands of dB/km, so they're practical only for very short-range communications links of a few meters or less. Communications-grade glass fibers have attenuations ranging from approximately 20 to as little as one dB/km!

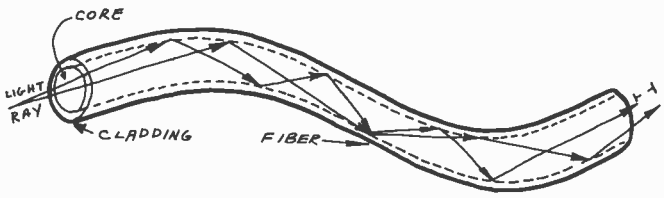


Fig. 1. Light rays in ordinary optical fibre take multiple paths causing narrow pulses to be stretched.

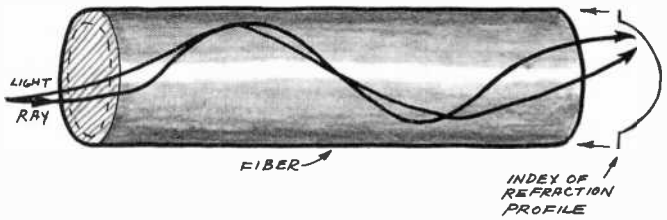


Fig. 2. A graded-index fiber is made so that pulse stretching is considerably less severe, allowing faster data transmission.

A 3-dB/km glass fiber one kilometer long attenuates only half the light injected into one end. In other words, apply one milliwatt of radiation into one end of a 1-km fiber and you'll receive half a milliwatt at the other end. Solid-state detectors can work with signal levels of a

few tens of nanowatts, so it's possible to transmit high-quality data for 10 km or more over a 3-dB/km fiber without the need for a repeater.

It's important to note that optical fibers do not transmit all wavelengths of light equally well. Figure 3, for example, graphically shows the amplitude-versus-wavelength response of two different fibers. Because of the variations in response over a range of wavelengths, it is important to match optical sources with wavelength-compatible fibers. We'll cover the selection of sources and detectors in Part 2 of this series.

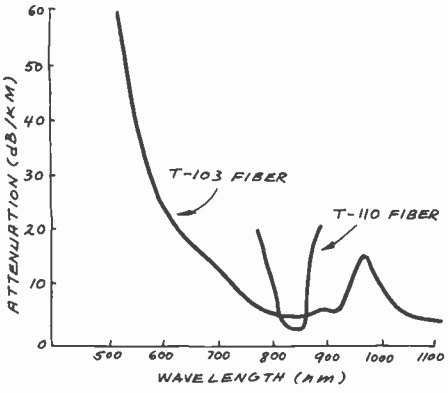


Fig. 3. Spectral response of two ITT communications-grade glass fibers.

Where to Buy Fiber. More than a dozen companies have entered the optical-fiber field, and communications-grade fiber should soon become available to experimenters for considerably less than a dollar a meter. In the meantime, you can purchase fiber from Edmund Scientific Company (Edscorp Bldg., Barrington, NJ 08007). Their catalog lists high-attenuation plastic fibers and 40-dB/km silica fiber. Another source for optical fibers is Math Associates (376 Great Neck Road, Great Neck, NY 11021), which sells communications-grade, low-loss fibers in lengths as short as one meter.

If you have the money and are serious about fiber communications, you can buy unjacketed fiber in minimum lengths of 500 or 1000 meters at prices ranging from 50 cents to $1.00 per meter. Here are some manufacturers to whom you can write for detailed specifications, prices and shipping information:

ITT Electro-Optical Products Division
7635 Plantation Rd.
Roanoke, VA 24019

Corning
Telecommunication Products Dept.
Corning Glass Works
Corning, NY 14830

Valtec Corporation
West Boylston, MA 01583

Siecor Optical Cables, Inc.
631 Miracle Mile
Horseheads, NY 14845

E.I. Du Pont De Nemours & Co.
Plastic Products and Resins Dept.
Wilmington, DE 19898

Quartz Products Corp.
688 Somerset Street
Plainfield, NJ 07061

Before ordering large reels of fiber, be sure you know exactly what your application is and how you intend to implement it. You should also have spent some time beforehand experimenting with short lengths of fiber to determine if you can work with the material without extraordinary difficulty, and if it can solve your communications problems better than an ordinary wire link.

Cutting Fibers. You can cut plastic fibers with a razor blade or hobby knife, but glass fibers require a more elaborate procedure.

EXPERIMENTER'S CORNER

continued

Here's how I cut them. First, I carefully strip off any protective coating(s) with a hobby knife. Some fibers are coated with acetate lacquer which can be removed with acetone. (Use acetone only in a well ventilated area and avoid contact with skin.) Next, tape one end of the fiber to your work surface and pull the exposed portion of the fiber over your index finger. Finally, lightly score the fiber over your finger with a carbide glass cutter while applying a small amount of tension to the fiber.

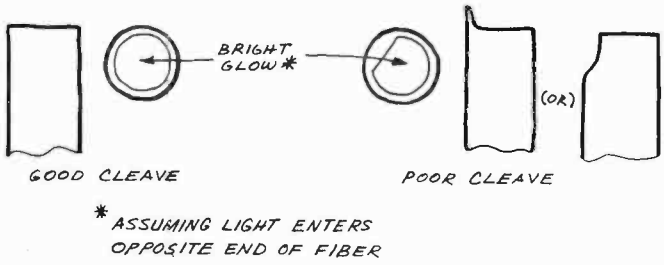


Fig. 4. Typical appearances of well and poorly cleaved fibers when viewed under 50-power magnification.

This procedure should result in an almost perfectly flat cleavage plane, but you must confirm this by examining the exposed end of the fiber with a 50-power phono-stylus microscope. Figure 4 shows what you will see when light is passing through the fiber. If the first cut is unsatisfactory, try again. You might even want to experiment with other methods of cleaving the fiber, such as scoring the fiber while simply pulling on the portion not taped to your work table.

Incidentally, be sure to carefully discard bits of fiber removed during cutting procedures. Small-diameter fibers can easily penetrate a finger or a bare foot!

Attaching Fibers to LEDs and Photodetectors. The two principal methods of attaching fibers to LEDs and photodetectors are removable connectors and fiber pigtails. Removable connectors are expensive, but AMP, Inc. (Harrisburg, PA 17105) has introduced a moderately priced connector which is finding widespread popularity. This connector will probably become available to experimenters in the near future.

Laser diodes and LEDs with factory-installed fiber pigtails cost hundreds of dollars. Motorola's solution to this problem is a new series of emitters and detectors with integral light pipes which mate with AMP connectors. One of the emitters (MFOD402F) includes a built-in integrated preamplifier. For more information, you can request data sheets for the MFOE102F LED and the MFOD102F and MFOD302F detectors from Motorola (P.O. Box 20912, Phoenix, AZ 85036).

Although I've found AMP connectors the best solution for coupling fibers to LEDs and detectors, I often attach fibers directly to epoxy-encapsulated LEDs. The easiest way to do this is to heat a small awl in a flame and push its hot point through the epoxy all the way to the semiconductor chip that emits the light. You should then test the LED to make sure it has not been damaged and that a bright point of light is visible at the exposed surface of the chip.

For temporary experiments, you can anchor a fiber in the hole using cyanoacrylate adhesive such as Eastman 910. For more permanence, insert the LED in a short length of heat-shrinkable tubing, insert the fiber into the LED (making sure the end has been cleaved properly) and surround the LED and fiber with epoxy. You'll need to hold everything together with tape, clothespins or clamps until the epoxy hardens.

For best results, pulse-modulate the LED and monitor the amplitude of the signal emerging from the opposite end of the fiber while slightly moving the end being cemented to the LED until maximum signal is received. This procedure is very much like tweaking the catwhisker in an old-fashioned crystal radio.

Because LEDs can also function as detectors, you can reverse this procedure as long as the source LED is made from the same type of semiconductor material as the receiver LED. Figure 5 shows a transmitter and receiver circuit you can use to align the fiber.

The procedure outlined above works best with GaAsP red LEDs encapsulated in clear epoxy. The 650-nm wavelength emitted by these diodes transmits well through most glass and plastic fibers, and

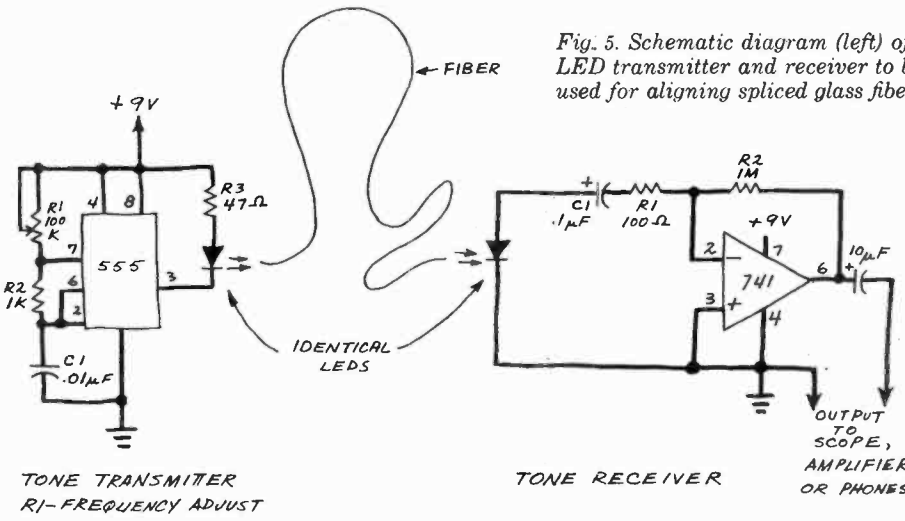
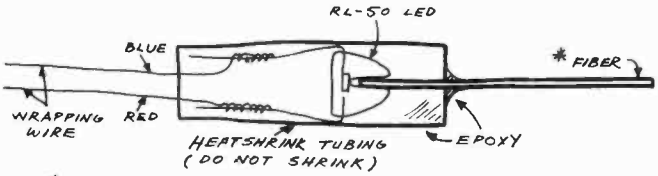


Fig. 5. Schematic diagram (left) of LED transmitter and receiver to be used for aligning spliced glass fibers.

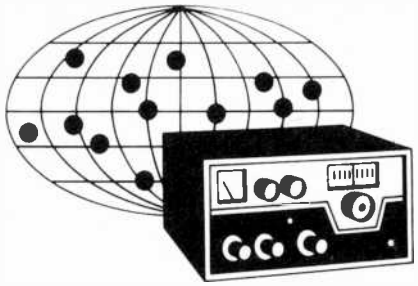
Fig. 6. One way (below) of mating a glass fiber to a common light-emitting diode.



the clear epoxy makes hole formation easier. Litronix RL-50 and RL-55 and Monsanto MV-50 miniature LEDs make excellent sources and detectors. Figure 6 shows a homebrew pigtailed RL-50 LED epoxied in a short length of tubing. Note how the leads are bent back and connected to lengths of wrapping wire.

If you find this procedure too time consuming, you can always try the AMP connectors mentioned earlier. The AMP Optimate single-position, fiber-optic connector is designed for single plastic fibers or bundles of glass fibers. It attaches quickly to an input/output bushing containing receptacle for an LED, photodiode or phototransistor.

To be Continued. In Part 2 we'll discuss fiber splicing and experiment with several pulse-modulated, data-transmission circuits. In the meantime, you can begin experimenting with a working light-wave communicator by turning to the Project of the Month in this issue. ◇



DX Listening

By Glenn Hauser

WIDER BANDS FOR SHORTWAVE BROADCASTING

DESPITE pessimistic early reports, just before it adjourned the World Administrative Radio Conference in Geneva approved substantial expansion of the international shortwave broadcasting bands. The expansion more or less legitimizes longstanding out-of-band operations, which certain countries have carried out under a regulatory loophole. Crowding on the 6-MHz band and the awful mixture of ham and broadcasting on 7 MHz were not resolved, but higher up it was a different story. Here are the new band limits: 9500-9900, 11650-12050, 13600-13800 (a completely new band), 15100-15600, 17550-17900, 21450-21850, 25670-26100 kHz (the last, a slight loss in a grossly underutilized band).

Canada has also reserved 3950-4000 kHz for domestic broadcasting and 7300-7400 for external broadcasting. The AM band also expands, in steps, up to 1705 kHz by 1990. The new shortwave broadcast bands do not officially take effect until 1989 (except 9 MHz, in 1985), to allow present fixed service occupants plenty of time to move. However, you can be sure many countries will jump the gun in order to establish squatter's rights on new frequencies. This should help alleviate overcrowding on the present bands.

Afghanistan. In August 1979, long before it invaded Afghanistan, the USSR began broadcasting *Radio Afghanistan* domestic programs from three sites in the Soviet Union. As always, no public announcement was made about this, leaving it to the BBC Monitoring Service and other astute monitors, such as Victor Goonetilleke in Sri Lanka, to make the proper deductions. However, for the March and April broadcasting season, USSR registrations filed with the International Telecommunication Union do show three of the four frequencies as targeted on Afghanistan or neighboring countries. At last report, these relays were on 7235 and 6190 kHz in the local mornings; listen at 0125 GMT for tone bursts typical of Soviet transmitter tuneups, and at 0130 for programming. However, during the summer, higher frequencies are likely to be used, perhaps 11710 or 15305. These channels have been fed by a frequency known to be in the "Afghan SSR," 6230 kHz. Both this frequency and 4775 could be monitored in North America around sunrise. Radio Afghanistan's only two English broadcasts (see April POPULAR ELECTRONICS) remained very difficult to pick up. The next country to be relayed from the USSR might want to reconsider the consequences. . . .

Antarctica. *Radio Nacional Arcángel San Gabriel* suddenly appeared last October on 6029 kHz, with a Spanish broadcast including "Horizontes de Hielo" at 0000-0200 GMT said to be coming from Argentina's Esperanza Army Base at the northern tip of Palmer Peninsula. Though the power was given as only one kilowatt, the station, named for the patron saint of communications weapons, could be heard almost every evening in North America except during the peak of the southern summer when there was too much daylight on the path. Ironically, in November, AFRTS-Washington made a regular seasonal expansion of its broadcasting hours *to* Antarctica, on 6030, resulting in the wiping out of reception of LRA-36 in North and South America after 0045 GMT.

Argentina made the most of the propaganda value of LRA-36, claiming that it was further confirmation of Argentina's sovereignty over a sizable hunk of Antarctica (which is supposed to be an "international continent"). It was also billed as the world's southernmost radio station, conveniently ignoring AFAN at the U.S. McMurdo Base. For once, Argentina rather than the U.S. can be accused of neocolonialism.

Australia. Once it was OK for people in China to write letters abroad, *Radio Australia* was inundated with mail from China—130,000 by the end of 1979. This avalanche persuaded the authorities to give the go-ahead to the reconstruction of the Darwin transmitter site, which was destroyed by a cyclone several years ago. Darwin would put an even better signal into China so the station could begin teaching the Chinese to speak Strine (Australian English). Though it obviously lacked the staff to manage its Listeners' Club, it was not until this year that Radio Australia disbanded it, and instituted a new QSL policy, restricting their availability to one month per year, instead of encouraging floods of useless reception reports.

Belize. The 20-kilowatt *Radio Belize* transmitter on 834 kHz has long had a mixed reception in the U.S. WCCO and WHAS, and their listeners, don't like the heterodyne it causes to their adjacent frequencies; DX listeners who can pull it past these two giants welcome a bit of exotica on the AM dial. But its days may be numbered. If 9-kHz spacing is adopted for the Americas, this "split" could be lost. Also, a QSL received by National Radio Club member Lance Sang revealed that the station is phasing out AM in favor of an FM network. But that would introduce some interesting new DX targets. Sporadic E could bounce as far inland as Amarillo, St. Louis and Roanoke, while reception along the Gulf Coast would be relatively common.

(Continued on page 90)

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CIRCLE NO. 8 ON FREE INFORMATION CARD

DX LISTENING *continued*

China. It had to happen. On Jan. 1, *Radio Peking*'s domestic program began carrying ads (for foreign merchandise only) to the tune of 70 minutes a day. The cost is $693 per minute, and those interested should call 868581, ext. 2522, or cable 0731. Peking's lead was followed by regional stations such as Heilongjiang.

Costa Rica. A station which figured in our "Revolution by Radio" article about *Radio Sandino* in POPULAR ELECTRONICS last November, *Radio Noticias del Continente*, has become a cause celèbre. Its leftist programming aimed at military dictatorships in South America brought strong official protests from Argentina, while Costa Rican authorities hemmed and hawed about what to do about it. It appears that the nominal "owner," Ana Lorena Cartín Leiva, a 29-year-old chemistry student, would hardly have the resources to run such an operation, according to an exposé by Argentinian Roberto H. Iglesias in the *Review of International Broadcasting*. She does happen to have been the secretary of a former owner, Francisco Aguilar Bulgarelli, whom a rival Costa Rican broadcaster labels as "a political friend of Kim Il Sung." Though supposedly a "commercial enterprise with nothing to hide," no ads were carried for many months until some trade-outs appeared with a few leftist publications and businesses. At last check, *TIRLR* was still plugging away on 9615 kilohertz, throughout most of the day and night.

Cuba. During a Christmas visit to *Radio Habana*, we wondered why they weren't broadcasting in English on mediumwave, which could cover much of the US, and reach an entirely different, and presumably larger audience than on shortwave. Less than a month later, *The Voice of Cuba* began a nightly 6-hour block of English (replacing Spanish) on 600 kHz. The programs, which begin at midnight Cuban time (EST/EDT) are similar or identical to those carried at other times from *Radio Habana* on shortwave. And a month after that, the same transmitter began carrying Radio Moscow in English all evening long and after 6 a.m., giving Americans for the first time the opportunity of hearing *Radio Moscow* on ordinary AM radios.

In the U.S., because of our relative isolation from other countries, we don't think of the AM band as suitable for international broadcasting, but now the Cubans are proving that it is. However, the Voice of America for many years has been beaming a powerful signal into Cuba on 1180 kHz from the Florida Keys. Turnabout is fair play. But one thing isn't fair: Cuba jams the *VOA*. By the way, you'll find *Radio Habana* on the top floor of the *Radio Progreso* building. But don't bother looking for signs—there aren't any.

We also discovered that Habana has three active FM stations, *Radio Progreso* on 92.1; *Radio Musical Nacional*, *CMBF* (classical) on about 93.75; and with a stronger signal, *Radio Enciclopedia*, which seemed slightly above 94.9 and identifies as in stereo on "95". This station, with its easy-listening music and brief informative talks, is heard throughout Habana in public areas, and makes an interesting DX target during tropospheric or sporadic E openings. The ultimate Cuban FM DX would be to pull in the music-only transmitter serving the Varadero Beach resort hotels on 98.4

MHz. Spotty reception there indicates its power is on the order of a few watts.

We were not invited to visit the *Radio Moscow* transmitter near Habana (dealt with in this column last August), and indeed for months *Radio Moscow* would not acknowledge that it existed. But last winter, Moscow began to register the appropriate frequencies as coming from Cuba. This opened the door last January for Kevin Mikell to receive the first *Radio Moscow* QSL reported to bear a "via Habana" endorsement.

During our visit, Cuba moved a Habana station from 790 to 1140 kHz, more effectively blocking reception of the Miami Cuban station *WQBA*. Meanwhile, anti-Castro elements in Florida have become more active in clandestine shortwave broadcasts varying around 7080 kHz several evenings per week before and after 9 p.m. local time. Harry Helms reports that two formerly separate operations, *Radio Abdala* and Comandante David's *Radio Libertad Cubana*, now coordinate transmissions and share facilities. The chances that they are actually broadcasting from "a small piece of free territory in the Oriente mountains" of Cuba are rather remote. In February, the FCC cracked down on Cuban clandestine broadcasts from Miami, busting a station called Radio Giron, which was not familiar to DX listeners.

Ecuador. *HCJB* has been experimenting with a 100-watt transmitter, 24 hours a day on 26020 kHz. Results have been remarkable. It's heard regularly in Europe and North America; and Arthur Cushen reports that reception in New Zealand peaks when it's midnight in Ecuador. This is further evidence that most countries have been missing the boat by ignoring the wide-open 11-meter band during the solar cycle peak. Meanwhile, *HCJB* continues its project to homebuild a mammoth 500,000-watt transmitter. To avoid influencing reception reports, they plan to put it on the air for tests later this year without announcing the frequencies and the precise times that it is being used.

Transkei. On Dec. 26, *Capital Radio* went on the air from this "homeland" in South Africa. Patterned after its London namesake, it's not for the blacks of Transkei, but is a private commercial outlet for South Africa. This area has been an extremely difficult one to DX in North America on mediumwave, because South Africa's very few AM stations have a power of only 5 kilowatts. But *Capital Radio* has 500 kW on 603 kHz which ought to make it to North America easily when conditions are favorable; North American 50-kW stations are regularly heard in South Africa. The time to start checking 603 is at the 0300 GMT sign-on (0400 on Saturdays and Sundays). But *Capital Radio* is also on shortwave, the better to serve Cape Town, initially with 10 kW, but to be raised to 50 and then 100. The morning frequency was 3950, but this may be changed seasonally.

U.S.A. Meanwhile, the shortwave scene in this country is becoming less stagnant. A New Orleans FM rocker, *WRNO*, has applied for shortwave, to beam 100 kW of rock and network news northeastward toward Europe. The North Dakota Farmers Union is considering applying for a shortwave station. The World Christian Broadcasting Corp. has bought land

on Alaska's Kenai Peninsula where they hope to install a 250-kW shortwave transmitter.

WYFR has abandoned its old Scituate, Mass. site, where even the towers have come down. Installations continue at the new Family Radio site near Okeechobee, Florida. The goal is a total of 10 transmitters. Another language, Italian, has been added; coming soon are a 24-hour "eastern Canada" service also audible in the USA and a broadcast to Cuba requiring a new high-angle antenna.

The *Voice of America* had no broadcasts in Persian until last year. It took the hostage crisis for *VOA* to be able to multiply its programs for Iran and other critical countries in the Middle East. *VOA* is so inadequately funded that only a crisis will generate the necessary government concern. Meanwhile, VOA does not bother to broadcast to such 'safe' areas as France, Germany, Italy, Spain, Japan in their own languages. If one of these countries were to become hostile to the U.S., then the VOA would consider talking to them as well.

U.S.S.R. Though *Radio Moscow*'s "news" is supposed to be live on the World Service, if not on the overnight North American Service, all its programming suffers from a lack of spontaneity. But twice a year, *Radio Moscow* broadcasts a *live* event—coverage of the big military parades in Red Square, on Nov. 7, the anniversary of the October Revolution, and on May Day. While you won't hear any speculation from this source on the latest pecking order in the Soviet leadership implied by the positioning of dignitaries, nor any commentary on Soviet military capability beyond the official line, this kind of broadcast is still a novelty on *Radio Moscow*. I heard it last November, and had a real sense of being there, as Gen. Ustinov and his troops hollered greetings back and forth across the square. Frequencies aren't known much in advance, but may be announced during the preceding few days; or if you scan the bands shortly before 0700 GMT on May 1, you should find this live coverage on separate frequencies in English, Russian, and perhaps even Chinese.

By the way, even before the threat of Olympic boycotting arose, *Radio Moscow* was making no promises that it would air any significant Olympic coverage, since it was assumed that it could be seen throughout the world on color TV.

Publications. *An Alternative Programming Strategy for International Radio Broadcasting*, by Kim Andrew Elliott, is a major new work in a neglected field. It examines the effectiveness of the "traditional programming approach" we are all familiar with, compared to an "alternative programming approach" exemplified by Rudy Espinal and "This is Santo Domingo." The 196-page PhD. thesis is available in print or microfilm via University Microfilms (inquire at any large library).

Information Sheet. This free list is all you need to become an "insider" in shortwave listening and DXing, not for the information it contains, but because it refers you to many other sources of information. It's yours for a self-addressed stamped envelope (from abroad, mint stamps equivalent to 31¢ are accepted; 17¢ in Canada), to Glenn Hauser, University Radio WUOT, Knoxville, TN 37916. We cannot promise a personal reply to specific questions. ◇

REVERSE IC SOCKET

Home-brew adapter simplifies correcting mirror-image wiring errors

BY GENE NELSON

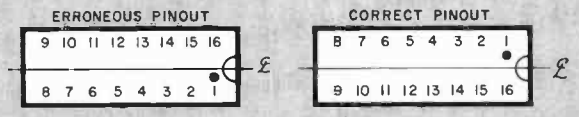
CHANCES are that many of you have had the following experience. An experimenter builds a complicated analog or digital circuit using printed circuit techniques, even thoughtfully installing sockets for the integrated circuits. But he wires the project for the *mirror image* of the proper IC pinouts! This error can be caused by mistakenly laying out the bottom of the board using a top-view pinout. It can also occur if the negative is inadvertently flipped before the etching process is begun.

Faced with this problem, the unfortunate experimenter has heretofore had only a few options, as follows. Discard the board and start from scratch; remove the IC, unsolder the socket, and solder the IC to the bottom of the board; or, leave the IC and socket in place but carefully cut the necessary foils and compensate for the inversion by soldering insulated jumper wires.

The "Reverse Socket" described here provides the experimenter with a much simpler solution. It's a home-brew socket adapter which inverts the mirror image again, thereby cancelling out the error. An easily and inexpensively constructed project, the Reverse Socket can be assembled using a DIP IC socket and commercial socket adapter or a small piece of perforated board and Vector type T-44 pins. If the inverted board contains more than one DIP IC, as many Reverse Sockets as are needed can be built.

Construction. The illustration reveals that if the incorrect pinout is transposed about the center line, the correct pinout is obtained. Accordingly, the Reverse Socket is constructed by mounting a "correct pinout" socket above an "erroneous pinout" socket adapter, both interconnected ("incorrect" pin 1 to correct pin 1, etc.) with short lengths of insulated hookup wire.

A 16-pin DIP socket adapter, such as Cambion Model 3728-01-03-00 can be used, or one can be made from a small piece of perforated board whose holes are 0.1 inch (2.5 mm) apart and 16 Vector type T-44 pins. A length of hookup wire is soldered to each socket adapter pin. The author wanted to keep his Reverse Sockets as compact as possible, so he used 0.5-inch (1.3-cm) lengths of Kynar insulated No. 30 wire with 0.1 inch (2.5 mm) of insulation removed from each end. Kynar insulation was found to be preferable to PVC plastic because of its greater tolerance to heat.



When incorrect pinout is transposed about the centerline, correct pinout is obtained.

When removing the insulation, take care not to nick the wire. Tin all surfaces before soldering. A "third hand" will make the task of soldering much easier. The "hand" can be either a commercial pivoting vise or a miniclip attached to one end of a length of No. 14 copper wire, the other end of which is secured to the work surface.

Place pieces of 1/16-inch (1.6-mm) diameter heat-shrinkable tubing 3/16 inch (4.8 mm) long over each socket adapter pin to prevent shorting. Next, bend the leads of a low-profile IC socket 45 degrees toward the center line of the socket and solder the free end of each jumper to the appropriate pin. To eliminate confusion during the crossover wiring of the socket adapter and socket, the author used wire having red insulation for one set of eight pins and wire with black insulation for the other set. He also recommends the use of tweezers and a soldering iron with a fine tip.

Be sure to check for inadvertent shorts caused by touching conductors, solder bridges, etc. The socket/socket adapter combination can then be made one rigid assembly by cementing small plastic sheets to the sides of the socket and socket adapter.

Use. The author's completed Reverse Socket adds 5/8 inch (1.6 cm) to the height of the IC with respect to the surface of the printed circuit board. In most cases, there will be sufficient clearance between the board and the top of the enclosure to accommodate the adapter. In particularly crowded enclosures, however, the height of the pc board spacers might have to be reduced accordingly.

This same basic idea can be used with any size or shape of IC socket, assuming that an appropriate socket adapter can be purchased or home brewed. Other types of foil layout errors can be corrected by interconnecting the socket and adapter to cancel them.

Naturally, one should make sure the board will be etched correctly *before* the process is begun. But should anyone unwittingly make such a mistake, this is an easy way to correct the error. ◇

CLEAR-CHANNEL AM STANDARD BROADCAST STATIONS

Courtesy of General Electric Co.

Frequency (kHz)	Class I - A Assignment
640	KFI, Los Angeles, CA
650	WMS, Nashville, TN
660	WNBC, New York, NY
670	WMAQ, Chicago, IL
700	WLW, Cincinnati, OH
720	WGN, Chicago, IL
750	WSB, Atlanta, GA
760	WJR, Detroit, MI
770	WABC, New York, NY
780	WBBM, Chicago, IL
820	WBAP, Forth Worth, TX
830	WCCO, Minneapolis, MN
840	WHAS, Louisville, KY
870	WWL, New Orleans, LA
880	WCBS, New York, NY
890	WLS, Chicago, IL
1020	KDKA, Pittsburgh, PA
1030	WBZ, Boston, MA
1040	WHO, Des Moines, IO
1100	WWWE, Cleveland, OH
1120	KMOX, St. Louis, MO
1160	KSL, Salt Lake City, UT
1180	WHAM, Rochester, NY
1200	WOAI, San Antonio, TX
1210	WCAU, Philadelphia, PA

Computer Bits

By Hal Chamberlin

ELECTRICAL NOISE

ELECTRICAL noise is a major problem in home computers. Generated within a computer itself, it can, in many cases, interfere with nearby radio and TV reception and even with the computer's own operation! Many unexplained home-computer malfunctions can, in fact, be traced to external noise. Since microcomputers are usually more prone to electrical-noise problems than large mainframe computers, let us explore the various sources of noise and their effect on personal-computer operation and suggest some methods of reducing or eliminating the problem.

Power-Line Noise. Of all environmental noise sources, power-line noise is perhaps the best understood and most easily suppressed. High-frequency spikes and "hash" generated by motors, switches, lamp dimmers, and lightning are the most troublesome types of power-line noise. Measured at a wall outlet, this noise can be several hundreds or even thousands of volts in amplitude. Fortunately for computer power supplies, however, the noise pulses are only a few microseconds in duration, so energy content is actually quite low.

Nearby lightning strikes, of course, would generate spikes of the highest amplitude, but strikes a mile or more away can also cause trouble. This noise appears on an oscilloscope as a rapid-fire series of narrow high-voltage spikes. It can enter the power system either from a direct strike on power-distribution equipment or by induction. Since power lines may be strung overhead for long distances, they efficiently pick up electrostatic and electromagnetic fields radiated by lightning strikes and conduct the resulting spikes into the computer owner's home.

Probably the power-line noise with the next highest amplitude is created by switching off an inductive appliance, allowing energy stored in the magnetic field of an inductive device to suddenly release as the field collapses. For a few dozen microseconds, a very high voltage is built up and may arc across the open switch contacts, feeding a high-voltage pulse with a fast rise time into the power line. Ac induction motors and transformers—even those in fluorescent lamp fixtures—are the most highly inductive. Large motors, such as those used in refrigerators and air conditioners, create an electrical noise even when they switch on because an internal starting winding switches off when they reach operating speed. Industrial plants with hundreds of very large motors and transformers constantly switching on and off present particularly hostile electrical environments for computers.

While the foregoing sources are responsible for occasional high-amplitude spikes on the power line, universal motors (those with brushes) and lamp dimmers generate lower-amplitude, but more continuous, noise. The obvious source of noise in universal motors originates with armature brushes that constantly spark during motor operation. Lamp dimmers with silicon-controlled rectifiers (SCRs) or triacs generate a small amount of noise on every alternation of the ac line because of the rapid turn-on characteristics of these semiconductors.

One might reasonably ask how power-line noise can get into a computer's logic circuitry if its very-narrow pulse widths cannot pass through the power transformer and rectifier diodes to actually change the dc supply voltages (large power-supply filter capacitors prevent this). It is *capacitively* coupled from the power supply's primary wiring directly into the regulated dc output wiring and then into the logic. In some computers with the primary wiring routed close to the logic circuitry, noise bypasses the power supply altogether and couples directly into the logic. It is not difficult to visualize how even a fraction of a picofarad of coupling capacitance can transfer more than 1 volt (the typical noise-immunity specification for most TTL and MOS logic) of the original 1000-volt spike into the logic circuitry and possibly cause an error. (Note: most computers are sensitive to noise only during part of their bus and memory cycles; hence, it is possible for the computer to ignore the majority of noise spikes.)

Preventing power-line noise from entering a computer is relatively easy—simply use a noise filter between the ac outlet and computer's line cord. Filters are most effective if located inside the computer's cabinet, right at the point where the power cord enters. Even if installed at the plug end of the computer's line cord, however, they can be very helpful in excluding power-line noise.

While filters are available from a number of sources, you might want to make your own filter circuit. A good power-line filter consists basically of two L-section low-pass r-f filters (to provide both common- and transverse-mode noise rejection), with inductors designed to handle several amperes of continuous current. Metal-oxide varistors (MOVs) are included to prevent possible damage from direct local lightning strikes but do not otherwise contribute to filtering out noise. (MOVs act like high-power zener diodes, shorting out electrical spikes that exceed about 300 volts in amplitude.)

A properly grounded three-wire ac outlet and computer line cord are required for *any*

noise filter to function properly. With non-grounded outlets, filtering efficiency will be very low and current leakage through the filter's capacitors could create a mild shock hazard.

Ac-line filters cannot cope with problems caused by low-frequency power surges and dips. Unlike noise spikes, surges and dips are long enough in duration for them to affect the computer's dc voltages. The only defense against this type of noise is a wide line-voltage range computer power supply or an expensive external ac voltage regulator.

Electrostatic Discharge. As you know, a tremendous static-electricity charge can be built up on your body simply by walking across a carpeted or plastic-tiled floor—expecially in very-low-humidity environments. When you reach for any metal, even without coming into physical contact, the charge almost instantly dissipates into what you touch. If what you touch is the cabinet of your computer, the rapid discharge can cause a running program to crash and, at its worst, even damage components in your computer.

Static discharges make a tremendous amount of electromagnetic noise. Charges of 5000 to 10,000 volts are not unusual and, when discharged through a typical body impedance of 100 ohms, can flow at peak currents of 50 to 100 amperes. Coupled with typical rise times of 10 nanoseconds, this creates incredible noise amplitudes.

To guard against electrostatic-discharge noise problems, a computer system must be designed from the ground up to be resistant. The best defense is to make all exterior packaging from insulating material, such as plastic. Then nothing in the system is exposed for you to discharge to and static-discharge problems are avoided. Fortunately, most manufacturers realize this problem and house their computers in plastic cabinets. But peripherals, such as disk drives and particularly printers almost always have exposed metal parts.

While plastic cabinets bestow immunity against direct static discharges, they provide no shielding for the powerful electromagnetic fields created by discharges to other metal in the vicinity of the computer. Hence, in practice, system crashes may be just as common as with metal-cased computers. The ideal cabinet would be metal encased in plastic. This would not only just about eliminate the static problem, but it would also prevent noise generated by the logic *inside* the computer from escaping and interfering with nearby radio and TV reception.

If you buy a static-sensitive computer, there are several steps you can take to reduce the incidence of crashes. The easiest is to keep the computer in an environment with concrete floors and to wear leather-soled shoes. You can also obtain an antistatic floor mat or carpeting with metal threads woven throughout if you cannot move your computer out of a carpeted area. Too, use of a humidifier in the room in which your computer is located will reduce the intensity of static discharges.

In really tough cases, a 2-watt resistor of 1 megohm or more can be attached at one end to your computer's, disk drive and printer cases. Then, when you approach your equipment, merely touch the free lead of the resistor first to safely bleed off any accumulated static charge. ◇

Computer Club Directory

(Continued from April 1980 issue)

Pennsylvania
The Central Pennsylvania Computer Club
1979 Crooked Oak Drive
Lancaster, PA 17601

Delaware Valley Chapter, SCCS
1228 Barrowdale
Rydal, PA 19046
Att: Martin Dimmerman

Kim-1/6502 User Group
109 Centre Ave.
Morristown, PA 19401
Att: Eric C. Rehnke

Northeast Computer Assoc.
834 Fowler Street
Philadelphia, PA

PET User Group
POB 371
Montgomeryville, PA 18936
Att: Gene Beals

Philadelphia Area Computer Society
La Salle College
Science Bldg.
20th & Olney Ave.
Philadelphia, PA 19141
Att: Dick Moberg or Jon Bondy

Philadelphia Area Club
404 Quince Street
Philadelphia, PA 19147

Pittsburg Area Computer Club
400 Smithfield Street
Pittsburg, PA 15222
Att: Fred Kitman

St. Thomas District
HS Computer Club
1025 Braddock Ave.
Braddock, PA 15104

Wilkes College
Computer Club
Math Dept.
Wilkes-Barre, PA 18703
Att: Eric Jansen

Puerto Rico
Caribbean Computer Club
52 Kings Court, 4A
Santurce, Puerto Rico 00911

Rhode Island
Rhode Island Computer Hobbyists (RICH)
POB 599
Bristol, RI 02809
Att: E.D. Iannuccillo

South Dakota
RCA 301 Users Group
RR2, POB 585
Rapid City, SD 57701
Att: Jay Roman

Texas
Alamo Computer Enthusiasts
7517 Jonquil
San Antonio, TX 78233
Att: John Stanton

Central Texas Computer Association
508 Blueberry Hill
Austin, TX 78745

Computer Hobbyist Group of North Texas
POB 1344
2377 Dalworth, No. 157
Grand Prairie, TX 75050
Att: Bill Fuller

El Paso Computer Group
213 Argonaut, #27
El Paso, TX 79912

Houston Amateur Microcomputer Club (HAMCC)
4223 S. W. Fwy., #203
Houston, TX 77707
Att: David M. Fogg

Houston Amateur Microcomputer Club
POB 37102
Houston, TX 77036,

JSC Computer Hobbyist Club
NASA LBJ Space Center
Houston, TX 77058
Att: W. Jenkins

MITIBUBUS
3845 LeBleu Street
Beaumont, TX 77707

NASA-JSC Computer Hobbyist Club
1011 Davenport
Seabrook, TX 77586
Att: Marlowe Cassetti

Northside Computer Group
5819 Brenda
San Antonio, TX 78240

Panhandle Computer Society
2923 S. Spring
Amarillo, TX 79103
Att: Tex Everett

Permian Basin Computer Group
Ector County School
POB 3912
Odessa, TX 79760
Att: John Robenaldt

Texas A&M University Microcomputer Club
POB M-9
Aggieland Station, TX 77844

Texas Computer Club
Rt. 1 Box 272
Aledo, TX 76008
Att: L.G. Walker

Theater Computer Users Group
Theater Sources, Inc.
4712 Northway Drive
Dallas, TX 75206

Utah
Salt Lake City Computer Club
2925 Valley View Ave
Holladay, UT 84117

Virginia
Amateur Radio Research & Development Corp. (AMRAD)
1524 Springvale Ave.
McLean, VA 22101
Att: Paul L. Rinaldo

Charlottesville Computer Hobbyist Club
1928 Arlington Blvd #209
Charlottesville, VA 22903

Crystal City Computer Club
3008 Mosby Street
Alexandria, VA 22305
Att: Russell E. Adams

COMPUTER CLUBS

continued

Dyna-Micro Users Club
POB 1053
Lexington, VA 24450
Att: Dr. Frank A. Settle, Jr.

IBM 5110/5100 Users Group
5541 Parliament Dr., Suite 104
Virginia Beach, VA 23462
Att: Richard E. Easton

Microcomputer Investors Association
2415 Ansdel Ct
Reston, VA 22091
Att: Jack Williams

Peninsula Computer Hobbyist Club
2 Weber Lane
Hampton, VA 23663
Att: Larry Polis

Roanoke Valley Computer Club
2026 Wynmere St. S.W.
Roanoke, VA
Att: Lee Yosafat

Tidewater Computer Club
677 Lord Dunmore Dr.
Virginia Beach, VA 23462
Att: Dawson Yeomans

Washington-Baltimore Computer Hobbyist Club
7711 Elba Rd.
Alexandria, VA 22306
Att: Richard Rubinstein

West Virginia
West Virginia Computer Society
167 Iroquois Trail
Ona, W. VA 25545
Att: Bill English

Washington
Apple Core Computer Club
220 N. 2nd St. #17
Yakima, WA 98901
Att: Jerry Stazinski or Russell Miller

Hex's Users Group
36012 Military Rd. S
Auburn, WA 98002
Att: Charles C. Worstill

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(Continued on page 98)

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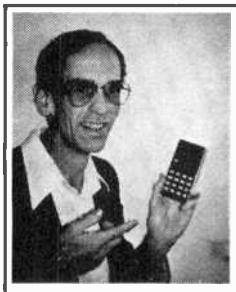

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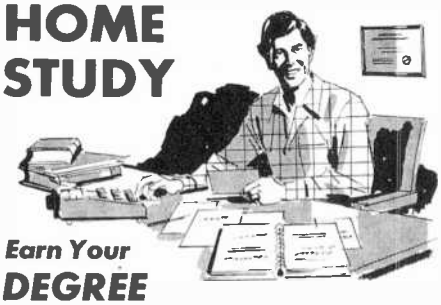

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Catalogs of Interest. Software Dynamics, 2111 W. Crescent, Suite G, Anaheim, CA 92801 (Tel: 714-635-4760) features SDOS, a 6800 Operating System; EDIT, a general-purpose context editor; MAL, a 6800 Assembler; IDB a 6800 interpretive debugger; SD BASIC V1.3, a business BASIC; a chess program compiled by SD BASIC; an I/O package; and a relocating assembler. Future programs include a relocating debugger for 6800/6809 and a link editor for the 6800/6809.

The Bottom Shelf, Inc., P.O. Box 49104-C, Atlanta, GA 30359 (Tel: 404-939-6031) features TRS-80 Level-II programs including: Checkbook II that has a five-column screen display with a field for alphanumeric codes. Screen prints can be made to a line printer, or diskette ($18.50); Information System, a data base manager that allows up to 40 characters per category and 200 characters per page ($24.50); and Exerciser allows user to create physical fitness goals and analyzes progress toward the goal ($12.50). Other software available includes BASIC Toolkit, System Doctor and Terminal Control, Business Mail List, Data Base Manager, Check Register Accounting System and Analysis Pad, and Library 100.

Microware Systems Corp., P.O. Box 4865, Des Moines, IA, 50304 (Tel: 515-265-6121). The 6800 software available includes A/BASIC, a true 6800 BASIC compiler which is ROMable. The A/BASIC Interpreter is source-compatible, extremely fast and implemented as an incremental compiler. It may be used as a text editor for the A/BASIC Compiler. The A/BASIC Source Generator is an optional enhancement for the A/BASIC Compiler (disk version only) to permit it to produce assembly language listings and source programs. This firm also has a LISP Interpreter and 6800 Chess.

Surveyor Package. For use with CP/M and BASIC, this program includes traverse (open or closed) with sideshots, stadia reduction, universal triangle solutions, volume by aver-

(continued on page 102)

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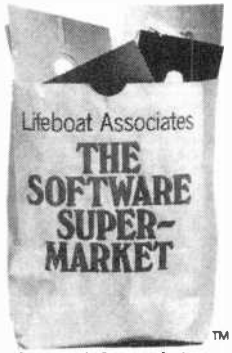

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COP400 Assembler Editor. The ASMB-COP400 assembler/editor development system can be used with the North Star operating system. Programs developed on a Z80/8080 host must be off-loaded to the target processor. The complete instruction set for the National COP400 is supported, as well as pseudo-operations for conditional assembly, data and string definition, and multiple location counter program development. On diskette with documentation is $75. Allen Ashley, 395 Sierra Madre Villa, Pasadena, CA 91107 (Tel: 213-793-5748).

8080/8085 Books. The two-volume *8080/8085 Software Design* handbooks (Book 1 at $9.50 and Book 2 at $9.95) published by Howard W. Sams form a complete compilation of programs and subroutines for the 8080/8085. Included in each program and subroutine is an in-depth study of the goals that the software must accomplish, the instructions used, and the strong and weak points of the developed software. The *TEA* (Tychon's Editor Assembler) at $8.95 describes this co-resident editor-assembler including source listing, while the *DBUG 8080 Interpretive Debugger* at $4.95 illustrates a program for entering, debugging and storing assembly language programs, complete with source code. All books are from the Blacksburg Group of Christopher Titus, Peter Rony, David Larsen and Jonathan Titus.

CP/M for the Altair. Implemented on the Altair and MITS 3202 series of floppy disks, the Altair CP/M allows access to all CP/M software. $145. Lifeboat Associates, 2248 Broadway, New York, NY 10024 (Tel: 212-580-0082).

OSI Sort. BPSort is a high-speed, machine-code sort/merge utility for Ohio Scientific floppy and hard-disk systems. 20,000 bytes can be sorted in 10 seconds. Files can be as long as an entire hard or soft disk and five keys handle ascending and/or descending sequence. Sort parameters use a simple BASIC program. BPSort is OS-DMS compatible and is supplied as part of the BPS Interactive Data Management System. $124 from BPS, 322 W. 57 St., New York, NY 10019 (Tel: 212-765-0815).

TRS-80 Statistics. The Advanced Statistical Analysis package may be used with Level II BASIC or Disk BASIC on a 16K TRS-80. Included in the system are 10 programs for describing data sets and conducting statistical data analysis; two utility programs for preparing, updating and listing data files stored on tape or disk; and a program to aid in selecting data samples. Programs include tape data files, disk data files, random sample, descriptive statistics, histogram, frequency distribution, analysis of variance, T-test for matched pairs, correlation and linear regression, multiple linear regression, time series analysis, and chi square analysis. $39.95 at Radio Shack stores or computer centers. ◇

PROJECT OF THE MONTH

Light-Wave Voice Communicator

BY FORREST M. MIMS

THIS MONTH'S project is an amplitude-modulated light-wave voice communicator that you can assemble from inexpensive, readily available components. You can use the communicator to send and receive high-quality voice signals over distances of hundreds of feet through the atmosphere or through an optical fiber "waveguide."

The Transmitter. The transmitter, which is shown schematically in Fig. 1, employs a 741 op amp as a high-gain audio amplifier which is driven by a microphone. The output of the 741 is coupled to *Q1*, which serves as the driver for a LED. Potentiometer *R1* is the amplifier's gain control. Miniature trimmer resistor *R6* permits adjustment of the base bias of *Q1* for best transmitter performance.

Gain control *R1* can be eliminated if *C1* and *R2* are connected directly to pin 2 of the 741. For maximum sensitivity, increase the value of *R2* from one to ten megohms and use a crystal microphone with a large diaphragm such as the Radio Shack Model 270-095. The miniature crystal microphones sold by many parts suppliers will also work, but they generate less output.

If you prefer, fixed resistors *R5* and *R7* and potentiometer *R6* can be replaced with two fixed resistors after *R6* has been adjusted for best transmitted voice quality. Disconnect *R5* from +9 volts and *R7* from ground, measure the resistance between the wiper of *R6* and the disconnected ends of *R5* and *R7*, and substitute fixed resistors having similar values.

The transmitter works best with near-infrared emitting GaAs, GaAlAs and GaAs:Si LEDs. GaAsP red LEDs can also be used, but they emit considerably less optical power and therefore are best suited for optical fiber links.

Whichever LED you select, it is important to limit its forward current to a safe operating level. A reasonable range of quiescent current is from 10 to 40 milliamperes. High-level audio inputs will raise the current substantially. Resistor *R8* determines the quiescent current, and its resistance should be 100 or more ohms. In my prototype, 330 ohms gave a standby current of 22 milliamperes.

For best results, insert a milliammeter between the emitter of *Q1* and the LED's anode and substitute a 1000-ohm potentiometer for *R8*. Adjust the potentiometer until the desired current level is achieved. Then remove the pot, measure its resistance, and replace it with a fixed resistor.

The Receiver. The light-wave receiver, which is shown in Fig. 2, consists of a 741 operated as a preamplifier and an LM386 power amplifier. Potentiometer *R2* is the gain control.

You can use various kinds of detectors as the front end of the receiver. Phototransistors are very sensitive, but they do not work well in the presence of too much ambient light. Note that a 100,000-ohm series resistor is required if you use a phototransistor. Solar cells and photodiodes work well. So do LEDs of the same semiconductor as the transmitter.

An interesting aspect of using LEDs as detectors is that, although they are not as sensitive as phototransistors, they are much less sensitive to the adverse swamping effects of ambient light. Using a LED as a detector also means you can switch the LED's anode between the input of the receiver and the output of the transmitter to form a light-wave voice transceiver capable of bidirectional communications through a single optical fiber. Of course, you'll need two complete transceivers to fully use this operating mode.

Going Further. This transmitter and receiver system will send voice across a room without the need for external optics. For ranges of hundreds of feet, you must use a lens to collimate the light from the LED. You must also use a lens to collect and focus light on the receiver's detector. For more information on the use of lenses and related subjects, see *Light-Beam Communications* (F. Mims, Howard W. Sams & Co., 1976).

It's difficult to align the invisible beam from an infrared transmitter LED, but you can eliminate this problem *and* communicate around corners by using an optical fiber. See this month's "Experimenter's Corner" for more about this subject. ◇

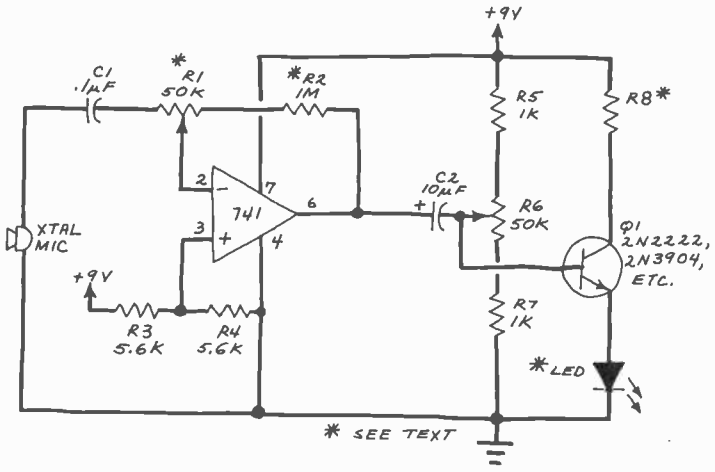

Fig. 1. Schematic of a light-wave voice transmitter.

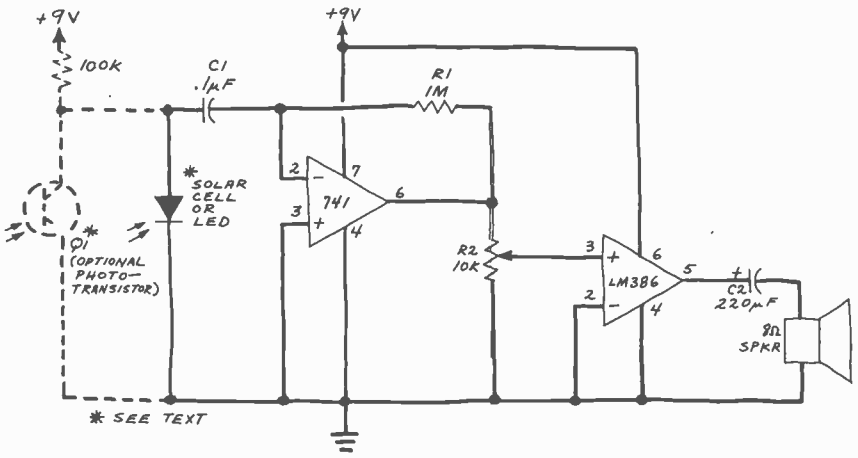

Fig. 2. A light-wave receiver to go with the transmitter.

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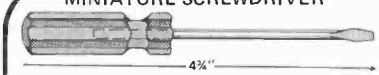

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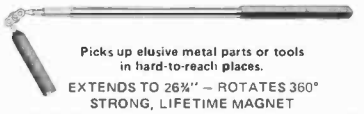


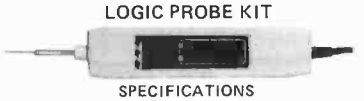
Picks up elusive metal parts or tools in hard-to-reach places.

EXTENDS TO 26¾" – ROTATES 360°
STRONG, LIFETIME MAGNET

MRT-2281 ..... $3.95

CSC CONTINENTAL SPECIALTIES

LOGIC PROBE KIT



SPECIFICATIONS

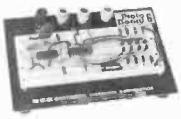
Input Impedance: 300,000 Ohms.
Thresholds: "Lo" 30%Vcc – "Hi" 70%Vcc
Maximum Speed: 300 nsec., 1.5MHz
Input Protection: ±50VDC continuous 117VAC for 15 sec.
Power: 30mA @5V – 40mA @ 15V – 25V max. reverse voltage protected; 36" cable with color coded clips included.
Operating Temp.: 0-50°C.
Dimensions: 5.8L x 1.0W x 0.7D in. (147 x 25 x 18mm)
Weight: 30 oz. (85 gm)

LPK-1 ..... $21.95/Kit

Proto Clips

14-PIN CLIP	PC-14	$ 4.50
16-PIN CLIP	PC-16	$ 4.75
24-PIN CLIP	PC-24	$10.00
40-PIN CLIP	PC-40	$16.00

Proto Boards



PB-6	$17.95
PB-100	19.95
PB-101	22.95
PB-102	26.95
PB-103	44.95
PB-104	55.95
PB-203	99.95
PB-203A	155.00
PB-203A-Kit	131.00

Jumbo 6-Digit Clock Kit

- Four .630"ht. and two .300"ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6¾ x 3⅛ x 1¾

JE747 ..... $29.95

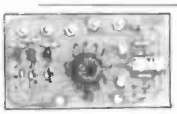
- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE701 — 6-Digit Clock Kit $19.95

Regulated Power Supply

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

JE200 ..... $14.95



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

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

JE205 ..... $12.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES

8080A	CPU	$ 7.95
8212	8-Bit Input/Output	3.25
8214	Priority Interrupt Control	5.95
8216	Bi-Directional Bus Driver	3.49
8224	Clock Generator/Driver	3.95
8226	Bus Driver	3.49
8228	System Controller/Bus Driver	4.95
8238	System Controller	5.95
8251	Prog. Comm. I/O (USART)	7.95
8253	Prog. Interval Timer	14.95
8255	Prog. Periph. I/O (PPI)	9.95
8257	Prog. DMA Control	19.95
8259	Prog. Interrupt Control	19.95

6800/6800 SUPPORT DEVICES

MC6800	MPU	$14.95
MC6802CP	MPU with Clock and Ram	24.95
MC6810AP	128X8 Static Ram	5.95
MC6821	Periph. Inter. Adapt (MC682D)	7.49
MC6828	Priority Interrupt Controller	12.95
MC6830L8	1024X8 Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	7.95
MC6852	Synchronous Serial Data Adapt.	9.95
MC6860	0-600 bps Digital MODEM	12.95
MC6862	2400 bps Modulator	14.95
MC6880A	Quad 3-State Bus Trans. (MC8726)	2.25

MICROPROCESSOR CHIPS—MISCELLANEOUS

Z80(780C)	CPU	$13.95
Z80A(780-1)	CPU	15.95
CDP1802	CPU	19.95
2650	MPU	19.95
6502	CPU	11.95
8035	8-Bit MPU w/clock, RAM, I/O lines	19.95
P8085	CPU	19.95
TMS9900JL	16-Bit MPU w/hardware, multiply & divide	49.95

SHIFT REGISTERS

MM500H	Dual 25 Bit Dynamic	$.50
MM503H	Dual 50 Bit Dynamic	.50
MM504H	Dual 16 Bit Static	.50
MM506H	Dual 100 Bit Static	.50
MM510H	Dual 64 Bit Accumulator	.50
MM5016H	500/512 Bit Dynamic	.89
2504T	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4.95
2522	Dual 132 Bit Static	2.95
2524	512 Static	.99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4.00
2529	Dual 240 Bit Static	4.00
2532	Quad 80 Bit Static	2.95
3341	Fifo	6.95
74LS670	4X4 Register File (TriState)	2.49

UART'S

AY-5-1013	30K BAUD	5.95

MICROPROCESSOR MANUALS

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

ROM'S

2513(2140)	Character Generator(upper case)	59.95
2513(3021)	Character Generator(lower case)	9.95
2516	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

RAM'S

1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(6101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024X4	Static 450ns	7.95
2114L	1024X4	Static 450ns low power	10.95
2114-3	1024X4	Static 300ns	10.95
2114L-3	1024X4	Static 300ns low power	11.95
5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4.95
7489	16X4	Static	7.75
74S200	256X1	Static Tristate	4.95
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16 pin 250ns	9.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00

PROM'S

1702A	2048	FAMOS	$5.95
2716INTEL	16K*	EPROM	59.95
TMS2516	16K*	EPROM	39.95
(2716)	*Requires single +5V power supply		
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I	16K**	EPROM	29.95
	**Requires 3 voltages, —5V, +5V, +12V		
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

JE600 HEXADECIMAL ENCODER KIT

FEATURES:
- Full 8 bit latched output for microprocessor use
- 3 User Define keys with one being bi-stable operation
- Debounce circuit provided for all 19 keys
- LED readout to verify entries
- Easy interfacing with standard 16 pin IC connector
- Only +5VDC required for operations

FULL 8 BIT LATCHED OUTPUT—19 KEYBOARD

The JE60C Encoder Keyboard provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8 bit microprocessor or 8 bit memory circuits. Three (3) additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with LED readouts. Also included is a key entry strobe.

JE600 ..... $59.95
Hexadecimal Keypad only $14.95

DIGITAL THERMOMETER KIT

- Dual sensors—switching control for indoor/outdoor or dual monitoring
- Continuous LED .8" ht. display
- Range: -40°F to 199°F / -40°C to 100°C
- Accuracy: ±1° nominal
- Set for Fahrenheit or Celsius reading
- Slim, walnut case - AC wall adapter incl.
- Size: 3-1/4"H x 6-5/8"W x 1-3/8"D

JE300 ..... $39.95

62-Key ASCII Encoded Keyboard Kit

The JE610 62-Key ASCII Encoded Keyboard Kit can be interfaced into most any computer system. The JE610 Kit comes complete with an industrial grade keyboard switch assembly (62 keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and –12V @ 10mA for operation.

FEATURES:
- 60 Keys generate the full 128 characters, upper and lower case ASCII set
- Fully buffered
- 2 user-define keys provided for custom applications
- Caps lock for upper case only alpha characters
- Utilizes a 2376 (40 pin) encoder read only memory chip
- Outputs directly compatible with TTL/DTL or MOS logic arrays
- Easy interfacing with a 16-pin dip or 18-pin edge connector

JE610 ..... $79.95
62-Key Keyboard only . . $34.95

HICKOK — LX303 Portable LCD Digital Multimeter

- Big ½ inch high, 3½ Digit Liquid Crystal Display • Over 200 Hours of operation with a 9V battery • Automatic zero, polarity and overrange indication • 100mV DC F.S. sensitivity • 1% basic accuracy • 19 ranges and functions • Rugged Cycolac® case and removable cover, stores test lead set • Full one year warranty

SPECIFICATIONS: DC volts 15 ranges: 0.1mV to 1000V, Accuracy ±0.5% rdg ±0.5% f.s. Input imped. 10MΩ. Max. input 1kV except 500V on 200mV range. AC Volts (40Hz to 5kHz): 0.1 to 500V, Accuracy ±1.0% rdg ±3.5% f.s. (~2dB max. @ 5kHz). Max. rating 600V Resistance 10 Low Power Ranges: 0.1 to 20MΩ. Accuracy ±0.5% rdg ±0.5% f.s. (±1.5% rdg on 20MΩ range) input protected to 120V AC on ranges. DC Current 10 ranges: 0.1mA to 100mA. Accuracy ±1.0% rdg ±0.5% f.s. Dimensions and Weight: 5-7/8" x 3-3/8" x 1-3/4", 8 oz. POWER: 9V battery (not included) or Nickel-Cad. adaptor. READ RATE: 3/sec.

LX303 Digital Multimeter $74.95

PART NO.	DESCRIPTION	PRICE
RC-3	115V AC ADAPTER	7.50
CC-3	PADDED CARRYING CASE	7.50
VP-10	X10 DC PROBE ADAPTER (Up to 10K)	14.95
VP-40	40kV DC PROBE	35.00
CS-1	10 Amp DC Current Shunt	14.95

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5-80

The Incredible "Pennywhistle 103"

$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable).
Maximum Data Rate	300 Baud.
Data Format	Asynchronous Serial (return to mark level required between each character).
Receive Channel Frequencies	2025 Hz for space, 2225 Hz for mark.
Transmit Channel Frequencies	Switch selectable: Low (normal) = 1070 space, 1270 mark; High = 025 space, 2225 mark.
Receive Sensitivity	-46 dbm accoustically coupled.
Transmit Level	-15 dbm nominal. Adjustable from -6 dbm to -20 dbm.
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz.
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar).
Power Requirements	120 VAC, single phase, 10 Watts.
Physical	All components mount on a single 5" by 9" printed circuit board. All components included.

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align.

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
- 8 each UPD416-1 (16K Dynamic Rams) 250NS
- Documentation for conversion

TRS-16K $75.00

JUST WRAP™

- 30 AWG wire
- Daisy chain or point-to-point
- No stripping or slitting required—just wrap
- .025" square posts
- Built-in cut off
- Includes 50 ft. wire

Part No.	Wire Color	Price
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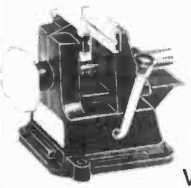
JW-1-W	White	14.95
JW-1-Y	Yellow	14.95
JW-1-R	Red	14.95

JUST WRAP™ Replacement Wire

Part No.	Color		Price
R-JW-B	Blue	50 ft. roll	$2.98
R-JW-W	White	50 ft. roll	2.98
R-JW-Y	Yellow	50 ft. roll	2.98
R-JW-R	Red	50 ft. roll	2.98

JUST WRAP™ Unwrap Tool $3.49



Vacuum Vise

Vacuum-based light-duty vise for small components and assemblies. ABS construction. 1⅛" Jaws, 1¼" travel. Can be permanently installed.

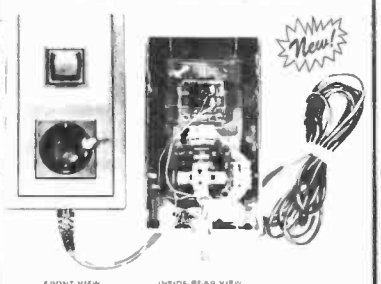
VV-1 ..... $3.49

ADJUSTABLE WRENCH

- Two Sizes: 6" and 10"
- Professional Quality
- Chrome Vanadium Steel

6"– AW-6 . . $4.95 10"– AW-10 . . $6.95

JOYSTICK VIDEO CONTROLLER



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- IDEAL FOR ALL VIDEO GAMES OR REMOTE CONTROL PROJECTS
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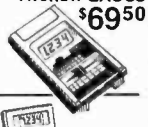
- 2 MINIATURE POTENTIOMETERS—40K OHM EACH
- SPST PUSH BUTTON CONTROL
- 5-WIRE CONNECTION CABLE – 5 FEET LONG
- RUGGED PLASTIC CASE

JVC-40 ..... $4.95 each

DIGITAL MULTIMETERS

Sinclair PDM35 Reg. $69.95 **$49.95**

Hickok LX303 **$69.50**



B&K PRECISION 3½-Digit Portable DMM Model 2800

Beckman TECH310 **$130.**

MURAPHONE Cordless Telephone System

Reg. $89.95 **$74.95**

GTE Flip-Phone **$37.95**

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Model VM520 **$19.95**

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100 MHz 8-Digit Counter

CSC

▪ 20 Hz to 100 MHz range ▪ LED display ▪ Fully automatic

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Model BP2000-69TR **$14.95 ea.**

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Model 388

CSC Logic Monitor

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15 MHz Triggered Miniscope Model MS-15 Reg. $319.00 **$269.95**

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▪ Sine-, square-, triangle- and separate TTL square wave output ▪ Frequency range: 1Hz-100KHz

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B&K PRECISION Portable Digital Capacitance Meter

Model 820

▪ Measures capacitance from 0.1pF to 1 Farad ▪ Resolves to 0.1pF ▪ 10 ranges for accuracy and resolution ▪ 4 digit easy-to-read LED display ▪ 0.5% accuracy

WAHL ISOTIP 60 Cordless Soldering Iron

$29.95 Model 7800

Thermal-Spot Circuit Tester Model 5800 $29.95

Miniature High Fidelity 3-Way Stereo Speakers

$69.50 PR Reg. $149.95

Model HF-9

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8-Track Tape Player with AM/FM/MPX Radio Model C-777 **$52.50**

Cassette Tape Player with AM/FM/MPX Radio Model CAS-888 **$57.50**

CSC Logic Probe

▪ Compact circuit powered ▪ Detects pulses as short as 50 μsec ▪ DTL/TTL/HTL/CMOS compatibility **$44.95**

Model LP-1

Proto Preassembled Boards

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Fully assembled breadboard contains four OT-59S sockets, seven OT-59B bus strips and four 5-way binding posts

CSC Proto Board with Built-in Power Supplies

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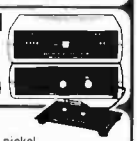
CSC 3½-Digit 0.1% Digital Capacitance Meter Model 3001

▪ 9 ranges from 1999 pF to 199.9 μF ▪ 0.1% of reading accuracy Reg. $190.00 **$170**



DIGITAL MULTIMETER Simpson 461

Complete with nickel-cadmium batteries, AC charger/adapter, test leads **$149.95**

BSR X-10

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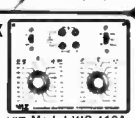
Appliance Modules $14.50 Ultrasonic Commaid Console with Hand Held Remote $59.95
Wall Switch Modules $14.50

Stereo Power Booster

Model POW-40 ▪ 40W stereo **$24.95**

RC Circuit Box

▪ 36 resistors (15 Ω to 10 MΩ) ▪ 18 capacitors (100 pf to 0.22 μf) Reg. $49.95 includes test leads **$42.**



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Model 1827

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RO170 Rectifier C23784 5 for $1.00 100 for $15.00

Mini Reed Switch C23840 5 for $1.00

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TI-30SP	17.95	Language Translator NEW	279.95
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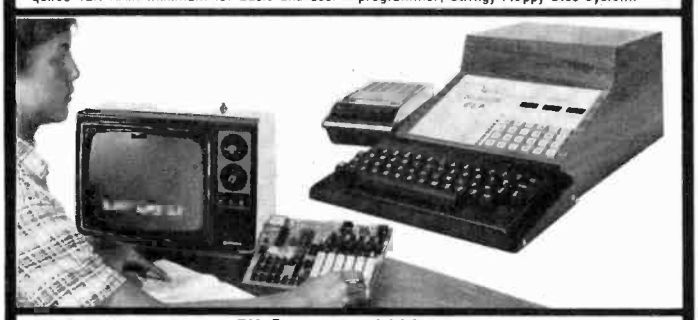

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The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not Included In others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating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

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Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year. Issues 1-12 bound $16.50.

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

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

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

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74LS190N	1.06	CD34001 Pair	.50	8098	.65				
74LS221N	1.95	CD4000	.16	8109	1.25				
74LS250N	.67	CD4001	.28	8T10	4.50				
74LS367N	1.35	CD4002	.28	8T13	3.00				
		CD4006	1.10	8T20	5.50				
LINEAR		CD4007	.28	8T23	3.10				
CA3045	.90	CD4008	.28	8T24	3.50				
CA3046	1.10	CD4009	.45	8T25	3.20				
CA3081	1.80	CD4010	.45	8T26	1.69				
CA3082	1.90	CD4011	.28	8T28	2.75				
CA3089	2.95	CD4012	.28	8T97	1.69				
LM301AN/AH	1.35	CD4013	.39	8T98	1.69				
LM305H	.87	CD4014	1.00						
LM307N	.35	CD4015	1.00	**MOS/MEMORY**					
LM308N	.89	CD4016	.45	**RAM**					
LM309K	1.50	CD4017	1.25	2101-1	3.95				
LM311H/N	.90	CD4018	.94	2102-1	.95				
LM317T/K	3.75	CD4019	.45	2102AL-4	1.25				
LM318	1.35	CD4020	1.02	2102AN-2L	1.60				
LM320K-5	1.50			21L02-1	1.18				

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2107B-6	3.75		
2111-1	3.75		
2112-2	3.95		
2114L 300ns	7.40		
4116 200ns	9.50		
8-4116 200ns	64.00		
25138	.8.30		
MM5262	.40		
MM5280	3.00		
MM5320	9.95		
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P5101L	8.95		
4200A	9.95		
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GAY38500-1	9.95		
MCM66751A	9.95		
9368	3.50		
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416	16.00		
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MM5311	5.50		
MM5312	3.90		
MM5314	3.90		
MM5369	2.10		
MM5841	14.45		
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DS0026CN	3.75		
DS0056CN	3.75		
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6502	12.50		
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6522	13.50		
6800	17.50		
6802	18.75		
6820	9.95		
6850	12.95		
8080A	8.95		
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8253	15.00		
8255	9.25		
8257	19.50		
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8748	75.00		
8748-8	70.00		
8755A	65.00		
N82S23	2.95		
N82S123	3.50		
N82S126	3.75		
N82S129	3.75		
N82S131	3.75		
N82S136	8.75		
N82S137	8.75		
DM8577	2.90		
8223	2.90		
8/2716 Intel	240.00		

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30 pin edge	2.50
44 pin edge	2.75
100 pin edge	4.50
100 pin edge WW	S. 2.75

IC SOCKETS
Solder Tin Low Profile

PIN	1UP	PIN	1UP
8	.15	22	.30
14	.14	24	.35
16	.16	28	.42
18	.27	36	.58
20	.29	40	.37

2 level 14 pin one 20

WIRE WRAP LEVEL 3

PIN		PIN	
14	.32	24	.86
16	.33	28	1.00
18	.57	40	1.23

CRYSTALS

1 MHz	4.50
2 MHz	4.50
4 MHz	4.25
5 MHz	4.25
10 MHz	4.25
18 MHz	3.90
20 MHz	3.90
32 MHz	3.90
32768 Hz	4.00
1.8432 MHz	4.50
3.5795 MHz	1.20
2.0100 MHz	1.95
2.097152 MHz	4.50
2.4576 MHz	4.50
3.2768 MHz	4.50
5.0688 MHz	4.50
5.185 MHz	4.50
5.7143 MHz	4.50
6.5536 MHz	4.50
14.31818 MHz	4.25
18.432 MHz	4.50
22.1184 MHz	4.50

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AY5-9100	10.50
AY5-9200	16.50
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74C923	5.50
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½ watt 5% per type .05

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MAN3	CC	125	.39
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DL747/750	CA/CC	600	1.95
DL750	CC	600	1.95
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FND500/507	CC/CA	500	1.35
FND503/510	CC/CA	500	.90
FND800/807	CC/CA	800	2.20
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4 digit Bubble			.80
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MAN4740	CC	40	1.20
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Heathkit model 07 oscilloscope. Need schematic and manual. Saxe Dobrin, 426 W. Marshall St., San Gabriel, CA 91776.

R & D Instruments S1715 or 1715BR square-wave generator. Need schematic or operating manual. J. Morgan, 3008 Ozark Rd., Chattanooga, TN 37415.

The Voice of Music model 1484-2 stereo tuner amplifier. Need operating manual, service manual, parts list and schematic. Vick F. Griffin, Box 2752, Wichita, KS 67201.

Singer Metrics model SPA 3/25a Panoramic spectrum analyzer. Need operating manual and schematics. Phil LeMieux Measurement Arts, Inc., Bldg. 24-4, 555 Valley St., Providence, RI 02908.

Fisher model 203 80-watt stereo receiver. Need schematic. Charles Harris, 7614 Vicar St., New Carrollton, MD 20784.

Standell Super Artist bass guitar amp and **Bell & Howell** model 34 oscilloscope. Need schematics and parts lists. Billy Happoldt, 3886 Ridge Ave., Macon, GA 31204.

Allied Radio, Knight Star Roamer. Need schematic and alignment information. Larry Cook, 362 East South St., Richland Center, WI 53581.

RCA WO-88A oscilloscope. Need owner's manual or schematic. R. Gray, Box 1313, Donaldsonville, LA 70346.

ESS Trans-static I speaker. Need owner's manual with fuse requirements and schematic. Erich Lauff, 78 Pressley Rd., Asheville, NC 28805.

Potter model MT-24 tape transport, model EC-36 tape transport control and model MA-315 record/playback amp. Need schematics and service or operating manuals. James Lee, 38 Woodcrest Ave., Ithaca, NY 14850.

Beta Instruments Corp., "Betacom" residence intercom, circa 1951-52. Need schematic. E. C. Alexander, 1425 Marlon Ct., Geneva, IL 60134.

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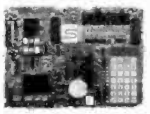
SYM-1



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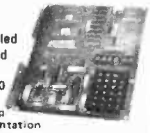

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APS 24-1	24	1.0	APS 24-2.2	24	2.2
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WIRE WRAPPING TOOLS

O.K.'s Model BW-630 battery operated wrapping tool, uses two size "C" batteries (not included) for making "Modified" wrap of No. 30 wire around .025" square post. This unit is lightweight, and has positive indexing and anti-overwrapping device.
CATALOG NO. 25-00630 ..... $34.95

O.K.'s Model BW-2628 tool is same as above, but is for wrapping Nos. 26 to 28 wires.
CATALOG NO. 25-02628 ..... $39.95

O.K.'s Model WSU-30M Manual wire wrapping tool is a three in one hand tool that strips No. 30 wire, makes "Modified" wraps and even unwraps previously wrapped posts.
CATALOG NO. 25-16000 ..... $7.95

O.K.'s Model WSU-30 is the same as above, but makes "Regular" instead of "Modified" wraps.
CATALOG NO. 25-15000 ..... $6.95

VECTOR's Model P178-1 Wiring Pencil guides and wraps insulated wire onto circuit leads from replaceable bobbins. Connections are made by soldering with a 750°F iron. When heat is applied, wire coating melts, permitting solder that is under the coating to bond the junction.
CATALOG NO. 23-81781 ..... $7.95

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VECTOR's Model P180 Slit-N-Wrap hand tool uses 130°C rated Poly-Nylon wire for wrapping gas-tight wraps around .025" square posts. The tool slits the wire before wrapping and can make "Daisy-Chain" connection, so no pre-cut or pre-stripping is required. It comes complete with two 100' spools of wire and a P183 Knife Tool.
CATALOG NO. 23-81800 ..... $25.00

VECTOR's Model P160-4T is a battery powered high speed wrapping gun that incorporates Model P180 Slit-N-Wrap tool above for high speed wrapping applications. With built-in Ni-Cads and recharger unit.
CATALOG NO. 23-86490 ..... $99.50

VECTOR's Model P160-4T1 is same as above, but it operates from 110V AC for continous operation.
CATALOG NO. 23-86491 ..... $99.50

VECTOR's Model P184 Slit-N-Wrap hand tool is the same as Model P180 Tool described above, however, it uses 150°C rated Tefzel wire for ultimate in reliability.
CATALOG NO. 23-81840 ..... $30.00

VECTOR's Model P184-4T is a battery powered wrapping gun that incorporates Model P184 Slit-N-Wrap Tool for high volume production. Complete with Ni-Cads and recharger unit.
CATALOG NO. 23-88490 ..... $105.00

VECTOR's Model P184-4T1 is AC powered version of above for non-stop continous operation.
CATALOG NO. 23-88491 ..... $105.00

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In order to specify the color of insulation, please replace the "X" in price table below with the proper color number from the following table:

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BROWN	1	BLUE	6
RED	2	VIOLET	7
ORANGE	3	GRAY	8
YELLOW	4	WHITE	9

INSULATED LENGTH	PACKAGE OF 50 CATALOG NO.	PRICE	PACKAGE OF 100 CATALOG NO.	PRICE	PACKAGE OF 500 CATALOG NO.	PRICE	PACKAGE OF 1000 CATALOG NO.	PRICE
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1.5"	30-1502X	0.94	30-1503X	1.68	30-1504X	5.04	30-1505X	9.24
2.0"	30-2002X	0.98	30-2003X	1.75	30-2004X	5.25	30-2005X	9.63
2.5"	30-2502X	1.02	30-2503X	1.83	30-2504X	5.49	30-2505X	10.06
3.0"	30-3002X	1.05	30-3003X	1.90	30-3004X	5.70	30-3005X	10.45
3.5"	30-3502X	1.14	30-3503X	1.98	30-3504X	5.94	30-3505X	10.89
4.0"	30-4002X	1.18	30-4003X	2.05	30-4004X	6.15	30-4005X	11.28
4.5"	30-4502X	1.22	30-4503X	2.13	30-4504X	6.39	30-4505X	11.72
5.0"	30-5002X	1.25	30-5003X	2.20	30-5004X	6.60	30-5005X	12.10
6.0"	30-6002X	1.33	30-6003X	2.35	30-6004X	7.05	30-6005X	12.93
7.0"	30-7002X	1.45	30-7003X	2.50	30-7004X	7.50	30-7005X	13.75
8.0"	30-8002X	1.52	30-8003X	2.65	30-8004X	7.95	30-8005X	14.58
9.0"	30-9002X	1.60	30-9003X	2.80	30-9004X	8.40	30-9005X	15.40
10.0"	30-1012X	1.68	30-1013X	2.95	30-1014X	8.85	30-1015X	16.23
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7402	0.17	7492	0.43	74198	1.45	74LS125	0.48	74S04	0.36	74C73	0.71	4012	0.22	4518	1.13
7403	0.17	7493	0.43	74199	1.45	74LS126	0.48	74S05	0.36	74C74	0.48	4013	0.39	4519	0.62
7404	0.18	7494	0.65	74251	1.09	74LS132	0.80	74S09	0.38	74C76	0.71	4014	0.95	4520	1.13
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7410	0.17	74121	0.34	74366	0.62	74LS153	0.84	74S30	0.35	74C93	0.97	4020	1.13	4582	0.88
7411	0.20	74122	0.39	74367	0.62	74LS154	1.09	74S40	0.35	74C95	1.09	4021	1.13	4584	0.74
7412	0.20	74123	0.49	74368	0.62	74LS155	0.74	74S64	0.38	74C107	0.69	4022	0.95	4702	7.10
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7416	0.24	74132	0.65			74LS158	0.74	74S76	0.58	74C157	1.89	4025	0.22	4705	9.25
7417	0.24	74141	0.79	74LS00	$0.27	74LS160	1.01	74S78	0.58	74C160	1.17	4027	0.39	4706	9.75
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7445	0.69	74162	0.87	74LS32	0.32	74LS194	0.87	74S287	3.20	74C903	0.59	4050	0.39	40193	1.37
7446	0.69	74163	0.87	74LS37	0.32	74LS196	0.85	74S300	1.60	74C904	0.59	4051	1.19	40194	1.08
7447	0.62	74164	0.87	74LS38	0.32	74LS197	0.85	74S305	1.60	74C905	6.00	4052	1.19	40195	1.08
7448	0.69	74165	1.95	74LS40	0.27	74LS221	1.90	74S310	2.85	74C906	0.59	4053	1.19		
7450	0.19	74166	1.20	74LS42	0.66	74LS253	0.99	74S312	1.05	74C907	0.59	4060	1.49	**LINEAR**	
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7474	0.29	74181	1.95	74LS78	0.38	74LS366	0.66	**74Cxx**		74C928	7.80	4077	0.59	uA711A	0.39
7475	0.48	74182	0.78	74LS83	0.78	74LS367	0.66					4078	0.39	uA723A	0.49
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ADVERTISERS INDEX

READER SERVICE NO.	ADVERTISER	PAGE NO.
2	Active Electronics Sales Corp.	109
3	Amelect, Inc.	97
4	Ancrona Corporation	114
5	APF Computer	Cover 4
6	Apple Computer	Cover 2
7	AP Products	12
	Audio Technics, Inc.	90
	Bullet Electronics	104
8	BYTE	89
	Camelot Direct	53
9	Chaney Electronics	108
	Classified Advertising	116, 117, 118, 119
	Cleveland Institute of Electronics, Inc.	26, 27, 28, 29
70	Cobra	Cover 3
1	Communications Electronics	98
10	Communications Technology Group	119
11	Components Express, Inc.	96
12	Computique	108
13	Concord Computer Components	86
14	Creative Computing Magazine	97
15	Custom Craft	86
16	DAK Industries	15
17	Delta Electronics	115
18	Digi-Key Corp.	105
19	Discwasher	20
20	DSI Instruments, Inc.	30
	Educational Calculator Devices	99
22	Eico	98
23	80 Microcomputing	92
	Electronic Technical Institute	88
25	Enercon	85
	Fordham Radio Supply	108
26	General Engines Company	119
27	Godbout Electronics, Bill	115
	Grantham College of Engineering	99
28	Guardian Electronics	13
29	Hardside	100
30	Hayden Books	102
31	Heath Co.	69
69	Heath Co.	40
32	Hobby World	104
29	Hustler	85
33	Illinois Audio	92
34	Information Unlimited	90
35	International Components Corp.	114
36	Jameco Electronics	106, 107
37	J&R Music World	102
	JS & A National Sales Group	1, 9
38	Kiloband Micro Computing	100
39	Lifeboat	101
40	Maxell Corp. of America	54
	MICROCOMPUTER MART	101
41	Media Marketing	94
	Mercury International	76
42	McIntosh Laboratory, Inc.	10
43	National Guard	39
	Netronics R & D Ltd.	45
	Netronics R & D Ltd.	95
44	Novation, Inc.	6
	NRI Schools	16, 17, 18, 19
45	Ohio Scientific	5
47	OK Machine & Tool Corp.	35
48	OK Machine & Tool Corp.	7
49	OK Machine & Tool Corp.	87
50	Olympic Sales	113
51	Omnisonix	24
52	Paccom	90
52	PAIA Electronics, Inc.	98
54	PAL "Firestik" Antenna Corp.	98
55	Parts Masters, Inc.	92
56	Peoples' Computer Co.	82
57	Percom Data Company, Inc.	2
58	Personal Software	11
59	Pioneer Electronics	22
60	Poly Paks	113
61	Quest Electronics	110
	Radio Shack	70
62	Rainbow Computing, Inc.	74
63	RCA Home Computer	33
64	Riehl Time corp.	75
65	RNB Enterprizes	84
	Sabtronics International	14
	Sharper Image, The	23
66	Shopsmith	91
71	Solarex	99
68	University of the Trees, Press	60

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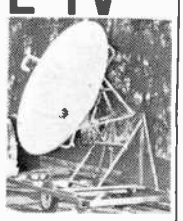

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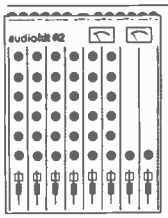

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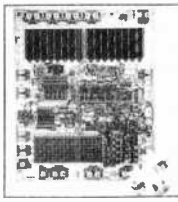

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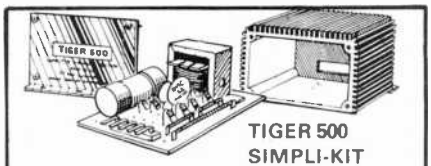

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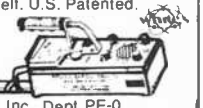

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CELEBRATE W.C. FIELDS 100th Birthday! Order his 16mm B&W 400' Snd Film "Much Ado About Golf." Low priced @ $29.95 ea (40. list), or "Bank Dick" or "Never Tell A Lie", each 800' 16mm B&W Snd film, $69.95 ea ($80. reg), add $3. per reel for ship. Price changes next month. Castle Travel Films, 200' Color Mag Snd $19.95 ea ($32.95 list) "San Juan" or "New York", or Ali-Spinks I, boxing upset of century. 4 reels S-8 Color/Snd, complete 64" version, only $150. PPD. (you save $75.). "Who's On First" Abbott & Costello 100' S-8 B/W Snd Baseball comedy only $12.95 PPD, 200' S-8 Snd $29. "Black Sunday" Super Bowl crowd endangered; 400' Paramount Feature S-8 color snd $64.95 + $2. ship (you save $5.). Another May special, complete set 16mm B&W snd News Parades covering the tumultuous 60's. 400' film, set of 10—'60-'69, $397.50 PPD. Sold in sets only — real news for collectors. Video Cassette special, expires 5/20 '79 World Series Video Movies (Pittsburgh/Baltimore), hilites of all 7 games only $69.95 ea (reg $74.95) + $2. ship. Indicate Beta or VHS, Charge your films & tapes to MasterCharge & Visa. Ill res. + 6% tax. Hollywood Gold Video movie cat., $1.50; Univ. S-8 film cat. $1.25; Columbia film cat. $1.25; Columbia VTR cat. 75; Paramount features 40¢; asst brochures, Sportlite, Ring Classics, Cloud 9, 40¢ ea. SPORTLITE FILMS, Elect-5, Box 24-500, Speedway, IN 46224.

MISCELLANEOUS

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CORVAIR PARTS — 290 page, 4500 item catalog rushed. Clark's Corvair Parts, Inc., Shelburne, Mass 01370.

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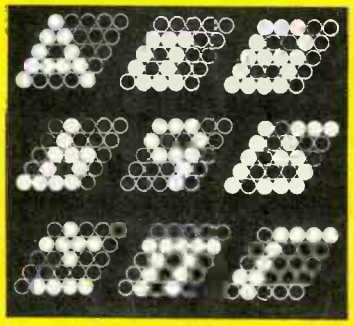
ELECTRONICS WORLD

Personal Electronics News

STARTLING ACCEPTANCE OF COMPUTERS is projected by a University of California Office of Interdisciplinary Programs study. By 1990, 40-million personal computers, enough to put one in over 50% of U.S. homes, will have been sold to first-time users, and no major technological breakthroughs are needed to make the projection a reality. The study found the majority of current owners to be male, aged 20 to 45, middle class, and well educated, with 7 out of 10 having at least a B.A. degree. Their educational background is most often engineering, business, natural science, or mathematics, but many are self-taught on computers. It was found that 80% used computers at work or work closely with someone who does. Main uses for personal computers are for video games, board games, and text editing.

JAPANESE FIRM ENTERS U.S. COMPUTER RETAIL MARKET. Super Brain, Inc. which has retail stores in Tokyo and Osaka, will offer a wide range of personal and business microcomputers as well as a complete line of peripherals. Los Angeles was selected for the company's first retail outlet location.



NEW ALPHANUMERIC DISPLAY forms numbers, upper- and lower-case letters, and scientific symbols using nested arrays of 23 dots or less as compared to typical 35-dot displays. Called the Laitram system, the dots are tilted at a 60° angle to form the characters with a minimum of lights. The format can be multiplexed on a 5X5 matrix and extended row formats can be used for dynamic scrolling to display entire messages. For specialized displays, arrays may contain the least number of elements to do the required job. Licensing to use the system is available from Laitram, Box 50699, New Orleans, LA 70150 (504-733-6000).

AN AUDIO RECORDING WORKSHOP will be held in conjunction with this summer's Aspen (Colorado) Music Festival. The Aspen Audio-Recording Institute workshop will be offered three times during the summer (June 23-July 13, July 14-August 3, and August 4-24) and will have a maximum of ten students per session. Combining hands-on experience with lectures, classes are conducted by professional recording-industry representatives. The various music events at the Aspen Festival provide a range of opportunities on which to practice recording techniques. For more information, call 212-581-2196.

HOME VCR SALES UP 73.4% over last year for the month of January reports the Electronic Industries Association. Total video cassette recorder sales to retailers were 40,443 units, compared to 23,330 for 1979. Total U.S. market for color TV receivers also increased from 622,111 to 636,316 for the month.

THE UNITED STATES ROBOTICS SOCIETY announces a major reorganization and expansion plan in response to increasing demands for information. The first step is the transfer of USRS' primary communications function from the Rio Grande Valley to Silicon Valley. Commitment has also been made to expand membership, staff, and activity to recognize the widespread conviction that robots and artificial intelligence will have a significant place in our society. Correspondence should be sent to USRS, 616 University Ave., Palo Alto, CA 94301.

TWELVE HOURS RECORDING ON A CASSETTE can be achieved on Norwood's XLP[4] system. By recording on all four tracks (two sides of tape) of a C-90 cassette, for instance, at a speed less than ½ in./s, the XLP[4] 24-hour, 2-speed player/recorder can record a complete book of up to 250,000 words. The two-speed electronic system plays and records at normal speed as well. Norwood Industries has recorded and released over 85 novels, book classics, radio shows and religious selections. The audio "Novels-on-Tape" library is said to be expanding at a rate of five titles per week.

COBRA'S PUNCH-THROUGH SOUND COMES TO CAR STEREO.

The same technology that brought a quality of sound to CB never before thought possible, now brings a quality of sound to car stereo never before heard.

Introducing Cobra's Punch-Through Sound.

AM/FM Stereo sound. 8-track or cassette sound. Big, booming sound that gives you great highs and low-down lows. Because whichever Cobra receiver you choose, you get a full 25 watts of power plus an FM sensitivity of 1.9 micro-volts. And when you match your Cobra receiver to any one of Cobra's 2-way or 3-way speakers you get a sound that really sings. Add a Cobra graphic equalizer/amplifier and boost your power output to 60 watts. And get a sound you can feel.

See your Cobra radio dealer today. And when you buy a Cobra you also get a one year warranty and the assurance that there's a national network of factory service centers to help you with installation, service and advice.

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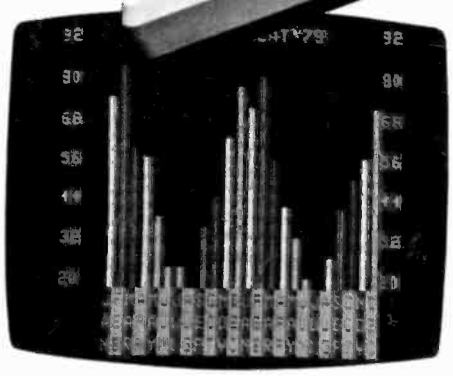

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Consider these features: 9K RAM, with 14K BASIC in ROM, 53-key typewriter keyboard. A fine resolution picture, generated on your television set or monitor in 8 colors!

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When you want to go beyond APF's library of educational, home-and-personal management or entertainment programs... when you want to create your own programs... you can. The Imagination Machine is programmable in BASIC and 6800 machine language. The Imagination Machine is also expandable. Just add our "Building Block", an optional, four-port expansion device, and you can hook up a printer, telephone modem, and additional memory cartridge or mini-floppy disk drive.

For the name of your nearest Imagination Machine dealer call, TOLL FREE: 1-800-223-1264. (New York residents call: (212) 758-7550) or write: APF Electronics, Inc. 444 Madison Avenue, N.Y., N.Y. 10022.

$599. Manufacturer's suggested retail price.

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