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SENSES MOVEMENT AT A DISTANCE

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Tested In This Issue:
Audio Control Spectrum Analyzer/Equalizer
The best supported personal computer you can buy.

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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 negatively charged air 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 O₃, whereas the molecular formula for ionized oxygen is O₂ 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:

<table>
<thead>
<tr>
<th>Name</th>
<th>*Ions</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energaire</td>
<td>438,000</td>
<td>$79.95</td>
</tr>
<tr>
<td>Omega 700</td>
<td>63,000</td>
<td>245.00</td>
</tr>
<tr>
<td>AirCare</td>
<td>72,000</td>
<td>149.95</td>
</tr>
<tr>
<td>Modulion</td>
<td>75,000</td>
<td>79.95</td>
</tr>
</tbody>
</table>

*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**

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.

**JS&A PRODUCTS THAT THINK**

Dept P.O. One JS&A Plaza
Northbrook, III. 60062 (312) 564-7000
Call TOLL-FREE ......... 800 323-6400
In Illinois Call ............ (312) 564-7000
©JS&A Group, Inc., 1980
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 alphanumeric-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 EGOST™, 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 EGOST™, 1K-byte of display memory and a comprehensive user's manual that includes an assembly language listing of EGOST™ 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.

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.

CIRCLE NO. 57 ON FREE INFORMATION CARD

MAY 1980
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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 B.Eng. 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 B.Eng. 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 B.Eng. curriculum is for four years. Consequently, some EE's are battling B.Eng.'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 Salberg
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-floppies.

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.

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.

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.
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 R6 conduct 0.5 ampere; and R5 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. Scheстопол’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 0.000025 cou-
From the trace gone where you've the ratios SOLVING LISSAJOUS PATTERNS centimeter radiation lombs per kilogram.

Substituted easily for conventional light-sensitive transistors and supply since verter used jumper of the receiving er. To use transceiver attached, transceiver the authors warning to anyone who uses Blow cheka and horizontal axis intersections, the ratio is: vertical frequency/horizontal frequency = horizontal axis intersections/vertical axis intersections.—D. J. Koscchea 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.

BW-2630 BATTERY TOOL

The new BW-2630 is a revolutionary battery powered wire-wrapping tool. The tool operates on 2 standard "C" size NiCad batteries (not included) and accepts either of two specially designed bits. Bit model BT-30 is for wrapping 30 AWG wire onto .025" square pins; BT-2628 wraps 26-28 AWG wire. Both produce the preferred "modified" wrap. Designed for the serious amateur, BW-2630 even includes both positive indexing and anti-overwrapping mechanisms — features usually found only in industrial tools costing five times as much. Pistol grip design and rugged ABS construction assure performance and durability. In stock at local electronic retailers or directly from OK Machine & Tool Corporation

3485 Conner St., Bronx, N.Y. 10475 U.S.A.
Tel. (212) 994-6600 Telex 125091

Minimum billing $5.00, add shipping charge $2.00
New York State residents add applicable tax

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 incorrectly 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.

CIRCLE NO. 66 ON FREE INFORMATION CARD

Ward's 

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” X 22” X 7.5” (45.7 X 55.9 X 19.1 cm); weight is 25 lb (11.36 kg) $999.

CIRCLE NO. 91 ON FREE INFORMATION CARD

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” X 22” X 7.5” (45.7 X 55.9 X 19.1 cm); weight is 25 lb (11.36 kg) $999.

CIRCLE NO. 91 ON FREE INFORMATION CARD

High-Technology Phono Cartridge

Heading the new Dynamic Interface series of phono cartridges from Empire Scientific is the model 800LAC. The unit uses a vaporized-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 ±12a

CIRCLE NO. 88 ON FREE INFORMATION CARD

Sports Radar

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

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 X 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” X 22” X 7.5” (45.7 X 55.9 X 19.1 cm); weight is 25 lb (11.36 kg) $999.

CIRCLE NO. 91 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

Logic-Controlled Cassette Deck

Aiwa's AD-M700BU (black finish) and its sister unit, AD-M700U (silver finish), are designed to use metal, Co60, 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 ±12, −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

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-
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) received 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 $59.95 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®**

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

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POPULAR ELECTRONICS
McIntosh
"A Technological Masterpiece..."

McIntosh C 32

"More Than a Preamplifier"

McIntosh has received peerless acclaim from prominent product testing laboratories and outstanding international recognition! You can learn why the "more than a preamplifier" C 32 has been selected for these unique honors.

Send us your name and address and we'll send you the complete product reviews and data on all McIntosh products, copies of the international awards, and a North American FM directory. You will understand why McIntosh product research and development always has the appearance and technological look to the future.

NEW PRODUCTS continued

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 X5 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

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 suppression by 30 dB) is given as 1.6 µV (equivalent to 9.3 dB), 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

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 60K 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. $3995.

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" X 4½" (16.6 X 11.5 cm). Standard Model 3 A/C ($12.50) is 5½" (14.6 cm) wide, holds boards up to S-100 bus size. Maxi Model 3 C/C ($14.95) is 7½" (19.5 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

Twelve-Inch Video Monitor

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

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.

Personal Software, Inc., also produces the VisiCalc®, the Vitable® system, the Vitable® 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.
**NEW PRODUCTS continued**

**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 de-

lay. 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

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**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 at 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 provide negligible transient IM distortion. HF 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

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**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" X 3.25" X 1" (8 X 8 X 2.5 cm). $52. Address: Remark International, 4 Sycamore Drive, Woodbury, NY 11797.

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**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

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**Your breadboarding is a super-snap with a solderless A P Super-Strip.**

Build a circuit almost as fast as you dream it up. Pull it apart and do another—everything's as good as new.

Our versatile Super-Strip mini-breadboards give you the same top-quality contacts you get in our full-scale ACE All-Circuit Evaluators. Not so "mini," either. You can build circuits with as many as nine 14-pin DIPs. Instant-mount backing and quick-removal screws make stacking and racking a snap, too.

Where to buy? Phone (toll-free) 800-321-9668 for the name of your local A P distributor. And ask for our complete A P catalog, The Faster and Easier Book.

"Faster and Easier is what we're all about."

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AmericanRadioHistory.Com
Low Cost Computerized 
Burglar Alarm System 
Home - Office - Business 

NO INSTALLATION 
Just plug the Guardex 8000 alarm system in, make several 
simple control adjustments to suit your particular building and 
its works! There are no other wires to run. This totally self-con-
tained 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, tele-
phones, etc. from break-in type noises such as breaking glass, 
prying metal, or forcing a door open. The Guardex 8000 pro-
tects 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. 

URNS 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 de-
tected, (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 lists 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 in-
stantly 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 sensitivity control. 

The Guardex 8000 Alarm System is walnut grained and dis-
guised to look like a small stereo speaker (6¼" x 9½" x 8") 
and weighs less than 6½ pounds. 

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 protec-
tion 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 busi-
ness 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) 
Dealer Inquiries Invited 

CALL TOLL FREE 
(800) 423-5499 
California residents: 
(213) 889-1414 collect. 

GUARDIAN 
eLECTRONICS, INC. 
31133 Via Colinas, Dept. PE, 
Westlake Village, Calif. 91361
Sabtronics Model 2035A Handheld DMM Kit

No other hand-held DMM offers you so much performance for such low cost.

- **0.1% Basic DCV Accuracy**
- **Easy one-hand operation**
- **6 Functions - 32 Ranges**
- **Touch-and-hold capability**
- **Two-terminal input for ALL measurement functions**
- **Hi-and-Low Power Ohms**
- **Easy-to-build, one evening assembly**
  
  *With optional THP-20 Probe.

**Plus these standard features:**

- Large, easy-to-read LCD readout; automatic polarity; automatic zero; automatic decimal point; low battery indicator; overload protection on all functions and ranges, and 200 hour operation from a 9V transistor battery.

**Model 2035A**

$74.95

**BRIEF SPECIFICATIONS:**

- **DC VOLTS:** 100µV - 1000V, 5 ranges
- **AC VOLTS:** 100µV - 1000V, 5 ranges
- **DC CURRENT:** 0.1µA - 2A, 5 ranges
- **AC CURRENT:** 0.1µA to 2A, 5 ranges
- **Hi-OMHS:** 0.1Ω - 20MΩ, 6 ranges
- **Lo-OMHS:** 0.1Ω - 20MΩ, 6 ranges
- **Size:** 3½" Width x 5½" Length x 1 5/8" Height
- **Weight:** 11 oz. (including batteries)
- **Overload Protection:** 1000V DC or AC peak, all voltage ranges, 250V AC or DC peak, all Ohms ranges, 2A/250V fuse all current ranges.

**To: Sabtronics International, Inc., 5709 N. 50th Street, Tampa, FL 33610**

Please send me

- Model 2035A Handheld Multimeter kit(s) @ $74.95 ea. .................................................. $
- Shipping and handling @ $5.00 per kit (see below) .................................................. $
- Model THP-20 Touch-and-Hold Probe(s) @ $19.95 ea. .................................................. $
- Model AC-110 Battery Eliminator(s) @ $7.95 ea. .................................................. $
- Model HVP-30 30V DC High-voltage Probe(s) @ $29.95 ea. .................................................. $
- Florida residents add 4% State Sales Tax  .................................................. $

**TOTAL** .................................................. $

I enclose check or money order. Bill my Master Charge or Visa Card Account # .................................................. Expiration date  ..................................................

*Allow 2-3 weeks clearance time for personal checks. No C.O.D.*

Name ..................................................

City .................................... State ....................................

Street ..................................................

**Antique Radio Servicing Publications**

Antique Radio Servicing & Styling sold 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.

**Popular Electronics**

AmericanRadioHistory.Com
INCREDIBLE CASSETTE OFFER!

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 high of frequency response or tape hiss.

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. 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 Cadillacs or Corvettes!

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 $49.

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.

Crystal use little electricity, so the battery should last up to a year, and may be easily changed by any jeweler.

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.

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.

DAK INDUSTRIES INCORPORATED

Call TOLL-FREE .................. (800) 423-2636
In California Call .................... (213) 984-1559
10845 Vanowen St., North Hollywood, CA 91605

CIRCLE NO. 15 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:

NRI Schools
McGraw-Hill Continuing Education Center
3939 Wisconsin Avenue
Washington, D.C. 20016

NRI cropped
Feedback Cause:

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.

Feedback Cure:

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.

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.

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

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

AmericanRadioHistory.com
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, 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.
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Audiophile Recordings

DIGITAL RECORDING VOL. III: Bizet, Carmen Prelude; Berlioz, Rákóczi March; Diz from Damnation of Faust; Brahms, Hungarian Dance No. 5; Ginasiera, 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 Argentinean 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 OK-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.
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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 Polare 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 a 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.

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Audio Control Model C-101
graphic equalizer and spectrum analyzer

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"×6"×9" (483×165×229 mm) and weighs 63 1/2 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, 64, 120, 240, 480, 960, 1920, 3840, 7680, and 15,360 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 directivity 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 15,360 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 for 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, the 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 s 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. The calibration 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-analyzing 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 "k" (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 calibrer of performance is more than adequate for the intended use of this instrument, although professional SLMs typically have closer tolerances. It appears that the Audio Control microphone (or a pair of them) should make a fine adjacent 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)
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 dB, 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 15.5-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’ work to flat-tune 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.

---

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

**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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CIRCLE NO. 93 ON FREE INFORMATION CARD
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 24 1/4" X 13 3/4" X 10 3/4" deep (616 X 350 X 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 1 1/2" (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 reverbant 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.

Woofers 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 measurements 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 uncored. 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.

Impedance curve shows rated minimum of 5 ohms.
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Accessory Kit RW-50 contains 50 pcs of AWG 20 (0.8mm) insulated jumper wires of assorted lengths from ½’’ (13mm) to 4’’ (100mm). Both ends are stripped and bent 90° for easy insertion. In stock directly from

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POPULAR ELECTRONICS
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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 X 0.7 mil (76 X 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-kermalloy shield to minimize hum induction by external fields. Weighing 6.1 grams, the Model 350E has standard 1/2-inch (12.7-mm) mounting centers. Its suggested retail price is $55.

**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 STR 100 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 extremely high 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 response in the test arm was at 9 Hz, with an amplitude of 0 dB. Square-wave response from the CBS STR 112 record showed a single overshoot and well-damped low-level ringing at the 16,000-Hz style frequency frequency. Tracking our high-speed test records was good at 1.8 grams and, in most cases, at 1.5 grams. The cartridge was able to play the 80-microin level of the 300-Hz tones on the German Hi-Fi Test Record at 1.8 grams and the 70-microin 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 TTR 102 and TTR 103 records. High-frequency tone bursts of the TTR 103 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 TTR 102, the reading was 2 to 3%. (Few cartridges can track the 27 cm/s maximum level on this record.) In the subjective tests, the TTR 102 and TTR 103 records were indistinguishable even at the highest level.

The TTR 102 and TTR 103 records were indistinguishable even at the highest level.
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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.

| 7 6 5 4 3 2 1 0 | DATA BUS LINE NUMBER
|-----|------------------|
| 0 0 0 0 1 1 1 | LOGIC VALUE OF EACH LINE

Table 1—Decimal—Binary—Hexadecimal Equivalents

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Binary</th>
<th>Hexadecimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0000</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0001</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0010</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0011</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0100</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0101</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>0110</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>0111</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
<td>9</td>
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</tr>
<tr>
<td>13</td>
<td>1101</td>
<td>D</td>
</tr>
<tr>
<td>14</td>
<td>1110</td>
<td>E</td>
</tr>
<tr>
<td>15</td>
<td>1111</td>
<td>F</td>
</tr>
</tbody>
</table>

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 hexadecimal form. Thus, 00001111 can be represented by OF (hex). Writing a 16-bit address in binary will convince you of the value of binary to hexadecimal conversion. This conversion is listed in Table 1.

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 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.

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 (30c) 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 pushbutton switches is closed. The Q output is coupled to transistor QT 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, 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.

SEQ-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 proper sequence: 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 and B4-37---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.

B1-3C---Short Branch if EF1=0. If the EF1 input line is a logic zero, the

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.

PO-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.

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 to 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

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.

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, labeled "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 deactivated. 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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When connected to a computer, the computer must echo the character received. This data is received by the VID which processes the information, converting it to data suitable to be displayed on a CRT (using an RS 232 interface), or a monitor (keyboard) which performs the housekeeping relative to whether it is a keyboard input or a CRT display. The VID processes the keyboard input and performs the housekeeping relative to whether it is a keyboard input or a CRT display.

The VID processes the keyboard input and performs the housekeeping relative to whether it is a keyboard input or a CRT display.

ASCII/BAUDOT

VBD

The VID processes the keyboard input and performs the housekeeping relative to whether it is a keyboard input or a CRT display.

ASCII/BAUDOT

VBD

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The VID processes the keyboard input and performs the housekeeping relative to whether it is a keyboard input or a CRT display.

ASCII/BAUDOT

VBD

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ASCII/BAUDOT

VBD

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the beginning address of that set of instructions.

The third column, \textit{OP CODE}, represents the hexadecimal machine code for the instruction plus any extra byte required to modify 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, \textit{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 \textit{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 \texttt{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 \texttt{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

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

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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 to allow the loop to 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>
<thead>
<tr>
<th>TABLE II—PROGRAM</th>
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</thead>
<tbody>
<tr>
<td><strong>LABEL</strong></td>
</tr>
<tr>
<td>Start</td>
</tr>
<tr>
<td>1st Test</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1st Release</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2nd Test</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td>2nd Release</td>
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<tr>
<td></td>
</tr>
<tr>
<td>3rd Test</td>
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<tr>
<td></td>
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<tr>
<td>3rd Release</td>
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<tr>
<td></td>
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<tr>
<td>4th Test</td>
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<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>4th Release</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

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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 x 12 or 60 seconds.

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

The program from address 0048 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.

---

**Table:**

<table>
<thead>
<tr>
<th>LABEL</th>
<th>PROGRAM ADDRESS</th>
<th>OP CODE</th>
<th>MNEMONIC</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlock</td>
<td>0039</td>
<td>7B</td>
<td>SEQ</td>
<td>Set Q output high (unlock door), go to next instruction</td>
</tr>
<tr>
<td>5-Sec. Delay</td>
<td>003A</td>
<td>F8 FF</td>
<td>LDI</td>
<td>Load FF (1111 1111) into the D register</td>
</tr>
<tr>
<td></td>
<td>003C</td>
<td>A1</td>
<td>PLO</td>
<td>Loads D register into low-order half of register-1</td>
</tr>
<tr>
<td></td>
<td>003D</td>
<td>B1</td>
<td>PHI</td>
<td>Loads D register into high-order half of register-1</td>
</tr>
<tr>
<td>Timer</td>
<td>003E</td>
<td>C4 C4</td>
<td>NOP</td>
<td>Waste time to increase delay</td>
</tr>
<tr>
<td></td>
<td>0040</td>
<td>C4 C4</td>
<td>NOP</td>
<td>Decrement (reduce) the contents of register-1 by 1</td>
</tr>
<tr>
<td></td>
<td>0042</td>
<td>21</td>
<td>DEC</td>
<td>Load the high-order byte of register-1 into the D register</td>
</tr>
<tr>
<td></td>
<td>0043</td>
<td>91</td>
<td>GHI</td>
<td>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. End of 5-sec. time delay, branch to Start.</td>
</tr>
<tr>
<td></td>
<td>0044</td>
<td>3A 3E</td>
<td>BNZ</td>
<td>Decrement the contents of register-1 by 1</td>
</tr>
<tr>
<td></td>
<td>0046</td>
<td>30 00</td>
<td>BR</td>
<td>Load the D register with OC (0000 1100)</td>
</tr>
<tr>
<td>1-Min. Delay</td>
<td>004B</td>
<td>F8 OC</td>
<td>LD1</td>
<td>Load the D register with OC (0000 1100)</td>
</tr>
<tr>
<td></td>
<td>004A</td>
<td>A2</td>
<td>PLO</td>
<td>Load OC from the D register into the low-order half of register-2</td>
</tr>
<tr>
<td>Loop 1</td>
<td>004B</td>
<td>F8 FF</td>
<td>LDI</td>
<td>Load the D register with FF (1111 1111)</td>
</tr>
<tr>
<td></td>
<td>004D</td>
<td>A1</td>
<td>PLO</td>
<td>Load FF from the D register into the low-order half of register-1</td>
</tr>
<tr>
<td></td>
<td>004E</td>
<td>B1</td>
<td>PHI</td>
<td>Load FF from the D register into the high-order half of register-1</td>
</tr>
<tr>
<td>Timer Start</td>
<td>004F</td>
<td>C4 C4</td>
<td>NOP</td>
<td>Waste time to pad out the delay</td>
</tr>
<tr>
<td></td>
<td>0051</td>
<td>C4 C4</td>
<td>DEC</td>
<td>Decrement the contents of register-1 by 1</td>
</tr>
<tr>
<td></td>
<td>0053</td>
<td>21</td>
<td>DEC</td>
<td>Load the high-order byte of register-1 into the D register</td>
</tr>
<tr>
<td></td>
<td>0054</td>
<td>91</td>
<td>PHI</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td>0055</td>
<td>3A 4F</td>
<td>BNZ</td>
<td>Decrement the contents of register-2 by 1. (Register-2 contains 1100 from address 004A)</td>
</tr>
<tr>
<td>Loop 2</td>
<td>0057</td>
<td>22</td>
<td>DEC</td>
<td>Load the contents of register-2 into the D register</td>
</tr>
<tr>
<td></td>
<td>0058</td>
<td>82</td>
<td>PLO</td>
<td>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</td>
</tr>
<tr>
<td></td>
<td>0059</td>
<td>3A 4B</td>
<td>BNZ</td>
<td>End of 1-min. delay, branch to Start. This sets the Q output low to de-activate the solenoid and lock the door. The program then awaits further switch operations.</td>
</tr>
<tr>
<td></td>
<td>005B</td>
<td>30 00</td>
<td>BR</td>
<td>The program advances to address 005B, where it is told to branch (30) back to the Start (00).</td>
</tr>
</tbody>
</table>

MAY 1980
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 

\[ Q = 0.707 \]

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

\[ f_c = \frac{1}{2\pi(R_1R_2C_1C_2)^{\frac{1}{2}}} \]

In the high-pass filter of Fig. 1A, the value of

\[ C_1 \]

is chosen to equal that of

\[ C_2 \]

and the resistance of

\[ R_1 \]

is chosen to be half that of

\[ R_2 \]

This simplifies the equation for the cutoff frequency so that it takes the form

\[ f_c = \frac{1}{2.828\pi C_1R_1} \]

Similarly, in the low-pass filter of Fig. 1B, the resistance of

\[ R_1 \]

is chosen to equal that of

\[ R_2 \]

and the capacitance of

\[ C_2 \]

is chosen to be half that of

\[ C_1 \]

The simplified equation for the low-pass cutoff frequency is

\[ f_c = \frac{1}{2.828\pi C_1R_2} \]

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

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**BY JOHN H. ROBERTS**

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

HIGH PERFORMANCE "SCRATCH & RUMBLE" FILTERS
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 output 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 "chassis ground" which is designated in Fig. 2 using the conventional chassis-ground symbol. Contrast this with the system ground symbol appearing at the input and output terminals of the project. An earth-ground symbol signifies system signal ground to differentiate it from the artificial "chassis ground."

A single-ended supply is represented to the right of the passive components as a battery generating voltage $V_{\text{supply}}$. 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 preceding 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 available from Phoenix Systems, 375 Springfield 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.

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**AmericanRadioHistory.Com**

MAY 1980
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 legs 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 tapping 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.

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 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 champion 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 dilemma. 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 IQ 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 $90.95 complete with Staunton designed pieces and UL approved 110V AC adapter.

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 12" 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.

Enjoy It for 10 Days—At Our Expense
As a gift or for yourself, the "7" is unquestionably the finest chess computer you can select...but, if within 10 days, you are not satisfied, simply return it for a prompt, no-questions-asked refund.

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"Chess Challenger-10 Wins Microchess Tourney"

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President, Fidelity Electronics

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"Its successor, the new Chess Challenger "7", is infinitely more powerful."

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S. Samole

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Final Results
Reprinted Courtesy of Personal Computing, February, 1979. P 86. (Darken lines ours.)

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Chess Challenger-10 Wins Microchess Tourney

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 Genius Offspring

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"Its successor, the new Chess Challenger "7", is infinitely more powerful."

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S. Samole

President, Fidelity Electronics

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"Chess Challenger-10 Wins Microchess Tourney"

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MAY 1980

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"Chess Challenger-10 Wins Microchess Tourney"

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MAY 1980

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"Chess Challenger-10 Wins Microchess Tourney"

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

One of the reasons Maxell has such a great following is because of our leader. It has a built-in non-abrasive head cleaner designed to remove the oxide residue other tapes leave behind, without damaging your tape heads.

It also points out what side of the tape you're on (A or B) as well as which direction the tape is traveling. So it's almost impossible to make a mistake. 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.
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 portion 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 linearity tends 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

<table>
<thead>
<tr>
<th>Resistor</th>
<th>Value</th>
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<tbody>
<tr>
<td>R1</td>
<td>22,000 ohms</td>
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<tr>
<td>R2</td>
<td>47,000 ohms</td>
</tr>
<tr>
<td>R3</td>
<td>100,000 ohms</td>
</tr>
<tr>
<td>R4</td>
<td>1000-ohm trimmer potentiometer *</td>
</tr>
<tr>
<td>R5</td>
<td>1 megohm</td>
</tr>
<tr>
<td>R6</td>
<td>12,000 ohms</td>
</tr>
<tr>
<td>R7</td>
<td>5000-ohm multi-turn trimmer potentiometer</td>
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<tr>
<td>R8</td>
<td>62,000 ohms</td>
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<td>R9</td>
<td>10,000 ohms, 1%</td>
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<tr>
<td>R10</td>
<td>40,560 ohms, 1%</td>
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<td>R11</td>
<td>2000-ohm, 5%</td>
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<tr>
<td>R12</td>
<td>47 ohms, 10%</td>
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</table>

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>0.1-µF capacitor</td>
</tr>
<tr>
<td>C2</td>
<td>0.47-µF capacitor</td>
</tr>
<tr>
<td>C3</td>
<td>0.22-µF capacitor</td>
</tr>
<tr>
<td>C4</td>
<td>100-µF capacitor</td>
</tr>
<tr>
<td>C5</td>
<td>0.01-µF capacitor</td>
</tr>
<tr>
<td>C6</td>
<td>0.1-µF capacitor</td>
</tr>
</tbody>
</table>

Misc. — Battery holder, IC socket (1), three-conductor flexible cable, 3/16" to 1/4" ID thin-wall brass or copper tubing, spaghetti, E-POX-E ribbon, acrylic spray, plastic case (Radio Shack 270-627), 1/8"-thick clear plastic sheet, black spray paint, glue, mounting hardware, etc.

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 $12.00; R9 and R10 at $1.75 each.
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.

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 end of the transducer leads. The copper wire should extend about 1" past the tubing. Connect the cable leads to Jumper J1 and Trimmer R22 using male-female radio connectors. The 4001 values in the circuit are 5%, unless otherwise specified. (See Parts List.)

**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.**

**Fig. 1. The circuit board layout for the transducer.**

**Fig. 3. Diagram of the parts list.**

### 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 Inc.** (600 Technology Pkwy, 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 286.2-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.
- **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.
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°F 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, R4 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 0.01 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.

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.
Ion Fountain

YOUR ULTIMATE AIR FRESHENING/IONIZING SYSTEM. TOP QUALITY.
LOW PRICE. STATE OF THE ART.

Breakthrough. The new Ion Fountain™ is in a class by itself. This negative ion generator gives you power to saturate your home or office with billions of refreshing ions. Without fans or any moving parts it puts out a pleasant breeze. A pure flow of ions pours from the top like water from a fountain, filling your room. The result? Your air feels like fresh ocean air—pure, crisp, and wonderfully charged.

The price? Only $79.95. That’s a price breakthrough because no other company can offer you a unit with higher ion output or better quality than the Ion Fountain™, even at triple our price.

HOW CAN WE DO IT?
Six years of experience helps. Plus a lot of ingenuity, aggressive research and a personal commitment to give our customers the best we can.

UTP Ion Research Center is a branch of our educational publishing company. And our commitment in publishing to give birth to new ideas and methods that enrich humanity is part of the Ion Research Center too. We’re in business to serve you and your environmental needs.

WHAT ARE IONS?
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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Our rapid-growth technology, which sometimes takes its toll on the quality of our air, has also come up with the solution. Following Nature’s model of the thunderstorm which uses a high electrical charge to purify, revitalize and stimulate the air, the UTP Air Energizer has been developed imitating this process. Both the thunderstorm and the Air Energizer fill the air with negative ions, restoring the natural electrical balance to the polluted, energy-depleted air. But the Ion Fountain can be used indoors in the home, office, workshop, laboratory, etc., keeping a fresh supply of ionized oxygen available night and day. This new breakthrough in fresh air control is not a cover-up which masks or deodorizes. The unit actually removes the dust, smoke, bacteria and pollen particles from the air by attaching ions to them and causing them to sink to the earth where they can be vacuumed up rather than inhaled. At the same time ions electrically stimulate the energy-stripped air.

YOUR CHOICE

OF TWO TOP-QUALITY UNITS!
There’s only one unit that’s better than the Ion Fountain. That’s our own Executive System Four™. It sells for $159. It has an even higher ion output. Plus! Our special Dial-An-Ion feature allows you to adjust the ion output anywhere from low to high. Not everyone knows that the need for ions varies. A large smoky room will require higher output than a small room. And some people want fewer ions while sleeping than while working. The new Executive System Four is our answer to this need for output flexibility.

FACTS YOU NEED TO KNOW
The Ion Fountain™—System Five

Ion density: 430,000 ions per cm³/sec. at 1 meter, 1.55 million ions per cm³ at 50 cms.
Use: Large room or office—9000 cu. ft.
Warranty: 1 year
Output voltage: 15 KV
Ozone: Less than 2 parts per billion
Dimensions: 5½” x 4½” x 2¾”

Executive System Four™

Ion density: Low to maximum of 540,000 ions per cm³ at 1 meter. 1.6 x 10⁶ ions per cm³ at 50 cms.
Output voltage: 15 KV
Ozone: Less than 2 parts per billion
Use: Large room or office 10,000 cu. ft.
Warranty: 1 year

If the Executive System Four is better, why did we bring out the Ion Fountain? Not everybody is willing to pay $159 for an air ionizing unit, no matter how good it is. Just like not everyone drives Rolls Royces. Most drive less expensive cars. The Executive System Four is for the person who wants the absolute best quality and doesn’t mind paying a little extra to get it. If you want highest ion output, flexibility, and a beautiful oak paneled case, buy the Executive System Four.

If you want something at half the price of the Executive System Four, but still better than any other unit costing up to $250, buy the Ion Fountain.

HOW TO GET ONE
To place your order now just send a check for $79.95 plus $3 shipping for the Ion Fountain. Or send $159 plus $4 shipping for the Executive System Four. Tell us your full street address as we cannot ship to Post Office boxes. (California residents add 6% sales tax.)

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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-
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 log 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)

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>10,000-µF, 25-volt electrolytic</td>
<td></td>
</tr>
<tr>
<td>C17, C20, C21</td>
<td>1000-µF, 6-volt electrolytic</td>
<td></td>
</tr>
<tr>
<td>C18</td>
<td>0.47-µF, 6-volt tantalum</td>
<td></td>
</tr>
<tr>
<td>C19</td>
<td>3.3-µF, 6-volt tantalum</td>
<td></td>
</tr>
<tr>
<td>C22</td>
<td>2.2-µF, 6-volt tantalum</td>
<td></td>
</tr>
<tr>
<td>C24</td>
<td>0.047-µF, disc ceramic</td>
<td></td>
</tr>
<tr>
<td>D1, D2</td>
<td>3-ampere, 100-PIV rectifier</td>
<td></td>
</tr>
<tr>
<td>D8</td>
<td>through D14</td>
<td>1N4001 rectifier</td>
</tr>
<tr>
<td>D15</td>
<td>4.7-volt, 1-watt zener diode</td>
<td>(1N3825 or equivalent)</td>
</tr>
<tr>
<td>F1</td>
<td>1/2-ampere fast-blow fuse</td>
<td></td>
</tr>
<tr>
<td>IC3</td>
<td>UNL-2232A Sprague Integrated Motion Detector</td>
<td></td>
</tr>
<tr>
<td>Q1, Q26</td>
<td>2N4921 npn silicon transistor</td>
<td>(or equivalent)</td>
</tr>
<tr>
<td>Q8, Q10</td>
<td>through Q23</td>
<td>Sprague RT108 npn silicon transistor</td>
</tr>
<tr>
<td>Q9, Q24, Q25</td>
<td>Sprague RT106 npn silicon transistor</td>
<td>(or equivalent)</td>
</tr>
</tbody>
</table>

The following are 5% tolerance, 1/4-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 291.80 ABC2 or similar), silicone thermal compound, suitable enclosure measuring approximately 10" X 5" X 3/4" or 25.4 cm X 12.7 cm X 8.3 cm (Buff RC 1100 or similar), barrier block terminal strip, hookup wire, solder, hardware, etc.

Note:—The Sprague UNL-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.

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![Diagram](image)

*Fig. 12 to simplify interconnection of Optodec 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 character...
characteristic 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 Q8 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 lighting 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 R6 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, it 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.

PARTS LIST FOR SIREN DRIVER MODULE

C23—1-µF, 25-volt electrolytic
D3—3-ampere, 100-PIV rectifier
D4 through D7—1N4001 rectifier
Q4, 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, ½-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 (Vexo 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, hook-up wire, solder, hardware, 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 2½" X 2½" X 1½" or 7 cm X 5.4 cm X 4.1 cm (Bud CU-2100-A or similar), barrier block terminal strip, hook-up 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 2½" X 2½" X 1½" or 7 cm X 5.4 cm X 4.1 cm (Bud CU-2100-A or similar), barrier block terminal strip, hook-up wire, solder, hardware, etc.

Fig. 7. Schematic diagram of Siren Driver module appears at left.
Fig. 10. Shown above is the component placement guide for Opdec system's Siren Driver module printed circuit board.

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

Fig. 9. Component placement guide for the Signal Processor pc board, which includes power supply, is below.
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 23/4" X 2 1/4" X 1 1/4" (7cm X 5.4cm X 4.1cm). Each printed circuit is mounted using 1/4" (6.4-mm) spacers. A 1/16" (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 also be color-coded. Because the cost of the ULN-2232A IC sensor is comparable to that...
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.

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 lighting 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 similar phenomenon is not a problem in the area to be protected, simply eliminate the lighting 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 l) can be used to sink current from the positive supply through a dynamic loudspeaker to ground.

In Conclusion. Opdec is a 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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Every day, people are victimized right at home, but with this alarm system, you can stop intruders in their tracks. It generates an invisible, ultrasonic field that detects all motion within a living area up to 20 feet wide and 30 feet long. No intruder can go undetected. The system includes a loud built-in alarm, and you can also add an optional-extra super-loud siren or bell. Either way, the boldest intruder will be scared away and your neighbors will know exactly what's happening!

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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 VDD. During the brief interval that S1 is closed, the counter's CLO CK input is at VSS. 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

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
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.

**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.**

**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**—IN914 silicon switching diode
- **DISI**—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, 1/4-watt, 10% carbon-composition resistor
- **R2**—1000-ohm, 1/4-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 Lauruswood 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.
An on-chip oscillator, whose frequency is determined by the value of C1, governs the multiplexing of the BCD digits and provides 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 Soldiercons 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-

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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.

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

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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.

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 1/12) 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 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

![Image of bicycle odometer](https://example.com/bicycle_odometer.png)
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Programmed for over a century
The built-in computer on a chip will always display the correct time date and month. Also, it automatically updates the watch calendar for long and short months, leap years and its programmed until the year 2000.

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The natural side-view display lets you tell the time, day and date without twisting your arm into an uncomfortable position.

Numbers always visible
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.

10 Display functions
The Sunwatch is capable of displaying the following information: hour • minutes • seconds • month • day • year • speed calibration • AM/PM indicator • seconds count-off

Extreme accuracy
Unlike other electronic watches using tuned crystals to control timing accuracy, the Sunwatch incorporates a unique, programmable, microcircuit synthesizer to make it the first watch in history that is accurate to less than 1 second per month. That’s 5 times more accurate than the latest quartz Accutron.

The Power Source
Tiny silicon power cells, which are constantly being energized by natural sunlight, daylight or ordinary light bulb keep the Sunwatch energy storage system charged. Thus, the Sunwatch will not be exposed to light, it will continue to operate for months on stored power.

The most indestructible watch in the world
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.

Completely waterproof
Leave the Sunwatch in salt water for months. Dye 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.

Shock resistant to 3,000 Gs
You can crash it into a rug-surface brick wall at 90 mph with no noticeable effect. Wear it while doing heavy work, exercise or any strenuous activity.

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

Pressure resistant
There are no air spaces inside the Sunwatch. Therefore, it is not susceptible to high pressures such as might be encountered diving to great depths.

The perfect watch for a lifetime
Imagine split-second accuracy for the rest of your life. Sunwatch is a virtually indestructible, beautifully styled, space-age timepiece, and it’s available in three exciting finishes. Brushed stainless steel, Gold tone stainless steel, or a Durable black finish on stainless steel. All Sunwatches come with a matching stainless steel band with remotely links and adjustable clasp.

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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WATT WIZARD™

POWER FACTOR CONTROLLER CUTS THE COST OF RUNNING ELECTRIC APPLIANCES BY AS MUCH AS 50% -- AND YOU CAN EVEN SEE THE SAVINGS!

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 is."

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 80%, depending on the application. 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 shows the test results and notes 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 influenced by the frequency and independent of load and supply voltage. When heavily loaded, the motor draws line current that is nearly in phase with the voltage. Under light 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 energy is small, the large current causes considerable (heat) loss energy 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 no longer in phase with the voltage, therefore does as much useful work as before, but it and the voltage are smaller, resulting in a net saving of electric power."

THE SAVINGS CAN ADD UP

Like everything else, the cost of electricity 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 $5 for electric air conditioners 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 bill. And the amount of savings, of course, depending on which appliance you use it 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, allowing longer motor life and reducing the amount of cooling 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 VAC plug-in model we tested. It’s for single phase fractional HP. 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 electrical 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 you can 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 spurge 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 IFL digital blocks, this IC contains all the active circuitry needed for a user to create an almost unlimited range of sounds.

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 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 16 and 17 to ground. This vco's output goes to the mixer and envelope-select circuits.

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 squarewave 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 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.

![Block Diagram](image-url)
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 railroad 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,
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.

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,C7,C15,C20,C23**—0.1-µF capacitor
- **C8,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
- **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
- **S6**—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 bread-
board. 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.
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 and R) will have no dc offset. This is so because under quiescent conditions the V 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 purchased 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 greatly appreciated.—Michael Wojtusiak, New York, NY.

A. A typical flash unit is shown schematically in the figure. When power switch 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.
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.

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 milliwatts.

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EXPERIMENTER'S CORNER continued

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.

![Figure 3. Spectral response of two ITT communications-grade glass fibers.](image)

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:

- Valtic Corporation
  West Boyleston, 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
- Corning
  Telecommunication Products Dept.
  Corning, NY 14830

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.

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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 yourfinger 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 (MFOE402F) includes a built-in integrated preamplifier. For more information, you can request data sheets for the MFOE102F LED and the MFOE102F and MFOE102F 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 cyanacrylate 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 cathwhisker 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
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.
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WIDER BANDS FOR SHORTWAVE BROADCASTING

DESPISTE 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 legitimates 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 kHz 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 Gocnetilleke in Sri Lanka, to make the proper deductions. However, for the March and April broadcasting season, USSR registrations filed with the International Telecommunication Union 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 morning; listen at 0125 GMT for tone bursts 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 led by a frequency known to be in the "Afghan SSR" 8230 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, ARPTS, 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 propagation case 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 neo-colonialism.

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 Shire (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 exoticia 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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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 866851, ext. 2522, or cable O731. Peking's lead was followed by regional stations such as Hellingjian.

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 celebre. Its leftist programming aimed at military dictatorships in South America brought strong official protests from Argentina, while Costa Rican authorities hammed and hawed about what to do about it. It appears that the nominal "owner," Ana Lorren Carin Leiva, a 29-year-old chemistry student, would hardly have the resources to run such an operation, according to an expose by Argentinian Roberto H. Iglesias in the Review of International Broadcasting. She does happen to have been the secretary of a former owner, Francisco Aguirre Bulgarelli, whom a rival Costa Rican broadcaster labels as "a political friend of Kim Il Sung." Though supposedly aiming a "commercial enterprise without thing 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 plugged 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 entire 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 to 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 93.75, and with a stronger signal, Radio Enciclopedia, which seemed slightly above 94.9 and identifies itself 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 WOBA. Meanwhile, anti-Castro elements in Florida have become more active in clandestine shortwave broadcasts, with a frequency being raised to 50 kHz to serve Cape Libertad Cuba, now coordinate transmissions and share facilities. The chances that they are actually broadcasting from "a small piece of free territory in the Orient mountains" off 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

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CIRCLE NO. 66 ON FREE INFORMATION CARD 91
on Alaska's Kenai Peninsula where they hope to install a 250-kW shortwave transmitter.

WYFF 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-antenna 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 holstered 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 could 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).

**Publication 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 31c are accepted, 17c in Canada), to Glenn Hauser, University Radio WUOT, Knoxville, TN 37996. We cannot promise a personal reply to specific questions.
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 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 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

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**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 thousands of miles long, 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. As 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, can 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 winding directly into the regulated dc output winding and then into the computer's power supply, from which the primary winding 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 microsecond 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 when 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

**POPULAR ELECTRONICS**
electrostatic discharge. As you know, a tremendous amount of static noise, generated by 5000 to 10,000 volts is 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, a good shielding system must be designed from the ground up to be resistant. The best defense is to make all exterior packaging of insulating material, such as plastic. Then nothing in the system is to be made available to you for discharging 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 are immune against 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 chassis may be just as common as with metal-cased computers. The ideal cabinet should be metal encased in plastic. This would not only 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 television reception.

If you buy a static-sensitive computer, there are 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 Mmegohm or more can be attached to and run in parallel with the I/O bus of the computer, MOS, 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.
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Roanoke Valley Computer Club
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Attn: Karl Brackhaus
Canadian Computer Club
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A Word About Creative Computing
You might think the term "creative computing" is a contradiction. How can something as precise and logical as electronic computing possibly be creative? We think it can be. Consider the way computers are being used to create special effects in movies - image generation, colorizing, and computer driven cameras and props. Or an electronic "sketchpad" for your home computer that adds animation, coloring and shading at your direction. How about a computer simulation of an invasion of killer bees with you trying to find a way of keeping them under control?

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Cataords of Interest. Software Dynamics, 2111 W. Crescent, Suite G, Anaheim, CA 92801 (Tel: 714-635-4780) 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.

Microwave Systems Corp., P.O. Box 4865, Des Moines, IA, 50304 (Tel: 515-286-6121). 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-

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(continued on page 102)
SOFTWARE SOURCES cont'd

COP400 Assembler Editor. The ASMBL-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, 396 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. Sam's complete a form 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 TFA (Tychon's Editor Assembler) at $8.95 describes this co-resident editor-assembler including source listing, while the DBG 8080 Interpretive Debugger at $4.95 illustrates a program for extracting, 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).

OS/1 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 key handles ascending and/or descending sequence. Sort parameters use a simple BASIC program. BPSort is O/S-OMS 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 file data, 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.
Light-Wave Voice Communicator

By Forrest M. Mims

This month's project is a dual-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.
HANDBOOK OF AUDIO CIRCUIT DESIGN
by Derek Cameron

Bridging the gap between theory and basic design practices in audio, this book is written for the reader who has completed a course in basic electronics. It begins with an overview of basic design principles and proceeds through the principles of general audio-circuit design and then into amplifier planning and implementation. Important coverage includes both positive- and negative-feedback, bias stabilization, and output arrangements.


MOBILE RADIO SERVICING MADE EASY
by Leo G. Sands

Servicing two-way mobile radio equipment can be a lucrative pursuit, but only if you know what you are doing. This book can get you started. Its seven clearly and concisely written chapters contain a wealth of information for those who are getting or merely thinking of getting started in mobile radio servicing. Starting with a chapter devoted to servicing requirements, the book goes on to detail required licenses, technical skills, and test equipment required, equipment inspection, performance measurements, and alignment and tuneup. The last two chapters are devoted to troubleshooting and field servicing. The book closes with a glossary of terms commonly used in mobile radio.

Published by Howard W. Sams & Co., 4300 West 62 St., Indianapolis, IN 46268. Soft cover. 144 pages. $4.95.

TOWERS' INTERNATIONAL OP AMP LINEAR-IC SELECTOR
by T.D. & N.S. Towers

This handy reference book lists important electrical and mechanical specifications and substitutes for almost 4500 domestic and foreign linear ICs. It begins with a general introduction to basic op-amp theory, followed by tabulated listings of the devices. Seven appendices are included. The first four explain tabulation coding, op-amp terms, manufacturer codes, and manufacturer house numbers. The final three appendices contain tabulation codes for device applications, case outlines and pinouts, and codes for pinout connections. A good one-source reference book for op amps and other linear ICs with op-amp characteristics.

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CIRCLE NO. 26 ON FREE INFORMATION CARD
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 60% 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 25 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 format 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 65 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.
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