

# Popular Electronics®

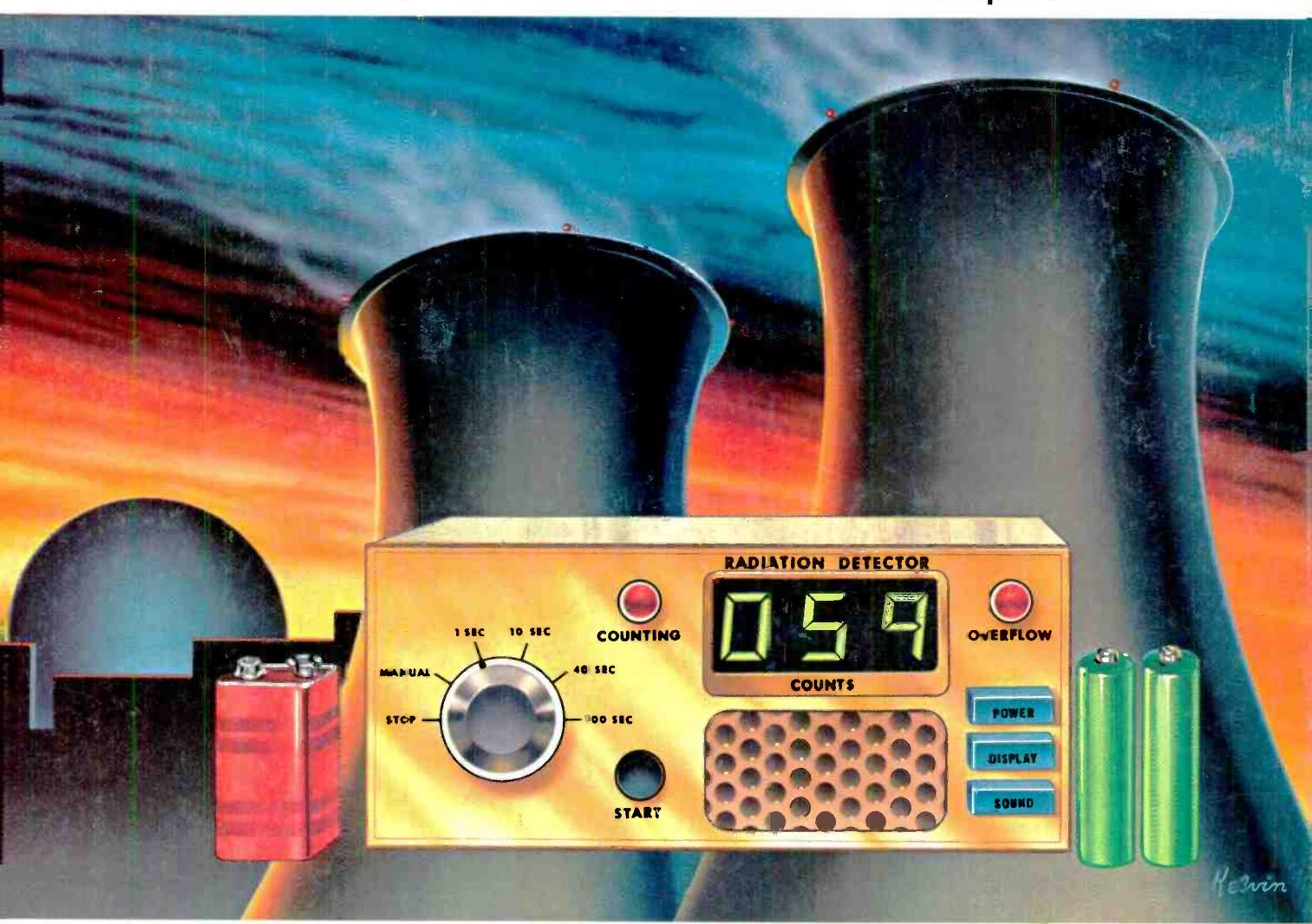
WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

JANUARY 1980/\$1.25

**Rebirth of Bass-Reflex Speakers  
TRS-80 Computer "Real Time" Timer  
Low-Cost "Micro Meter" for DC Volts**

## A Personal Radiation Monitor

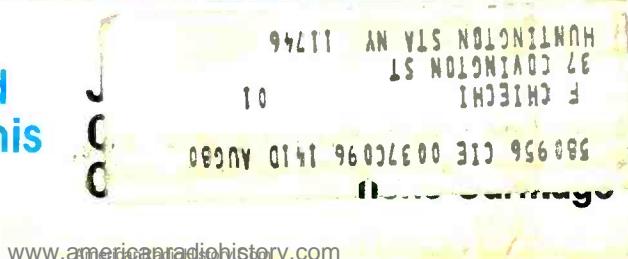
● Solid-State Detector ● Portable ● Chirp Alarm



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Tested  
In This  
Issue





# We're looking for the most original use of an Apple since Adam.

What in the name of Adam do people do with Apple Computers?

You tell us.

In a thousand words or less.

If your story is original and intriguing enough, you could win a one-week all-expense paid trip for two to Hawaii. Which is the closest we could come to paradise.

## Win fabulous prizes for creative writing.

To enter, drop by your nearest Apple dealer and pick up an entry blank. Fill it out. Then write an article, in 1000 words or less, describing the unusual or interesting use you've found for your Apple.

A jury of independent judges will cast the deciding vote for the grand prize: a week for two, airfare included, in Hawaii.

The judges will also choose 16 additional winners, two each from eight categories:

graphics/music, entertainment, home, business, education, scientific, professional, and industrial. And each winner will choose from a long list of longed-after Apple peripherals—from Apple Disk II's to Graphics Tablets to printers. Or you can take a \$250 credit towards the purchase of any Apple product.

The contest ends March 31, 1980. All winners will be notified by May 15.

Entry forms are available at your participating Apple dealer. Call 800-538-9696, (800-662-9238 in California), for the one nearest you.

Mail the entry blank, your article and any photos to: Apple Computer, "What in the name of Adam" contest, 10260 Bandley Drive, Cupertino, CA 95014.

And may the juiciest application win.

**apple computer**

# Sports Radar



*Here's how an exciting new micro-electronic breakthrough will make your children heroes and improve your tennis game.*

*Just point the gun and read the results.*

When Roger started pitching for his little league team, he was just another player. And his arm was no better than anybody else's.

Two months later a small miracle took place. Roger was the best pitcher on the team and had a fast ball that was the most powerful in his league—and all thanks to his father.

Roger's success came from a radar gun—the same type device used by police to catch speeding motorists.

#### SCRAMBLED EGGS

The minute Roger's father was able to clock his son's pitching speed, Roger was subconsciously given a daily challenge of pitching harder and faster to beat his previous speed. The more he practiced, the better he got.

Roger's father paid \$2,000 for the radar gun. But in his upper class neighborhood, it wasn't too unusual for a father to spend that kind of money to help his son.

#### SPEEDING CITATION

A large manufacturer of radar-type security devices saw what Roger's father had done and felt that there was a definite need to produce a low cost radar unit designed exclusively for the sports market.

The company, Solfan Systems, developed the Sports Radar gun—a major breakthrough in projectile speed detection as well as electronic radar circuitry.

Using the doppler effect of radar and phased-lock-loop circuits, Solfan has developed the Sports Radar gun that compares to even the most sophisticated of police radar units that cost \$2,000.

#### OVERLAND EXPRESS

The Sports Radar gun is held in your hand and pointed toward the pitcher. You turn it on, press the ready button, and point the gun. The gun will ignore the moving arm of the pitcher but will lock in on the moving ball. The radar unit would then follow the ball for approximately ten milliseconds and the built in computer measures and computes the speed and flashes the reading on the display. The gun registers the speed to the exact mileage within one-half miles per hour.

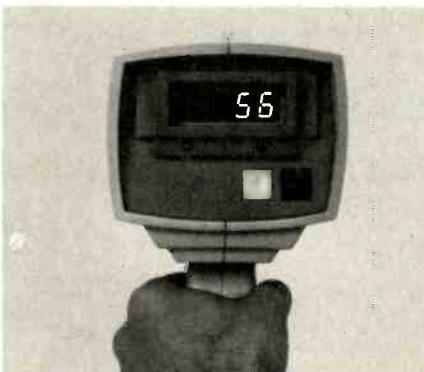
The gun can be mounted on a tripod so that the person taking the measurements can also catch the ball.

In tennis, the speed of the serve can be measured by aiming the gun at the person serving. You can also use the unit by yourself by setting the unit on a tripod and measuring the speed from behind.

#### WORKING AND PLAYING

Aside from its extreme accuracy and advanced electronics, the unit is priced to meet the budget of every sports-minded athlete or parent. It's only \$149.95 complete.

You can measure the speed of baseballs, soccer balls, tennis balls, golf balls, hockey pucks, downhill skiers, radio controlled model airplanes or anything that moves—even automobiles.



*The speed is flashed on the large LED display and is shown in miles per hour.*

The unit accepts two commercially available 6-volt lantern batteries which you can purchase locally or from JS&A for only \$2 each. The batteries will last for weeks with normal use.

#### SUCCESS AND GOOD THINGS

The unit comes in a sports blue color and weighs 38.4 ounces, exclusive of batteries. It's rugged, well built and designed to endure the typical use and abuse it would normally receive.

We urge you to test this exciting new product during our 30-day free trial. Order the Sports Radar gun. When you receive it, measure your child's pitching speed. Test it on your own tennis serve. See how knowing your speed will actually improve it as you try to outperform your previous record fast pitch or serve. Then decide if the Sports Radar gun doesn't make a very exciting addition to your sports equipment.

#### ONE FOR THE MONEY

If you are not convinced that the Sports Radar gun is something that you'll use constantly to help improve your game, return it for a prompt and courteous refund, including your \$3.50 postage and handling. You can't lose—and chances are your son will at least have the most popular new product in the neighborhood.

To order one for your test, simply send your check for \$149.95 plus \$3.50 for postage and handling to JS&A Group, Inc., at the address shown below. (Illinois residents please add 5% sales tax.) Credit card buyers may call our toll-free number below. If you wish to buy a set of two six-volt batteries, simply add \$4.00 to your order.

We'll then send your unit, the batteries (if you order them from us), a 90-day limited warranty and complete easy-to-understand instructions.

Radar electronics for the sports enthusiast is now a reality. Watch your game improve by ordering your Sports Radar gun at no obligation, today.

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# The World's biggest SALE of Bearcat® scanners!

**Communications Electronics**, the world's largest distributor of radio scanners, celebrates the Electra introduction of four new Bearcat brand monitors with the world's largest scanner sale. From now, until January 31, 1980, you can save hundreds of dollars during the world's largest scanner sale!

Even the new Bearcat models 300, 220 and Eight Track scanners are on sale. If you've previously purchased a Bearcat scanner, then you already know you're getting all the real, live excitement that a television program or newspaper can't provide. If you don't have at least one Bearcat scanner, the time to buy is now!

Since CE distributes more scanners worldwide than anyone else, we can give you rock bottom prices. Our warehouse facilities are equipped to process over 1,000 Bearcat scanner orders per week and our order lines are always staffed 24 hours. We also export Bearcat scanners to more than 300 countries and military installations. Almost all items are in stock for immediate shipment, so save now and get a Bearcat scanner during the **world's largest scanner sale!**

## NEW! Bearcat® 300

**Available February - March, 1980**

List price \$499.95/CE price \$329.00  
**7-Band, 50 Channel • Service Search • No-crystal scanner • AM Aircraft and Public Service bands. • Priority Channel • AC/DC**  
Bands: 32-50, 118-136 AM, 144-174, 421-512 MHz.  
The new Bearcat 300 is the most advanced automatic scanning radio that has ever been offered to the public. Since the Bearcat 300 has over 2,100 active frequencies in memory, you can touch one button and search any of many preprogrammed services such as police, fire, marine and government. Of course, you still can program your own frequencies and monitor up to 50 channels at once. Since the Bearcat 300 uses a bright green fluorescent digital display, it's ideal for mobile applications. The Bearcat 300 now has these added features: Service Search, Display Intensity Control, Hold Search and Resume Search keys, Separate Band keys to permit lock-in/lock-out of any band for more efficient service search. Reserve your Bearcat 300 now for February - March, 1980 delivery.

## Bearcat® 250

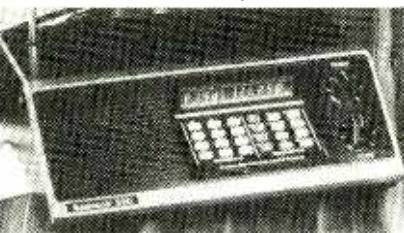
List price \$399.95/CE price \$259.00

**50 Channels • Crystalless • Searches Stores • Recalls • Self-Destruct • Priority channel • 50 Channel • 6-Band.**  
Frequency range 32-50, 146-174, 420-512 MHz.  
The Bearcat 250 performs any scanning function you could possibly want. With push button ease you can program up to 50 channels for automatic monitoring. Push another button and search for new frequencies. There are no crystals to limit what you want to hear. A special search feature of the Bearcat 250 actually stores 64 frequencies, and recalls them, one at a time, at your convenience. Automatic "count" remembers how often frequencies are activated by transmission so you know where the action is. Decimal display shows the channel, frequency and other programmed features. The priority feature samples your programmed frequency every two seconds. Plus, a digital clock shows the time at the touch of a button. The Bearcat 250. Scanning like you've never seen or heard before.



**NEW! 50-Channel Bearcat 300**

## NEW! Aircraft Bearcat 220



## Aircraft Bearcat® 220

List price \$399.95/CE price \$259.00

**Aircraft and public service monitor.** Frequency range 32-50, 118-136 AM, 144-174, 420-512 MHz. The Bearcat 220 is one scanner which can monitor all public service bands plus the exciting AM aircraft band channels. Up to twenty frequencies may be scanned at the same time.

Not only does this new scanner feature normal search operation, where frequency limits are set and the scanner searches between your programmed parameters, it also searches marine or aircraft frequencies by pressing a single button. These frequencies are already stored in memory so no reprogramming is required. The Bearcat 220 also features a Priority channel, Dual scanning speeds, Patented track tuning and Direct channel access and AC/DC operation.

## NEW! Bearcat® 211

List price \$339.95/CE price \$229.00

**Frequency range: 32-50, 146-174, 420-512 MHz.** The Bearcat 211. It's an evolutionary explosion of features and function, 18-channel monitoring. With no-crystal six-band coverage, Dual scan speeds. Color-coded keyboard. Even a digital clock. All at a modest price. More scanning excitement than you bargained for.

## Bearcat® 210

List price \$299.95/CE price \$199.00

**10 Channels • 5 Bands • Crystalless**

**Frequency range: 30-50, 146-174, 420-512 MHz.** Use the simple keyboard to select the 10 channels to be scanned. Automatic search finds new frequencies. The 210 features patented selectable scan delay, push button lockout, single antenna, patented track tuning, AC/DC operation. With no crystals to buy. Ever!

## NEW! Bearcat® 8 Track

List price \$99.95/CE price \$79.00

**4 Channels • 2 Bands • Plays off any AC or DC Powered 8 Track Tape Player.**

**Frequency range: 36-44, 152-162 MHz.**

The Bearcat 8 Track Scanner. It converts any 8 track tape player into a live-action scanning radio.

This incredibly compact 4-channel/2-band crystal scanner plugs into the tape player where an 8 track cartridge normally goes. Police, fire, emergency calls—as-it-happens scanning excitement—from an existing home entertainment center, in-car/in-boat system or portable 8 track tape player. The Bearcat 8 Track Scanner plugs live-action into any 8 track player. Anywhere. Crystal certificates # A-135cc are \$4.00 each.

## Bearcat® Four-Six

List price \$169.95/CE price \$109.00

**The first 4 Band, 6 Channel, Hand-Held Scanner.**

**Frequency range: 33-47, 152-164, 450-512 MHz.** The Bearcat Four-Six offers "hip pocket" access to police, fire, weather and special interest public service broadcasts. Lightweight. Extremely compact. The Bearcat Four-Six—with its popular "rubber ducky" antenna and beltclip—provides "go-anywhere/hands-off" scanning.

## NEW! Aircraft and UHF

### Bearcat® ThinScan™

List price \$149.95/CE price \$99.00

**World's smallest scanner!**

The Bearcat ThinScan™. High-performance scanning has never been this portable. There are now three models available. The BC 2-4 L/H receives 33-44 and 152-164 MHz. The BC 2-4 H/U receives 152-164 and 450-508 MHz. The new high-performance Aircraft ThinScan model BC 2-4 AC receives 118-136 and 450-470 MHz. Go ahead, size it up. The Bearcat ThinScan™ measures 2 1/4" across. Just 1" deep. And 5" high. Four crystal-controlled channels are scanned every 1/2 second providing immediate access to police, fire, weather and other special-interest broadcasts.



**NEW! Bearcat 8 Track scanner**

CIRCLE NO. 1 ON FREE INFORMATION CARD

## INCREASED PERFORMANCE ANTENNAS

If you want the utmost in performance from your Bearcat scanner, it is essential that you use an external antenna. We have six base and mobile antennas specifically designed for receiving all bands. Order #A60 is a magnet mount mobile antenna. Order #A61 is a gutter clip mobile antenna. Order #A62 is a trunk-lip mobile antenna. Order #A63 is a 3/4 inch hole mount. Order #A64 is a 1/4 inch snap-in mount, and #A70 is an all band base station antenna. All antennas are \$25.00 and \$3.00 for UPS shipping in the continental United States.

## OTHER BEARCAT ACCESSORIES

SP50 AC Adapter	\$12.00
SP51 Battery Charger	\$12.00
SP55 Carrying Case for Four-Six	\$15.00
SP57 Carrying Case for ThinScan	\$15.00
SM210 Service manual for Bearcat 210	\$15.00
SM220 Service manual for Bearcat 220	\$15.00
SM250 Service manual for Bearcat 250	\$15.00
B-31.2 V AA Ni-Cad's for Four-Six (Pack of 4)	\$15.00
B-41.2 V AAA Ni-Cad's for ThinScan (Pack of 4)	\$15.00
B-5 Replacement memory battery for Bearcat 210	\$5.00
A-135cc Crystal certificate	\$4.00
Add \$3.00 shipping for all accessories ordered at the same time.	

## TEST A BEARCAT SCANNER FREE

Test any Bearcat brand scanner purchased from Communications Electronics™ for 31 days before you decide to keep it. If for any reason you are not completely satisfied, return it in new condition with all parts in 31 days, for a courteous and prompt refund (less shipping and handling charges).

## MADE BY ELECTRA

Since all Bearcat scanners are products of Electra Company, a Division of Masco Corporation of Indiana, you can be assured of the finest monitor radios available in the world. With your Bearcat scanner, you will receive a complete set of simple operating instructions and a one-year limited warranty from Electra. If service is ever required for any Bearcat scanner just send your receiver to an Electra national service center.

## BUY WITH CONFIDENCE

All Bearcat scanners are extraordinary scanning instruments. They provide virtually any scanning function that the most professional monitor could require. To get the fastest delivery from CE of any Bearcat scanner, send or phone your order directly to our Scanner Distribution Center. Be sure to calculate your price using the CE prices in this ad. Michigan residents please add 4% sales tax. Written purchase orders are accepted from approved government agencies and most well rated firms at a 10% surcharge for net 30 billing. All sales are subject to availability. All sales on accessories are final. Prices and specifications are subject to change without notice. Out of stock items will be placed on backorder automatically unless CE is instructed differently. International orders are invited with a \$10.00 surcharge for special handling in addition to shipping charges. All shipments are F.O.B. Ann Arbor, Michigan. No COD's please. Cashier's checks will be processed immediately and receive an order priority number. Personal checks require three weeks bank clearance.

Mail orders to: **Communications Electronics**, Box 1002, Ann Arbor, Michigan 48106 U.S.A. Add \$5.00 per scanner for U.P.S. ground shipping, \$9.00 for faster U.P.S. air shipping or \$30.00 for overnight delivery to most major U.S. cities via Federal Express or Airborne Air Freight. If you have a Master Charge or Visa card, you may call anytime and place a credit card order. Order toll free 800-521-4414. If you are outside the U.S. or in Michigan, dial 313-994-4444. You may also order via TWX 810-223-2400. Dealer inquiries invited. All order lines at **Communications Electronics** are staffed 24 hours.

Since this **multi-million dollar scanner** is the world's largest, please order today at no obligation to assure a prompt order confirmation and delivery.

*When you follow the leader to real excitement, your journey ends at Communications Electronics.*

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POPULAR ELECTRONICS

JANUARY 1980

25<sup>TH</sup>  
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# Popular Electronics®

VOLUME 17, NUMBER 1

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE



## About the cover:

The personal radiation monitor featured this month can be used to check relative levels from many types of radioactive sources.

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# Editorial

## ELECTRONIC SAFETY

Fatalities due to electric shock are rather rare. Nonetheless, one should not lightly dismiss the hazards of working with and around electronic equipment. It makes sense to minimize any risk, you'll agree, regardless of how small it is. Accordingly, here's a partial list of personal safety rules that I've practiced in recent years.

- (1) Hire someone to erect your ham, CB or TV roof antenna. Seems that every few months someone doing it himself hits an electric power line . . . and poof!
- (2) If you're working on electronic equipment, be sure the ac plug is pulled out of the wall socket; don't ever depend on an on-off switch to do the job.
- (3) Beware of transformerless sets; they might have a "hot" chassis. (Use an isolation transformer to play safe.)
- (4) Don't use a wet finger to check signal paths.
- (5) Replace frayed ac line cords or extension cords as soon as you notice them.
- (6) If your electric drill cannot be grounded, be sure to use one that has double insulation.
- (7) Check your communication gear for proper lightning protection.
- (8) Discharge electrolytic capacitors before starting work on equipment.

There are other, even more remote, hazards that are somewhat related to electronics. These include laser light, microwave energy, and ionizing radiation (medical/dental X rays, nuclear radiation, etc.).

The biological effects of the last can be insidious, of course, since there is no proven bottom threshold for genetic damage. Not to worry, though, say all the journals I've read. Irradiation from natural and man-made sources are said to be well within "acceptable" limits. Typical whole body annual doses are reported to be 0.102 rem for natural radiation, 0.072 rem for medical radiation, and 0.0026 from TV and other consumer electronic products, for a total of about 0.176 rem. The long-term maximum yearly "safe" dose is said to be 0.500 rem, so there appears to be plenty of leeway.

Nonetheless, some people worry about radiation exposure, especially when a nuclear accident occurs. Under normal circumstances, radiation from nuclear reactors, fallout, etc., accounts for less than 0.005 rem/year, which is a tiny addition to anyone's radiation burden. To place this in its proper perspective, terrestrial radiation in Denver, Colorado is about 0.058 rem higher than in Florida. So one can substantially reduce a dose rate simply by moving to a coastal plain area. Should anyone be terribly concerned about nuclear power plant leakage, radioactive waste deposits, or what-have-you, the radiation monitor described in this issue may give you some reassurance.

*Art Salsbury*

# Step up to your next computer.



## STEP UP TO A C4P FROM OHIO SCIENTIFIC

You know about computers. In fact, you probably own one now. One that you might be thinking of expanding. We have a better idea. Take a giant step into the personal computing future with an amazing, new C4P from Ohio Scientific.

## SPEED SEPARATES THE COMPUTERS FROM THE TOYS

The C4P MF has execution speed that is twice as fast as Apple II or Commodore PET and over THREE times as fast as TRS-80. They are many times faster than the recently introduced flock of video game type computers. And, as if that weren't fast enough, the C4P nearly doubles its speed when equipped with the GT option.

Just look at the back panel of the C4P MF.



All the I/O you'll ever need!

### SCUND

- 1—programmable tone generator  
250 — 20KHz
- 1—8 bit companding digital to analog converter for music and voice output.

### HUMAN INPUT EXPANSION

- 2—8 axis joystick interfaces
- 2—10 key pad interfaces

### HOME INTERFACE

- 1—AC-12 AC remote control interface

### DISPLAY

- 32 x 64 with upper and lower case
- 2048 Characters
- 256 x 512 effective Graphic Points
- 16 Colors

### SOFTWARE

Ohio Scientific offers a comprehensive library of both systems and applications software for the C4P.

The C4P is an outstanding premium computer — years ahead of the market. We know because there's nothing quite like it for the price, anywhere. And probably won't be for a very long time.

CIRCLE NO. 48 ON FREE INFORMATION CARD

### C4P \$698

8K BASIC-in-ROM, 8K of static RAM and audio cassette interface. Can be directly expanded to 32K static RAM and two mini-floppy disks.

### C4P MF \$1695

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 C4P MF starts with 24K RAM and a single mini-floppy and can be directly expanded to 48K and two mini-floppies. Over 45 diskettes now available including games, personal, business, educational and home control applications programs as well as a real time operating system, word processor and a data base management system.

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

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

## OHIO SCIENTIFIC

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# Letters

## COMMENTS ON PRINTER ARTICLE

Your otherwise excellent "How to Buy a Computer Printer" article (November 1979) unfortunately misrepresented the dot-matrix

printhead. The vast majority of impact printheads are only one column wide and print the character one column at a time, with four or five columns per character. I don't think anyone making a microcomputer printer wastes the hardware to have the 35 solenoids that would be required for the device you picture.—Mike Firth, Dallas, TX.

*Sorry if the illustration was misleading. It was meant only to demonstrate how various pins can be fired to generate a character in print. You are correct that most printers form each character a column at a time.—Ed.*

We read with disappointment your remarks on electro-sensitive printers in "How to Buy a Computer Printer." Electro-sensitive paper for our Comprint 912 is not "very fragile" and

does not require handling with "utmost care to prevent wrinkling and soiling." And electro-sensitive paper is not "impossible to photocopy." Finally, this paper costs about half that of plain paper and reusable ribbons.—Harlan E. Dybdahl, Computer Printers Int'l., Inc., Mountain View, CA.

The drawbacks noted about electro-sensitive printers, after noting their important advantages, are largely true. Your company's printer is, in part, an exception to the rule, since it uses a paper that is, indeed, not fragile and does produce good photocopies.—Ed.

## ADDRESS CORRECTION

For our "Tunable FM Antenna Amp" described on page 12, September 1979, note that our correct address is Andover House, 247 N. Main St., Andover, MA 01810.—Roland M. von Sacken.

## MASSAGING THE PROGRAMS

The "Simple TRS-80 Programs Solve Electronics Calculations" article (August 1979) contains a few errors. Level 1, for example, cannot differentiate between two letters as being equal unless the letters are assigned numerical values. These appear in Table 1 on lines 60, 62, 65, and 67 and in Table 2 on lines 370, 380, and 390. Corrections are as follows:

### TABLE 1

```
10 R=1:C=2:V=3:P=4
30 P."SELECT DESIRED FUNCTION"
50 ON A G. 70, 110, 145, 180
(delete lines 60, 62, 65, and 67)
```

### TABLE 2

```
1 Q=1:F=2:B=3
```

When running a 4K machine, one usually conserves as much memory as possible. For this reason, for example, lines 100 through 150 in Table 2 could be put on one line.—David Street, Pottstown, PA

. . . In the Ohm's Law program, line 40 asks for a numerical input (A), but the computer tells the user to enter letter R, C, V, or P. When a letter is entered at a request for numerical information, the input variable is assigned to the value currently associated with that letter. Since R, C, V, and P are not referenced earlier in the program, A is set to approximately 1.90432E-6. The statement "IF A=R G. 70" asks if A is numerically equal to R, not if A contains the letter R. Changes should be as follows:

```
40 IN. "RESISTANCE->R, CURRENT=C,
    . . . ,A$"
60 IF A$="R" G. 70
62 IF A$="C" G. 110
65 IF A$="V" G. 145
67 IF A$="P" G. 180
```

A\$ is read as A-string, where a string variable may contain a letter or a string thereof. This error is made again on lines 360 through 390.—William C. Crowder, Winnetka, IL.

# Out of Tune

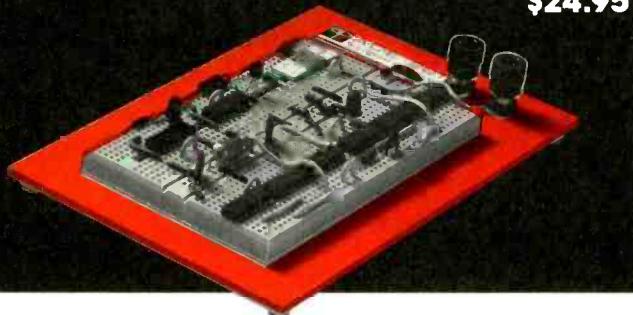
In "Vehicle Low-Fuel Indicator" (August 1979), in Fig. 3, component placement guide, change the labelling of Q2 to SCR1 and Q3 to Q2.

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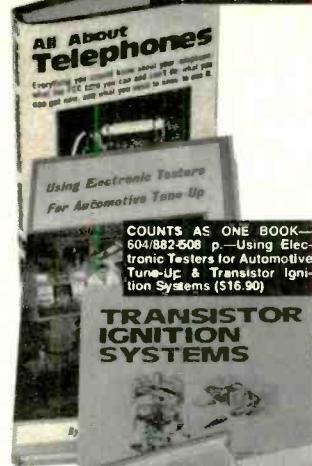
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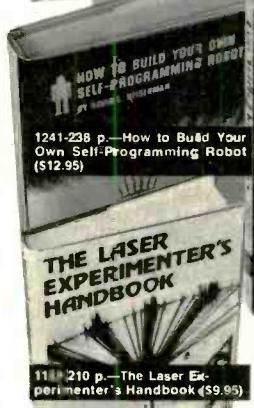
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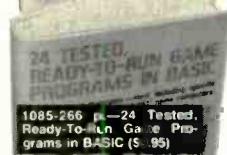
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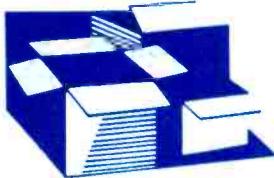
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## New Products

*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.*

### Budget FM Tuner

NAD's Model 4020 is an FM tuner whose no-frills design uses a conventional dial-type station readout and eschews meters in favor of tuning and signal strength in-

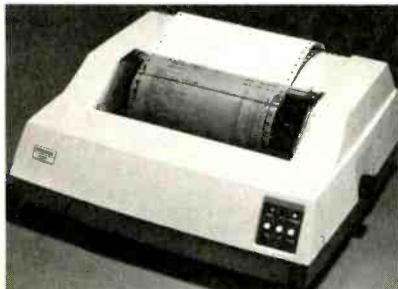


dicators using LEDs. According to the unit's specs, an input of 38 dBf is sufficient to give 50-dB quieting in stereo. High-level (65 dBf) S/N is 70 dB, with channel separation of at least 32 dB, 30-15,000 Hz. Stereo THD is rated at 0.4% at 100% modulation; alternate channel selectivity is said to be 62 dB. \$175.

CIRCLE NO. 89 ON FREE INFORMATION CARD

### Microtek Bidirectional Printer

Microtek's MT-80 series bidirectional impact printer features 80- and 120-column printing at a rate of 125 characters per second. It has the full 96 upper- and lowercase ASCII character set in three software-selectable fonts (5, 10, and 15 char-



acters/inch) on original plus three copies. The 10-cpi font uses a 7 X 9 dot matrix. Microprocessor controlled, the printer contains a 240-character buffer and can accommodate up to 4K of optional data buffers in 1K increments. A comprehensive self-diagnostic program is automatically run on power up. Features pin-feed paper

handling, accepts fan-fold forms from 4.5" to 9.5" wide; up to 10 tabs; skip-over perforation capability. Size is 7.3" X 17.7" X 14.8" (185 X 450 X 375 mm). \$835 serial RS-232 version.

CIRCLE NO. 91 ON FREE INFORMATION CARD

### Edmund "Heat Sleuth"

Edmund Scientific's "Heat Sleuth" is a compact electronic device that helps track down costly heated-air leaks quickly and easily. Its heat wand traces small currents of air from shrunken caulking, inef-



fective weatherstripping, cracks in siding, etc. It can also be used to check the effectiveness of refrigerator door seals, air-conditioning losses, and excessive heat accumulation around furnaces and water heaters. The solid-state Sleuth features a meter that indicates temperature variations as low as 0.2° over a 35° to 95° F range, but is most effective when used on cold and/or windy days. Operates on a standard 9-volt battery. \$39.95.

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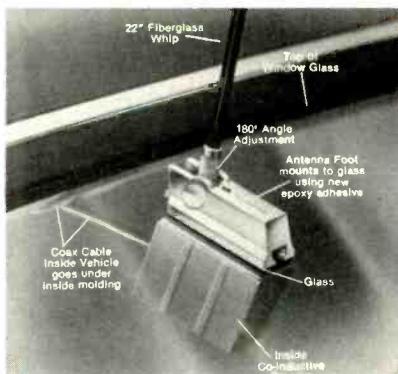
### Hitachi 5-inch Dual-Trace Scope

Hitachi's Model V-152 5" oscilloscope provides a dc-to-15-MHz (-3-dB) bandwidth and dual-trace operation. Among its features are a built-in sync separator for video, X-Y operation, Z-axis input for intensity modulation, a trace rotator, X10 sweep-time magnifier, and 5" (127-mm) CRT with 8 X 10 divisions. Display modes include CH1, CH2, DUAL, ADD, and DIFF. Specifications: 5 mV to 5 V/div. ±5% sensitivity dc to 15 MHz; 0.2 μs to 0.2 s/div. ±5% sweep time in 19 steps; 100 ns/div. maximum sweep rate; 24 ns rise time; more than 4 div. at 15 MHz nondistorted maximum amplitude; 1-megohm shunted by 30 pF input impedance; dc to 500 kHz, 5 mV to 5 V/div. X-Y operation with 3° phase difference from dc to 10 kHz.

CIRCLE NO. 93 ON FREE INFORMATION CARD

### CB Glass-Mounted Antenna

Astro-Fantom from Avanti is a new half-wave omnidirectional CB mobile antenna that measures only 22" (560 mm) tall and can be mounted on glass without tools in a matter of minutes. No ground plane is required nor are there any holes to drill. An



on-glass design developed by Avanti makes mounting of the antenna base on the outside of a vehicle window and the coaxial cable on the inside simple and convenient. A coinductive coupler establishes a tuned circuit to transmit and receive signals directly through the glass. The antenna can be quickly removed for storage, car washing, and theft protection.

CIRCLE NO. 94 ON FREE INFORMATION CARD

### Hypercardioid Microphone

Beyer Dynamic's new M-69 hypercardioid dynamic microphone is designed for live performance and recording applications. Its frequency response, rated at 50 to 16,000 Hz, is said to be almost ruler flat



above 150 Hz, with a smooth rolloff that eliminates rumble without excessive loss of low bass. In addition, its sharp directivity suppresses feedback and audience noise. With a rated output of -51 dBm and 200-ohm impedance, the M-69 is said to minimize noise problems of preamp input stages and tolerate well the long cable runs often necessary in live recording. The mic is supplied with a standard Cannon-type 3-pin connector. \$150.

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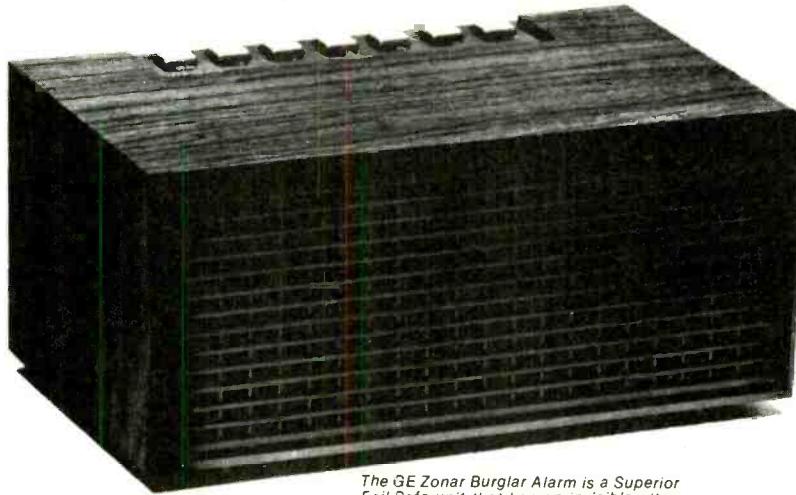
### Electronic Ruler Computer

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## NEW PRODUCTS

# The Protectors

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*The GE Zonar Burglar Alarm is a Superior Fail-Safe unit that has an invisible ultrasonic beam to detect intruders.*

The two new products shown in this ad are the latest in space-age electronics. The Zonar Burglar Alarm compares with similar burglar alarms selling for \$200 or more. The Micro FM Wireless Mike, the world's smallest wireless microphone, represents new technology in the field of FM Radio-Electronics.

We bought both of these products from the manufacturers and tested them under every possible condition. The following are the results of our experiments with both the Zonar Burglar Alarm and the Micro FM Wireless Mike. Please read on. The results may surprise you!

### THE GE ZONAR BURGLAR ALARM

The new GE Zonar Burglar Alarm sounds a loud (85db) alarm — so loud that it can cause pain — and scare away intruders that cross the invisible ultrasonic beam.

The Zonar Burglar Alarm requires no installation and it is portable, so you can place it anywhere in your home. Operating the Zonar is as easy as turning on your television. To arm the unit, you simply press the On Instant or On Delay button. You now have 35 seconds to leave your home. When you return, you enter and you have 10 seconds to press in your secret code numbers. This will disarm your unit. The personalized code numbers for alarm shut-off means that only you or your family knows the code to disarm the alarm.

The Zonar Burglar Alarm looks like a handsome piece of furniture and its small unobtrusive design helps to make it less noticeable. It measures only 7" X 4" X 3" and weighs less than two pounds. To help protect your home or office, it comes with warning decals for windows or doors that state, "WARNING Protected by Electronic Surveillance Equipment", to help deter potential burglars.

The GE Zonar Burglar Alarm is battery operated, so even if a burglar cuts off your power, the unit will still be operational to alert you and your neighbors.

The GE Zonar Burglar Alarm comes with

complete instructions and a One-Year limited warranty backed by General Electric. Should your unit ever malfunction, you may drop it off at any authorized General Electric Dealer or you may use GE's convenient service-by-mail center.

To order your unit for a 30-day test, simply send your check for \$69.95 plus \$2.50 postage and handling to Chandler's, One Chandler Plaza, Chantilly, Virginia 22021 (Virginia residents please add 4% sales tax.) Credit Card Buyers may call our 24-hour Toll-Free number below.

### THE MICRO FM WIRELESS MIKE

The micro FM Wireless Mike is a miniature microphone that picks up your voice and transmits it through any standard FM radio.

The new Micro FM Wireless Mike measures only 1 1/2" X 1/2" and weighs less than one ounce. We found that the superior electronic components put into the microphone surpass anything else on the market. It has a transmitting range of over 300 feet (the length of a football field) and its exceptional fidelity gives you clear reception with practically no interference. Unlike citizen band radios, which operate in the 27 to 29 Megahertz range, the Micro FM Wireless Mike uses the 88 to 108 Megahertz range, giving you the freedom to operate from your car radio, portable radio or home stereo.

BUT WAIT, THERE'S MUCH MORE. The Micro FM Wireless Mike is capable of more than just being a remote mike. It can be used as an intercom in both your home and office. For example, if you are in the garage and your wife or children are in the upstairs bedroom, you can turn on the mike and use it just like an intercom. Secondly, it is small and can be clipped to your jacket while in meetings or during a speech in your conference room or office. The Micro FM Wireless Mike is FCC approved for use in homes, apartments, offices or factories.

Finally, it's inexpensive — only \$29.95 complete with 27" flexible antenna, carrying case, operating instructions and a fresh 1.3 volt



*The Micro FM Wireless Mike has a range of over 300 ft. and transmits through any standard FM Radio.*

mercury battery (which can be replaced at any hearing aid or radio-electronics store).

Your Micro Mike comes with a 90 day limited warranty backed by two substantial companies. Should a malfunction ever occur, there's a complete service-by-mail center as close as your postman.

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### OUR OPINION

We are convinced that both of these new products are superior in value and quality.

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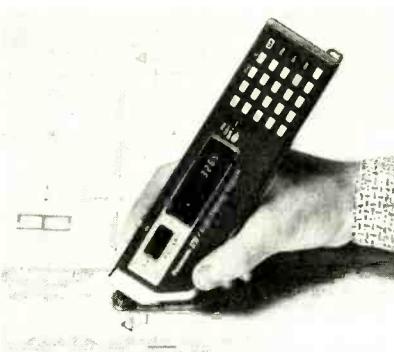
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### NEW PRODUCTS *continued*



### Heath Microprocessor Trainer Accessory

Now you can upgrade Heathkit's Model ET-3400 microprocessor trainer to full personal-computer status with the ETA-3400 accessory. Providing 1K of additional



Ruler/Computer developed by Panasonic Co. The "Ruler That Thinks" employs a small displacement measuring wheel to directly measure lengths, distances, areas, volumes, etc., in linear, square, or cubic units in any scale from any document. A multifunction calculator is integrated into the ruler to permit measured data to be used automatically in computations. Intermediate measurements can be stored in the calculator's memory. The computer displays values directly in millimeters, centimeters, or meters and converts to either inches or feet simply by pressing a function key. Additional features include addressable memory; metric and area conversion; percent, add-on, and discount computation; square-root and pi keys; floating decimal arithmetic; mixed calculations; etc. \$99.95.

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RAM (up to 4K optionally), the accessory features a new monitor in ROM, tiny-BASIC interpreter in ROM, an audio cassette interface, and a serial interface for a video terminal. Connects to the trainer with a 40-conductor ribbon cable (supplied). \$150 kit; \$47 for optional 3K RAM chip set.

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### Head-Maintenance Kit

Designed to fit easily into a standard compact cassette box, which in turn will fit into any cassette storage cabinet, the TDK HC-05 head-maintenance kit contains a



selection of items necessary for proper care of tape heads. Included are a non-toxic head-cleaning fluid, a mirror, a brush, felt probes, and a probe applicator. \$5.99.

**CIRCLE NO. 98 ON FREE INFORMATION CARD**



midrange semihorn driver, and  $\frac{3}{4}$ " (19-mm) liquid-cooled dome tweeter. Crossovers are at 700 Hz and 7.5 kHz, and system response is down 3 dB at 44 Hz. Three-position switches provide level control for the midrange driver and tweeter. System impedance is nominally 4 ohms (3.2 ohms minimum), and sensitivity is 87 dB SPL (on-axis at 1 meter) when driven by 1 watt of power. Dimensions are  $31\frac{1}{8}'' \times 14'' \times 11\frac{7}{16}''$  D (797 X 356 X 291 mm). \$300.

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### Microcomputer Intrusion Alarm

The MassaSonic Ultrasonic Intrusion Alarm uses a microcomputer system said to distinguish real targets from moving air and thus eliminate false alarms. The unit plugs into any normal ac outlet and is rat-



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Starting at just \$129.95 for a Level "A" operating system, you can now build the exact computer you want. Explorer/85 can be your beginner's system, OEM controller, or IBM-formatted 8" disk small business system... yet you're never forced to spend a penny for a component or feature you don't want and you can expand in small, affordable steps!

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For just \$129.95 (plus the cost of a power supply, keyboard/terminal and RF modulator, if you don't have them already), Explorer/85 lets you begin computing on a significant level... applying the principles discussed in leading computer magazines... developing "state of the art" computer solutions for both the industrial and leisure environment.

## Level "A" Specifications

Explorer/85's Level "A" system features the advanced Intel 8085 CPU, an 8355 ROM with 2k deluxe monitor/operating system, and an 8155 ROM/I/O—all on a single motherboard with room for RAM/ROM/PROM/EPROM and S-100 expansion, plus generous prototyping space.

(Level "A") makes a perfect OEM controller for industrial applications and is available in a special Hex Version which can be programmed using the Netronics Hex Keypad/Display.)

PC Board: glass epoxy, plated through holes with solder mask

• I/O: provisions for 25-pin (DB25) connector for terminal serial 1/O, which can also support a paper tape reader

... provision for 24-pin DIP socket for hex keyboard/display... cassette tape recorder input... cassette tape control output... speaker output... LED output indicator on SOD (serial output) line... printer interface (less drivers)... total of four 8-bit plus one 6-bit I/O ports

• Crystal Frequency: 6.144 MHz • Control Switches: reset and user (RST, 7.5) interrupt... additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard • Counter/Timer: programmable, 14-bit binary • System RAM: 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems... RAM expandable to 64k via S-100 bus or 4K on motherboard.

**System Monitor (Terminal Version):** 2k bytes of deluxe system monitor ROM located at F000 leaving 0000 free for user RAM/ROM. Features include tape load with labeling... tape dump with labeling... examine/change contents of memory... insert data... warm start... examine and change all registers... single step with register display at each break point, a debugging/training feature... go to execution address... move blocks of memory from one location to another... fill blocks of memory with a constant... display blocks of memory... automatic baud rate selection... variable display line length control (1-255 characters/line)... channelized I/O monitor routine with 8-bit parallel output for high speed printer... serial console in and console out channel so that monitor can communicate with I/O ports.

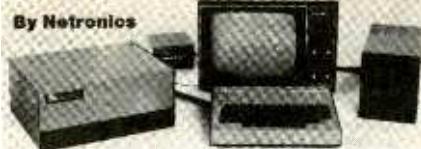
**System Monitor (Hex Version):** Tape load with labeling... tape dump with labeling... examine/change contents of memory... insert data... warm start... examine and change all

## Netronics R&D Dept., Dept. PE-1

333 Litchfield Road, New Milford, 06776

Please send the items checked below—

- Explorer/85 Level "A" Kit (ASCII Version), \$129.95 plus \$3 p&h.
- Explorer/85 Level "A" Kit (Hex Version), \$129.95 plus \$3 p&h.
- 8k Microsoft BASIC on cassette tape, \$64.95 postpaid.
- 8k Microsoft BASIC in ROM Kit (requires Levels "B," "D," and "E"), \$99.95 plus \$2 p&h.
- Level "B" (S-100) Kit, \$49.95 plus \$2 p&h.
- Level "C" (S-100 6-card expander) Kit, \$39.95 plus \$2 p&h.
- Level "D" (4k RAM) Kit, \$69.95 plus \$2 p&h.
- Level "E" (EPROM/RAM) Kit, \$5.95 plus 50¢ p&h.
- Deluxe Steel Cabinet for Explorer/85, \$49.95 plus \$3 p&h.
- ASCII Keyboard/Computer Terminal Kit (features a full 128 character set, upper & lower case, full cursor control, 75 ohm video output convertible to baudot output, selectable baud rate: RS232-C or 20 ma. I/O, 32 or 64 character by 16 line formats, and can be used with either a CRT monitor or a TV set (if you have an RF modulator), \$149.95 plus \$2.50 p&h.
- Hex Keypad/Display Kit, \$69.95



By Netronics

registers... single step with register display at each break point... go to execution address. Level "A" in the Hex Version makes a perfect controller for industrial applications and can be programmed using the Netronics Hex Keypad/Display.

## Hex Keypad/Display Specifications

Calculator type keypad with 24 system defined and 16 user defined keys. 6 digit calculator type display which displays full address plus data as well as register and status information.

## Level "B" Specifications

Level "B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards and includes: address decoding for onboard 4k RAM expansion select-able in 4k blocks... address decoding for onboard 8k EPROM expansion selectable in 8k blocks... address and data bus drivers for onboard expansion... wait state generator (Jumper selectable), to allow the use of slower memories... two separate 5 volt regulators.



Explorer/85 with Level "C" card cage.

Level "C" includes a sheet metal superstructure, a 5-card gold plated S-100 extension PIC board which plugs into the motherboard. Just add required number of S-100 connectors

## Level "D" Specifications

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

## Level "E" Specifications

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for soon to be available RAM IC's (allowing for up to 12k of onboard RAM).

## Order A Coordinated Explorer/85 Applications Pak!

Experimenter's Pak (\$AVE \$12.50)—Buy Level "A" and Hex Keypad/Display for \$199.90 and get FREE Intel 8085 user's manual plus FREE postage & handling!

Student Pak (\$AVE \$24.45)—Buy Level "A," ASCII Keyboard/Computer Terminal, and Power Supply for \$319.85 and get FREE RF Modulator plus FREE Intel 8085 user's manual plus FREE postage & handling!

Engineering Pak (\$AVE \$41.00)—Buy Levels "A," "B," "C," "D," and "E" with Power Supply, ASCII Keyboard/Computer Terminal, and six S-100 Bus Connectors for \$514.75 and get 10 FREE computer grade cassette tapes plus FREE 8085 user's manual plus FREE postage & handling!

Business Pak (\$AVE \$89.95)—Buy Explorer/85 Levels "A," "B," and "C" (with cabinet), Power Supply, ASCII Keyboard/Computer Terminal (with cabinet), 16k RAM, 12" Video Monitor, North Star 5-1/4" Disk Drive (includes North Star BASIC) with power supply and cabinet, all for just \$1599.40 and get 10 FREE 5-1/4" minidisks (\$49.95 value) plus FREE 8085 user's manual plus FREE postage & handling!

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Power Supply Kit for North Star Disk Drive, \$39.95 plus \$2 p&h.

Deluxe Case for North Star Disk Drive, \$39.95 plus \$2 p&h.

Experimenter's Pak (see above), \$199.90 postpaid.

Student Pak (see above), \$319.85 postpaid.

Engineering Pak (see above), \$514.75 postpaid.

Business Pak (see above), \$1599.40 postpaid.

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Send Me Information

By Netronics

## ASCII/BAUDOT, STAND ALONE



COMPLETE  
FOR ONLY  
**\$149.95**

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

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

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

## VIDEO DISPLAY SPECIFICATIONS

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

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

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

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

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Netronics R&D Ltd., Dept. PE-1

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Please send the items checked below—

Netronics Stand Alone ASCII Keyboard/Computer Terminal Kit, \$149.95 plus \$3.00 postage & handling.

Deluxe Steel Cabinet for Netronics Keyboard/Terminal In Blue/Black Finish, \$19.95 plus \$2.50 postage and handling.

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

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

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

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

Total Enclosed (Conn. res. add sales tax) \$ \_\_\_\_\_

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**We make it easy for you.** Radio Shack is a retailer as well as a manufacturer. When the store is also the factory, you're apt to get less fiction and more fact. Also, Radio Shack has more company-owned and operated service stations than almost anyone we know of in the audio business (54 to be specific).

**We've stood the test of time.** Could it be we sell so much Realistic because we've been around since 1921—long before those other brands were even a twinkle in daddy's eye? Although hi-fi is typically a younger person's product, maybe the kids prefer to bet their hard-earned bucks on the outfit with the grayest hair.

**We have the edge on technology.** Then there's this to consider: The same company that puts Realistic out front also builds and markets the world's most popular personal computer, the TRS-80™. It seems to us that a company smart enough to design

equipment as innovative and complex as a computer is a logical one to choose to build your stereo receiver!

**We're close to you.** Need another good reason to buy Realistic? Let's take availability. Instead of tens or hundreds of places to find it, we offer over 7,300—wherever you go in the USA or Canada—and a surprising number of overseas locations as well. Being more available doesn't necessarily make us more lovable. But it goes a long way towards assuring you of being able to get in touch with us when you need advice on adding a tape deck or replacing a lost instruction manual.

**We've challenged the rest and won your trust.** Incidentally, we're not picking on Kenwood, Pioneer and Technics. The same half-million-plus folks who chose Realistic also probably had a crack at buying Sansui<sup>®</sup>, Marantz<sup>®</sup> and Fisher<sup>®</sup>. The important thing is . . . they didn't!

# Radio Shack<sup>®</sup>

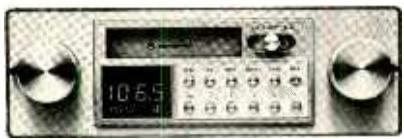
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ed at 120° of coverage in any room up to 1,000 sq. ft. Control is via a touch keyboard through which one of more than 1700 three-digit codes can be entered to disarm the unit. When tripped, the system sounds a siren rated at 105 dB SPL at 1 ft for four minutes and rearms automatically. An optional battery/siren unit provides up to 48 hours of continuous emergency power. \$270. Address: Massa Products Corp., 280 Lincoln St., Hingham, MA 02043.

## Motorola All-Electronic Car Radio

Motorola's in-dash Model 830SX AM/FM-stereo radio with cassette player has electronic station scan and search, 5-station memory for each band, Dolby noise



reduction, a mute switch, and a CrO<sub>2</sub> tape switch. Station frequencies and time are displayed with numeric LEDs. The radio produces up to 20 watts rms power at 1%

THD (DIA method). The muting switch operates on both AM and FM, and the Dolby system can be used on both FM and tape. Other controls include front-to-rear fader, left-right balance, bass and treble, and a loudness contour switch. The cassette deck features automatic tape reversing, locking fast forward and rewind, tape-direction indicator, and automatic eject when radio or ignition is turned off. Specifications: 65-dB FM selectivity at 400 kHz; 62-dB S/N at 100 microvolts; 0.105% max wow and flutter; 40-dB separation. \$450.

CIRCLE NO. 99 ON FREE INFORMATION CARD

## Stereohedron Pickup

Newly added to the line of Pickering cartridges using the Stereohedron stylus geometry is the XSV-4000, designed for tracking ability equal to the demands of direct-to-disc and digitally mastered records. Equipped, like other Pickering cartridges, with a brush said to provide low-frequency damping and also remove dust from the record grooves, the new model operates with an effective stylus force of 1 gram ± 0.25 gram. Output is rated at 0.7 mV/cm/s ± 2 dB, with frequency

response reported to extend from 10 to 36,000 Hz. Designed to work into a load of 47 kilohms in parallel with 275 pF, the pickup has a rated separation of 35dB at 1 kHz. Styli for monophonic LPs and 78-rpm discs are available at extra cost. \$160.

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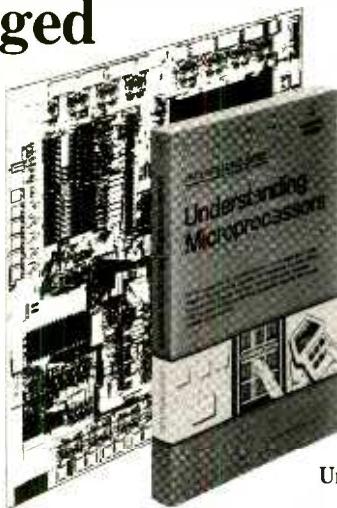
## Trantronics Continuity Checker

The "Electronic Workmate" is a new leadless continuity checker from Trantronics. It needs no hookup leads because the cir-



cuit is completed through the hands and body of the user. It can be used to troubleshoot circuits and components, trace wiring, and simplify cable and harness assembly. \$15.95. Trantronics Co., 13101 N.E. Hwy. 99, Vancouver, WA 98665.

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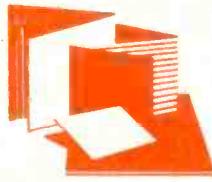
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# New Literature

## VIDEO EQUIPMENT REFERENCE BOOK

In addition to information on major video equipment brands (Sony, JVC, Panasonic, etc.), a new 64-page catalog from Adwar has listings and rates of video equipment rentals, film-to-tape transfer and duplication, and modifications for video cameras, recorders, and monitors. Several new modifications applicable to the up-grading of home videocassette equipment are given. Address: Adwar Video Corp., 100 Fifth Ave., New York, NY 10011.

## PC BOARD GRAPHICS BULLETIN

A new electronic circuit packaging, repair, and prototyping system called Quik-Circuit™ from Bishop Graphics is described in Technical Bulletin No. QC-102. The Quik-Circuit system is for use in building printed circuit boards and prototypes quickly and making on-the-spot pc board repairs. It uses pressure-sensitive copper component mounting configurations, donut pads, tape and copper sheets and is particularly intended for low-voltage applica-

tions such as TTL, ECL, and CMOS. Address: Bishop Graphics, Inc., 5388 Sterling Center Dr., Box 5007, Westlake Village, CA 91359.

## RELAY SPECIALTIES CATALOG

The most recent segment of a planned four-volume master source book of relays, timers, and other control components, is a 144-page catalog illustrating and describing relays of approximately 20 U.S. manufacturers, stocked by Relay Specialties. Manufacturers include Potter-Brumfield, Struthers-Dunn, C.P. Clare, and others. Address: Relay Specialties, Inc., 13-00 Plaza Rd., Fair Lawn, NJ 07410.

## OSBORNE MICROCOMPUTER BOOKS

A brochure from Osborne & Assoc. lists new additions to its catalog of books on microcomputers, as well as software material and consulting and design services available. Also included is information on upcoming publications such as handbooks for 8086 and PET users. Programs in BASIC for the PET computer are available on cassette. Address: Osborne/McGraw-Hill Inc., 630 Bancroft Way, Berkeley, CA 94710.

## KEYBOARD CATALOG AND APPLICATION GUIDE

A 36-page catalog (No. KB79-1) describes the Cherry line of both hard-contact (gold crosspoint) and solid-state (capacitive) keyboards as well as switches, and keycaps. A five-page introductory

section gives step-by-step procedures for solving keyboard problems with any type of board. Particular details are given on the new solid-state keyboards. Address: Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, IL 60085.

## CONCEALED MOBILE ANTENNA BROCHURE

Antenna Specialists' new six-page brochure (SD-726) features its ASP-1000 "no-profile" totally concealed uhf antenna. It also contains information and specs on the complete line of high- and low-band vhf and uhf professional disguise antennas, including universal and replacement models. Address: The Antenna Specialists Co., 12435 Euclid Ave., Cleveland, OH 44106.

## SEMICONDUCTOR CROSS-REFERENCE

The new Workman Semiconductor Catalog and Cross Reference (X79) contains over 150,000 WEP references to numbers of similar units from other sources. Specifications and outlines are given. Address: Workman Electronic Products, Inc., Box 3828, Sarasota, FL 33578.

## DIP HANDLING SYSTEMS

A new 20-page catalog covers DIP insertion, extraction and handling systems and special tools—all for use with MOS ICs. Special items include a Mini Drill series, a plated-through hole inspection prism, "Heat-a-Dip" stations, etc. Address: Micro Electronic Systems Inc., 159 Main St., Danbury, CT 06810.

## Don't settle for less. Get the best from Vector!

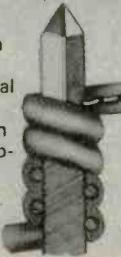
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- ✓ Vector tools slit insulation over full wrapped length of post—competitive tool wedges wire against post corner, a less reliable way.
- ✓ Daisy-chain wiring  reduces number of wraps needed.
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The Air Energizer shown above is the least expensive negative ion generator on the market, selling for only \$74.95. That's \$5 cheaper than our nearest competitor. It is also the best. If you are comparing units you need to know the facts. With the UTP Air Energizer you even get *more* for your \$5 less. We can charge less and give you a higher quality unit because we are a common ownership company. And we are in business to serve you and your environmental needs. Our major competitor is a mail order house that promotes dozens of products every year, but the UTP Ion Research Center is a branch of an educational publishing company. For the past several years we have researched and developed one special electronic product: negative ion generators. This specialization enables us to be the industry's frontrunners. And the System Five Air Energizer is our latest breakthrough in Air Ionization.

#### WHAT DO IONS DO FOR YOU?

Frankly, as marketing director I was pretty skeptical of our Ion Research team's work until one day two years ago when I was walking to work. The season's first thunderstorm had just ended. The air was sparkling clean and almost magically alive. I took a deep breath. The new energy in the fresh air made my head tingle. But as I walked into the office building where I work I immediately felt a drop in energy. The air was dull and lifeless—"stuffy feeling".

Was I experiencing what our Ion Researchers had been telling me all along for the last four years? I decided to test it. I put a UTP Air Energizer on my desk. Skepticism gave way to enthusiasm. I felt great. I still have that unit on my desk.

#### WHAT MADE THE DIFFERENCE

Have you ever wondered what makes this kind of difference in the air? It isn't just our attitude when we're out in Nature versus being in a crowded city. It isn't that it's a weekend and not a workday.

The difference lies in the electrical balance of the air or the quantity of "ions" present.

#### 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.

#### WHAT'S THE SOLUTION?

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 Air Energizer can be used indoors in the home, office, work-shop, laboratory, etc., keeping a fresh supply of ionized oxygen flowing from its emitters night and day. This new breakthrough in fresh air control is not a cover-up which masks or deodorizes, but 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.

#### MORE FOR LESS

Why do we say you get more for less money? A typical marketing technique is to take your weakness and assert that it is one of your strengths. This is exactly what our competitor has done. Their ads proclaim the wonders of "miracle fuzz", the bronze fuzz ball emitter on their unit. But using bronze fuzz and calling it a new invention is really old hat. It was first introduced in England many years ago. In fact we ourselves brought out a bronze fuzz unit called System Three over a year ago because it's cheaper than needles. But we are discontinuing it because we want to maintain our reputation for the highest quality, and stainless steel emitter needles are so much better. A single, large fuzz ball emitter is difficult, if not impossible, to clean. It quickly gets so dirty that its efficiency is reduced. We are the only manufacturer we know of that uses *self-cleaning* stainless steel emitter needles.

#### YOUR CHOICE OF TWO TOP-QUALITY UNITS!

There's only one unit that's better than System Five. That's our own System Four. It sells for \$159. It has an even higher ion output. Plus! Our special **Dial-An-Ion** 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 System Four is our answer to this need for output flexibility. And we're the first and only ones to offer this special feature at this price. If System Four is better why did we bring out System Five?



#### SYSTEM FIVE

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.

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 System Four.

If you want something at half the price of System Four, but still better than any other units costing up to \$250, buy System Five.

#### HOW TO GET ONE

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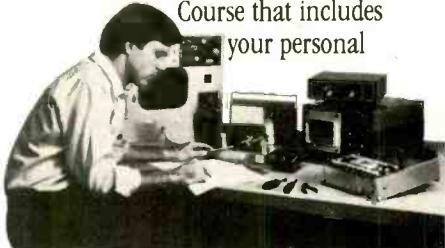
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# Stereo Scene

By Harold A. Rodgers  
Senior Editor

## SHORT SUBJECTS

**O**N A RECENT trip to Japan as the guest of Lux Audio, I was able to prevail upon my hosts to supply me with a listening room in which I could use some of their equipment at length. All of the demonstrations we had heard up to that point (a group of sales representatives and several other journalists were also on the trip) were of the 10-to-15-minute variety. Unfortunately, it is hard to get more than a fleeting impression of a piece of audio gear in that short a time. It struck me, therefore, that a prolonged listening session might stimulate the intellect (I would get to know the equipment better) and the esthetic sense (I could hear a piece of music all the way through).

**Feedback: Friend or Foe?** I should prefer my account of what happened by admit-

ting that up to now I have been very skeptical about claims of substantial differences of amplifiers. Detailed accounts of double-blind tests in which experienced listeners had been unable to distinguish power amplifiers of highly divergent design by sound as long as they were operated within their limits had impressed me profoundly. Accordingly, I had come to the conclusion that most of the subtle sonic differences were due to transient overloads. The experience on this occasion, however, suggests that other factors may well be involved.

The main character in the scenario is the Luxman MQ-68 power amplifier, a vacuum-tube design. The most unusual feature of this amp is that its feedback loop is switchable to give 16 dB of feedback or no feedback at all. In the open-loop mode, the unit delivers 20 watts per channel to an 8-ohm load with 0.3% THD. Closing the loop raises the output power to 25 watts per channel and lowers THD to 0.05%. What we were listening for was any apparent difference between the two modes.

Obviously, there was a difference—otherwise this tale would be pointless—but it was hardly what I had expected. With feedback connected, the bass was clearer and "tighter," an effect that can be explained on the basis of the lower output impedance (higher damping factor) characteristic of that mode of operation. But, at the same time, the treble seemed to become compressed and some sense of ambience seemed to disappear. It is not obvious why this occurred.

Transient intermodulation does not seem to be the answer, for the amplifier is very clean in the open-loop mode. Furthermore,

feedback level is modest, and slew limiting is not usually a problem with vacuum-tube audio amps. One possible answer is that, while the higher damping factor exercises tighter control over the woofer, it simultaneously overdamps the tweeter. That is to say, it may be preferable to let the tweeter radiate whatever energy is stored as acoustic power, even if it is slightly late, rather than to damp it out. This idea is not as far-fetched as it may sound at first, nor is it even new. It seems to have been thinking along these lines that prompted ESS to use current feedback (which, unlike the voltage feedback usually applied, lowers damping factor) in the amplifier for its Transar. The idea is that since the speaker is designed to have no significant resonances in its operating passband, damping is unnecessary and would only be a hindrance.

This view is not necessarily endorsed by Lux personnel, and they, in fact, have suggested further experimentation to see if a less conjectural explanation can be found. Any findings will, in due course, be reported in this column. In the meantime, Lux engineers are carefully studying feedback to be certain when and how its application really does "make a good amplifier better."

**Additional Notes on Ambience.** Since the October installment of this column, which dealt with ambience and its recovery from recordings, some errors have been brought to my attention along with some expansion of ideas presented at that time. First, my apologies to Erik Rørbaek Madsen of Bang & Olufsen, whose name was mangled.

Bob Berkovitz of Teledyne Acoustic Research, who was working with David Hafler at the time the ambience circuit was devised, points out that in the original version the level control was from common neutral of secondary speakers to common ground of the amplifiers. Thus, if the control is set for its maximum resistance a maximum of out-of-phase information emanates from the secondary speakers. At its minimum setting, the two sets of speakers are effectively in parallel, giving double stereo. In intermediate positions, the control feeds any desired mix of in-phase and out-of-phase components to the secondary speakers.

Since the impedance of the control should be approximately the same as impedance of the speakers, another variation is possible:

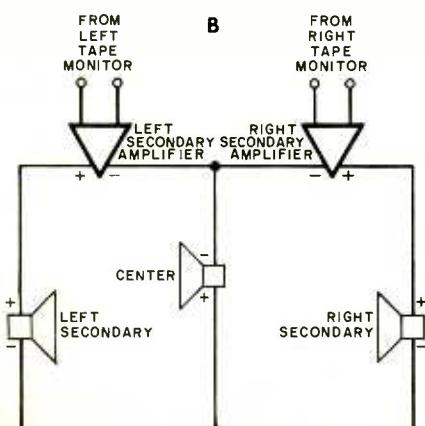
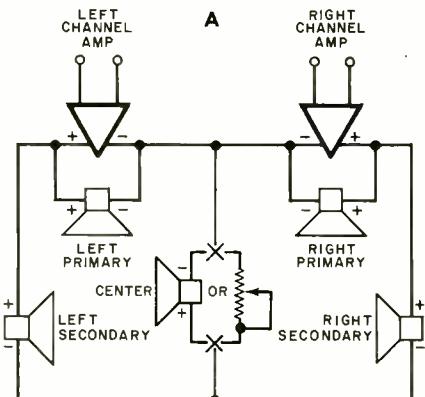


Fig. 1. Variations on speaker arrangements given in October 1979.

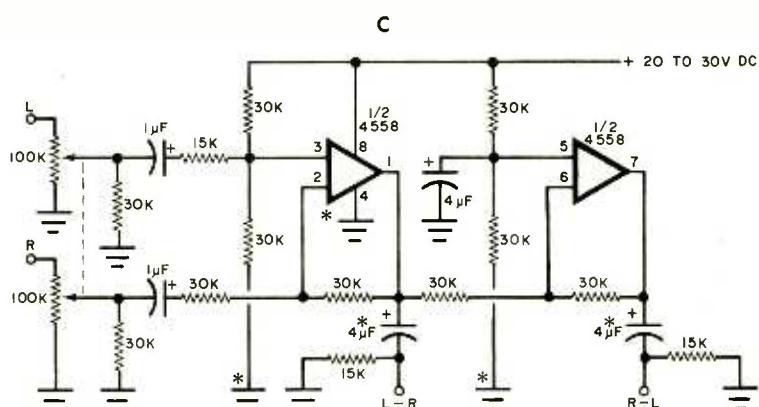


Fig. 2. A practical version of the circuit shown at C in the October 1979 issue.

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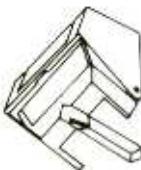
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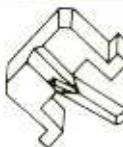
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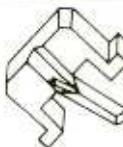
**N95HE\***

Hyperelliptical  
stylus



**N72EJ**

Biradial (Elliptical)  
stylus



**N72B**

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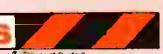
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substitute an additional loudspeaker for the control. This speaker would carry an L R signal and should be located halfway between the primary pair to solidify the center image. Circuits A and B, originally given in October, are both candidates for this treatment as shown in Fig. 1.

Concerning circuit C, C.F. Kerry Gaulder, chief engineer of Source Engineering, points out that scaling of the resistors so that signals from left and right channels have equal gain is not entirely a straightforward matter. He has designed a practical version of the circuit that he kindly consented to have published here (Fig. 2).

The 100k potentiometer at the input gives a broad enough range of control to allow the circuit to be connected either to a spare low-level output (a tape monitor, for example) or to the power amp's loudspeaker terminals. Power should be applied to the ambience circuit before the rest of the system is turned on, otherwise a strong "thump" will be delivered to the loudspeakers. This problem can be cured by using a balanced, bipolar power supply. The ground connections marked with asterisks should be returned to the negative bus in that case, and the output coupling capacitors, also marked with asterisks, can be omitted if desired. The IC can be a type 4558 op amp or equivalent, and the 100-kilohm dual ganged input pot should have a linear taper. The load presented to the pot by the rest of the circuit and the 30-kilohm shunt resistors give an approximate audio taper.

#### Audiophile Recordings.

MOUSSORGSKY: PICTURES AT AN EXHIBITION, NIGHT ON BALD MOUNTAIN. The Cleveland Orchestra, Lorin Maazel conducting. Telarc Digital 10042. It seems like a pretty safe bet that most of the people who listen to *Pictures at an Exhibition* do so in recorded performances rather than in concert halls, which means that, while they may think they know what Ravel's brilliant orchestration sounds like, they don't at all. Compression and limiting, the principal culprits in watering down sonics have been banished from this disc, producing a sound that is certainly a revelation (though still not quite as good as "live"). The vast dynamic range, especially from the deep percussion (a Telarc trademark?) pushes the disc to its extremes. Surface noise is never a problem, but is just barely audible in soft passages. *Night on Bald Mountain* was revised considerably by Rimsky-Korsakov (who was also no slouch as an orchestrator). It is not quite the tour de force that *Pictures* is, but this recording really captures it well.

CARLO CURLEY GOES DIGITAL: THE ALLEN DIGITAL COMPUTER ORGAN IN THE GREAT HALL, ALEXANDRA PALACE, LONDON. Chalfont SDG 303. Here is true poetic justice—a digital recording of a digital electronic organ. The recording has excellent dynamic range (enough to incinerate your speakers with steady loud tones, if you're not careful) and an amazing clarity. This is not your everyday electronic organ—it has 164 stops, 5,500 watts of amplifier power and 380 speakers—and it ought to show "purists" who insist on pipes a thing or two. Curley has put the vast technology to good use, choosing satisfying registrations and interpretations for works from Baroque through Late Romantic. ◇



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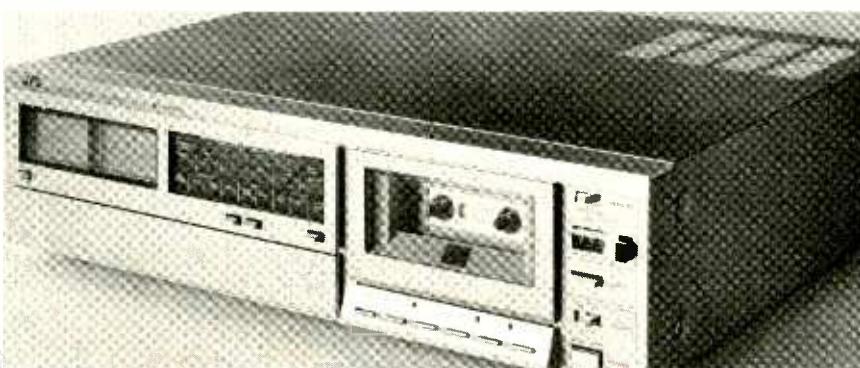


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# Julian Hirsch Audio Reports



## JVC Model KD-A8 cassette deck has computerized tape optimization



Of all the features in the Model KD-A8 cassette deck, the automatic computerized tape optimization system that

JVC calls "B.E.S.T." (Bias, Equalization, Sensitivity-of-Tape tuning) is the most striking. With it, the deck is fully compatible with all modern tape formulations, including metal-particle.

This front-loading deck has two motors, two heads, and a logic-operated solenoid transport control system. It also has JVC's ANRS noise-reduction system plus a Super ANRS system that gives additional high-frequency dynamic range. Operating flexibility, head design, and mechanical and electronic sophistication make the KD-A8 one of the most advanced cassette decks presently on the market.

Relatively compact, the KD-A8 measures only 17 1/4" W x 15 1/4" D x 4 1/4" H (450 x 390 x 124 mm) and weighs 24.2 lb (11 kg). Suggested retail price is \$850.

**General Description.** Most of the KD-A8's controls are located behind a door on the lower part of the front panel. Pressing a button swings the door down to reveal a pair of microphone jacks, a headphone jack, two small recording-level controls, and a single output-level control.

On this subpanel are also three lever switches. TAPE SELECT has positions for CrO<sub>2</sub>, NORM, FeCr, and METAL that set approximate bias and recording equalization for each basic tape type. Selection between chrome and ferric (NORM) is made automatically by the notch on the back of chrome (or other 70-μs, high-bias) cassettes.

The ANRS switch has OFF, ON, and SUPER positions. (ANRS is almost identical in effect to the Dolby-B system, although its circuits are quite different. The two are sufficiently alike so that Dolby tapes can be played satisfactorily on an ANRS deck, and vice-versa.) SUPER compresses the high frequencies of a recorded signal and, during playback, applies a complementary expansion. The result is a slightly greater dynamic range at the higher audio frequencies. Tapes made with Super ANRS, are fully compatible neither with ANRS nor Dolby.

Labelled s&l (Search & Lock), the third switch is used to set recording gains automatically when the maximum level from the source can be determined in advance, as when dubbing. In its MANUAL position, the switch allows recording gain to be set by the two input-level controls in the usual manner. If the highest level to be recorded is presented while the switch is held in its spring-loaded SET position, the circuits follow the program and "hold" the maximum level encountered. They then electronically adjust recording gain for a +3-dB indication from this signal when the switch is

deck is fully compatible with all tape formulations including metal-particle

released and allowed to return to its S&L position. This gain setting is maintained until the deck is shut off or until the circuit is cleared by setting the switch to MANUAL.

Below the back-lighted cassette compartment are the touch switches that control the transport mechanism through solenoids. Although their functions are similar to those of most other cassette-deck controls, they are interlocked in an unusual way. For example, to set up recording levels, REC and PAUSE must be pressed simultaneously, after which the PLAY button must be touched. The PAUSE control can be released only by pressing PLAY or STOP. It is not necessary to stop the tape to switch between fast forward, rewind, and play. A "flying-start" recording can be made while playing a tape by holding down PLAY and pressing REC.

The MEMORY system can be set to have the deck go into either STOP or PLAY when the rewinding tape registers 000 on the tape counter, and a TIMER STANDBY feature allows unattended power switch-on and operation by an external timer in either playback or record.

The display system consists of paired meters calibrated from -20 to +5 dB and an array of 20 red and green LEDs. Below the LEDs are two small buttons labelled COMPUTER CAL START and PRESET and a third labelled REC MUTE. The LEDs give visual indication of operating status at all times, a necessity in view of the deck's many modes of operation. Four LEDs indicate the basic tape type selected, two indicate whether ANRS or SUPER ANRS has been switched on, and one with the legend NON REC lights when recording is inhibited by the absence of a safety tab on the cassette. An s&l LED informs the user when the Search & Lock recording-gain system is operating in place of the regular input-level controls. Finally, a REC MUTE LED comes on when the button below it is held in to mute the recording input signal without stopping tape motion. Used with the PAUSE button, REC MUTE permits editing of a tape as it is being made and eliminates stop/start transients that sometimes accompany operation of a PAUSE control.

The key feature of the KD-A8 is its microprocessor-controlled B.E.S.T. tape-optimization system. With a tape loaded and the TAPE SELECT switch set for its formulation, a touch of the COMPUTER CAL START button sets the system into operation.

First, the transport advances slightly to make sure that coated tape contacts the heads. Then a 1000-Hz reference tone, followed by a 6300-Hz tone, are recorded on both channels. During the recording of the 6300-Hz tone, bias is automatically adjusted over a considerable range in 32 discrete steps. The recording stops, the tape is rapidly rewound, and the section just recorded is played back. The bias level that yields a 6300-Hz playback level equal to the level of the 1000-Hz reference signal is stored in computer memory and is used during the balance of the recording with that tape.

(Continued on page 26)

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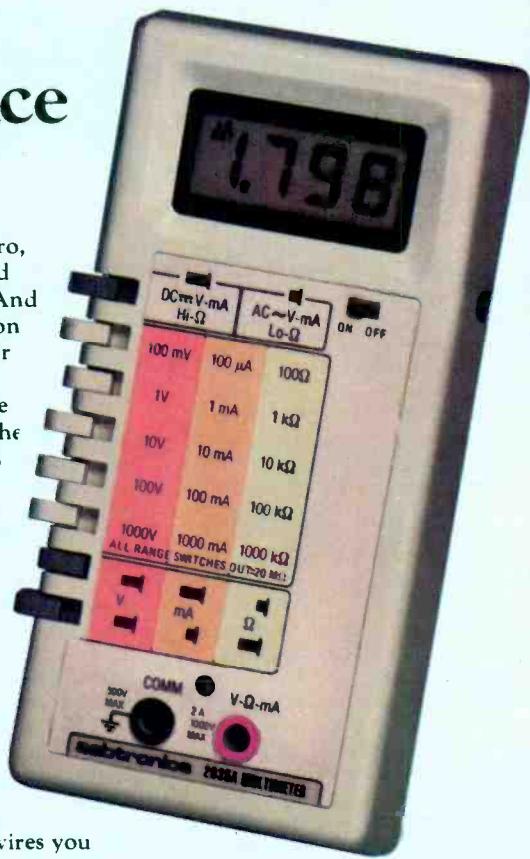
probe. Of course, auto zero, auto polarity and overload protection are standard. And you get 200 hour operation from a single 9V transistor battery. A low battery indicator warns you of the last 20% of battery life. The large, crisp LCD readouts allow easy viewing even in bright sunlight.

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Next, a 10,000-Hz signal is recorded while the recording equalization is varied in eight steps for first one and then the other channel. Following this, a 1000-Hz signal is recorded on both channels in 16 steps of increasing amplitude. The deck plays back these signals and determines the equalization that gives a 10,000-Hz playback level equal to that of the 1000-Hz reference tone in each channel. This value is stored for subsequent use.

Since overall sensitivity might have been changed slightly by the above operations, the 1000-Hz playback sequence is used to set overall record/playback gain to the level required by the ANRS circuits. The tape then rewinds to the beginning and stops, ready for use.

The complete process takes less than 25 seconds. Shutoff of the deck causes loss of the stored information. One can use the fixed settings for each basic type of tape by pressing the PRESET button. As each portion of the B.E.S.T. cycle is completed, a green LED comes on to show that BIAS, EQ, and SENS have been set. At the end of the cycle, the READY LED comes on. (If the PRESET button is used, the PRESET LED comes on.)

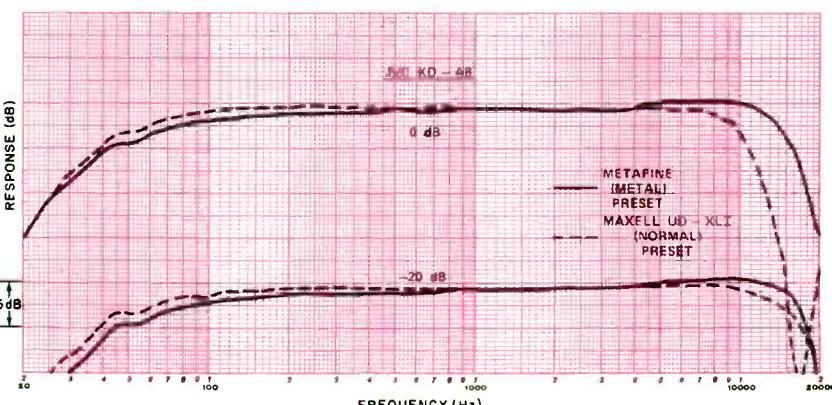
If for any reason, such as an incorrect setting of the TAPE SELECT switch, the computer cannot find appropriate settings, it repeats the test cycle. If the problem persists, the PRESET LED comes on and an ERROR LED blinks. (This latter LED can be extinguished only by pressing the PRESET button.) When the computer's work is done, the sequentially flashing LED display becomes a peak program-level indicator that responds to the stronger of the two channel signals. In this mode, the LEDs come on at levels of -10, -5, 0, +5, and +10 dB.

**Laboratory Measurements.** We tested the deck with the tapes recommended by JVC: Maxell UD-XLI for NORM, TDK SA for CrO<sub>2</sub>, Sony Daud for FeCr, and Scotch Metafine for METAL. JVC says that similar tapes should give essentially identical results after use of the B.E.S.T. system. We verified this by spot testing, but did not perform full tests with any other brands of tape.

The playback frequency response was measured with TDK and TEAC standard tapes for the 120- and 70-microsecond equalization characteristics. Both tapes yielded no more than  $\pm 1$ -dB response variation over their full range (40 to 10,000 Hz for TEAC, 40 to 12,500 Hz for TDK).

Record/playback frequency response at a -20-dB level with all four recommended tapes differed only slightly, and then mostly at frequencies above 10 kHz. Although there were almost no signs of the usual head-contour ripples in the bass range, the low-frequency response rolled off slightly below 100 Hz and more rapidly below 45 Hz. There were measurable differences in high-frequency response between the PRESET and B.E.S.T. adjustments, but these too were above 10 kHz.

Larger differences between the tapes were apparent in the record/playback response at a 0-dB level. With UD-XLI, the response was nearly flat up to about 7 kHz and dropped at higher frequencies to in-



Frequency responses for two types of tape with preset bias and equalization.

tersect the -20-dB curve at 15 kHz or 16 kHz, depending on whether the PRESET or B.E.S.T. was used. TDK SA had a more extended high-frequency response than UD-XLI, and with B.E.S.T., the 0-dB curve remained above the -20-dB curve all the way to 20 kHz. Sony Daud tape had even better resistance to saturation, especially with B.E.S.T., which kept the two curves 10 dB apart to 20 kHz.

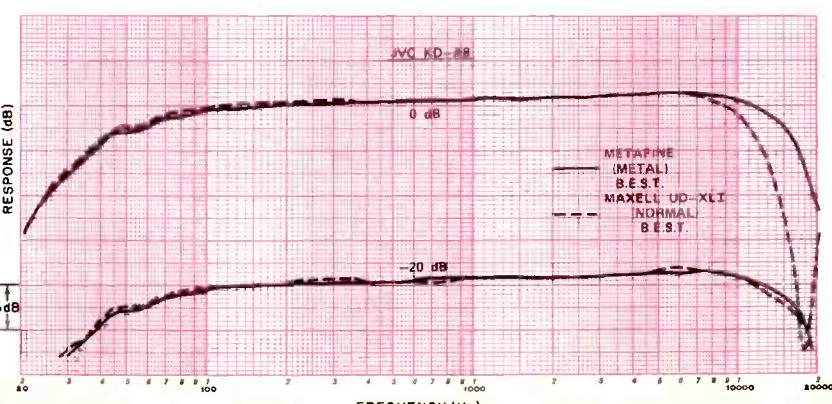
Metafine tape had virtually the same response shape at 0 and -20 dB, with the full 20-dB difference still present at 10 kHz and 15 to 16 dB separating the curves even at 20 kHz. This is a level of performance akin to what we would expect from a good-quality home open-reel deck at 7 1/2 ips and never from a cassette deck (least of all from a two-head deck).

Tracking error of the recording and playback ANRS circuits amounted to less than 1 dB at any frequency up to 15 kHz at recording levels of -20 to -40 dB. It typically was less than 0.5 dB. Performance this good is rarely seen in conventional Dolbyized cassette decks as it requires exact matching of recording and playback signal levels for the specific tape used. This facility is not always available on today's cassette decks, but JVC's B.E.S.T. system accurately performs this matching function every time COMPUTER CAL is pressed.

A LINE input of 70 mV or a microphone input of 0.16 mV was needed for a 0-dB recording level. The microphone pream-

plifier overloaded at 115 mV, an unusually high figure for a cassette deck. Playback output from a 0-dB signal was between 260 and 287 mV, depending on the tape used. Unweighted S/N ratio, referred to the level that gave 3% playback distortion (a +7- to +8-dB signal, depending slightly on the tape used) was 48 to 50 dB. With A weighting, S/N ranged from 56.5 dB (UD-XLI) to 60 dB (Metafine). ANRS improved the S/N, with CCIR/ARM weighting, to 66.2 dB with Metafine tape. Noise increased by about 10 dB though the microphone input at maximum gain but was much less at more reasonable gain settings. Playback third-harmonic distortion at a 0-dB recording level was 0.5% with UD-XLI and SA, 1% with FeCr, and 0.7% with Metafine.

One major problem with metal tapes has been erasure, which requires a very powerful magnetic field and usually a special erase-head design. JVC has solved that problem, as we measured a 75-dB erasure at 1 kHz from a 0-dB recording with Metafine and better than 80 dB with other tapes. (The residual signal was below the noise level and could not be detected even with a narrow-band spectrum analysis.) Crosstalk between channels was 55 dB down with a TDK AC-352 test tape at 1 kHz. Tape speed was 0.3% fast but did not vary over the length of a C60 cassette. Flutter was the lowest we have ever measured from a cassette recorder; with TDK AC-342 tape, it was 0.028% wrms and with Metafine.



Frequency responses using the B.E.S.T. optimization system.

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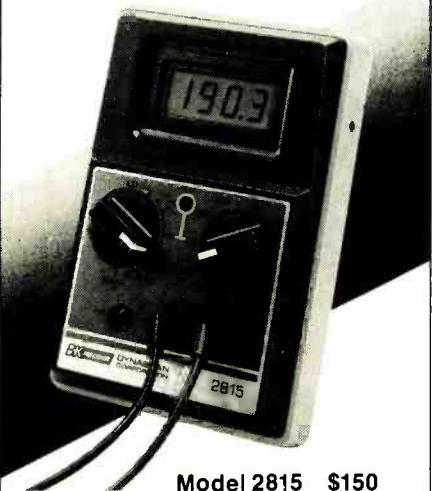
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CIRCLE NO. 10 ON FREE INFORMATION CARD

(Continued from page 26)

$\pm 0.04\%$  CCIR (weighted peak). Combined record/playback flutter was only slightly greater at 0.033% and 0.055%. In the fast speeds, the transport wound through a C60 cassette in 70 seconds.

Meter ballistics were slightly slower than for a true VU meter, reading about 90% of the steady state value on 0.3-second tone bursts repeated once per second. The peak LEDs, of course, responded instantly to this signal, with a decay time of about a second. A 200-nW/m Dolby-level test tape gave a reading of

TIMER STANDBY mode, is that timing must be set to allow an extra minute or so of operation before the desired program appears, since the deck goes through the B.E.S.T. cycle whenever power is first applied.

Our only criticism concerns the exposed COMPUTER CAL buttons. Although the manual warns against touching START while the tape is in motion, as it will then be erased, it is too easy to make this mistake. We feel it would have been preferable had these buttons been located behind the hinged door.

## Performance Specifications

Specification	Rating	Measured
R/P frequency response		
-20-dB level	Metafine: 25-17,000 Hz $\pm 3$ dB TDK SA: 25-17,000 Hz $\pm 3$ dB	44-17,500 Hz $\pm 3$ dB
0-dB level	Maxell UD-XL I: 25-16,000 Hz $\pm 3$ dB Metafine: 25-12,500 Hz $\pm 3$ dB TDK SA: 25-8,000 Hz $\pm 3$ dB	40-18,500 Hz $\pm 3$ dB 34-17,500 Hz $\pm 3$ dB 38-16,000 Hz $\pm 3$ dB 40-12,000 Hz $\pm 3$ dB
With B.E.S.T., -20 dB for all tape types	40-12,500 Hz $\pm 1$ dB	100-13,000 Hz $\pm 1$ dB (MET) 100-13,800 Hz $\pm 1$ dB (SA) 75-12,000 Hz $\pm 1$ dB (XL-I) 75-11,500 Hz $\pm 1$ dB (FeCr)
S/N Ratio ANRS OFF	60 dB (A-wtd, 1 kHz, 3% THD, Metafine tape)	60 dB
ANRS ON	Improved by 5 dB at 1 kHz by 10 dB above 5 kHz	Improved 9.5 dB wide-band (CCIR / ARM wtd)
Channel separation	35 dB at 1 kHz	55 dB at 1 kHz
Flutter	0.035% wrms	0.028% wrms
Harmonic distortion (1 kHz, metal tape)	0.12% DIN 0.4% 3rd harmonic at 0 dB	0.04% DIN / CCIR 0.7%
FF/rewind time (C60)	85 seconds	70 seconds
Input sensitivity	MIC 0.2 mV LINE 78 mV	0.16 mV 70 mV
Outputs	LINE 0-300 mV PHONES 0.5 mW max, 8-1,000 ohms	Max. 260 to 287 mV Not measured

+3.5 dB on the recorder's meters; +1 dB corresponded to the 160-nW/m used on some test tapes, and +5 dB corresponded to the 250 mW/m used on more recent tapes. The headphone level was sufficient to drive even 200-ohm phones to uncomfortable listening levels.

**User Comment.** The B.E.S.T. system made all tapes essentially equal in low-level frequency response. Other differences, such as headroom, distortion, noise, and dropouts, remained measurable and sometimes audible.

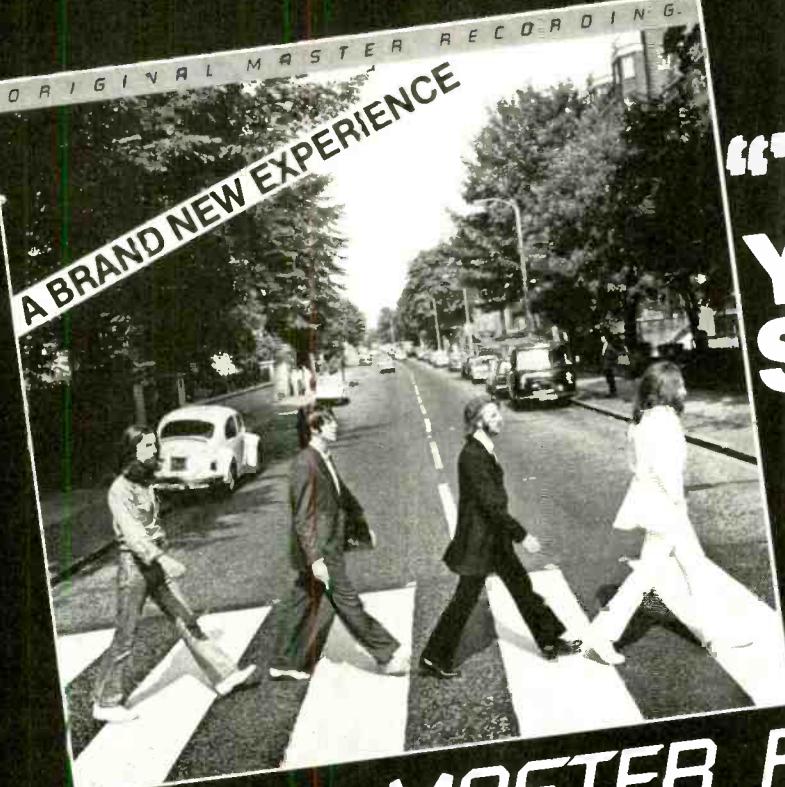
Fortunately, considering the sophistication of the product, the owner's manual is very specific in warning of possible incorrect operation. For instance, if the TIMER STANDBY switch is left on in RECORD, the next time power is applied, the deck will go into record and erase anything on the tape. Hence, one must take care to set the TIMER switch to OFF before shutting off the deck or return recorded cassettes to proper storage. Another peculiarity, related to the

Overall sound quality of the deck was easily as good as we have ever heard from a cassette recorder. Our severe test of reproducing FM interstation hiss was easily passed. With UD-XL I tape, there was a barely audible difference between reference signal and tape playback—not in the high frequencies, but in the low-frequency quality. Using the other tapes, the deck rendered the noise signal very accurately, which is unusual, especially because the recording level was -5 dB on the meters. The unit's exceptional headroom of 7 to 8 dB above indicated 0 dB paid off here.

Although our signal sources were limited to disc records, we can attest that the KD-A8's performance, especially with Metafine tape rivals that of some fine open-reel decks. Yet, considering its exceptional versatility and compatibility with virtually any quality tape, its price is certainly reasonable. If you're a dedicated tape nut, it will probably seem attractive.

CIRCLE NO. 101 ON FREE INFORMATION CARD

(Continued on page 30)



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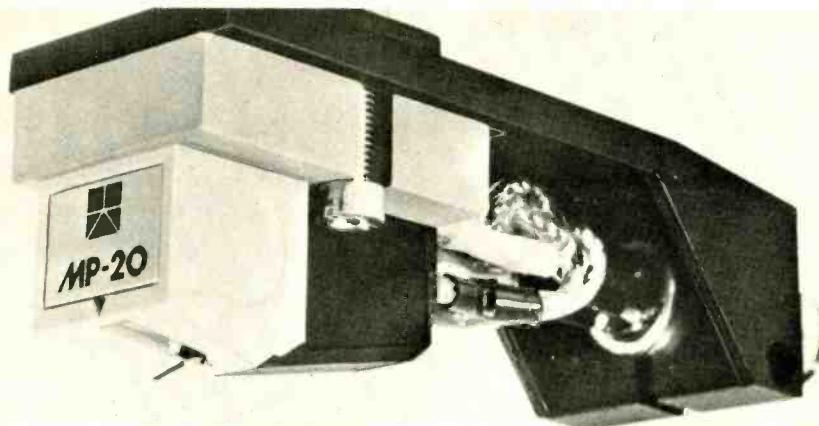


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## Osawa Model MP20 induced-magnet stereo phono cartridge



THE NEW Osawa MP20 phono cartridge heads the line of cartridges imported from Japan by Osawa & Co.

(USA), Inc. Like the previous Osawa cartridges, the MP20 employs the induced magnet principle, but several refinements in details provide it with exceptional performance qualities.

Price of the MP20 is \$175. The cartridge is also available installed in a magnesium-aluminum universal headshell as the Model MP20H for \$200.

**General Description.** The fixed magnet is made of samarium-cobalt, enabling the mass and size of the magnet system to be reduced without sacrifice of magnetic strength. The armature, moved by the stylus cantilever, is of the permalloy magnetic material used in other Osawa cartridges. The cartridge body is molded of a fiberglass-reinforced plastic for high rigidity and freedom from internal resonances. Its mounting surface is exceptionally thick and contacts the headshell of the tonearm over an extended area to ensure close alignment with the shell surface. The contact pins are gold-plated to prevent corrosion and provide a low-resistance electrical connection. The stylus assembly is easily replaceable by the user.

The moving system of the Osawa MP20 is responsible for much of its outstanding performance. The stylus cantilever is made of boron, an extremely hard, rigid material, and is supported by a butyl-rubber damping system that maintains the compliance constant over a wide range of temperature and humidity conditions. The diamond stylus shape is elliptical with radii of 0.4 X 0.7 mils and is nude-mounted to the cantilever.

The MP20 is meant to be terminated in 47,000 ohms shunted by a 100-picofarad capacitance, and has a nominal output of 4 millivolts at a 5-cm/s velocity, with channels balanced within 1.5 dB. The frequency response (no test record or tolerance is specified) is given as 20 to 23,000 Hz. The range of tracking forces is 1.5 to 2.0 grams, with 1.8 grams being the optimum force. The cartridge is slightly heavier than some, weighing 7.8 grams.

**Laboratory Measurements.** We installed the cartridge in the moderately massive tonearm of an integrated record player and operated it at the recommended 1.8-gram force. The ability of the cartridge to track very high velocities was demonstrated by the excellent sine-wave output it produced from the 30-cm/s 1000-Hz tones on the Fairchild 101 test record. The 300-Hz tones of the German Hi Fi Institute record were playable at their maximum 100-micron level without audible distortion, and at the 90-micron level when we used the 1.5-gram minimum rated force. Very high-level 32-Hz tones on one of our records were tracked easily even when the force was a mere 0.6 gram!

Cartridge output was 4 mV when playing

the 3.54-cm/s standard-level bands of the CBS STR100 test record with the levels of the two channels matched within 0.2 dB. The 1000-Hz square wave of the CBS STR112 test record showed about 4 cycles of damped ringing at about 20,000 Hz. Our measured vertical stylus angle with the CBS STR160 record was 23°.

Measurements with several types of test records showed a very flat frequency response up to about 15,000 Hz, with a rising output between 15,000 Hz and the 20,000-Hz upper limit of most of the records. The output was typically 4 to 6 dB higher at 20,000 Hz than at 1000 Hz. To verify the high-frequency stylus resonance, we used the JVC TRS-1005 record, which sweeps from 1 to 50 kHz. The peak, approximately 2.5 dB in amplitude, was at about 25,000 Hz, after which the output fell off rapidly.

To a greater extent than frequency response, the measured channel separation of a cartridge is a function of the test record used. Results obtained from a number of test records yielded 25 to 30 dB of separation in midrange. There was a wider variation in the separation at 20,000 Hz, ranging from 10 to 25 dB, depending on the test record used. With the TRS-1005 record, we found that channel separation maintained a strong 20 dB or more at frequencies well above the 25,000-Hz stylus resonance.

Tracking distortion of the cartridge was measured with the Shure TTR102 and TTR103 test records. Behavior of the MP20 was rather unusual with both rec-

smooth, flat  
response with  
no coloration  
of any kind

ords. IM distortion with the TTR102 record and the 10.8-kHz tone-burst distortion on the TTR103 record varied only slightly over the wide range of recorded velocities on these test records. Measured values fell between 1.7% and 3% at velocities from 7 to 30 cm/s. Although we have measured lower distortion from a number of cartridges at low velocities, we have rarely seen such low distortion, particularly IM, at the highest velocities.

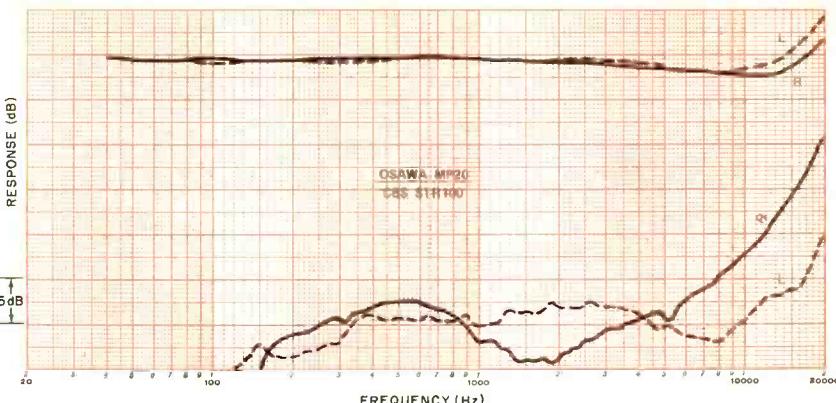
The tracking ability of the MP20 was emphatically confirmed when we played the Shure ERA III and ERA IV "Audio Ob-

### Performance Specifications

Specification	Rating	Measured
Output voltage (1 kHz, 3.54 cm/s)	2.8 mV	4 mV
Channel balance (1 kHz)	1.5 dB	0.2 dB
Frequency response	20-23,000 Hz	Confirmed
Channel separation (1 kHz)	25 dB	30 dB (STR100)
Weight	7.8 grams	Not measured
Tracking-force range	1.5-2.0 grams (optimum 1.8 grams)	Confirmed
Recommended load	47,000 ohms; 100 pF	Confirmed

stacle Course" records. The highest levels of every selection on both records were played with no sense of strain at the rated 1.8-gram force of the cartridge. This has been matched by at most one or two cartridges that we have tested in the past.

**User Comment.** With respect to its relatively high output, close channel-level matching, outstanding channel separation, and low distortion, the MP20 is one of the most refined and compromise-free cartridges on the market. It will track anything we know of that has been recorded commercially on discs. It sounds every bit as good as it measures—better, in fact, since we could not hear any effects of high-frequency resonance. Of course, there is little or no program material on records above 15,000 Hz, and most speakers have a reduced output at those frequencies. In addition, although load capacitance does not seem to be critical, the total presented by our turntable cables and preamp input considerably exceeds



Frequency response and crosstalk for left and right channels.

100 pF. At any rate, we heard only a smooth, flat response with no coloration of any kind, and with the sense of ease that denotes solid tracking and low distortion.

It looks and sounds to us as though OSAWA has added a worthy leader to its cartridge product line.

CIRCLE NO. 102 ON FREE INFORMATION CARD

## Celestion Ditton 662 three-way speaker system with passive radiator



**T**HE Ditton 662 is the top of Celestion's line of loudspeaker systems. Employing a three-way design, it has dome-type midrange and treble drivers and a 12" (305-mm) woofer working in conjunction with a 12" passive radiator. Celestion calls the latter an "Auxiliary Bass Radiator," or ABR. Rated response of this floor-standing model is 38 to 20,000 Hz  $\pm 3$  dB into a 2-pi-steradian space (a hemisphere) in front of the unit.

Impedance is a nominal 8 ohms, and the Ditton is rated to handle 20 to 160 watts of continuous power. It is also rated to deliver a 90-dB SPL when driven by 2.9 watts of pink noise.

The system enclosure measures 41 $\frac{1}{2}$ "H  $\times$  15 $\frac{3}{4}$ "W  $\times$  11 $\frac{1}{4}$ "D (1057  $\times$  400  $\times$  298 mm) and weighs about 75 lb (34 kg). The enclosure is available in oiled American walnut or elm finish. Two snap-on grilles cover the entire front surface of the cabinet. Price is \$749.50.

**mirror-image pairs provide good stereo spread**

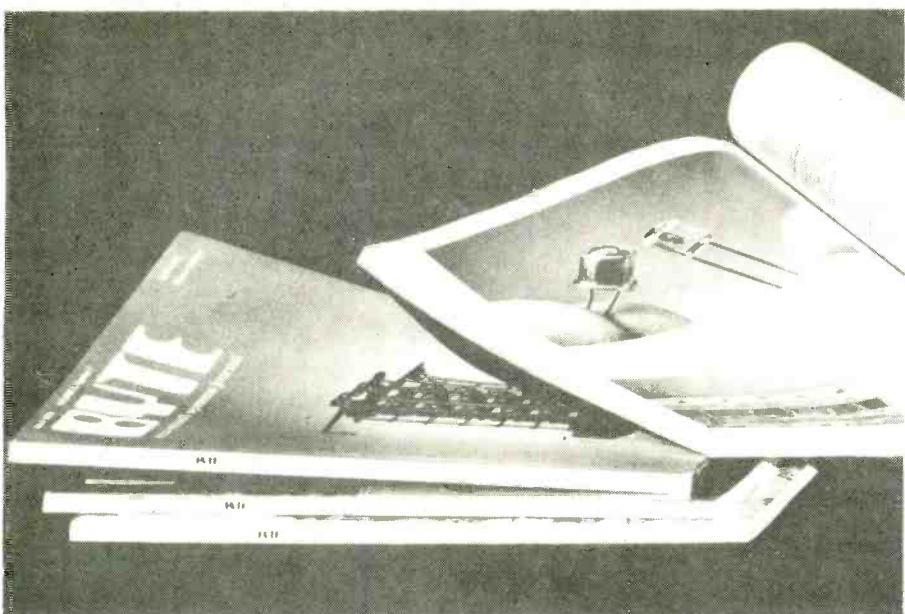
**General Description.** More than half the 90-liter volume of the cabinet is devoted to the bass radiators. The two heavy 12" cones appear to be superficially identical, but the lower ABR lacks a voice coil and magnet structure and has an 18-Hz resonant frequency. Combined with the driven radiator, the ABR gives the bass system a Q of 0.49 and a -3-dB point of 38 Hz.

Crossover to a 2" (50.8-mm) dome radiator occurs at 700 Hz. The crossover network includes compensating components to equalize the impedance variations of the midrange driver and provide a proper resistive termination for a third-order Butterworth bandpass filter. A similar approach is used in the treble crossover, which drives a  $\frac{1}{4}$ " (19.1-mm) dome tweeter at frequencies from 4500 Hz to the upper limit of the speaker system. The tweeter is protected by a 500-mA fast-acting fuse. No external midrange and tweeter level controls are provided.

Both upper-range drivers are offset from the center line of the cabinet. Accordingly, to ensure good stereo imaging, the systems are made in mirror-image pairs.

**Laboratory Measurements.** We set up two Ditton 662s in the front of our listening room in the normal stereo configuration, locating them about 6" (152 mm) from the wall. The response curve in the reverberant field of the room revealed a smooth, slightly rising high end, with only a slight difference in high-frequency response between the two speaker systems when measured on-axis of one and about 30° off-axis of the other. This condition indicates good high-frequency dispersion.

Bass response was measured separately for the driven and passive (ABR) cones, using close mike spacing. We then combined the two curves to form the bass curve of the system. Acoustic crossover between the two cones occurred at about



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55 Hz. Splicing the bass curve to the mid-range and high-frequency curve, we obtained an overall frequency-response variation of  $\pm 3.5$  dB from 27 to 20,000 Hz, which slightly bettered Celestion's rating. Needless to say, this is excellent performance from any speaker system. The shape of the curve suggested either a slight rise at the low- and high-frequency ends of the spectrum or a broadly depressed midrange. Our curve revealed a strong resemblance to the anechoic response curves published by Celestion in that the rises and dips occurred at the same frequencies, although they tended to be slightly greater in our measurements.

Bass distortion of the woofer system was exceptionally low. At a 1-watt input, distortion was less than 1% down to 40 Hz and rose slowly to 2.5% at 30 Hz and 7% at 25 Hz. (These figures were derived by

sounded right with every kind of music and delivered prodigious low-bass output

combining readings made at the driven and passive cones.) Increasing the drive to 10 watts made surprisingly little difference in distortion at most frequencies; measurements were 3.6% at 30 Hz and 10% at 25 Hz.

System impedance was about 8 ohms in local minima at 100 and between 1000 and 2000 Hz and dropped to about 7 ohms at 20,000 Hz. Maximum values were 22 ohms at 5000 Hz, 38 ohms at 50 Hz, and more than 50 ohms at 20 Hz. When driven by 2.83 volts of random noise in the octave centered at 1000 Hz, the system delivered an 89-dB SPL 1 meter from the grille. This is slightly greater sensitivity than rated, although the measurements were made under somewhat different conditions. The tone-burst response was good at all frequencies tested though not exceptional.

**User Comment.** We were impressed with the smoothness and balance of the Ditton 662's sound. There was no harshness or other unnatural coloration to remind us that we were listening to a speaker system. In every part of the audio range, this speaker system easily held its own in A-B comparison with other fine speaker systems. It sounded "right" with every type of music we played and delivered prodigious low-bass output without distortion when called upon to do so. The sound was never heavy or boomy, even on male voices. Stereo imaging was good.

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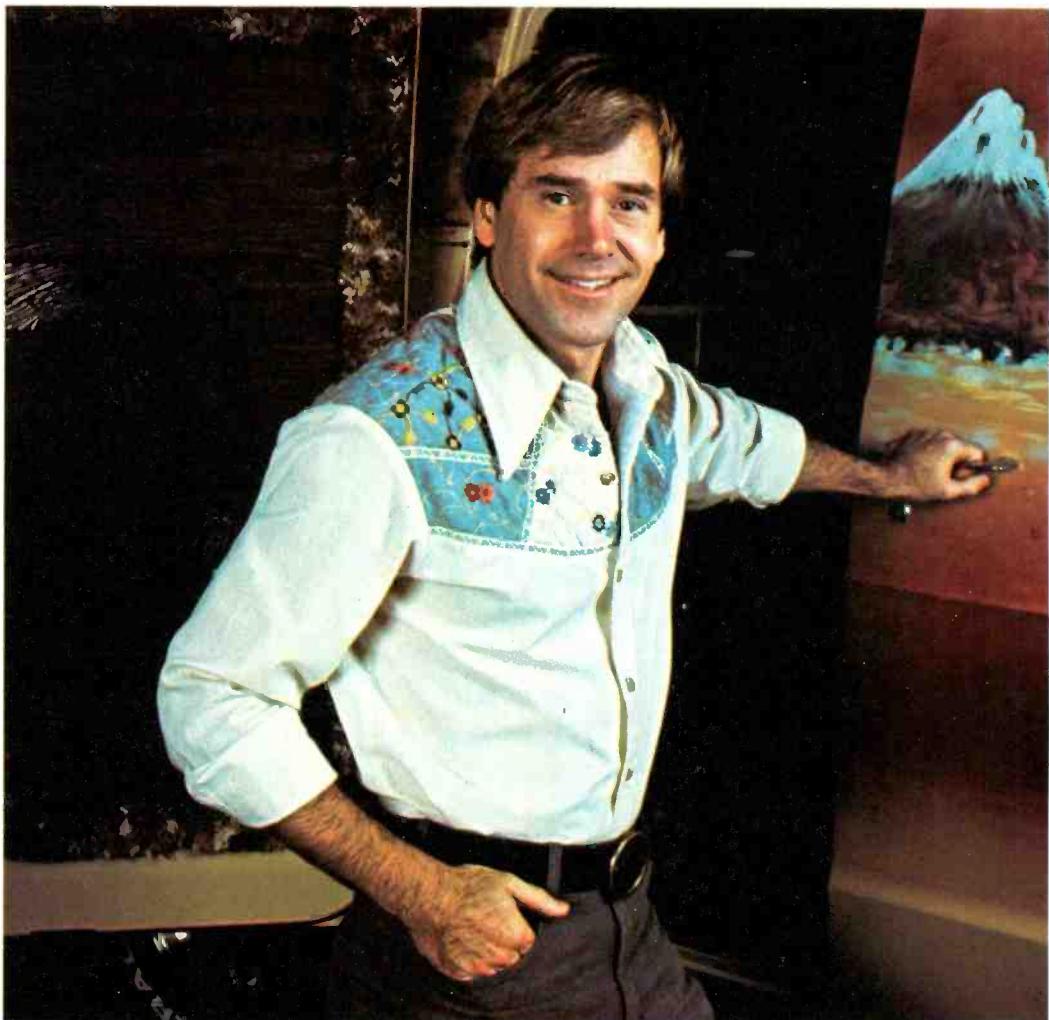
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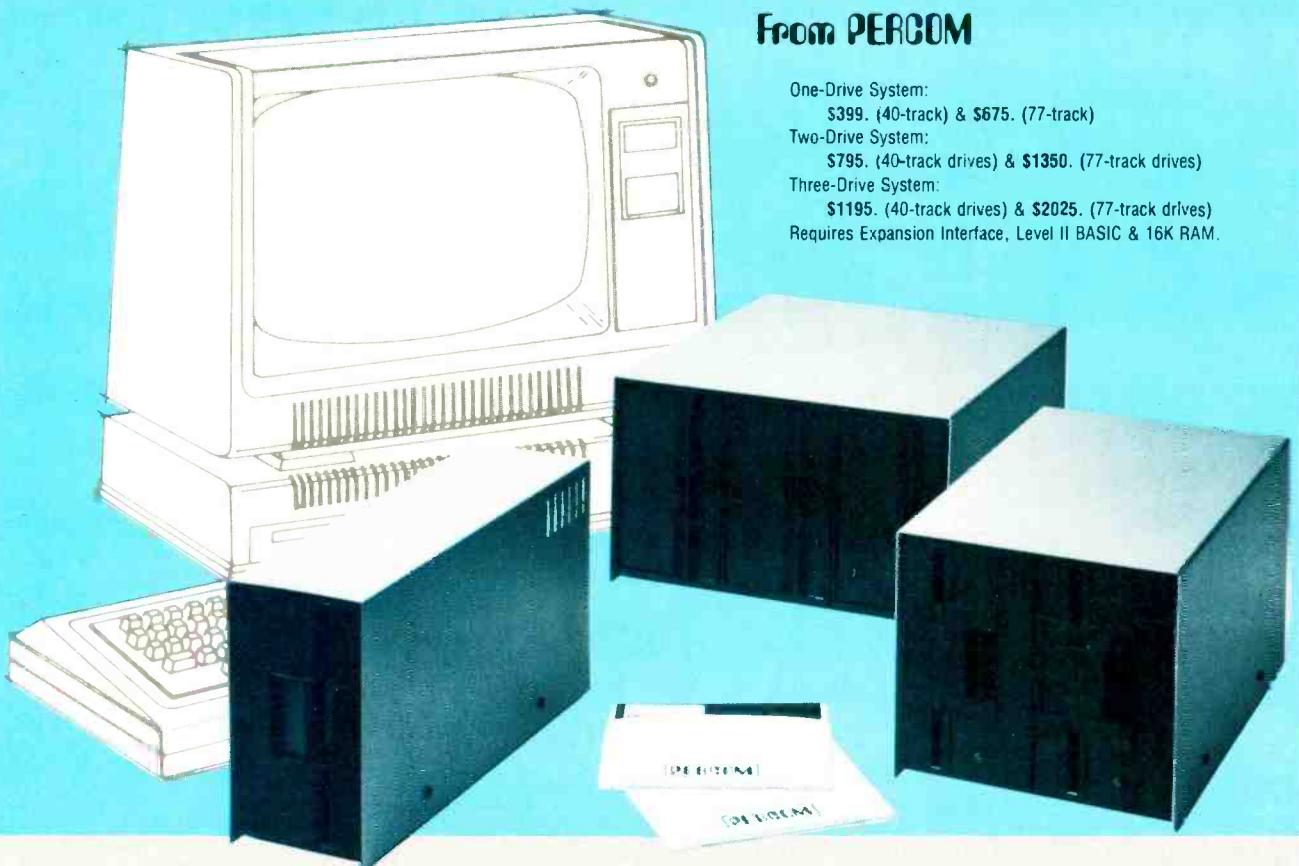
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THOUGH its function as a personal warning monitor is not as important as that of a fire alarm or a gas detector, a radiation monitor can give peace of mind to people who are apprehensive about the hazards of possible radiation leakage and radioactive devices. This concern is obviously heightened whenever the news media report a nuclear incident of one kind or another.

The RED-ONE battery-powered radiation monitor project described here detects local radiation levels from man-made and natural sources. It indicates relative radiation, which is perfectly satisfactory for alerting one to excess radiation levels.

Two versions of the monitor are described. The simpler one produces an audible "chirp" for each detected gamma ray. The other teams up a three-decade counter with the basic circuit to count and display gamma-ray events over a controlled period of time, sounding a chirp for each event.

The RED-ONE is a sophisticated unit that offers many advantages over earlier radiation detectors. Replacing fragile, cumbersome, and less-sensitive Geiger-Muller tubes, this monitor is built around a solid-state cadmium-telluride (CdTe) detector. About the size of a transistor, the device offers high sensitivity, low bias-voltage requirements, extremely low power consumption, and solid-state reliability. Moreover, cost is competitive with tube-detector types.

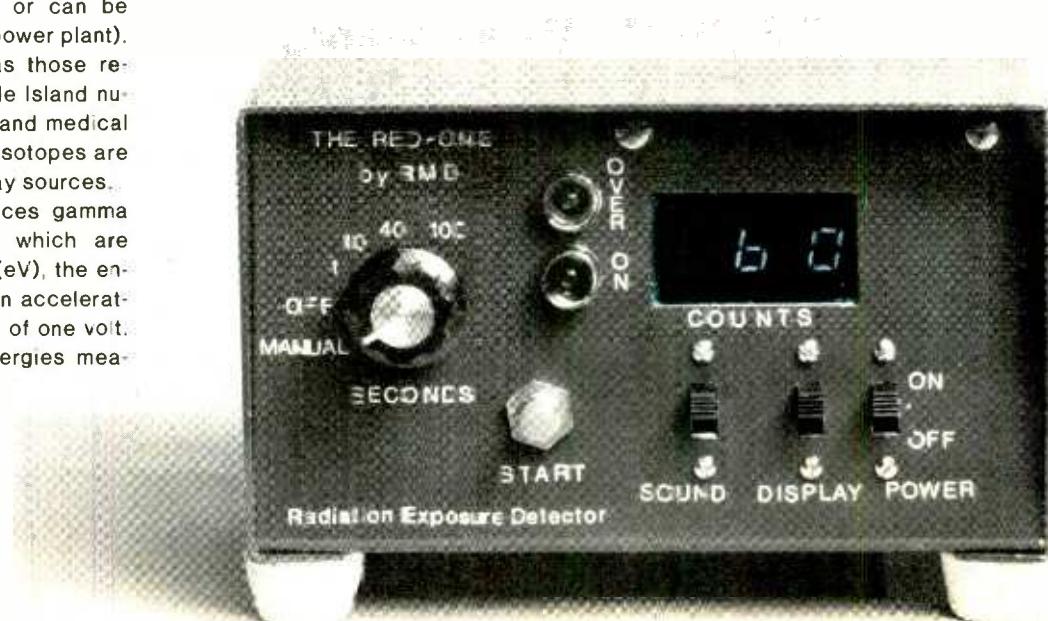
**Radiation and Its Detection.** Gamma rays can occur naturally (from substances such as uranium) or can be man-made (as in a nuclear power plant). Radioactive gases, such as those released during the Three Mile Island nuclear power plant incident, and medical diagnostic and therapeutic isotopes are typical man-made gamma-ray sources.

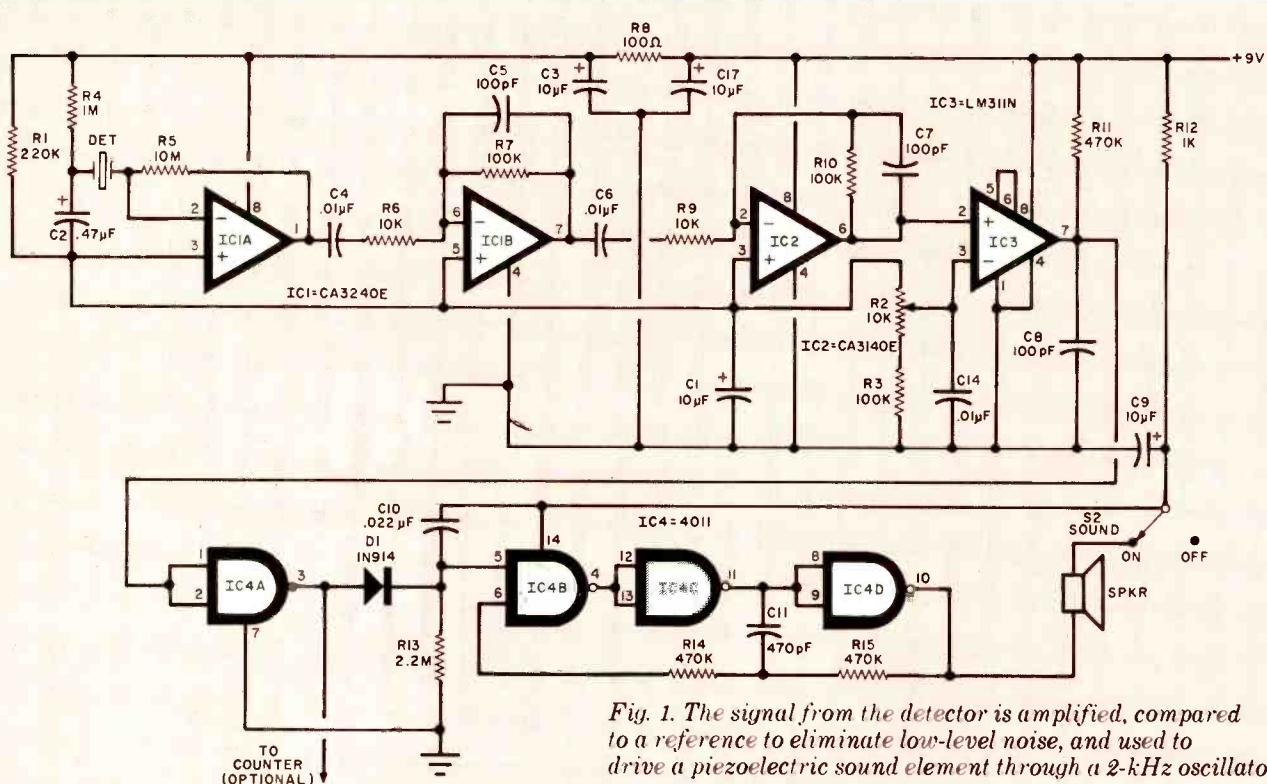
Each radioisotope produces gamma rays of specific energies which are measured in electron volts (eV), the energy acquired by an electron accelerated by a potential difference of one volt. Gamma rays have high energies mea-

# BUILD A Personal Radiation Monitor

*Uses latest cadmium-telluride detector to provide audible or visual indication of radiation level*

BY JOHN STEIDLEY  
MARTIN NAKASHIAN and  
GERALD ENTINE





*Fig. 1. The signal from the detector is amplified, compared to a reference to eliminate low-level noise, and used to drive a piezoelectric sound element through a 2-kHz oscillator.*

## PARTS LIST—FIG. 1

C1, C3, C17—10- $\mu$ F, 16-V tantalum  
 C2—0.47- $\mu$ F, 35-V tantalum  
 C4, C6, C14—0.01- $\mu$ F disc ceramic  
 C5, C7, C8—100-pF disc ceramic  
 C10—0.022- $\mu$ F disc ceramic  
 C11—470-pF disc ceramic  
 D1—1N914 diode  
 DET—CdTe radiation detector (see text and Note below)  
 IC1—CA3240E dual FET op amp (RCA)

IC2—CA3140E op amp (RCA)  
 IC3—LM311N comparator (National)  
 IC4—4011 quad NAND gate  
 The following are  $\frac{1}{4}$ -watt, 10% resistors unless otherwise specified:  
 R1—220,000 ohms  
 R2—10,000-ohm pc potentiometer  
 R3, R7, R10—100,000 ohms  
 R4—1 megohm  
 R5—10 megohms  
 R6, R9—10,000 ohms  
 R8—100 ohms

R11, R14, R15—470,000 ohms  
 R12—1000 ohms  
 R13—2.2 megohms  
 SPKR—Piezoelectric sound element (Kyocera KBS 27DB-3A or similar)  
 S2—Spst switch  
 Misc.—Suitable enclosure, 9-volt battery including holder and power on/off switch, 0.005" brass foil for shield, machine hardware, etc.  
 Note—For availability of kit and parts, see Parts List for Fig. 2.

sured in thousands of electron volts (keV), the typical range being from 100 to 1000 keV. Lower-energy rays are absorbed by even a fraction of an inch of lead, while high-energy rays can pass through many inches of lead.

When gamma rays are absorbed by a CdTe detector such as that used in RED-ONE, an electrical-charge burst is produced and amplified to detect the event. Higher-energy rays produce greater charge bursts.

The gamma-ray sensor in RED-ONE is designed to allow detection of reasonable gamma-ray levels and to permit many interesting experiments to be made. For example, bricks in many New England fireplaces have detectable (though very-low-level) amounts of radioactivity. By observing indications with either version of the monitor, an estimate of activity level can be made.

**About the Circuit.** The basic detector/beeper circuit is shown in Fig. 1. The output of radiation detector *DET* goes to the input of the FET operational amplifier, which provides impedance matching and initial amplification. Additional amplification is provided by *IC1B* and *IC2*. Feedback capacitors *C5* and *C7* shape the pulse and improve S/N.

The output from *IC2* at pin 6 is about 40  $\mu$ s wide and has a height that is proportional to the amount of charge deposited on the detector. Signal level here is about 1 mV/keV of collected charge. Unfortunately, thermally generated charge carriers and leakage current in the detector also produce about 30 mV of noise impulses. Adjustment of *R2*, however, ensures that comparator *IC3* discriminates against and prevents this low-level noise from triggering the comparator. Signal pulses that override

the noise cause the comparator's output and, hence, NAND gate *IC4A*'s input to go low. Resistor *R13* keeps pin 5 of *IC4B* low to turn off the 2000-Hz (approximately) oscillator made up of *IC4B*, *IC4C*, *IC4D*, *R14*, *R15*, and *C11*.

When a detected event causes *IC4A* to go low, *IC4A*'s output goes high. This high signal is passed through now forward-biased diode *D1* to raise the pin-5 output of *IC4B*, which causes the oscillator to sound via the piezoelectric transducer, *SPKR*. The approximately 20-ms *C10R13* time constant maintains the high state of pin 5 of *IC4B*. When *IC4A* reverts to low, *D1* prevents rapid discharge of *C10* and maintains the time constant. The oscillator thus generates a 20-ms chirp for each detected gamma-ray event.

If you wish to count and display the number of events as they are generated

## PARTS LIST—FIG. 2

B1—4 AA cells (not in kit)  
 B2—9-volt battery (not in kit)  
 C12—0.001- $\mu$ F disc ceramic  
 C13—0.1- $\mu$ F disc ceramic  
 C15—0.01- $\mu$ F disc ceramic  
 C16—10- $\mu$ F, 35-V tantalum  
 DISPL1,DISPL2,DISPL3—7-segment, common-anode LED  
 IC6—555 timer  
 IC7,IC8—4518 dual BCD counter  
 IC9—4013 dual D flip-flop  
 IC10—14553 3-decade counter  
 IC11—14543 7-segment decoder/driver  
 LED1,LED2—Red light-emitting diode  
 Q1,Q2,Q3—2N4402 transistors  
 The following are 1/4-watt, 10% resistors unless otherwise specified:  
 R16, R17, R18, R30, R32, R33—10,000 ohms  
 R19 through R27—470 ohms  
 R28—100 ohms  
 R29—100,000-ohm pc potentiometer  
 R31—47,000 ohms  
 S1—Dpdt switch  
 S3—Spst switch  
 S4—Normally open pushbutton switch  
 S5—2-pole, 6-position rotary switch  
 Misc.—Suitable enclosure (LMB453 or similar); battery holders; control knob; machine hardware; red filter; etc.

Note—The following are available for non-commercial use from Radiation Monitoring Devices, Inc., 44 Hunt St. Watertown, MA 02172: complete kit of parts for Fig. 1 for \$85; complete kit of parts for Figs. 1 and 2, including case but not batteries, for \$125. Also available separately: CdTe radiation detector for \$60. Add \$5 for shipping and handling. Massachusetts residents, please add 5% tax. Allow 6 weeks for delivery. Available in U.S.A. only.

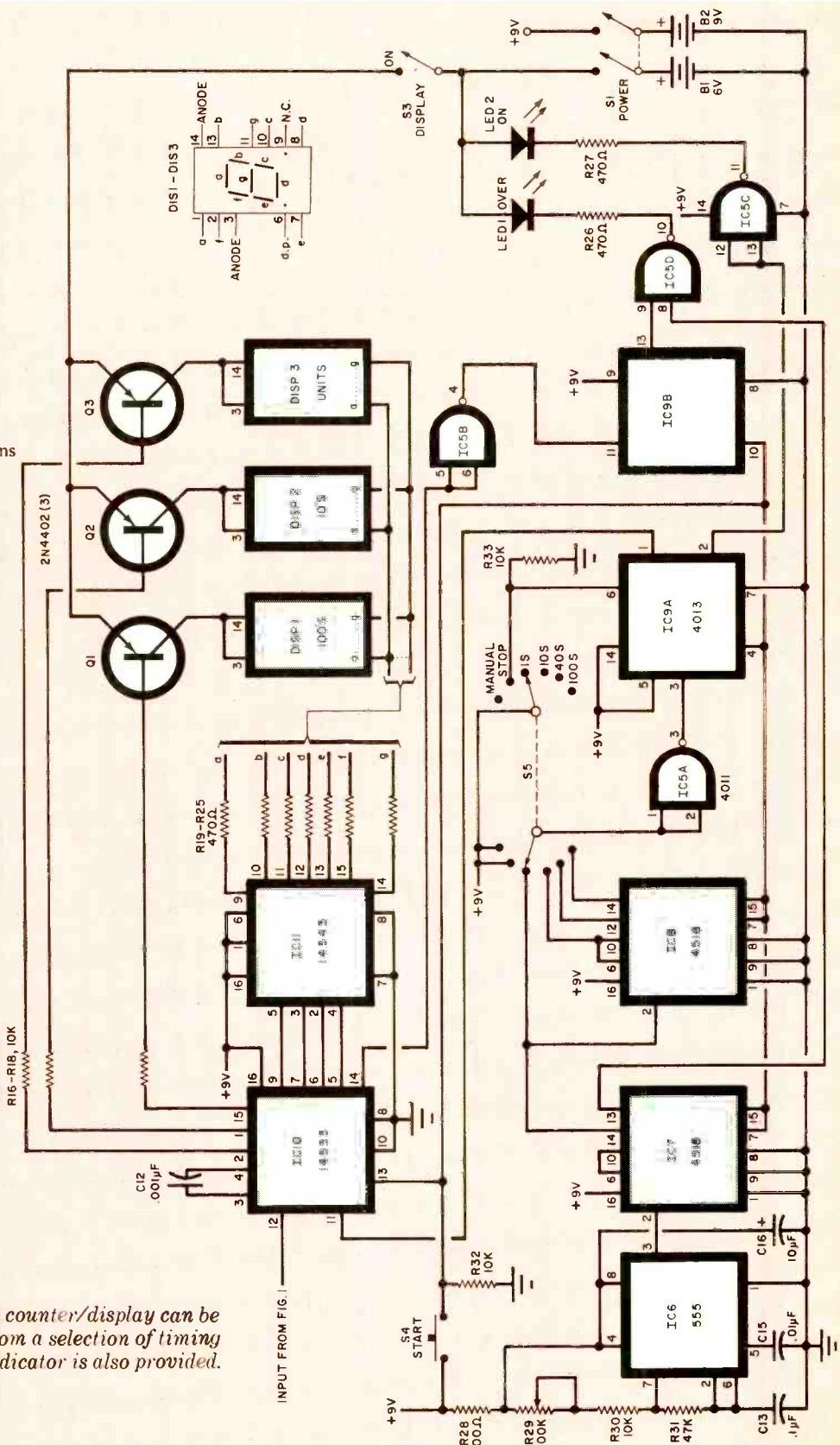


Fig. 2. The conventional 3-digit counter/display can be enabled either manually or from a selection of timing signals. A blinking overrange indicator is also provided.

at the output of IC4A, you can add the circuit shown in Fig. 2 to that in Fig. 1. The combination of IC10, IC11, and seven-segment displays DIS1, DIS2, and

DIS3 and digit drivers Q1, Q2, and Q3 make up a conventional three-digit counter/display system. The output of IC4A drives counter IC10.

Operation of IC10 is controlled by the signal at its pin-11 input. This signal can be either manually applied or automatically generated by an internal timer.

## Radiation Monitor *continued*

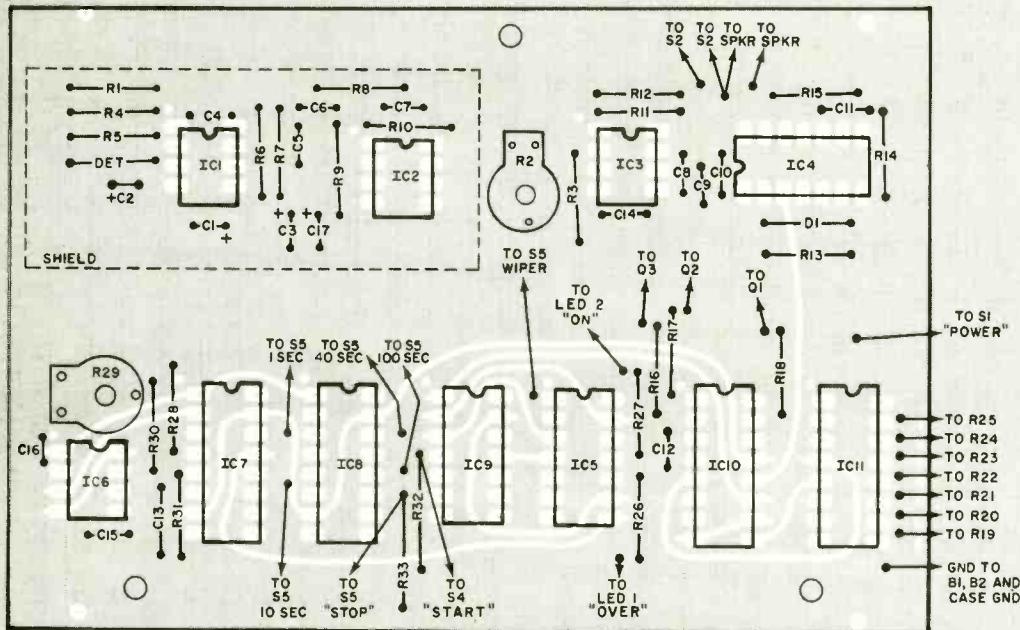
When S5 is set to MANUAL, the pin-1 output from IC9A continuously increments the counter/display for each incoming count from IC4A. When 999 counts are exceeded, pin 14 of IC10 goes low and, via NAND gate IC5B, clocks flip-flop IC9B. The output of IC9B at pin 13 is NANDed with a 2-Hz signal from IC7 to flash OVER (LED1) two times a second.

This flashing continues until START switch S4 is pressed to reset IC9B.

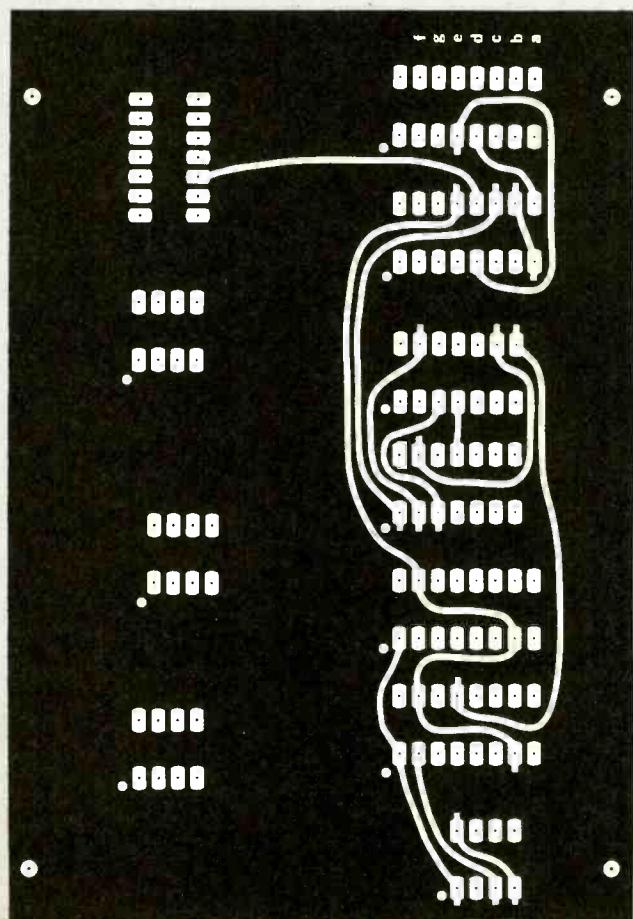
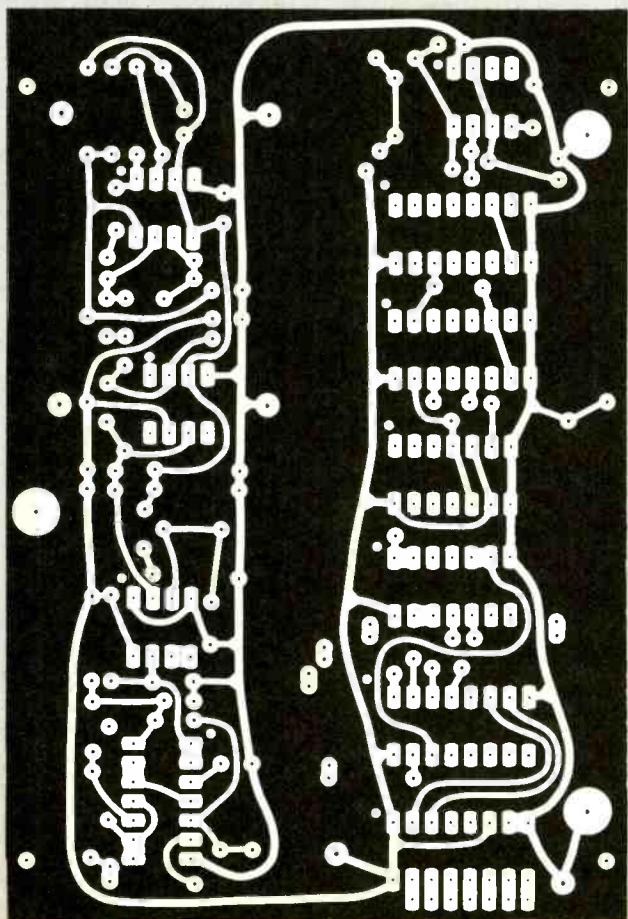
Internal timing is based on 100-Hz 555 timer oscillator IC6. Frequency is determined by C13, R13, R30, and adjustable R29. The oscillator drives divide-by-100 IC7, whose output at pin 14 is 1 Hz. Counter IC8, switch S5, NAND gate IC5A, and flip-flop IC9A generate

1-, 10-, 40-, and 100-second timing periods. START switch S4 initiates timing by resetting the two counters and flip-flop.

Power for the Fig. 1 circuit can be a conventional 9-volt battery or dc power supply. When the Fig. 2 circuit is added, four AA cells in series can be used to power the LED display. POWER switch S1 controls both power sources.



*Fig. 3. Actual-size etching and drilling guides for the two-sided pc board are shown below. Component mounting on the top is at left. Note that the upper portion of the board (containing the audible circuit shown in Fig. 1) can be detached if only that circuit is to be used.*



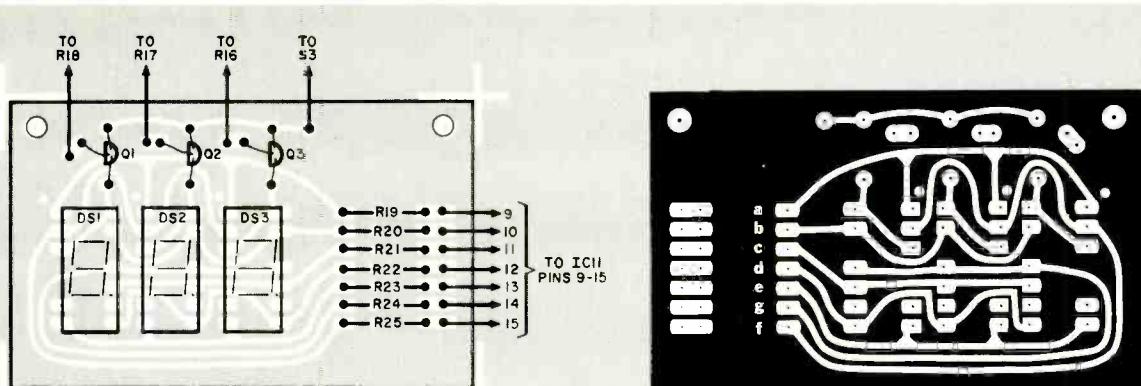


Fig. 4. Actual-size etching and drilling guide and component layout for the display board.

**Construction.** Since there are relatively high-impedance, low-level analog signals present in the IC1 and IC2 stages of RED-ONE, good circuit-board construction techniques *must* be exercised. The use of a printed circuit board and Molex Soldercons is strongly recommended.

Actual-size etching and drilling guides for the double-sided board and its component-placement diagram are shown in Fig. 3. At some component locations, pads appear only on the bottom side of the board. At these points, holes should be drilled from the bottom and components mounted from the top. If you elect to build only the beeper version of the Red One, you can separate and disregard the upper half of the guide. The only interconnecting trace between the two guide sections is from IC4 to IC10.

The etching-and-drilling guide and component-placement diagram for the optional display board are shown in Fig. 4. This is a single-sided board.

In addition to normal precautions used when soldering solid-state devices, special care must be taken with the detector. Use a low-wattage, fine-tipped soldering pencil and fine solder and provide a heat sink for the leads with longnose pliers. Use only enough heat and solder to give reliable, solid connections.

Begin assembly by installing and soldering into place the resistors, capacitors, and Soldercons (if used) on the main pc board. Some points that require soldering on both sides of the board are indicated by short tabs on the pc pads. In addition, any pad on the component side of the board from which a foil runs requires soldering to the component lead. This suggests the use of Molex Soldercons as opposed to IC sockets. Provisions for using miniature clips at

critical test points and where interboard connections occur are indicated in the Fig. 3 component-placement diagram.

Tape a  $\frac{1}{8}$ " (3.2-mm) thick piece of foam rubber around the detector to cushion it from mechanical shock. (Because of its piezoelectric design, any mechanical shock to it will cause the detector to generate a false output.) Use copper foil or 0.005" (0.13-mm)

thick brass to fabricate an electrical interference shield to prevent external influence on the low-level analog signals generated in the detector. Shape it as an open-faced box measuring  $2\frac{1}{2}'' \times 1'' \times \frac{1}{2}''$  (63.5  $\times$  24.5  $\times$  12.7 mm). Then solder the box to four miniature clips spaced on the board as indicated in Fig. 3. (This box also holds the foam-rubber-wrapped detector gently against

(Continued on page 46)

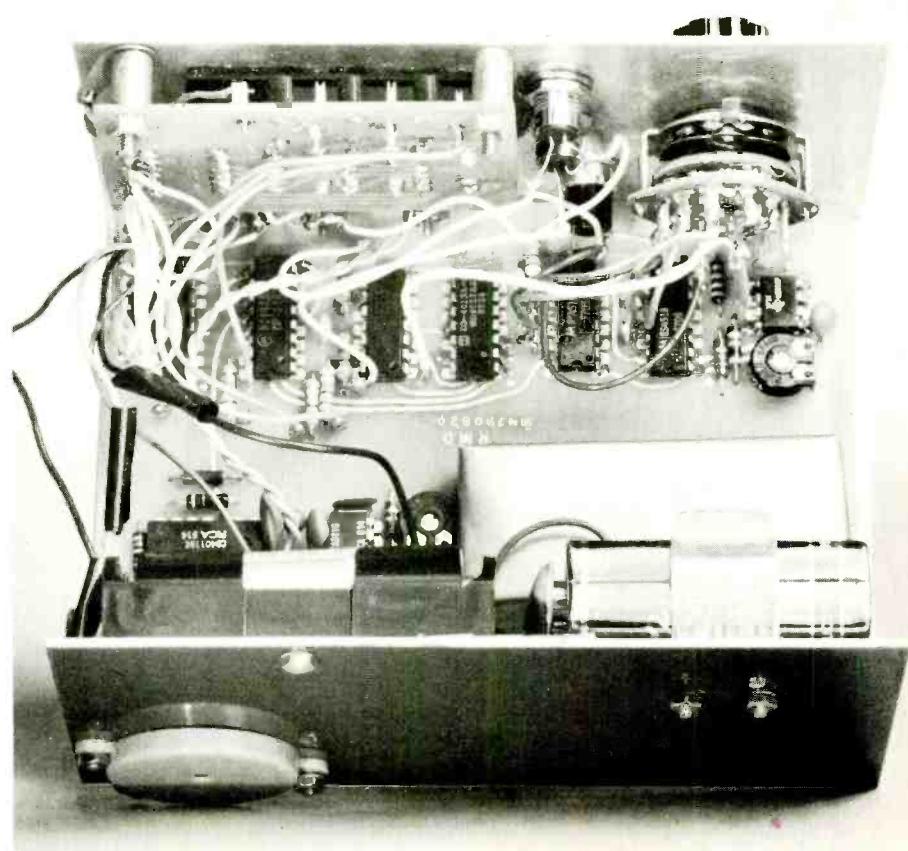


Photo of the author's prototype shows the main pc board mounted on chassis bottom with sound element on back and display on front.

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## Radiation Monitor *continued*

the main pc board.) Rubber cement a 4" X 2½" X ¾" (102 X 63 X 9.5 mm) piece of foam-rubber carpet pad to the bottom of the main pc board. Assemble the display board, if used.

All components should be mounted inside a prepared metal case that measures 5" W X 3¾" D X 2¾" H (127 X 92.3 X 70 mm) if you build the counter/display version of the project (smaller if you elect to build only the beeper version). Install the SPKR chirper on the outside surface of the box's rear wall, the battery holder on the inside surface. Rubber cement the main pc board assembly to the floor of the box, making sure it will not interfere with the controls or battery holder and does not contact the case. (The foam rubber between main pc board assembly and case ensures maximum mechanical protection and vibration insulation.)

Mount the display board with ¾" (9.5-mm) long spacers and machine hardware, using a ground lug on one post. Install the switches, LEDs, and connecting wires, referring back to Fig. 1 and the component-placement guides. Don't forget the ground wire to the chassis (case), and use twisted-pair leads for S2 and SPKR. Label the front panel with a dry-transfer lettering kit and cement a red filter over the display window.

**Calibration and Use.** Prior to applying power to the RED-ONE, recheck all wiring and component orientations. Then turn on the power and, with a voltmeter connected from pin 3 of IC3 to ground, adjust R2 for minimum voltage. This lowers the noise threshold so that triggering will occur even on electrical noise. Output pin 7 of IC3 will now fire rapidly or be continuously at ground potential. This will cause a steady tone or continuous chirping.

Using the voltmeter, or an oscilloscope set to the dc mode, slowly adjust R2 to raise the IC3 pin-3 reference voltage toward maximum. Chirp rate will gradually decrease, eventually ceasing altogether. Continue to adjust R2 only slightly past this point. This eliminates false triggering on electrical noise. Gamma rays that deposit less than the minimum energy required to overcome this threshold will also be rejected. The equivalent energy of a typical low-level gamma photon is 30 keV.

Calibrate the timing chain by adjusting R29 and observing total on time of LED2 with S5 in one time position. With a little patience, you can adjust R29 to obtain accuracy within a fraction of a

second. Gross adjustment can be made in the 10- and fine adjustment in the 100-second periods. Accuracy is determined by the stability of IC6 and its associated resistors and capacitors.

RED-ONE can be used to estimate exposure to radiation from natural and man-made isotopes and to measure changes in exposure. Units of radiation exposure include the roentgen, which is approximately equal to the absorption of 0.01 joule of gamma radiation by 1 kg of matter, and the rem (roentgen-equivalent-man), which measures the equivalent biological damage to man by any form of radiation. Average radiation exposure in the U.S. is about 0.2 rem/yr from natural sources. RED-ONE's sensitivity is between 20 and 40 counts/min/millirem/hr. Hence, natural background radiation produces about 1 count/min.

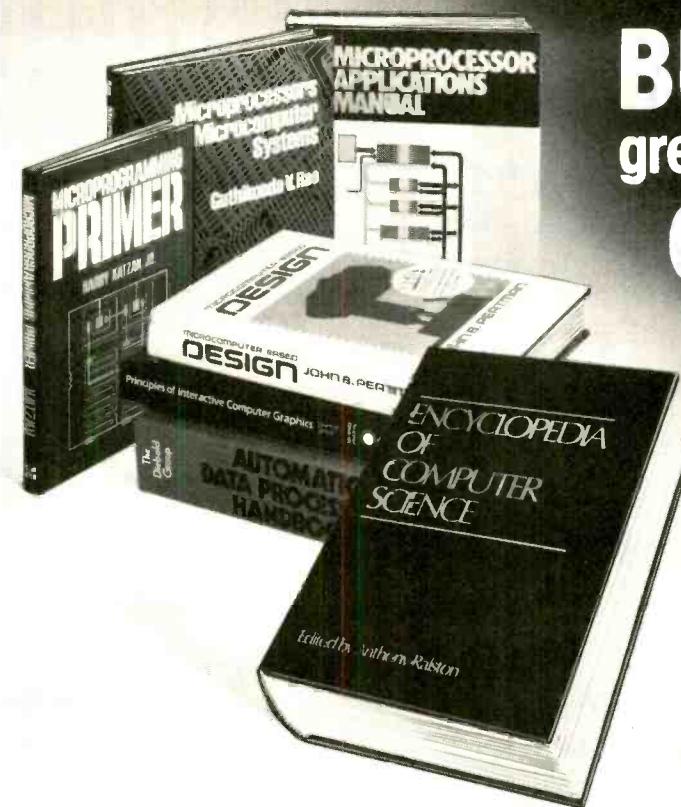
Natural background radiation levels can vary by as much as a factor of two, depending on where you live, the materials from which your house is built, and your altitude above sea level (the last due to cosmic rays). In addition, variables in detector construction and electronic components influence noise level and, therefore, overall detection sensitivity. Actual count-rate measurements are not as important as are changes in count rate due to the presence of radioactive material or environment changes.

It is important to note that random emissions of radioactivity will cause the monitored rate to apparently change from reading to reading. To estimate this statistical deviation, assume that any given count is accurate to within plus and minus the square root of the number of counts. Therefore, a display of 100 should be interpreted as  $100 \pm 10$  counts, a display of 120 counts as  $120 \pm 11$ , etc. This means that the numerical difference between any two measurements is significant only if it is greater than the sum of the two square roots. For example, if your readings are 100 and 120, the numerical difference is 20 and square-root sum is 21 ( $10 + 11$ ); because 20 is less than 21, there is no reason for concern. However, if your figures are 100 and 169, the difference is 69 and square-root sum is 23 ( $10 + 13$ ), which gives you reason for concern because 69 is much greater than 23.

Once you have established a normal background level for your RED-ONE, you can compare readings at various locations and investigate possible radioactive sources. So now you can satisfy your curiosity about radiation levels in your locale. ◇

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P39429



# A SECOND LIFE FOR VENTED SPEAKERS

BY DAVID B. WEEMS

*How modern design approaches have revived interest in reflex speaker systems.*

**A** DECADE ago the bass-reflex speaker was an endangered species. During the last few years, however, it has made a spectacular comeback, and is now a respected competitor of acoustic suspension systems.

The arrival of acoustic suspension speakers in the 1950s was an important milestone in loudspeaker development. Reversing the traditional practice of putting a stiffly suspended speaker in a large cabinet to achieve good low-bass response, the acoustic- or air-suspension system used a driver with an ultracompliant suspension mounted in a small enclosure. The timing was fortuitous. Stereo, just around the corner, would put a premium on space-saving speakers. When demonstrations proved that the little acoustic-suspension speakers could outperform many larger systems, the era of the compact speaker system began.

Though the closed box beat the reflex competition on several counts, there was a single overriding reason why many manufacturers converted their production to sealed systems: the reflex was just too complex and unpredictable. Leading engineers argued about how to tune the system and how big to make the box. G.A. Briggs, the late English authority, once compared reflex enclosures to heads of lettuce, saying that

one rule, "the bigger the better," applied to both. Later he added the qualifier, "within reason." "Like lettuce," he said, "loudspeaker enclosures can get so big they go to seed."

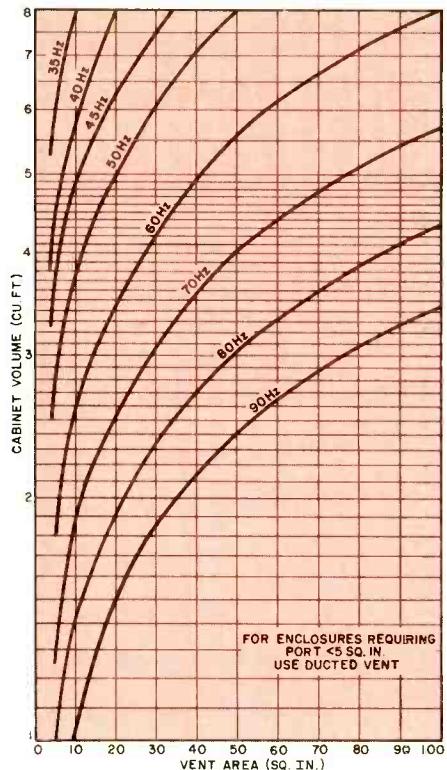
In the 1950s, "within reason" was about the only guide available. Hobbyists built enclosures to dimensions obtained from charts that scaled box volumes according to advertised speaker diameter and ignored all other parameters. Thoughtful experimenters, suspicious of such reliance on cone size alone, wished for a more precise guide. So it wasn't surprising that the audio world greeted the acoustic-suspension speaker with enthusiasm—and almost abandoned the reflex.

The surrender to the closed box was not quite total, though. James F. Novak, now Vice President of Engineering at Jensen Laboratories, made an analysis of enclosures for high-compliance speakers in 1959 that reiterated some of the virtues of the reflex. He claimed that high-compliance drivers in properly designed vented boxes reduced distortion and extended bandwidth. Novak described an ideal reflex system consisting of a driver with relatively high magnetic damping in a box that had an air compliance lower than that of the driver's equivalent suspension compliance. He specified the relatively low Q (amplitude

of the peak at resonance) of 0.3 to 0.4 for the driver. Novak's speaker/box compliance ratio was 1.44. (The compliance of an air volume for a given driver varies directly with the volume of the air and inversely with the square of the driver's effective piston area.)

Novak's work introduced a new principle to vented speaker design, the optimum volume concept. His compliance ratio brought precision to the drivers in the specified range of Q. With drivers outside that range, particularly those with higher Qs, the results remained unpredictable.

A. N. Thiele, an Australian electrical engineer, saw Novak's paper and noticed that Novak's mechanical equivalent circuit for the reflex had the same general form as an electrical high-pass filter. Applying filter theory to reflex design, Thiele found that he could predict characteristics such as cut-off frequency, optimum enclosure tuning, and the shape of the response curve near cut-off. In 1962 he published a definitive paper in an Australian journal that laid the foundation for a new approach to vented loudspeakers. He included data for 28 different designs, or alignments. Although his work was largely ignored in the United States, after about 10 years it was "discovered." Thiele's analysis was expanded by Richard Small, an Ameri-



*Fig. 1. Design chart to be employed for enclosures with simple vent.*

can engineer who subsequently emigrated to Australia; it was then put to practical use by Ray Newman, Senior Systems Engineer at Electro-Voice; D. B. Keele, Jr., now Senior Transducer Engineer at JBL; Pat Snyder of Speakerlab, and others.

**Woofers and Resonators.** To fully appreciate Thiele's contribution, you must compare the present state of the art to that of just a few years ago. Vented speaker systems have been in use for about 50 years, but that half-century has been filled with widespread misconceptions and even superstitions about how such speakers work. During that time there was no mystery about the performance of Helmholtz resonators themselves.

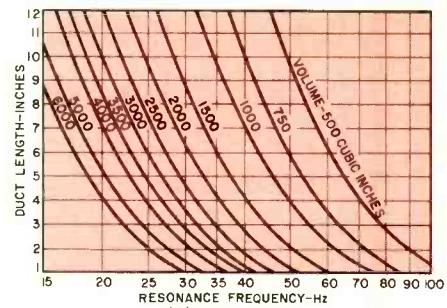
Helmholtz, studying the resonance behavior of air volumes in the mid-19th century, showed that any enclosed air volume that is vented will have a single natural frequency of resonance determined by the volume of the enclosed air and the area of the vent. Specifically it is the mass of air in the port coupled to the compliance of the air in the enclosure that produces the resonance. As the vent is made smaller, the air directly in the vent reaches a higher velocity and forces air in front and back of the open-

ing to move with it. The increased moving mass lowers the frequency of resonance. To tune a small volume of air to a very low frequency, a simple vent must be small in area. Alternatively, a duct can be coupled to the vent to trap an even larger mass of vibrating air, reducing the frequency of resonance still further or allowing a larger vent for a given resonant frequency. Dimensions of vents and ducts (made from cardboard tubing obtainable from stationery or business supply stores) for tuning various enclosure volumes are given in Figs. 1 and 2 (the latter developed by Novak).

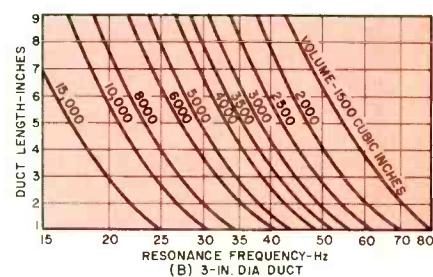
When a driver is installed in a ported box, the cone action alternately compresses and expands the enclosed air. Near the tuned frequency of the enclosure, the air "piston" in the port moves in phase with the driver cone, damping the movement of the cone rather heavily and making it appear to stand still at resonance. This damping, which offers some relief from the prodigious cone excursions that occur at low frequencies, is what attracted experimenters to vented designs in the first place. But too often their speakers exhibited a low-frequency hump that gave the reflex the derisive nickname "boom box."

In 1969, while researching an article for *POPULAR ELECTRONICS*, I asked engineers at several major companies for advice to hobbyists on how to design and tune a vented speaker. One group suggested that the box be tuned to the frequency of the driver's free air resonance, a traditional practice. A few advocated putting the box resonance above the driver resonance because such tuning produced a flatter impedance curve in the usable band. (Instead of the familiar double-humped curve, with the humps approximately equal in amplitude, this produced a large hump at a very low frequency and a minor hump at the upper resonance.) Still others contended that the box should be tuned below the driver's free air resonance so that the port could control distortion at the lowest frequencies.

Thiele's answer to the tuning question, interestingly, gives a clue as to why engineers from different companies offered such sharply conflicting advice in 1969. It's all a matter of driver Q. If Q lies in the range specified by Novak, the box should be tuned to the driver resonant frequency; higher Q demands a tuning below resonance and lower Q a tuning above. To see the details of how this works we'll have to look at Thiele's align-



(A) 2-IN. DIA DUCT



(B) 3-IN. DIA DUCT

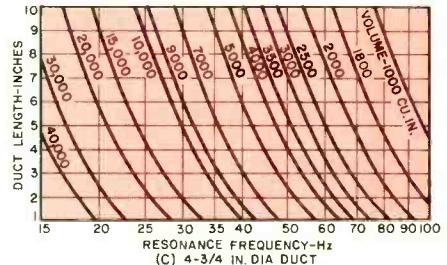


Fig. 2. Design charts for cardboard tube-ducted enclosures. Tubing diameters are inside measurements; duct length is measured from cabinet front.

ment chart. This, as rewritten by Keele, appears in Table I. Definitions are given in Table II.

Let's examine the data for alignment #5, a fourth order Butterworth (maximally flat) alignment. A good starting point is the value for  $Q_T$ , 0.383. This is the total Q of the speaker in the system, including internal amplifier resistance and resistance added by the speaker cable. For amplifiers with high damping factors, and with adequate speaker cables,  $Q_T$  can be considered to equal that of the driver alone. So for alignment #5 a speaker with a Q of about 0.38 would be ideal. Notice that this fits within the range specified by Novak.

Next we look for  $V_B$ , box volume. The table specifies the ratio of box volume to speaker compliance volume ( $V_{AS}$ ) as 0.7072. A designer would either obtain the value of  $V_{AS}$  from the manufacturer of the driver or he would measure it himself. Then he would multiply  $V_{AS}$  by 0.7072 to get the theoretically correct box volume. In the real world no reflex enclosure is perfect so this volume must

be enlarged. When Small applied Thiele's original data to typical vented enclosures, he found that he had to add about 30 percent to the theoretically correct volume to get the low-frequency performance predicted by the data.

In Thiele's original paper, the box volume ratio was not included in the table; instead a speaker/box compliance ratio was stated. A speaker/box compliance ratio would give the same value as a  $V_{AS}/V_B$  ratio, the inverse of the ratio shown in Table I. For alignment #5 that would be  $1/0.7072$  or 1.414. If that figure looks familiar it is almost exactly the ratio specified by Novak as optimum. Moving to other aspects of box design, the  $f_3/f_s$  ratio is 1.000. That shows that the system's bass response will be 3 dB down at the frequency of the driver's free-air resonance. The  $f_B/f_s$  ratio is also 1.000, so the box should be tuned to the free air resonance of the driver.

Now look at alignments #1-#4, for speakers with higher magnetic damping (lower Q). In #4, for example, a driver with a Q just slightly lower than that of #5 has a  $V_B/V_{AS}$  ratio that is less than half that of #5. Thus if you had two drivers that were identical except for Q, the one with the Q of 0.303 could be put into a box less than half the volume of that required by the driver with the Q of 0.383. But the other data for #4 show that the speaker with the lower Q will have its low-frequency cut-off moved up to  $1.43 f_s$  when the box is properly tuned to  $1.23 f_s$ .

On the other hand, speakers with higher Q's fit into the alignments beyond #5 and demand larger boxes, larger at least in the acoustical sense—in relation to the driver's equivalent air compliance. These boxes should be tuned to frequencies below the driver's resonant frequency. The reason for this kind of tuning is shown in Fig. 3. High-Q speakers have smaller magnets which give less control on the moving system at resonance. Coupled with a resonator these speakers may be subject to peaking before cut-off, but if they are matched to a box tuned too low, the combination of a box that rolls off the bass response and a driver that peaks can produce a flat response down to cut-off. Some of the Chebychev alignments extend the low-frequency cut-off to well below the driver resonance, but at the expense of some ripple in the passband. And if the Q is higher than about 0.7, distortion is greater.

Many engineers consider alignment #5 a good choice. Although this align-

**TABLE I—THIELE ALIGNMENT DATA AS REWRITTEN BY KEELE**

Alignment details			Box design				Aux. circuit	
No.	Type	Ripple (dB)	$f_3/f_s$	$f_B/f_s$	$V_B/V_{AS}$	$Q_T$	Peak Lift (dB)	$f_{PK}/f_s$
1	QB <sub>3</sub>	—	2.68	2.000	0.0954	0.180	—	—
2	QB <sub>3</sub>	—	2.28	1.730	0.1337	0.209	—	—
3	QB <sub>3</sub>	—	1.77	1.420	0.2242	0.259	—	—
4	QB <sub>3</sub>	—	1.45	1.230	0.3390	0.303	—	—
5	B <sub>4</sub>	—	1.000	1.000	0.7072	0.383	—	—
6	C <sub>4</sub>	—	0.867	0.927	0.9479	0.415	—	—
7	C <sub>4</sub>	0.13	0.729	0.829	1.372	0.466	—	—
8	C <sub>4</sub>	0.25	0.641	0.757	1.790	0.518	—	—
9	C <sub>4</sub>	0.55	0.600	0.716	2.062	0.557	—	—
9.5	C <sub>4</sub>	1.52	0.520	0.638	2.60	0.625	—	—
—	—	—	—	—	—	—	—	—
15	B <sub>6</sub>	—	1.000	1.000	0.366	0.299	+6.0	1.07

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ment will normally require a driver with a Q of approximately 0.38, it can be used with drivers of lower Q—with a sacrifice in system efficiency—if a resistance is put in series with the driver. The added resistance raises the  $Q_T$  to 0.383, and the design is executed as if the driver had been designed with a Q of 0.383.

To summarize the Thiele alignment data and make some comparisons, a driver with a very low Q can have an optimum box volume that is small compared to the driver's equivalent air volume compliance. This doesn't necessarily mean small boxes because low-Q speakers typically have a high compliance. Table III shows this correlation clearly. A system composed of a low-Q speaker in an optimum box volume should be tuned to a frequency above that of the driver's free-air resonance and it will cut off above that frequency. While this may seem to limit the low-frequency range of these speakers, note that speakers with low Qs also usually have low resonant frequencies. A high-Q speaker needs a box volume that

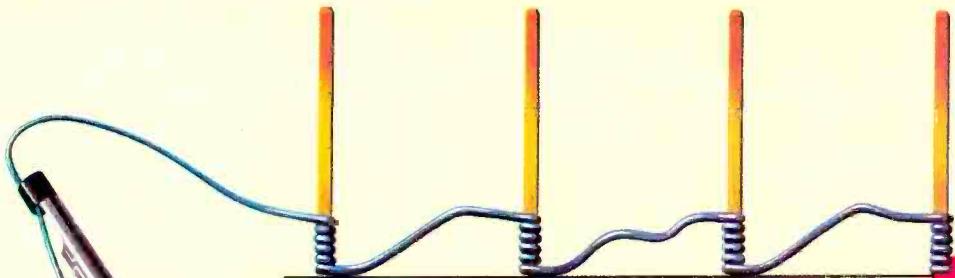
is large compared to its equivalent compliance air volume, but this box will be tuned below the speaker's free-air resonance. Again, high-Q speakers typically have lower compliance and higher resonance frequencies, so the box volume that is acoustically large for them may seem rather moderate to the beholder. These relationships may explain why engineers who worked with different kinds of drivers in the 1950s and 1960s offered such divergent advice on box design and tuning. Each school of thought was working on a single aspect of a larger problem. Thiele put it all together and developed a general theory of vented loudspeaker systems.

The Thiele data can be used in various ways. One obvious application is to design a box to match an existing driver. But it can just as easily show how to design a driver to fit a certain box size. The designer can compute an ideal cone mass, magnet size, voice-coil resistance, and other specifications for a driver that will work well in such a box. Or, knowing the specifications of this

(Continued on page 56)

**TABLE II—DEFINITIONS OF SYMBOLS USED IN THIELE DATA**

Symbol	Definition
<b>B</b>	Butterworth—alignments with flat response down to cutoff.
<b>C</b>	Chebychev—alignments with some degree of ripple in response.
<b>QB</b>	Quasi-Butterworth alignments.
<b><math>f_s</math></b>	Frequency of driver's free-air resonance.
<b><math>Q_{TS}</math> or <math>Q</math></b>	Q of driver at $f_s$ .
<b><math>Q_T</math></b>	Total Q of the driver in the system at $f_s$ . With modern amplifiers of low internal resistance, and a high damping factor, $Q_T$ will be approximately the same as $Q_{TS}$ unless speaker cable is excessively long or of inadequate gauge.
<b><math>V_{AS}</math></b>	Equivalent air compliance of driver. The volume of air that offers a compliance to the driver that is equal to the compliance of the driver's suspension.
<b><math>V_B</math></b>	Volume of air in box.
<b><math>f_3</math></b>	Cutoff frequency, response down 3 dB from mid-band level.
<b><math>f_B</math></b>	Frequency of box resonance, determined by internal volume of air and vent characteristics.
<b><math>f_{PK}</math></b>	Frequency of peak lift produced by auxiliary equalizer.



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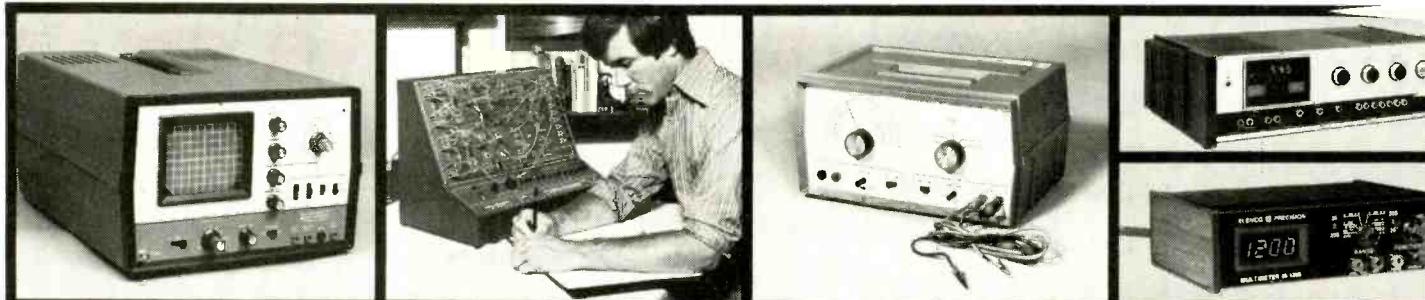


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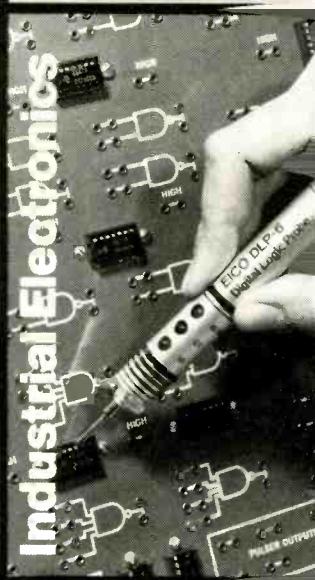
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## VENTED SPEAKERS *Continued*

driver, he can calculate the performance of the driver in various boxes. Although the Thiele alignments show optimum values, systems based on them may have box volumes other than those indicated by the table. Proper use of the data can let the designer predict system performance by computer, instead of by guesswork and trial and error.

As mentioned earlier, Thiele's original publication provided 28 different alignments. Table I shows 11: Thiele's first 9, an additional one labeled "9.5" by Keele, and an example of an electronically assisted design in #15. The table shown here was revised by Keele to make it more useful for designing a box to fit a driver rather than designing a driver to match a specific box volume.

Here is a concrete example of how to use the Thiele data. Let's assume a woofer with the following specifications:  $f_s = 40$  Hz,  $Q = 0.41$ ,  $V_{AS} = 5 \text{ ft}^3$ . The box should be tuned to  $0.927 f_s$ , or 37 Hz. This system will have a cutoff frequency of  $0.867 f_s$ , or about 35 Hz. If the value for the driver's  $Q$  had fallen between the values indicated in the table for adjacent alignments, the designer would interpolate to get correct box volume, resonance, and cutoff frequency.

**Equalized Alignments.** The first 9 alignments, and Keele's 9.5 alignment, consist of simple speaker/box combinations driven by a typical power amplifier. Thiele's complete listing shows systems with significant bumps or dips in the response curves that must be corrected by auxiliary electronic equalization. Some of these alignments are of little more than academic interest. For example, one group requires a great amount of bass boost at frequencies below the box resonance. Such systems would show excessive cone motion, a potential problem for all unfiltered vented speakers but one that extra boost below resonance would surely aggravate. Unloading occurs because below resonance the air in

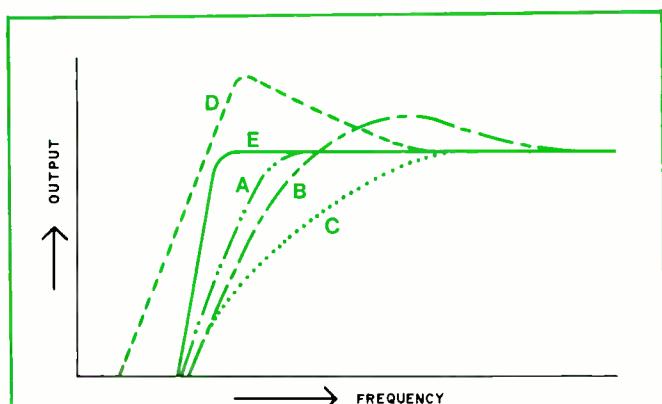
the vent moves as if in series with the cone, and out of phase with it. Now hardly at all restrained, the cone can be driven into distortion or even damaged by low-frequency noise or pulses. Many amplifiers and receivers have low-frequency filters, effective at infrasonic frequencies, but many listeners mistakenly fail to use them because they don't want to impair their system's frequency response. With vented speakers a correctly designed filter will give the effect of more bass, not less, because the bass is firm and undistorted.

Cone surging can also be eliminated by choosing Thiele's 15th alignment. It

offers a double dividend: a bass boost gives extended bandwidth in a small box and a cutoff of infrasonic noise. Alignments #15 and #4 use drivers of about the same  $Q$  and boxes close to the same size. But check the two systems for bass range. The assisted system gives response down to the free-air resonance of the driver instead of cutting off at  $1.45f_s$  as does #4. A driver with a free-air resonance of 35 Hz would cut off at about 51 Hz in alignment #4; alignment #15 with electronic assist extends its response to 35 Hz.

Keele has greatly expanded Thiele's data to include a wider range of drivers. His method is roughly this: design a system according to one of the first 9 alignments, then lower  $f_B$  by a half octave to produce a drooping low-frequency response. By adding a second-order high-pass filter with a  $Q$  of 2 and a 6-dB boost at  $1.07f_b$ , we can flatten the response and reduce the cutoff point to  $f_s$ .

Keele suggests that any driver with a resonance and a  $Q$  so placed that the ratio  $f_s/Q$  falls between 80 and 160 Hz is suitable for this alignment. The alignment works with relatively high-resonance, high- $Q$  drivers as well as with



*Fig. 3. Characteristic response curves for various reflex systems: (A) Fourth-order Butterworth; (B) reflex box with  $f_B$  too high; (C) reflex box with  $f_B$  too low, similar to system before equalization; (D) equalizer output to complement  $B_6$  speaker; (E) response of system that combines detuned box (C) with equalizer (D). If driver  $Q$  is 0.383, (A) represents optimum tuning for alignment #5. If box is tuned too high for this driver, response has a hump; if too low, bass is weak. Speaker with lower  $Q$  might require higher tuning to avoid weak bass; higher- $Q$  driver requires lower tuning for flat response. Comparisons assume drivers are identical except for differences in magnet strength—or  $Q$ .*

**TABLE III—THIELE/SMALL PARAMETERS FOR SEVERAL TYPICAL DRIVERS**

Brand	Model	Advertised diameter (in.)	$f_s$ (Hz)	$Q_{TS}$	$V_{AS}$ (cu ft)	(liters)
Electro-Voice	SP12C	12	45	0.67	5.9	165
	SP15C	15	40	0.45	9.9	280
	2145	12	30	0.51	5.5	155
	2135 (Ext. range)	15	40	0.25	10.5	300
	2231 (Low Freq. driver)	15	16	0.21	26.0	735
JBL (Prof. Series)	1204A	12	16.1	0.176	17.9	500
	W1508S	15	18.8	0.239	31.9	900

low-resonance, low-Q drivers. An appropriate driver in this sixth-order Butterworth alignment (all vented systems are at least fourth-order) should give a cut-off at 25 to 50 Hz. To use Keele's method, the designer chooses a box volume that is approximately equal to  $4.1Q^2V_{AS}$ , then tunes that box to  $0.3 f_s/Q$ . These same relationships hold in the data shown in Table I. Where the table shows only a single Q value, the Keele technique can be applied to any driver with a suitable ratio of resonance to Q.

Considering the advantages of the B6 alignment, it would be helpful if manufacturers would include tunable, 6-dB boost circuits in their amplifiers. An owner of a typical fourth-order Butterworth system could convert to sixth-order assisted operation by adding a longer tuning duct to the enclosure and switching in the boost that gives the proper response. For the present, if you want to experiment with equalized alignments you will have to build your own equalizer. Pat Snyder of Speakerlab has designed an equalizer to be inserted into the tape-monitor circuit of almost any amplifier or receiver. As originally designed, his circuit offers a variable degree of boost—from 0 dB up to about 10 dB. You can adjust the frequency of the boost by choosing two matched capacitors for each channel.

**Vents and "Vent Substitutes."** A small box can be tuned to a low frequency by a small simple vent, but a port can be too small for good performance. A small vent radiates just as much power as a larger one but causes air to move through it at higher velocity. If the velocity is great enough it will cause whistling and hissing and possibly even distortion. A box with a small vent can be tuned to the same frequency by enlarging the vent and adding a duct behind it.

In some small enclosures where a very low box resonance is necessary, the duct can occupy so much volume that the enclosure must be enlarged to accommodate the duct. Such systems can be tuned to the proper frequency by use of a "drone cone," or passive radiator. This "vent substitute" is a suspended cone, essentially a speaker without a motor. The drone can be tuned by adjusting its mass; the greater the mass, the lower its frequency of resonance. Because a vent substitute is solid and far denser than a gas, such as the air in a duct, the passive radiator requires hardly any more space than the panel area it occupies. Early systems of this

type usually had drones equal in diameter to that of the woofer, but current practice makes the drone's effective cone area about twice that of the woofer. An enlarged passive radiator piston can more easily provide the volume velocity necessary to effectively load the woofer.

**Driver Parameters.** Some people have objected that normal production variations in drivers preclude such precise calculations in box design. This has been answered in studies by Keele and Snyder. One driver parameter that is difficult for manufacturers to control precisely is compliance. In fact, in some kinds of suspension systems, the compliance changes with temperature or humidity. Fortunately, compliance variations are usually cancelled by compensating changes in other parameters. For example, if the compliance of a driver is reduced, the frequency of resonance will be raised, but the Q is also raised to a similar degree. Thus, the ratio of resonance to Q, a really important factor, is hardly affected. If the mass of the moving system is constant and the magnetic field around the voice coil unimpaired, the speaker will perform according to design specifications.

Finally we come to another aspect of the bass-reflex problem that has often plagued hobbyists, the information dam. Several years ago I wrote to a company and asked for specifications on its woofers. The reply suggested that I rely on the reputation of the brand rather than upon specifications. In the past there was an excuse for such reticence, the unreliability of acoustical measurements made under differing conditions. In fact most measurements were useful only to experienced engineers who could interpret them correctly. But most of the required measurements for Thiele data can be made by tests that are fairly simple and easily reproducible. There is no longer any reason for the attitude shown in the letter mentioned above. Several companies now offer complete Thiele data for their speakers. Table III shows some representative drivers with a summary of the Thiele data for each.

While the closed-box loudspeaker—which Small has shown to be analogous to a second-order filter network—still offers the ultimate in design simplicity, its overwhelming advantage has been reduced by the Thiele approach to vented-system design. It looks as if the bass reflex, having fallen into virtual oblivion, has been reborn, Phoenix-like, from its own ashes. ◇

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*Simple hardware addition plus BASIC Level-1 program creates a multipurpose timer to operate electric appliances, for timing chess games, and other useful control applications*

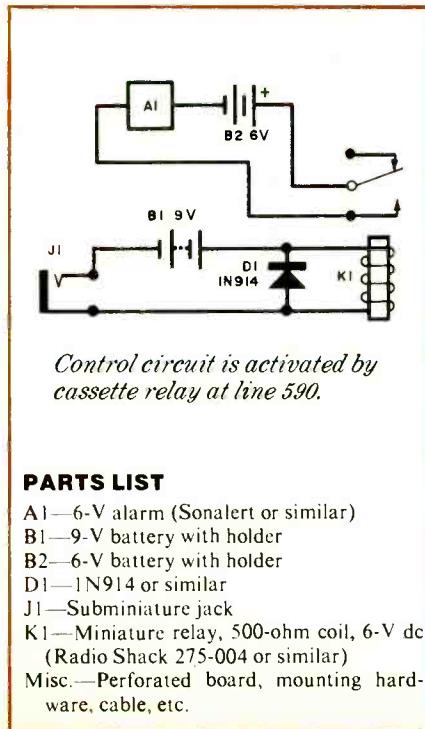
# A SIMPLE "REAL TIME" TRS-80 TIMER

**A** relatively simple BASIC program and an even simpler hardware addition to a TRS-80 Level I 4K digital computer, forms a programmable timer that can be set for a time period of one second to almost any desired interval. The BASIC program uses two "for-next" loops to calculate the desired delay. INPUT #A at line 590 activates the cassette relay which, in turn, operates the control circuit shown in the figure.

When the program is run, the user is prompted when it is necessary to enter a delay time, etc. For example, assume a three-minute timing interval. When the display indicates "ENTER DELAY TIME MODE," type "2" (for selecting minutes) on the keyboard, the computer will then prompt, "DELAY IN MINUTES," which is answered by typing in "3". The machine will then display "PRESS ENTER TO START THE TIMER." Once this is done, the timer is in operation. After three minutes, the TRS-80 will activate an external alarm. To de-activate the alarm, depress the TRS-80 "RESET" pushbutton (located behind the rear expansion door).

**Construction.** The circuit shown can be assembled on a small piece of perforated board, just large enough to hold the components.

Insert the subminiature phone plug of the TRS-80 cassette interface connector into jack J1. Relay K1 can be used to activate a heavy-duty relay operated by the ac power line for higher-current applications. ◇



#### PARTS LIST

- A1—6-V alarm (Sonalert or similar)
- B1—9-V battery with holder
- B2—6-V battery with holder
- D1—1N914 or similar
- J1—Subminiature jack
- K1—Miniature relay, 500-ohm coil, 6-V dc (Radio Shack 275-004 or similar)
- Misc.—Perforated board, mounting hardware, cable, etc.

#### PROGRAM

```

10 CLS
20 PRINT "TRS-80 REAL TIME TIMER"
30 PRINT
40 PRINT "A PROGRAMMABLE TIMER"
50 PRINT
60 PRINT "ENTER DELAY TIME MODE"
70 INPUT "(1) FOR SECONDS (2) FOR
    MINUTES (3) FOR HOURS";B
80 IF B=1 GOTO 500
90 IF B=2 GOTO 600
100 IF B=3 GOTO 700
110 GOTO 60
500 PRINT
510 G=1
520 INPUT "DELAY IN SECONDS";S
530 INPUT "PRESS ENTER TO START
    THE TIMER";A$
540 FOR J= 1 TO S
550 FOR K= 1 to 470 • G
560 NEXT K
570 NEXT J
580 PRINT "DELAY COMPLETED, CIR-
    CUIT ACTIVATED"
590 INPUT #A
600 PRINT
610 G=60
620 INPUT "DELAY IN MINUTES";S
630 GOTO 530
700 PRINT
710 G=60
720 INPUT "DELAY IN HOURS";S
730 INPUT "PRESS ENTER TO START
    THE TIMER";A$
740 FOR J= 1 TO S
750 FOR K= 1 TO 60
760 FOR L= 1 TO 470 • G
770 NEXT L
780 NEXT K
790 NEXT J
800 GOTO 580
810 END

```

# Measure Weak Direct Currents with the Sensitive Micro Meter

BY I. QUEEN

*Low-cost op-amp system can measure solar-cell output and currents in other low-level circuits.*

**I**F YOU PLAN to measure the output of a solar cell under low-light conditions, to work with micropower ICs, or otherwise experiment with weak-current circuits, you'll need a sensitive current meter. The Sensitive  $\mu$  Meter presented here will allow you to measure direct currents as small as a fraction of a microampere. Moreover, it is not subject to the disadvantages associated with standard panel microammeters—high cost, fragile movements, and relatively high internal resistance.

The project employs an operational amplifier to increase the sensitivity and effectively decrease the input impedance of a moderately priced, readily available 0-to-50 microammeter. It has three switch-selected scales; 0 to 0.5  $\mu$ A; 0 to 5  $\mu$ A; and 0 to 50  $\mu$ A. The circuit can be powered by a supply furnishing as little as  $\pm 2$  or  $\pm 4$  V, and can be constructed for about \$15.

**Circuit Operation.** A simple circuit for current-measuring applications is shown in Fig. 1. When an input current  $I$  is applied to the inverting input of the op amp, an inverted output signal is generated by the op amp. If the gain of the operational amplifier is very high, we can consider that the entire input current flows through feedback resistor  $R$ . An output voltmeter  $M$ , which is calibrated in terms of  $I$ , measures the product  $IR$ . The voltage drop across the operational amplifier is practically zero (the output voltage divided by the op amp's open-loop gain).

The schematic of the Sensitive  $\mu$  Meter is shown in Fig. 2. Switch  $S_2$  selects the range and determines the feedback resistance of the stage. When the switch is in its center (off) position, the feedback resistance is  $R_3$ , one megohm. An input current of 0.5  $\mu$ A will cause the output of the op amp to be 0.5 volt above ground when only  $R_3$  is in the feedback loop.

This output voltage will cause full-scale deflection of 0-to-50-microammeter  $M_1$  if the effective resistance between the output terminal of the operational amplifier and the negative terminal of the meter is 10,000 ohms. The internal resistance of the meter specified in the parts list is 1620 ohms, so the balance of the required resistance is supplied by  $R_4$ . This trimmer potentiometer is adjusted for full-scale deflection of the meter movement when the op amp output is at +0.5 volt.

The project is most sensitive when  $S_2$  is in its center (off) position and the feedback resistance is one megohm. In this operating mode, full-scale deflection of the meter corresponds to an input current of 0.5  $\mu$ A. Higher-current ranges are obtained by shunting  $R_3$  with other resistors to lower the overall feedback resistance. This is accomplished by placing  $S_2$  in one of its two other positions. When the range switch is placed in its 5  $\mu$ A position, the parallel combination of  $R_1$  and  $R_3$  causes the meter to deflect to full scale if the input current is five microamperes. Similarly, placing  $S_2$  in its 50  $\mu$ A position shunts  $R_3$  with  $R_2$  and causes full-scale deflection of

the meter movement when an input current of fifty microamperes exists.

Two shorting switches are included in the circuit. Switch  $S_1$  shorts the input of the project. It is used in conjunction with potentiometer  $R_5$  to zero the meter movement. The other switch ( $S_3$ ) is used to short the terminals of  $M_1$  when the meter is not being used. This minimizes mechanical shocks to the meter movement when the project is being transported. Diodes  $D_1$  and  $D_2$  protect the project from excessive input voltages. Jack  $J_2$  provides access to  $M_1$  so that the meter can be used in isolation from the rest of the project.

You might wonder why the circuit provides for a 0-to-50-microampere scale when meter movement,  $M_1$ , covers this range on its own. The following exercise performed by the author will illustrate the need for such a scale. A solar cell was connected across input jack  $J_1$  and illuminated so that the Sensitive  $\mu$ Meter indicated a current of 50  $\mu$ A. The cell was then connected to  $J_2$  and its output current measured using  $M_1$  alone. It indicated a current of 1  $\mu$ A.

The reason for this discrepancy between the two readings is that  $M_1$  presents a higher resistance to the solar cell when it is used independently than the project as a whole does. It is desirable to keep the internal impedance of a current-measuring instrument as low as possible. Thus, it is better to employ the project as a whole (as opposed to  $M_1$  or a similar meter alone) in the measurement of currents up to 50  $\mu$ A.

There is another significant advantage to the use of the Sensitive  $\mu$ Meter as opposed to a microammeter alone. Due to the clipping action of protective diodes  $D_1$  and  $D_2$ , the maximum output voltage of the op amp on any of the three ranges is

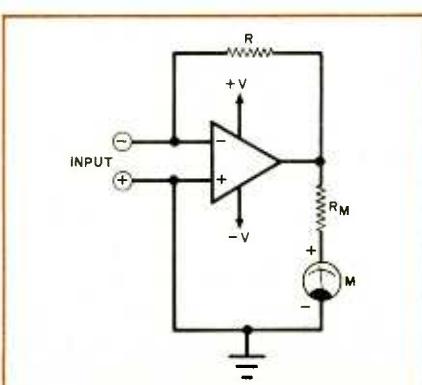
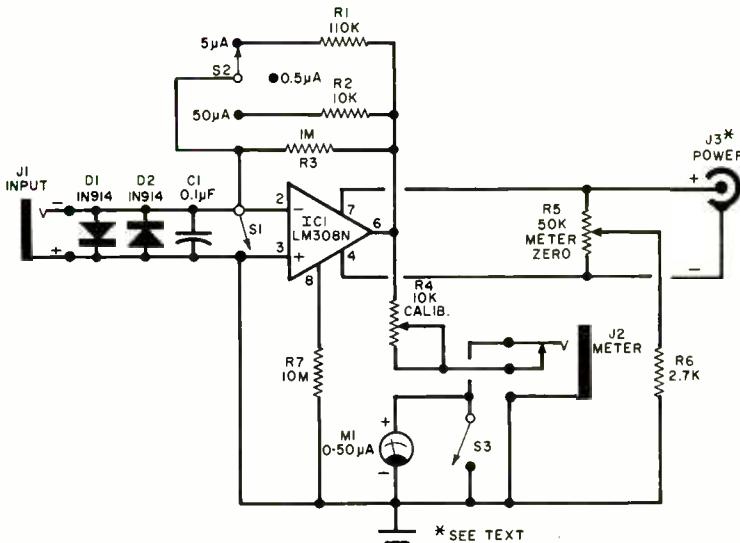


Fig. 1. Schematic of simple current-measuring circuit.

## PARTS LIST

- C1—0.1- $\mu$ F disc ceramic  
 D1,D2—1N914 diode  
 IC1—LM308N operational amplifier  
 J1—Open-circuit miniature phone jack  
 J2—Closed-circuit subminiature phone jack  
 J3—Phono jack (must be insulated from project enclosure)  
 M1—0-to-50- $\mu$ A meter movement (Radio Shack No. 22-051 or equivalent)  
 The following are  $\frac{1}{4}$ -watt, 5%-tolerance carbon-composition fixed resistors, unless otherwise specified:  
 R1—110,000 ohms (can be a series connection of 100,000 ohms and 10,000 ohms)  
 R2—10,000 ohms  
 R3—1 megohm  
 R4—10,000-ohm, linear-taper trimmer potentiometer  
 R5—50,000-ohm linear-taper potentiometer  
 R6—2700 ohms  
 R7—10 megohms  
 S1,S3—Spst toggle switch  
 S2—Spdt toggle switch with center-off position  
 Misc.—Suitable enclosure, perforated or printed circuit board, IC socket, circuit board spacers, machine hardware, control knob, hookup wire, solder, etc.



*Fig. 2. The gain of the operational amplifier and, hence, the range of the meter are determined by the amount of resistance in the feedback circuit.*

approximately 0.7 volt. This corresponds to less than a 50% overload of meter movement  $M_1$ , one that is highly unlikely to cause any permanent damage to the movement. An unprotected microammeter, on the other hand, can easily be "zapped" by the inadvertent application of high current overloads, a fact to which more than one electronics experimenter can ruefully attest.

Power for the circuit is furnished by an external supply via phono jack  $J_3$ . Note that the shell of this power jack must be insulated from chassis ground. The operational amplifier specified for use as  $IC_1$  is an LM308, a precision op amp that can be used with supply voltages ranging from  $\pm 2$  to  $\pm 20$  volts. Accordingly, a supply capable of furnishing bipolar voltages within these extremes (or a single-ended one rated at 4 to 40 V) should be employed to power the Sensitive  $\mu$  Meter. Potentiometer  $R_5$  is connected across the supply to allow zeroing of the meter movement under no-input conditions ( $S_1$  closed) for any suitable supply voltage.

**Construction.** The project is relatively simple, so the use of a perforated board and point-to-point wiring is an acceptable assembly technique. Alternatively, the project can be constructed using wrapped-wire or printed circuit connections. The author

housed his prototype in a  $4'' \times 2'' \times 1\frac{1}{2}''$  (10.2  $\times$  5.1  $\times$  3.8 cm) aluminum utility box. A Radio Shack No. 22-051 0-to-50-microammeter was used for  $M_1$ . This meter fits the enclosure with only a slight amount of overlap at the edges. Of course, a larger enclosure can be employed if it is preferred over the one selected by the author.

An LM307 operational amplifier can be used for  $IC_1$  in place of an LM308 if pin 3 is connected to project ground through the parallel combination of a 30,000-ohm resistor and a 0.1- $\mu$ F disc ceramic capacitor. This op amp will provide performance comparable to that of the LM308 if the circuit is modified as just described. Other operational amplifiers can also be used if variations in pinouts and possible compensation requirements are taken into account.

**Calibration and Use.** Connect a suitable power supply to  $J_3$ , observing polarities. Then close  $S_1$ , place  $S_2$  in its  $0.5\ \mu\text{A}$  position, and open  $S_3$ . Set the wiper of  $R_4$  halfway between the two extremes of its travel and adjust potentiometer  $R_5$  for a zero reading on meter movement  $M_1$ . Then open  $S_1$  and place  $S_2$  in its  $50\ \mu\text{A}$  position. Connect a suitable source of weak dc current to the input jack of the project using a length of shielded cable terminated with a miniature phone plug. A 1.5-volt battery and a series-connected 1-megohm

potentiometer can be used as a source of low-level dc.

Depending on the capabilities and sensitivity of the test equipment available to you, monitor either the current at  $J_1$  or the voltage at the output of the operational amplifier. Adjust the amplitude of the input current so that it equals  $50\ \mu\text{A}$ . Alternatively, monitor the output voltage of the op amp and adjust the amplitude of the input current until the voltmeter reads  $+0.500$  volt. Then adjust trimmer potentiometer  $R_4$  to obtain a full-scale ( $50\ \mu\text{A}$ ) reading on  $M_1$ .

The Sensitive  $\mu$  Meter is now calibrated and ready for use. In view of its high sensitivity, it is a remarkably stable instrument. At the start of each measuring session, the meter should be zeroed by adjusting potentiometer  $R_5$ . It should not be necessary to continually touch up this adjustment if a battery or regulated line-powered supply is used in conjunction with the project.

Thanks to the protective action of  $D_1$  and  $D_2$ , the meter movement is relatively immune from damage caused by current overloads. Overloads should still be avoided, however, especially severe ones that could damage the protective diodes. Finally, remember that it is good practice to keep shorting-switch  $S_3$  closed when the project is not being used. This will damp the meter movement and minimize the effects of physical shock upon it.

# ELECTRONIC MAGIC BOX

MOST OF the tools employed by fortune tellers in the practice of their craft—tarot cards, crystal balls, tea leaves, rune stones, etc.—were developed centuries ago. Now there's the Magic Black Box, a swami of the electronics world that employs digital techniques to divine and display answers to questions posed to it.

The Magic Black Box is a fun project that's relatively easy to build. It employs an EPROM, CMOS and low-power Schottky logic ICs, a 555 timer, and two eight-digit, seven-segment calculator-type LED displays. Current demand is low enough to make the use of a battery power source practicable. Total project cost is approximately \$30.

**About the Circuit.** The Magic Black Box is shown schematically in Fig. 1. Astable multivibrator *IC1* functions as a master clock, generating a train of pulses with a 98% duty cycle which is applied to various address counters and a display blanker. Counter *IC2* receives clock pulses directly from the

clock and generates a four-bit nibble that is applied to the four lower-order address input pins of read-only memory *IC4*. The nibble is also applied to the address inputs of 1-of-16 demultiplexer *IC6*, which selects and grounds the appropriate common-cathode lines of the display.

Clock pulses generated by *IC1* are also applied to NOR gate *IC7C*, which gates them and allows them to pass in inverted form to 12-bit counter *IC3*. This CMOS counter prescales the train of clock pulses by a factor of four and supplies a six-bit message-select word to the six higher-order address inputs of ROM *IC4*. An initial word is generated by *IC3* when power is first applied to the circuit. At that time, RC network *R3C2* produces a momentary logic-0 which is inverted by *IC7D* and applied to the reset input of the counter.

Read-only memory *IC4* accepts the ten-bit word generated by counters *IC2* and *IC3* and generates at its output a corresponding eight-bit word. The output lines of the ROM are buffered by

driver *IC5*, which can source enough current to cause the LED display to glow. This display is composed of *DIS1* and *DIS2*, two eight-digit, seven-segment surplus calculator readouts.

Clock pulses from *IC1* are also inverted by NOR gate *IC7B*. The inverted pulses are applied to the OUTPUT ENABLE inputs of tri-state driver *IC5*, causing the outputs of this chip to enter their high-impedance "off" state for seven microseconds after each negative transition at pin 3 of *IC1*. This allows the data that appears at the output of the ROM to stabilize, and precludes any possibility of display ghosting, an ailment common to many early digital clocks that used LSI circuits.

When CONJURE switch *S1* is depressed, a logic 0 is applied to pin 8 of *IC7C* and pin 3 of *IC7A*. Clock pulses are then inverted and gated to counter *IC3*. The logic 0 generated by *S1* is inverted by *IC7A*, and the resulting logic 1 is applied to the ENABLE inputs (pins 18 and 19) of demultiplexer *IC6*. This blanks the display during the interval

*Parlor game  
displays random,  
digitally generated  
answers to  
your questions*

BY MICHAEL J. FRIESE



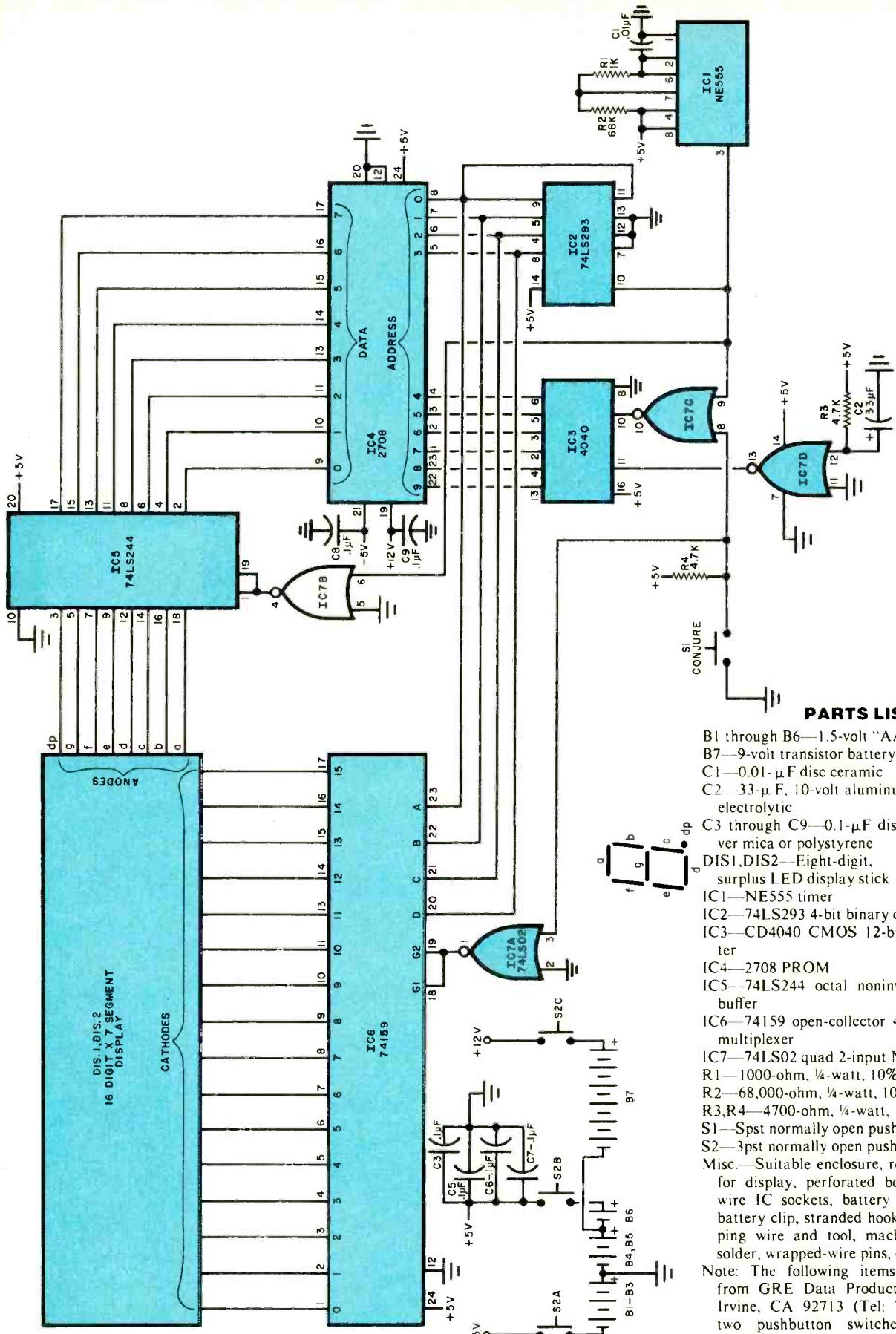


Fig. 1. Schematic diagram of the Magic Box. Answers are stored in the preprogrammed PROM IC4 and supplied to the display when called for.

#### PARTS LIST

B1 through B6—1.5-volt "AA" cell  
 B7—9-volt transistor battery  
 C1—0.01- $\mu$ F disc ceramic  
 C2—33- $\mu$ F, 10-volt aluminum or tantalum electrolytic  
 C3 through C9—0.1- $\mu$ F disc ceramic, silver mica or polystyrene  
 DIS1,DIS2—Eight-digit, seven-segment surplus LED display stick  
 IC1—NE555 timer  
 IC2—74LS293 4-bit binary counter  
 IC3—CD4040 CMOS 12-bit binary counter  
 IC4—2708 PROM  
 IC5—74LS244 octal noninverting tristate buffer  
 IC6—74159 open-collector 4-to-16-line demultiplexer  
 IC7—74LS02 quad 2-input NOR gate  
 R1—1000-ohm, 1/4-watt, 10% resistor  
 R2—68,000-ohm, 1/4-watt, 10% resistor  
 R3,R4—4700-ohm, 1/4-watt, 10% resistor  
 S1—Spst normally open pushbutton switch  
 S2—Spst normally open pushbutton switch  
 Misc.—Suitable enclosure, red acrylic filter for display, perforated board, wrapped-wire IC sockets, battery holders, 9-volt battery clip, stranded hookup wire, wrapping wire and tool, machine hardware, solder, wrapped-wire pins, etc.

Note: The following items are available from GRE Data Products, Box 17296, Irvine, CA 92713 (Tel: 714-751-7341): two pushbutton switches secured to mounting bracket for \$2.50; preprogrammed 2708 PROM for \$15.00. Prices include postage and handling for U.S. orders. Add \$1.00 for orders to be shipped to Canada, \$4.00 for orders to be shipped elsewhere. California residents, add 6% state sales tax.

that the Magic Black Box is conjuring up an answer to the question.

The project requires three supply voltages referenced to ground. Three AA cells (*B*<sub>1</sub>, *B*<sub>2</sub>, *B*<sub>3</sub>) generate -5 volts (actually -4.5 volts) for the *V<sub>BB</sub>* line of ROM *IC4*. Three additional AA cells (*B*<sub>4</sub>, *B*<sub>5</sub>, *B*<sub>6</sub>) provide +5 volts (actually +4.5 volts) for the positive supply terminals of the logic ICs and the 555 timer. The ROM requires an additional positive voltage, +12 volts. This is derived from the series connection of two AA cells (*B*<sub>4</sub> and *B*<sub>5</sub>, which are also used to generate +4.5 volts for the logic ICs) and *B*<sub>7</sub>, a nine-volt transistor battery. The various supply lines are bypassed by capacitors *C*<sub>3</sub> through *C*<sub>9</sub> to enhance circuit stability. Power is applied to the Magic Black Box by depressing three-pole pushbutton switch *S*<sub>2</sub>.

**Programming Details.** The 64 messages that the author composed for display by his Magic Black Box appear in Table I. A specially programmed PROM is needed to generate these responses. If you are an experienced hobbyist with

access to a 2708 PROM programmer, you can burn in the device yourself. Use either the hexadecimal listing that appears in Table II or the octal listing shown in Table III. If you don't want to program a PROM on your own, you can purchase a preprogrammed one from the source given in the Parts List.

The PROM can be programmed for the reproduction of messages other than those listed in Table I. Because the project employs seven-segment readouts, some letters cannot be displayed. Nevertheless, careful word selection will make it possible to convey most messages unambiguously. The display's character set appears in Table IV. Note that some alphanumeric characters have alternate seven-segment representations. These can be employed for variety or as upper-case characters.

Experimentation is facilitated by the Magic Black Box PROM Generator program listed in Table V. This compact BASIC program eliminates much of the drudgery that would otherwise be associated with the formulation of new

messages. It takes care of such housekeeping details as ASCII-to-seven-segment character translation, upper-to-lower-case character translation, message centering and editing.

To use the program, initialize your version of BASIC, allocating 1K of uncommitted memory for future use. This block of RAM will be used to store the 64 encoded messages that can be

**TABLE I—  
MAGIC BLACK BOX  
MESSAGE REPERTOIRE**

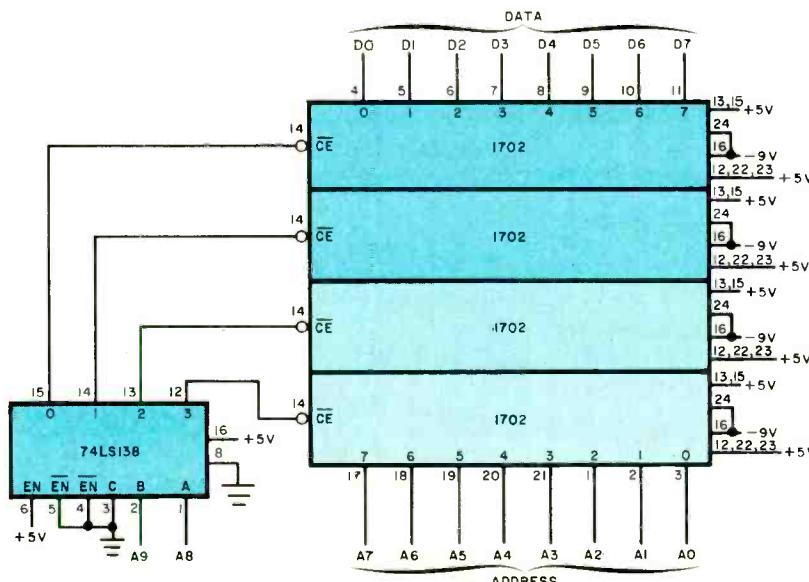
PHRASE 1	: YOUR QUESTION?
PHRASE 2	: I CANT SAY
PHRASE 3	: I SHALL NOT SAY
PHRASE 4	: I DONT tell
PHRASE 5	: REPEAT QUESTION
PHRASE 6	: I CAN not tell
PHRASE 7	: I CAN not say
PHRASE 8	: It IS UNCLEAR
PHRASE 9	: try AGAIN
PHRASE 10	: SURELY YOU JEST
PHRASE 11	: I CANT tell YOU
PHRASE 12	: I ETS SEE
PHRASE 13	: YES
PHRASE 14	: YES YES YES YES
PHRASE 15	: Is DECIDEably SO
PHRASE 16	: probably SO
PHRASE 17	: probably YES
PHRASE 18	: DEFINITELY SO
PHRASE 19	: DEFINITELY YES
PHRASE 20	: ASSERTEDLY SO
PHRASE 21	: A POSSIBILITY
PHRASE 22	: I CAN SEE that
PHRASE 23	: Good CHANCE
PHRASE 24	: Great CHANCE
PHRASE 25	: It IS probable
PHRASE 26	: Assertedly YES
PHRASE 27	: It IS POSSIBLE
PHRASE 28	: the stars SAY SO
PHRASE 29	: I HOPE SO
PHRASE 30	: OF COURSE
PHRASE 31	: It IS POSSIBLE
PHRASE 32	: no doubt
PHRASE 33	: POSSIBLY SO
PHRASE 34	: DEFINITE CHANCE
PHRASE 35	: uh-huh
PHRASE 36	: FAIR CHANCE
PHRASE 37	: sounds Good
PHRASE 38	: I'll bet on it
PHRASE 39	: No
PHRASE 40	: NO NO NO NO NO
PHRASE 41	: decidely not
PHRASE 42	: probably no
PHRASE 43	: probably not
PHRASE 44	: DEFINITELY no
PHRASE 45	: DEFINITELY not
PHRASE 46	: I doubt it
PHRASE 47	: NO CHANCE
PHRASE 48	: I dont SEE that
PHRASE 49	: barely probable
PHRASE 50	: not a CHANCE
PHRASE 51	: little CHANCE
PHRASE 52	: unfortunately not
PHRASE 53	: the stars SAY not
PHRASE 54	: ABSOLUTELY not
PHRASE 55	: OF COURSE not
PHRASE 56	: TINY CHANCE
PHRASE 57	: FAT CHANCE
PHRASE 58	: POSSIBLY not
PHRASE 59	: NOPE
PHRASE 60	: Not on SUNDAY
PHRASE 61	: NO POSSIBILITY
PHRASE 62	: SLIGHT CHANCE
PHRASE 63	: I bet AGAINst it
PHRASE 64	: PUSH the button

### WHEN YOU HAVE 1702s WHO NEEDS 2708s?

There are PROMs that can be used in the Magic Black Box other than 2708s. If you built the low-cost EPROM programmer that appeared in the February and March 1978 issues of POPULAR ELECTRONICS, you will probably prefer to use 1702s. Although they are low-density PROMs, they are inexpensive, readily available, and require only two power-supply voltages.

The circuit shown in this box replaces one 2708 with four 1702s and

one 74LS138 1-of-8 decoder/demultiplexer. Modifications to the Magic Black Box are minimal. Add one 16-pin and three 24-pin IC sockets to the perforated circuit board. Wire all 1702 address lines in parallel, and do the same for all 1702 data lines. The 1702s require +5-, -9-volt and ground connections, so the +12- and -5-volt supplies can be eliminated and a -9-volt supply installed instead. Make sure that the power supply wiring to each IC socket has been performed correctly before installing the 1702s.







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MAGIC BOX *Continued*

TABLE IV—DISPLAY CHARACTER SET

SYMBOL	PRIMARY	UPPER CASE ALTERNATE	SYMBOL	PRIMARY	UPPER CASE ALTERNATE	SYMBOL	PRIMARY
A	Ⓐ	Ⓐ	O	Ⓑ	Ⓑ	0	Ⓑ
B	Ⓑ	Ⓑ	P	Ⓒ	Ⓒ	1	Ⓒ
C	Ⓒ	Ⓒ	Q	Ⓓ	Ⓓ	2	Ⓓ
D	Ⓓ	Ⓓ	R	Ⓔ	Ⓔ	3	Ⓔ
E	Ⓔ	Ⓔ	S	Ⓕ	Ⓕ	4	Ⓕ
F	Ⓕ	Ⓕ	T	Ⓖ	Ⓖ	5	Ⓖ
G	Ⓖ	Ⓖ	U	Ⓗ	Ⓗ	6	Ⓗ
H	Ⓗ	Ⓗ	V	Ⓘ	Ⓘ	7	Ⓘ
I	Ⓘ	Ⓘ	X	Ⓛ	Ⓛ	8	Ⓛ
J	Ⓛ	Ⓛ	Y	Ⓜ	Ⓜ	9	Ⓜ
K	Ⓜ	Ⓜ	Z	Ⓝ	Ⓝ	PERIOD	Ⓝ
L	Ⓝ	Ⓝ	-	-	-	NOTE DOTTED (---) LINES SIGNIFY SEGMENTS NOT LIT AND ARE INCLUDED SOLELY FOR ORIENTATION	-
M	---	---					
N	---	---					

**Use.** Depress power switch S2. The Magic Black Box will inquire as to the question to be asked. Ask your question verbally and depress CONJURE switch S1. The project will consult its knowledge and provide a response.

Note that the Magic Black Box can be used for other purposes besides foretelling the future. With a little imagination, you can adapt it for such

games as make-believe horse races, cards, dice, etc. More serious applications like history or geography drills can also be implemented. You can build up a whole set of PROMs, each containing a different game or quiz. The BASIC program we have presented will help you do this. To change games or drills, simply substitute one PROM for another. ◇

TABLE V—ROM GENERATOR PROGRAM

```

10 PRINT" MAGIC BLACK BOX ROM GENERATOR": INPUT"STARTING ADDRESS":S
30 DIM A(99): FOR X=0 TO 99: READ A(X): NEXT: P=0
40 PRINT"PHRASE": P+1: INPUT L$: IF LEN(L$)>16 THEN PRINT"LINE TOO LONG": GOT040
45 IF VAL(L$)<>0 THEN NF=VAL(L$)-1: GOT040
46 IF L$="LIST" THEN N90
50 A=S+P*16: FOR X=0 TO 15: POKE A+X,0: NEXT: X=INT((16-LEN(L$))/2)
60 FOR Y=1 TO LEN(L$): Z=A+ASC(MID$(L$,Y,1))-32: IF Z=1 THEN PRINT"ERROR": GOT040
70 POKE A+X, Z: X=X+1: NEXT: POKE A+X-1, PEEK(A+X-1)+128: P=P+1: GOT040
90 PRINT"PHRASE": P+1: IF P<9 THEN PRINT" "
95 PRINT"!": A=S+P*16: FOR X=0 TO 15: Z=PEEK(A+X) AND 127: FOR Y=90 TO 0 STEP -1
100 IF Z<>ACV(Y) THEN NEXTY
110 PRINT CHR$(Y+32): NEXTY: PRINT"!": P=P+1: IF P<64 THEN N90
120 GOT040
200 DATA 0, 1, 34, 1, 1, 1, 2, 1, 1, 1, 1, 1, 64, 128, 1, 63, 6, 91, 79, 102, 109, 125, 1, 127
210 DATA 111, 1, 1, 1, 72, 1, 83, 1, 119, 124, 57, 94, 121, 113, 61, 118, 6, 30, 1, 56, 1, 55
220 DATA 63, 115, 103, 80, 109, 112, 62, 1, 1, 1, 110, 91, 1, 1, 1, 1, 1, 95, 124, 98, 94
230 DATA 123, 113, 111, 116, 4, 30, 1, 56, 1, 84, 92, 115, 103, 80, 109, 112, 28, 1, 1, 1
240 DATA 10, 91
OK

```

# The LM 339

## A Great Comparator

*Four independent comparator circuits on one chip can be used in a variety of analog and digital applications*

BY CLEMENT S. PEPPER

**T**HE KEY WORD to describe the 339 quad comparator is *versatility*. This device can interface a slow-moving analog signal to almost any logic family, will drive a LED, detect high- and/or low-voltage limits and can be used as a monostable oscillator.

What makes the 339 so versatile? Consider its power requirements as an example. The chip will work from a single dc source between 2 and 32 volts, or a split power supply from  $\pm 1$  to  $\pm 18$  volts. Current drain is a meager 0.8 mA, independent of supply voltage.

The common-mode range includes ground, even when operated from a single supply. With a typical input bias current of 25-nanoamperes, a 3-nanoampere offset and a 3-mV input offset voltage, the input can "look" at almost any source impedance without loading.

The 339 output stage is an npn transistor having an uncommitted collector so that an external pullup resistor can be used with a supply voltage different than that used by the remainder of the device. You can even hard-wire the outputs in an OR configuration. The transistor output stage will sink up to 20 mA, but you may have to live with a high saturation voltage (with 4 mA it is 250 mV). The output is compatible with TTL (fan-out of 2), DTL, ECL, MOS and CMOS.

The 339 chip contains four identical

comparators, and is available from many parts suppliers at prices as low as \$1 each.

**Device Operation.** The pinout for the 339 is shown in Fig. 1A. The numbers across each row indicate the noninverting and inverting inputs with the associated outputs for each of the four comparators in the chip.

A basic comparator is shown in Fig. 1B. Here, the input signal  $V_{IN}$  is compared with a fixed reference  $V_{REF}$ . Whenever the input signal exceeds the reference level by just a couple of millivolts, the output ( $V_O$ ) goes high. This action is illustrated by the associated waveforms.

Unfortunately, such a basic circuit can oscillate during the transition period, and although this might present a problem with slow analog signals, it would cause no trouble for the fast transition times associated with digital signals. This can be averted by using a small amount of positive feedback as shown in Fig. 1C. The feedback not only speeds up the transition, but adds a little hysteresis. Feedback resistor  $R_F$  is typically a high value, 10 megohms for example.

While hysteresis can eliminate the transient oscillation, it can also be put to work in a useful manner such as "cleaning up" input waveforms, acting like a

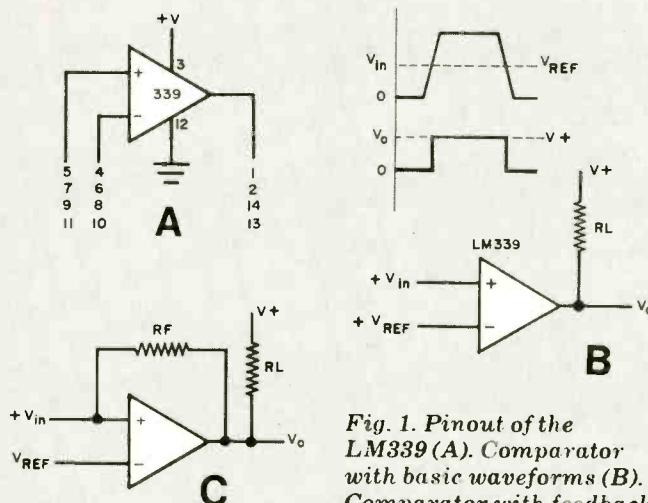
Schmitt trigger. However, most Schmitt triggers lack adjustability, and further along in this article, we will illustrate a 339 Schmitt trigger that does not have this problem.

**Analog-to-Digital Interface.** The input for a frequency counter is a good example of an analog-to-digital interface (not to be confused with an A/D converter as used in computers).

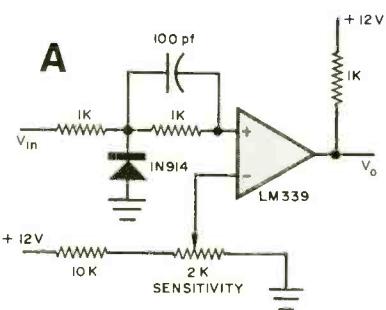
The input of a frequency counter must be capable of accepting a wide variety of signals, slow or fast, and provide a signal compatible with the digital counter circuits that follow. Also, since the input levels can span a broad range of levels, sensitivity adjustments are required. Then there must be a "threshold" established either to reject noise, or possibly to match a digital source. Such a circuit is shown in Fig. 2A.

Sine-wave performance (10 kHz) is shown in Fig. 2B with a 3-volt rms input and Fig. 2C with 1-volt rms input. This circuit has been used with excellent results to 1 MHz.

**CMOS to TTL Translation.** The circuit shown in Fig. 2A is also useful for translating various logic families. For this application, two series-connected 1N914 diodes may be substituted for the 2000-ohm potentiometer. This estab-



**Fig. 1.** Pinout of the LM339 (A). Comparator with basic waveforms (B). Comparator with feedback resistor for faster switching action (C).



**Fig. 2.** Counter input circuit (A). Output with 10-kHz, 3-volt input (B) and 10-kHz, 1-volt (C). Outputs are upper traces, with 5 V/div. Sine waves are at 2 V/div.

lishes a 1.4-volt reference compatible with both TTL and CMOS operating from a 5-volt supply. The 1000-ohm pullup resistor connected at the output has to be connected to the TTL 5-volt supply.

During the design of an 8-input oscilloscope circuit, the author connected eight such circuits, with all eight inputs connected to a source having a pulse 8-microseconds wide. The upper four traces of Fig. 3 came from one 339 package, while the lower four traces came from another 339 package. Actual time variations are about 200 nanoseconds. This illustrates the quality of diffusion techniques these days.

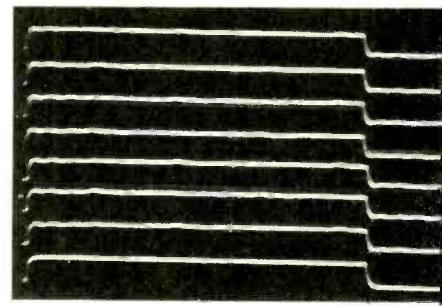
**High and Low Limit Detection.** Two comparators working together sense the low and high limits in the simplified capacitance measuring scheme shown in Fig. 4A. The unknown capacitor ( $C$ ) is charged from a constant-current source ( $I_1$ ). This results in a linear charging ramp whose slope is proportional to the capacitance (Fig. 4B). The limit voltages are 0.10 and 1.10 volts, so that the measurement becomes that of the time required to charge the capacitor to this higher voltage.

In the complete circuit (Fig. 4C), the addition of an exclusive-OR gate yields a pulse whose width is scaled to the val-

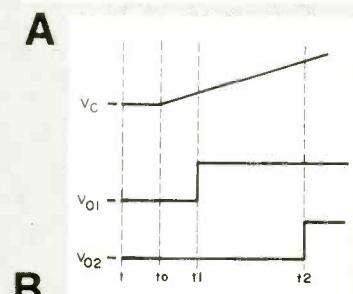
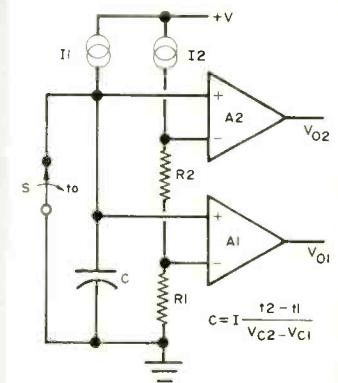
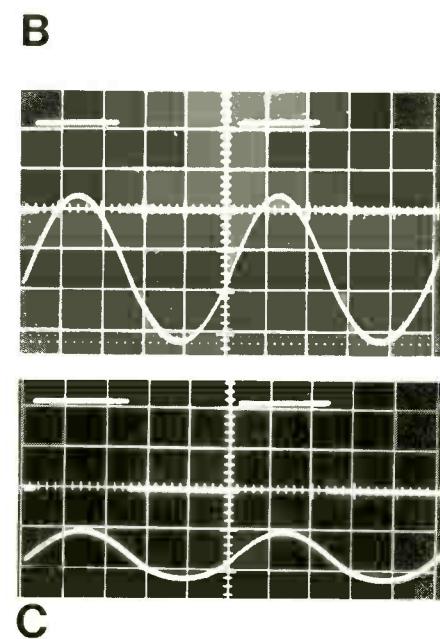
ue of the capacitor. Scope traces of a typical measurement are shown in Fig. 4D. The capacitance can be determined from the width of the pulse.

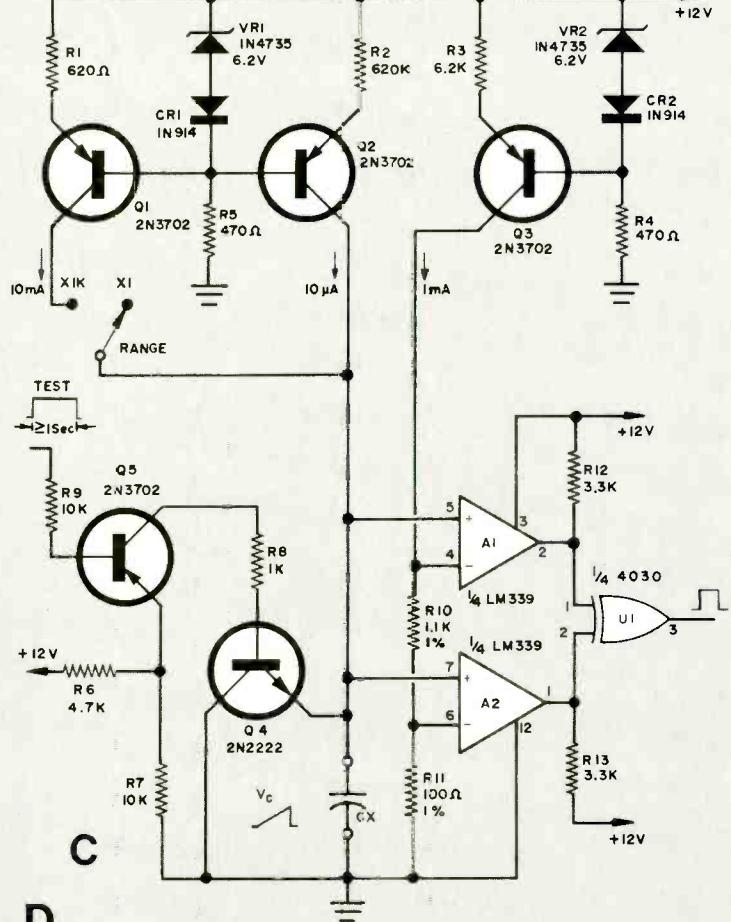
Earlier in this article, hysteresis was mentioned as one way to get high and low limit detection, such as used in a Schmitt trigger. The circuit shown in Fig. 5A uses a single comparator which does not have the precision of the dual comparator approach but is useful with looser tolerance circuits.

Although the circuit appears tricky, it is easy to understand. First, you have to know the desired upper and lower switching voltages. Then, select a zener



**Fig. 3.** Outputs of two separate 339 packages (four at top, four at bottom) show excellent matching.





*Fig. 4. Basic capacitance measuring circuit (A) and timing diagrams (B). Complete circuit (C) and output for 4.7  $\mu$ F (D).*

diode that falls midway between these voltages. Part of the problem comes when trying to get a zener diode of the correct value since zeners come in specific voltages. Therefore, pick the closest value. Select  $R_1$  for 5 to 10 mA of zener current.

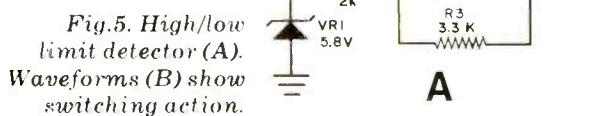
When the 339 output is low, some of the current through  $R_1$  flows through  $R_2$  and  $R_3$  into the output. We can safely assume that none flows into the noninverting (+) input. Pin 5 of the 339 will now be lower than the zener.

With the 339 output high, current flows through  $R_4$ ,  $R_3$  and  $R_2$  into the zener diode.

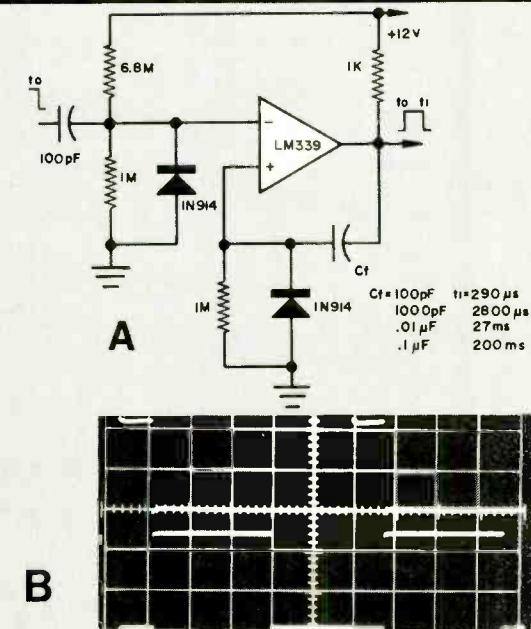
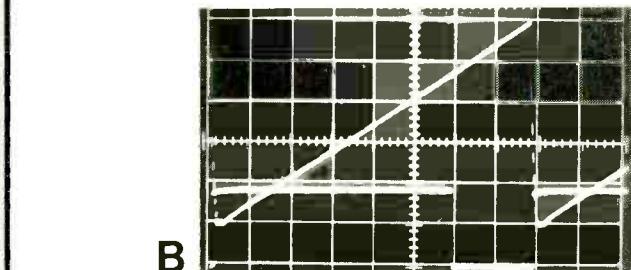
Although we will not go into a detailed circuit analysis, the "trick" here is to select the resistor values. In the circuit shown in Fig. 5A, the switching points are 7.7 and 4.0 volts. Build the circuit and vary the resistor values to get a feel for circuit operation. A typical waveform is shown in Fig. 5B.

**Monostable.** The circuit for a 339 monostable is shown in Fig. 6A, with an output waveform shown in Fig. 6B.

The inverting (-) input of the comparator is biased about 1.25 volts positive by the 6.8-megohm and 1-megohm voltage divider.



*Fig. 5. High/low limit detector (A). Waveforms (B) show switching action.*



*Fig. 6. Monostable circuit (A). In (B) 1710-Hz input is at top, output below (5 V/div).*

Triggering occurs on a negative-going input which forces the inverting input below ground. The 1N914 diode limits this to one diode drop. The resulting positive-going output is fed back to the noninverting (+) input, and the timing is determined by the discharge time of the feedback capacitor  $C_F$  and the 1-megohm resistor. This time is proportional to the capacitance value for the ranges shown in Fig. 6A.

Although this circuit may require some "tweaking" to achieve specific monostable action, it is useful to know about if you have an unused comparator in your design and require a monostable. ◇

BUILD A

# Metal Locator

BY ROBERT KRIEGER

WETHER it is put to work in searching for buried treasure, locating sunken pipes, or combing the Australian outback for fragments of a fallen space station, a metal locator can be a useful instrument. The locator described here uses a highly sensitive superheterodyne circuit. It is a true "from-scratch" project in which you even fabricate the search-head pickup-coil assembly. Assuming all parts and materials are bought new for this project, total cost should run about \$20.

**Circuit Operation.** The metal locator, shown in block-diagram form in Fig. 1, functions on the beat-frequency (heterodyning) principle. Here, two high-frequency r-f signals are combined, or "beat" together, in the FET mixer to produce a difference frequency. (Actually, the mixer output contains the original frequencies along with their sum and difference, but it is the difference frequency that interests us because it is the only one that lies in the audio range.)

The original signals are produced by a pair of FET oscillators operating at 650 kHz. The frequency was chosen on the basis of tests showing that, up to 350 kHz, sensitivity and depth of penetration are fairly low and constant for moderately small objects. At 400 kHz, there is a sharp increase in performance that persists up to 1.3 MHz, where the copper-

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 1. Good accuracy over temperature  
 2. Resolution  
 3. Sensitivity

**Good accuracy over temperature.** Crystal oscillators drift with temperature changes. This change is specified in parts per million (PPM). The 5500 TCXO (temperature compensated crystal oscillator) holds an accuracy of 1 PPM from 17° to 40°C. This corresponds to ± 450 Hz at 450 MHz. Counters with 2 PPM accuracy would read to ± 900 Hz at 450 MHz. Counters with .5 PPM accuracy would read to ± 450 Hz and so on.

**Resolution** What is the value of the least significant digit displayed? A counter with 10 Hz resolution would display 146.52000 MHz as 146.52000 i.e. with the last digit left off. A counter with 100 Hz resolution would display 146.5200. The 5500 with 8 Digits is capable of resolving 1 Hz from 50 Hz to 50 MHz and 10 Hz from 50 MHz to 512 MHz. Counters with only 7 digits usually can only resolve 10 Hz to 50 MHz and 100 Hz to 500 MHz. The above effects, accuracy and resolution are cumulative. Example: a seven-digit counter with 1.5 PPM accuracy reading 450 MHz would only be accurate to ± 675 Hz (± .00 Hz (last digit error) or ± 775 Hz. The 5500 with eight full digits and 1 PPM accuracy would be accurate to ± 450 Hz = 10 Hz (last digit error) or ± 400 Hz maximum. Not bad for \$99.95. You really need the eighth digit to achieve real accuracy.

**Sensitivity.** The 5500 requires only 10-15 mv of signal to stabilize and achieve an accurate reading. A one watt hand-held can be read with accuracy at a distance of 15-20 ft. from the counter using the T600 antenna. Counters with 150 mv sensitivity will only stabilize at distances of less than a foot.

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\*With AC-9 Adaptor.

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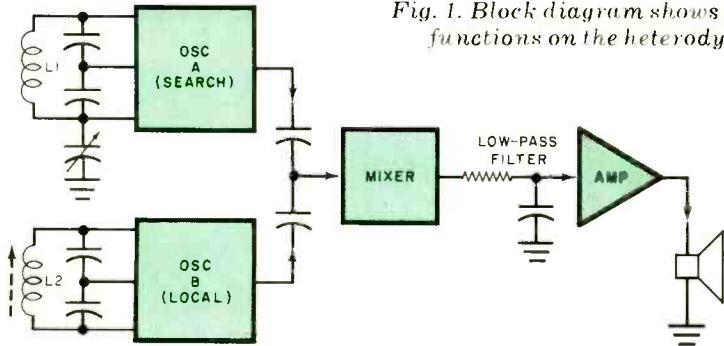


Fig. 1. Block diagram shows how the locator functions on the heterodyning principle.

braid Faraday shield (more about the shield later) loses its effectiveness. A frequency of 650 kHz gives excellent sensitivity and offers convenience in final adjustment. As designed, the metal locator can detect a nickel in free air at a distance of 6" (152 mm) or buried at a depth of 3" (76 mm) or more.

Assume that oscillators A and B in Fig. 1 are set to 650.454 and 650.400 kHz, respectively. Combining these in the FET mixer, we obtain signals at 650.454 kHz, 650.400 kHz, 1300.854

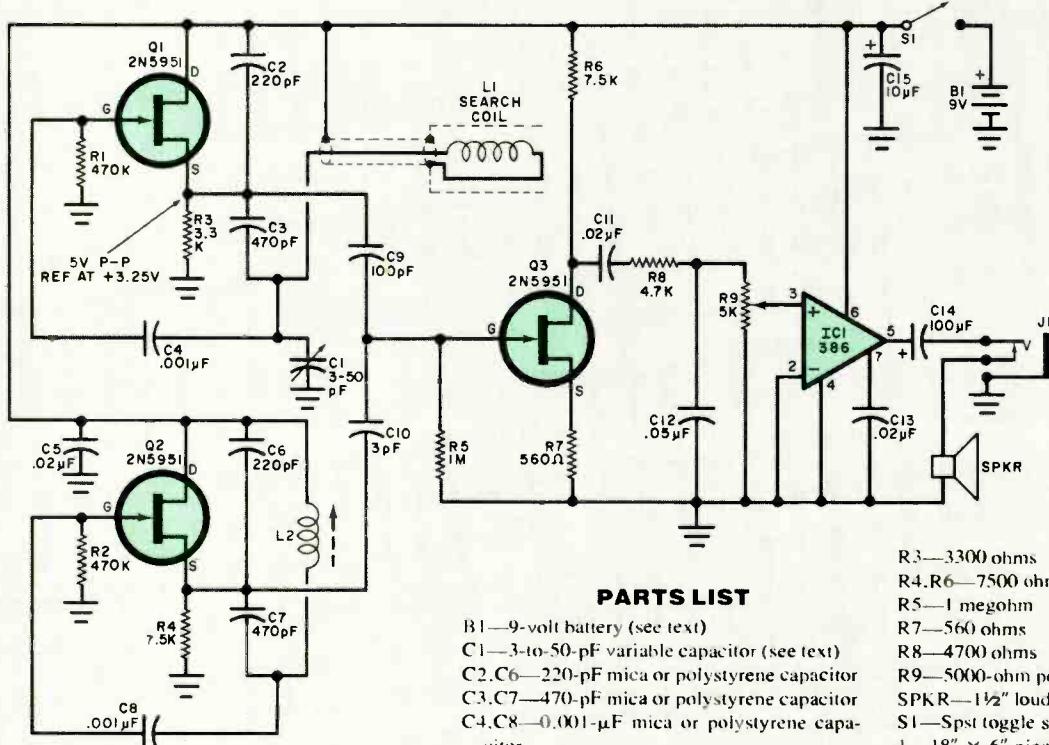
kHz and 54 Hz in the output. Since all we wish to pass on to the amplifier is the audible 54-Hz signal, the low-pass filter removes all higher frequencies. After amplification, the 54-Hz signal is heard from the loudspeaker.

When  $L_1$ , the inductor that forms the search head, is brought near a metallic object (on the surface or buried), its inductance changes slightly. The deeper the object is buried, the less the change. With  $L_1$  acting as one of the frequency-determining components of oscillator A,

the variation in  $L_1$  causes a frequency shift, say, to 650.440 kHz. Now, the difference between 650.440 kHz and the 650.400-kHz frequency of fixed oscillator B is 40 Hz. This means that the audible tone has shifted from 54 to 40 Hz to indicate the proximity to  $L_1$  of a metallic object.

The metal locator contains two stable Colpitts oscillators (Q1 and Q2 circuits in Fig. 2) that are both tuned to operate in the 650-kHz range. The oscillators are essentially identical, except that one employs search-head coil  $L_1$  as the inductive element and the other has small tunable inductor  $L_2$ .

For operation,  $C_1$  is set at its midpoint and then  $L_2$  is adjusted so that both oscillators are at zero beat (same frequency). Varying  $C_1$  will then tune oscillator Q1 out of zero beat and cause an audio tone to be heard. Note that source resistor  $R_4$  in the Q2 circuit is greater in value than  $R_3$  in the Q1 circuit. Since the Q1 circuit produces a low level of oscillation, it is necessary to damp the Q2 oscillator



#### PARTS LIST

- B1—9-volt battery (see text)
- C1—3-to-50-pF variable capacitor (see text)
- C2,C6—220-pF mica or polystyrene capacitor
- C3,C7—470-pF mica or polystyrene capacitor
- C4,C8—0.001- $\mu$ F mica or polystyrene capacitor
- C5,C11,C13—0.02- $\mu$ F capacitor
- C9—100-pF mica or polystyrene capacitor
- C10—3-pF capacitor
- C12—0.05- $\mu$ F capacitor
- C14—100- $\mu$ F, 16-volt electrolytic
- C15—10- $\mu$ F, 16-volt electrolytic
- IC1—LM386 1/2-watt audio amplifier IC
- J1—Miniature transfer-type phone jack
- L1—Search coil (see text)
- L2—AM loopstick antenna with tunable slug
- Q1,Q2,Q3—2N5951 n-channel FET
- The following are 1/4-watt, 10% tolerance resistors unless otherwise noted:
- R1,R2—470,000 ohms
- R3—3300 ohms
- R4,R6—7500 ohms
- R5—1 megohm
- R7—560 ohms
- R8—4700 ohms
- R9—5000-ohm potentiometer
- SPKR—1 1/2" loudspeaker
- S1—Spst toggle switch
- 1—18" x 6" piece of 1/4" plywood for search-head coil form
- 1—36" length of 3/4" diameter aluminum tubing
- 1—5' length of RG-58U coaxial cable
- 1—2' length of RG-8U coaxial cable
- Misc.—Perforated board (or printed-circuit board—see text); socket for IC1; 9-volt battery clip; Bud No. CU234 or similar aluminum case; 40' No. 28 enamel- or Mylar-coated magnet wire; control knobs (2); white glue; epoxy cement; plastic tape; 1/2" foam insulation tape; plastic cement; two small brass screws; machine hardware; spacers; hookup wire; solder; etc.

Fig. 2. Two stable Colpitts oscillators (Q1 and Q2) are tuned to operate in the 650-kHz range. They are essentially identical except for the two inductors.

to match the Q1 oscillator. This is the reason for the greater value for R4.

The key to operation of a Colpitts oscillator is the pair of capacitors that form a voltage divider across the inductor (C2 and C3 for Q1 and C6 and C7 for Q2). The capacitors and inductor in each circuit determine the frequency of operation for that circuit. In the Q1 and Q2 circuits, the FET's source is at signal ground. Therefore, because of the split capacitor action, the signal at the bottom of the inductor is 180° out-of-phase with that at the drain. Since the transistor inverts the signal by 180° and the split tank circuit inverts another 180°, an in-phase signal is fed back to the gate and sustains oscillations.

Increasing the value of C3 or C7 decreases the amount of feedback to the gate. If the value of this capacitor is made too large, there will not be enough feedback to sustain oscillation. Lowering its value to, say, 300 pF increases feedback and virtually guarantees oscillation, but the sine wave will not be as "clean" as it would be with a 560-pF capacitor value. The ratio of C2 to C3 or C6 to C7 should be about 1:3 for best overall operation. Although Q1 and Q2 appear to be arranged in a unity-gain source-follower configuration, R3 and R4 are actually working off the drains, since the sources are at feedback ground.

Mixer Q3 heterodynes the r-f signals and provides some degree of preamplification for amplifier IC1. Resistor R8 and capacitor C12 make up the low-pass filter that prevents r-f from entering IC1.

**Construction.** There is nothing particularly difficult in assembling the metal detector. The only conceivable problem area might be in fabricating the search-head assembly, which requires relatively simple woodworking. Several hours are required for allowing the glue to set in the search-head assembly. Therefore, it is best to start construction by fabricating this assembly and, while the glue is setting, assemble the electronics package.

Cut two 5 3/4" (146-mm) and one 5" (127-mm) disks from a sheet of 1/4" (6.4-mm) thick plywood. Lightly sand the cut edges to remove all splinters. Locate and mark the center of each disk and drill a 1/16" (1.6-mm) hole through each. Liberally coat both sides of the smaller disk with white glue and temporarily assemble the three disks with the smaller in the middle, using a nail to align the holes. Press lightly and then disassem-

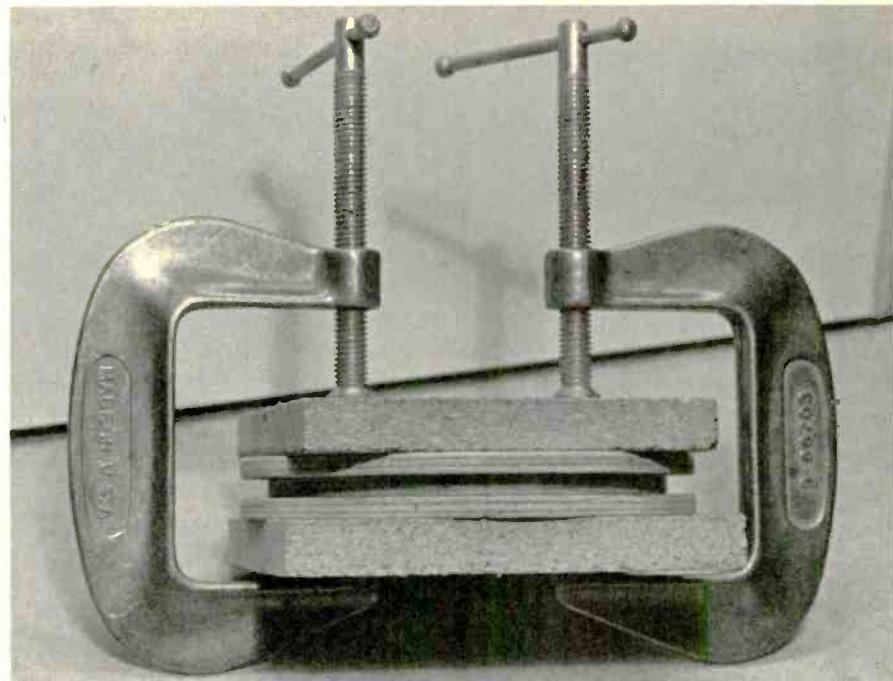


Fig. 3. Glue three plywood discs together with the smaller one in the middle. Use clamps or weights to ensure proper bonding.

Fig. 4. When glue has had time to set thoroughly, draw a D-shaped form on the assembly as shown.

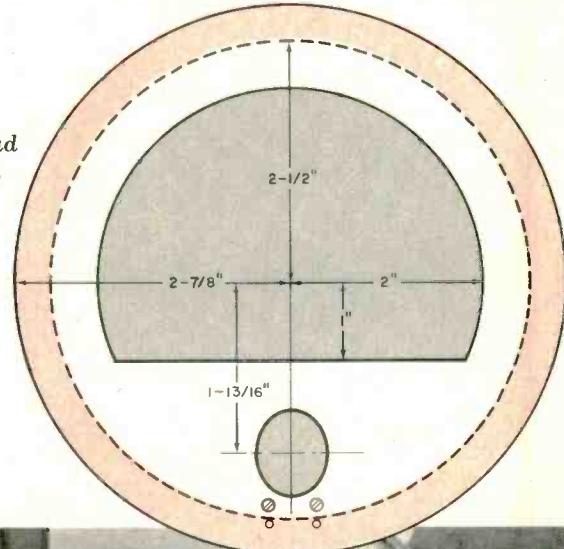
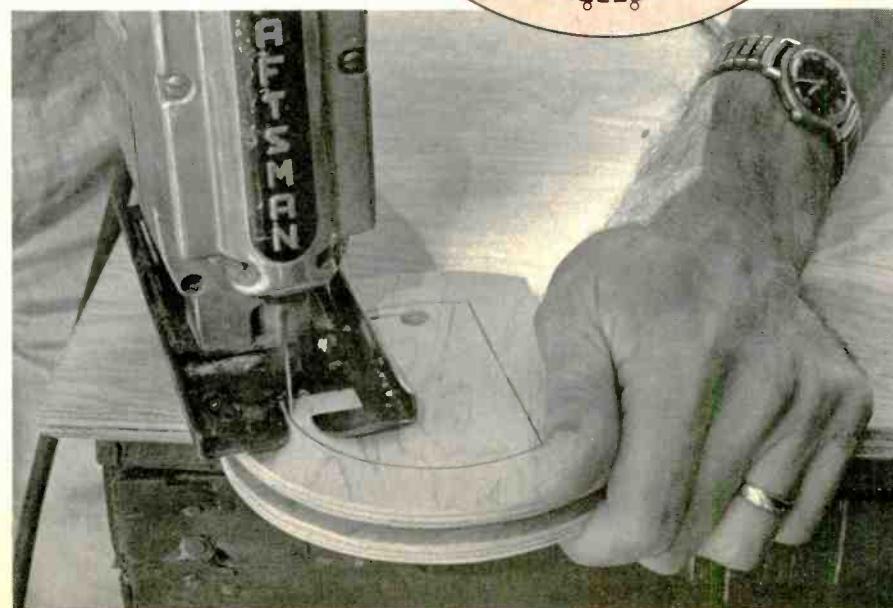
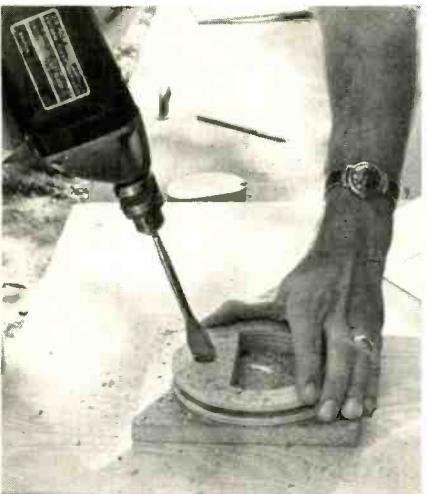
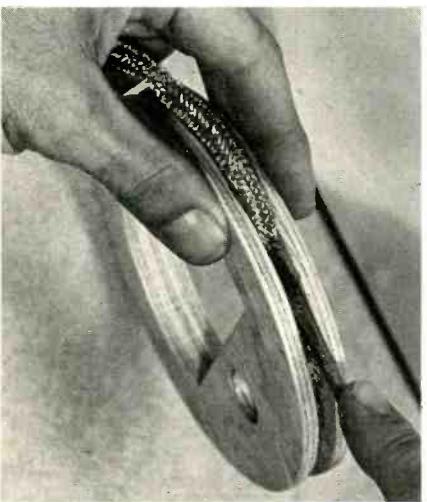


Fig. 5. Use a coping or sabre saw to cut out the form drawn on disc in Fig. 4.

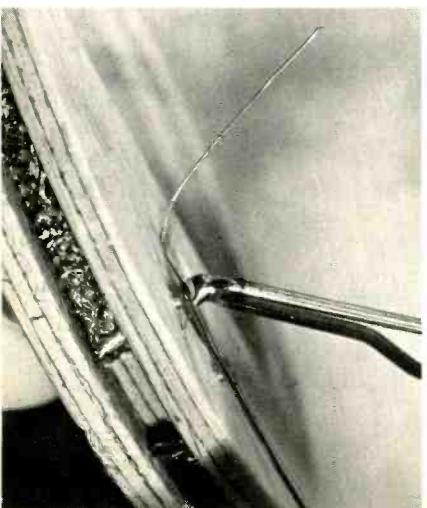




*Fig. 6. Drill shaft hole with wood bit, tilting it away from D cutout by about 18 degrees.*



*Fig. 7. The 20-turn coil is shielded with the braid from RG-8U coaxial cable.*



*Fig. 8. Bring free end of braid up through plywood sandwich and solder to an adjacent screw.*

ble. Allow the glue to air dry until the surfaces are just tacky. Then reassemble with the nail to assure proper alignment and clamp or weight the "sandwich" until the glue sets (Fig. 3). Alternatively, you can use epoxy cement as the binder, aligning the disks with the nail and clamping or weighting immediately upon application. Set the assembly aside for at least 6 hours to allow the glue or cement to set solidly.

Meanwhile, referring back to Fig. 2, assemble the electronics package on a piece of perforated board, using either point-to-point or Wire Wrap techniques. If you are particularly ambitious, you can design and fabricate your own printed circuit board for the project. In any event, use a socket for IC1 and, if possible, sockets for Q1 and Q2.

Do not wire L1 or C2 into the circuit just yet or mount the circuit board assembly into the case until directed to do so. Note that C1 specified in the Parts List is a standard 365-pF capacitor. To reduce it to 50 pF, carefully remove all but one of its rotor plates, taking care to avoid bending the remaining plate.

Once the glue or cement has thoroughly set in the search-head assembly, remove the clamps or weights. Pry out and discard the nail. Then, referring to Fig. 4, draw a D-shaped form on the assembly as shown. Use a sabre or coping saw to cut out this form (Fig. 5). Lightly sand the cut edges to remove all splinters and rough spots. Referring back to Fig. 4, locate the centers of the shaft and wire-exit holes. Drill the latter with a 1/16" bit. Use a 3/4" (19.1-mm) wood bit to drill the shaft hole, tilting it away from the D cutout by about 18° (Fig. 6). The angle is not critical, but it should be between 15° and 20° from perpendicular to permit convenient handling of the metal detector.

The 20-turn coil to be wound in the groove formed in the search-head sandwich must be shielded to reduce ground capacitance effects. The shield is a length of copper braid removed from RG-8U coaxial cable. Carefully slit the outer plastic jacket from about a 24" (61-cm) length of coax. Then slide the inner conductor out of the braid. With your fingers, flatten the braid and press one turn into the groove. Use a Phillips screwdriver to force the braid in place as shown in Fig. 7. Be sure to leave a gap of  $\frac{3}{8}$ " (9.5 mm) between the braid ends.

Drive two small brass screws into the top of the plywood sandwich near the shaft hole. Solder a length of hookup wire to one end of the braid. Pass the

*Photo of the completed metal locator with handle on front, controls on top, bottom and sides. Speaker is just under the handle.*



free end up through one of the 1/16" holes, and solder to the head of the adjacent screw. (Fig. 8). Cover the braid with a single layer of plastic tape, as shown in Fig. 9.

Use No. 28 enamel- or Mylar-coated magnet wire to wind the search coil. Scrape away about  $\frac{1}{2}$ " (12.7 mm) of the insulation and pass the wire up through the same hole as the wire to the shield is routed to the brass screw. Solder to the same screw. Then wind 20 turns of the magnet wire into the groove. Pass the free end up through the other 1/16" hole and solder to the screw adjacent to the hole. Coat the windings completely with plastic cement to prevent them from shifting and affecting frequency stability.

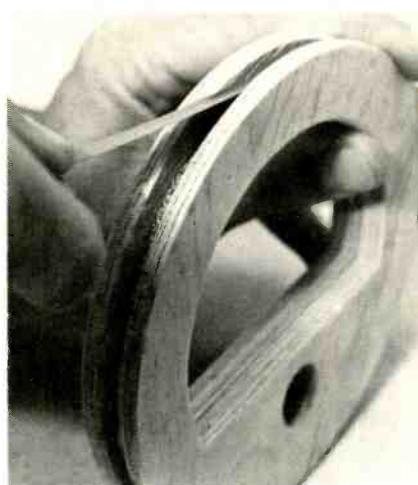
When the cement sets, cover the winding with a single layer of plastic tape. Lay in another turn of the wire braid, again leaving a  $\frac{3}{8}$ " gap between the ends and connecting one end, via a length of hookup wire, to the screw to which the inner braid and one end of the search coil is connected. Note, when

you are finished with this part of construction there should be three wires soldered to one screw and only one to the other. For thermal protection, cover the outer braid with a single layer of  $\frac{1}{4}$ " wide polyfoam weather stripping.

Several inches up on the aluminum shaft, drill a  $\frac{1}{4}$ " hole through which to pass the coaxial cable that interconnects electronics package with search coil. On the other end of the shaft, measure down  $\frac{1}{2}$ " and  $1\frac{1}{2}$ " and drill  $\frac{1}{8}$ " holes directly in line with the  $\frac{1}{4}$ " hole. Place the search-head assembly on a flat, level surface, top side up. Run a liberal bead of epoxy cement inside the shaft hole and around the head end of the shaft. Slide the shaft into the hole, orienting it so that the  $\frac{1}{4}$ " hole faces toward the screws in the search-head assembly. Prop the assembly up and let stand undisturbed until the epoxy cement sets.

When the cement sets, pass a 36" (914-mm) length of RG-58U coax through the  $\frac{1}{4}$ " hole and route through the shaft. Prepare the end of the coax and connect and solder it to the heads of the screws to which the search coil and shield are connected. The shield goes to the screw head to which the coil's two shield and one coil wires are connected, while the inner conductor goes to the other screw, as shown in Fig. 10.

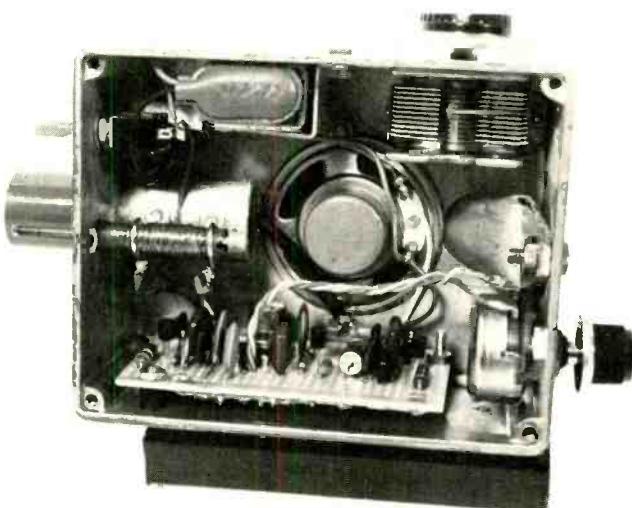
Now, referring to Fig. 11, machine the cabinet for mounting  $L_2$ ,  $SPKR$ ,  $S_1$ ,  $J_1$ ,  $C_1$ ,  $R_9$ ,  $B_1$ 's bracket, the handle and shaft, and the circuit-board assembly. Carefully deburr all holes. Then mount the handle, shaft, and battery bracket, in that order, with appropriate machine hardware. (Note that the shaft fits through a  $\frac{3}{4}$ " hole at one end of the box and is held in place with two sets of 6-32



*Fig. 9. Cover the coax shield braid with a single layer of plastic electrical tape.*



*Fig. 10. Coax is routed to search coil through the shaft with ends soldered to the proper screws.*



*Fig. 11. Photo showing inside of author's prototype. The shaft fits through hole at left. Handle and speaker are shown on the back of enclosure here.*

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$\times 1\frac{1}{4}$ " machine screws, nuts, and lockwashers through one wall of the box.)

Next, mount the speaker,  $C_1$ ,  $J_1$ ,  $S_1$ ,  $R_9$ , and  $L_1$  in their respective locations. Mount these components in the order given and connect and solder lengths of hookup wires to their lugs. Referring back to Fig. 2, connect and solder the free ends of the wires to the appropriate points in the circuit. Then mount the circuit board assembly inside the box, using spacers and 6-32 hardware. Snap the connector onto the battery terminals and slip the battery into its bracket.

**Operation and Use.** The critical factor in a metal detector is in the adjustment of both its oscillators to function on the same frequency. If possible, each oscillator should be tested separately with a frequency counter. If a counter is not available, use a standard AM broadcast-band radio tuned near the low end of the band (about 650 on the dial) and defeat first one and then the other oscillator by temporarily opening the source circuit while tuning. Tune the search ( $Q_1$ ) oscillator first and then the local ( $Q_2$ ) oscillator to the same frequency, adjusting  $L_2$  to bring the latter to the same frequency. When the oscillator and the radio are tuned to the same frequency, you will hear a "dead-air space," a band of silence resulting from the presence of an unmodulated carrier.

To use the metal detector, give it a couple of minutes to stabilize after first applying power. Adjust  $C_1$  for zero beat and then back off so that you hear a low-frequency tone from the speaker or earphone. Pass the search head over a metal object, and the tone should shift upward or downward in frequency, depending on the side to which you tuned off zero beat.

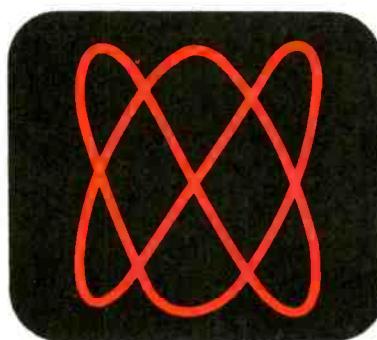
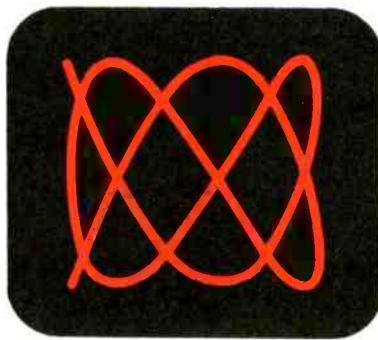
One final note: Maintain a low volume level from the speaker to prolong battery life. You can use an 8.4-volt mercury battery for  $B_1$  to provide superior service, since this type of battery maintains a relatively constant voltage over a longer period than can ordinary carbon-zinc batteries.

**In Conclusion.** As you use the metal detector described here, you will soon come to realize how well it works for locating buried metallic objects. Always bear in mind, however, that the smaller the object or the deeper it is buried, the more difficult it will be to locate. When working in noisy environments, such as at a beach with a pounding surf, use an earphone for best results. ◇

# LISSAJOUS PATTERN QUIZ

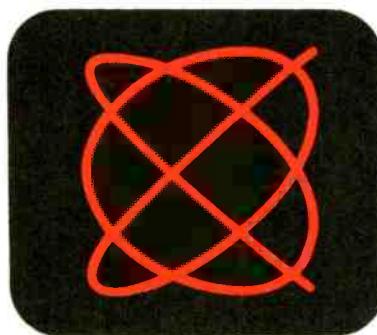
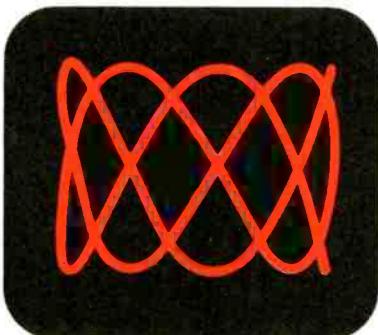
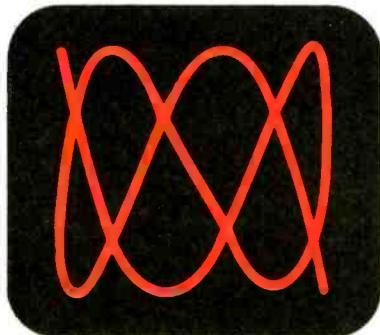
BY ROBERT P. BALIN

An unknown frequency can be determined by applying it to a scope's vertical terminals, while a signal of known frequency is applied to the horizontal. The resulting display, a Lissajous pattern, can then be analyzed to find the unknown. The ratio between the frequencies is equal to the ratio of the number of cycles (including halves) produced in each direction. For example, if there were 3.5 horizontal cycles and two vertical, the ratio would be 3.5:2 or 7:4. Then, if the horizontal frequency were 1000 Hz, the unknown would be 7/4 times 1000 or 1750 Hz. See if you can determine the unknown frequencies for the Lissajous patterns shown here. Answers are below.



1.  $V = 2800 \text{ Hz}$ .  $H = \underline{\hspace{2cm}}$

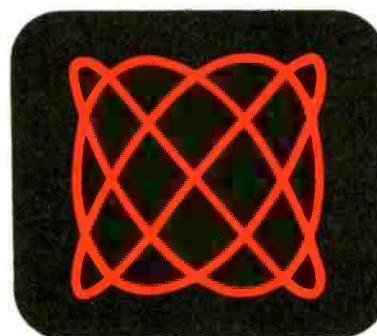
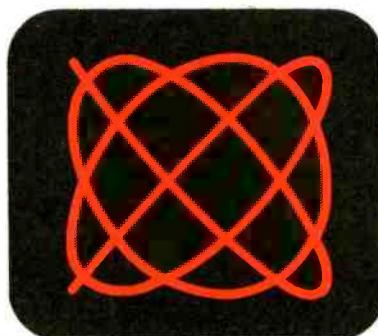
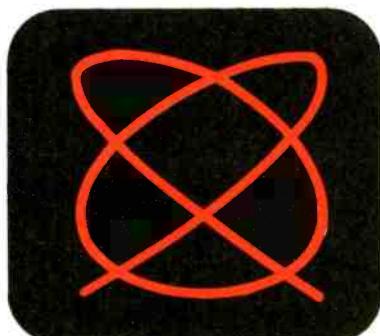
2.  $H = 500 \text{ Hz}$ .  $V = \underline{\hspace{2cm}}$



3.  $V = 1400 \text{ Hz}$ .  $H = \underline{\hspace{2cm}}$

4.  $H = 240 \text{ Hz}$ .  $V = \underline{\hspace{2cm}}$

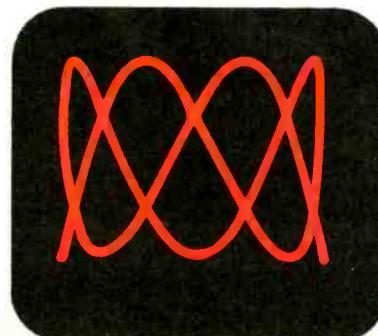
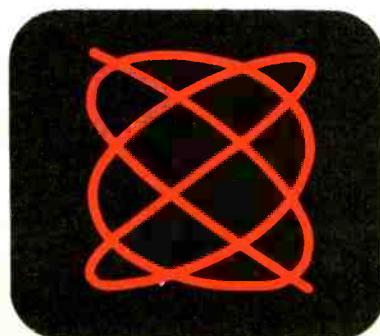
5.  $V = 1000 \text{ Hz}$ .  $H = \underline{\hspace{2cm}}$



6.  $H = 60 \text{ Hz}$ .  $V = \underline{\hspace{2cm}}$

7.  $V = 4200 \text{ Hz}$ .  $H = \underline{\hspace{2cm}}$

8.  $H = 120 \text{ Hz}$ .  $V = \underline{\hspace{2cm}}$

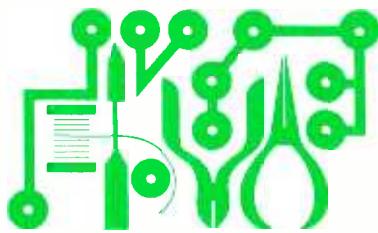


9.  $V = 3500 \text{ Hz}$ .  $H = \underline{\hspace{2cm}}$

10.  $H = 900 \text{ Hz}$ .  $V = \underline{\hspace{2cm}}$

1. 7.4, 1600 Hz  
2. 3.2, 750 Hz  
3. 7.3, 600 Hz  
4. 3.2, 450 Hz  
5. 5.6, 1200 Hz  
6. 4.5, 48 Hz  
7. 7.6, 3600 Hz  
8. 4.3, 1600 Hz  
9. 5.7, 4900 Hz  
10. 8.3, 2400 Hz

**ANSWERS:**



# Experimenter's Corner

By Forrest M. Mims

## SOLID-STATE OSCILLOSCOPE WRAP-UP

ONE OF the most popular topics that has been covered in this column is the solid-state oscilloscope. Many readers have requested additional information on this subject. Others have designed and built scopes of their own. This month, we'll review the recent history of solid-state scopes and describe several reader-designed versions. First, let's review a few basics.

**How They Work.** Figure 1 is a block dia-

gram of a typical solid-state scope. The horizontal sweep circuit is very straightforward and can be made up of standard TTL or CMOS ICs. An advantage of the CMOS logic family is its low power consumption and the flexibility of one of its members, the 4017, a chip that combines a counter and 1-of-10 decoder in a single package. The clock can be a simple 2-gate oscillator or an IC timer.

The operation of most solid-state scopes is straightforward. The display consists of an

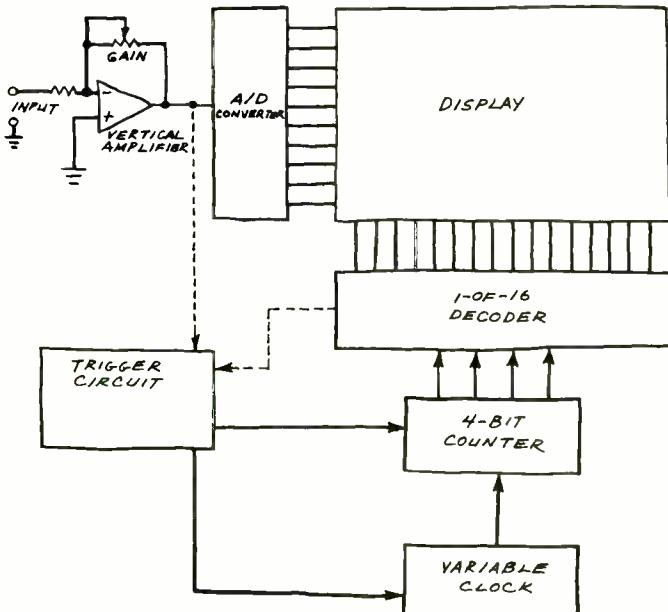


Fig. 1. Block diagram of typical solid-state scope.

gram of a basic solid-state scope. The horizontal sweep circuit is very straightforward and can be made up of standard TTL or CMOS ICs. An advantage of the CMOS logic family is its low power consumption and the flexibility of one of its members, the 4017, a chip that combines a counter and 1-of-10 decoder in a single package. The clock can be a simple 2-gate oscillator or an IC timer.

Most of the design variations in solid-state scopes occur in the vertical section's analog-to-digital converter. Early scopes required complicated voltage divider/comparator/decoder networks. Now, however, all of these functions are available in chips such as National Semiconductor's LM3914.

The operation of most solid-state scopes is straightforward. The display consists of an

array of optical elements such as LEDs or liquid crystals. Only one vertical column in the display is enabled at any instant, and the instantaneous amplitude of the applied waveform determines which element within that column is activated. If the horizontal sweep is synchronized with the frequency of the input signals, the outline of the applied waveform will be displayed as a pattern of dots. Synchronization can be achieved either by manually adjusting the timebase or by

means of an automatic trigger circuit that starts the sweep when the amplitude of the input signal exceeds a preselected value.

**Early Solid-State Scopes.** The development of visible LEDs in the early 1960's made possible compact graphic displays that could serve as the screens of solid-state scopes if teamed up with suitable driving and scanning circuitry. Back then, however, LEDs cost \$10 each and the necessary drive circuits would have been very complex. Accordingly, most work in the area of LED displays was limited to military projects.

I began experimenting with solid-state scope designs when LED prices began to tumble in the early 1970's. For those readers who have requested additional information, here's a condensed history of the solid-state scopes that have appeared in POPULAR ELECTRONICS and Electronics magazines:

In February 1974, I assembled a crude scope with a display made from eight LEDs. Figure 2 is a simplified schematic of this scope. The vertical drive circuit was far too complex for convenient expansion, so I experimented with series-connected LEDs having slightly different turn-on voltages. A rising voltage applied to a string of such LEDs causes them to light up in sequence. In spite of its simplicity, this method proved impractical because the LEDs had to be selected for various turn-on voltages.

Another simple way to create a bar-graph display is to connect LEDs across each of the resistors in a voltage divider, as shown in Fig. 3. As the voltage applied across the divider is increased, the voltage drop across each resistor increases proportionally. If the resistance of each resistor in the chain is larger than the one above it, then the LEDs will light up in bar-graph fashion as the voltage applied across the entire divider net-

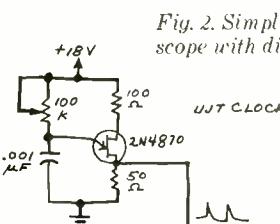
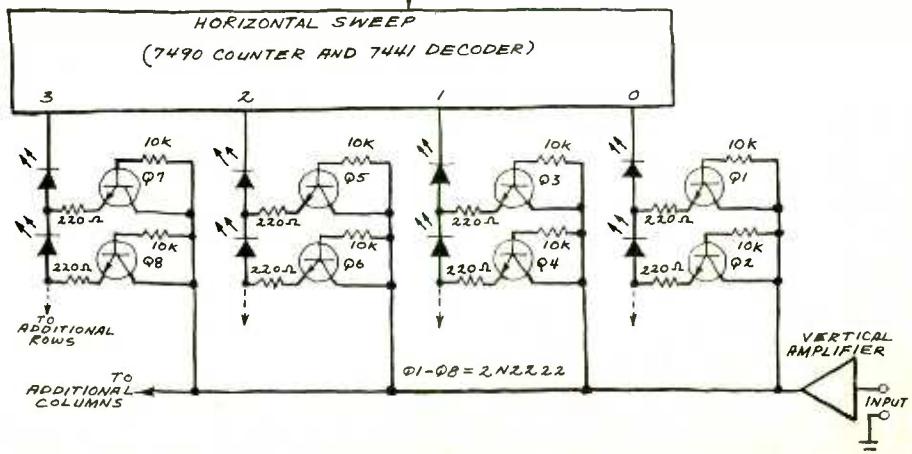


Fig. 2. Simplified schematic of an original scope with display made from eight LEDs.



## Experimenter's Corner *continued*

work increases. For example, using the resistance values shown in Fig. 3, I constructed a circuit in which the LEDs began to glow

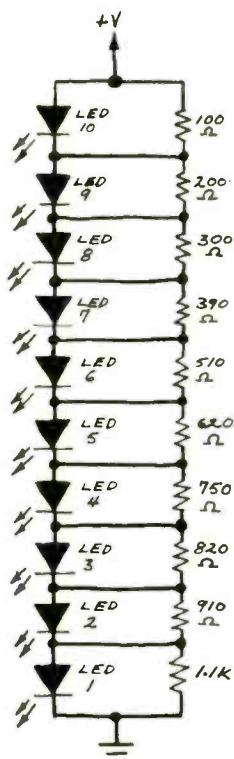


Fig. 3. Voltage-divider LED bar-graph display.

when the applied voltage was increased to the values shown below.

Led	Voltage
1	8.1
2	9.0
3	10.0
4	10.7
5	11.7
6	12.7
7	14.0
8	15.0
9	16.0
10	17.5

This vertical-axis circuit is very simple, but it has some major drawbacks. The input voltage must attain a relatively high value before the first LED begins to glow. Also, only bar-graph (not moving-dot) operation is possible. Nevertheless, I've

used this method to make a miniature solid-state scope with a  $10 \times 10$  LED screen. Figure 4 shows the circuit in simplified form. Excluding its power supply, this scope fits with room to spare in a pocket-calculator-size enclosure. Vertical sensitivity is adjustable from 0.01-volt per LED to 1.0 volt per LED, and horizontal sweep is adjustable from 20 microseconds per LED to 1.0 second per LED. Total power consumption of the display with all LEDs on is 308 milliwatts. The drive electronics consume another 54 mW. For more information about this scope, refer to "LEDs Replace CRT in Solid-State Scope" (*Electronics*, June 26, 1975, p. 110) and my book *LED Projects* (Howard W. Sams & Co., 1976, pp. 92-95).

A few years ago, Vernon Boyd de-

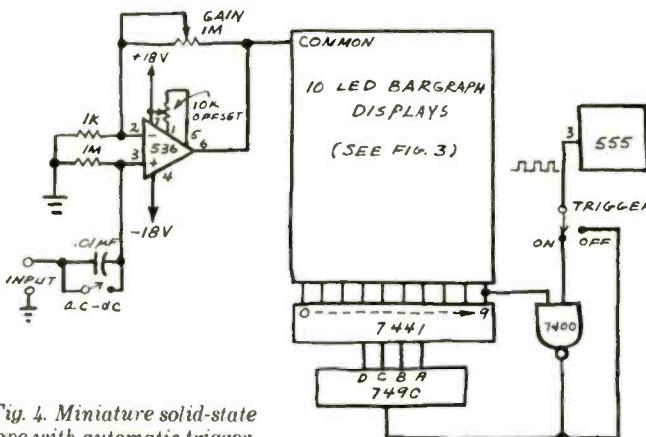


Fig. 4. Miniature solid-state scope with automatic trigger.

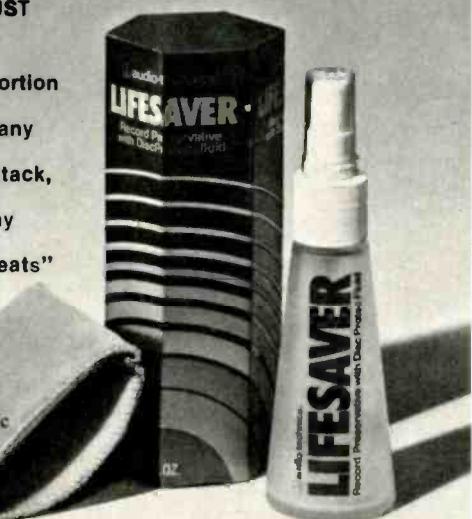
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scribed an improved solid-state scope in *Electronics* (November 24, 1977, pp. 128-130). His circuit employed a string of comparators and a decoder/driver network to generate a moving-dot readout. Almost one year later, the October 1978 installment of this column briefly described an improved scope with a  $10 \times 16$  LED screen. Construction and operating details followed in the April 1979 "Project of the Month."

The August 1979 "Project of the Month" was a "matchbox" LED oscilloscope. The key to the simplicity and tiny size of this scope was the use of the new LM3914 dot/bar display driver. Additional information about this scope, which can easily be expanded to provide a larger, more useful display, can be found in a brief article I wrote for *Electronics* (May 24, 1979, p. 169).

The most recent article in *POPULAR ELECTRONICS* related to solid-state scope technology was the hand-held LED spectrum analyzer featured on the cover of the September 1979 issue. This circuit's vertical driver is an LM3915, the logarithmic version of the LM3914.

Taken together, these articles will give you a good background in solid-state scope operation. If you don't have back issues of the various magazines that have been mentioned, consult a public or technical library.

**Readers' Solid-State Scopes.** Several readers have designed and built various solid-state scopes. For example, Bill Cikas, a self-taught electronics enthusiast

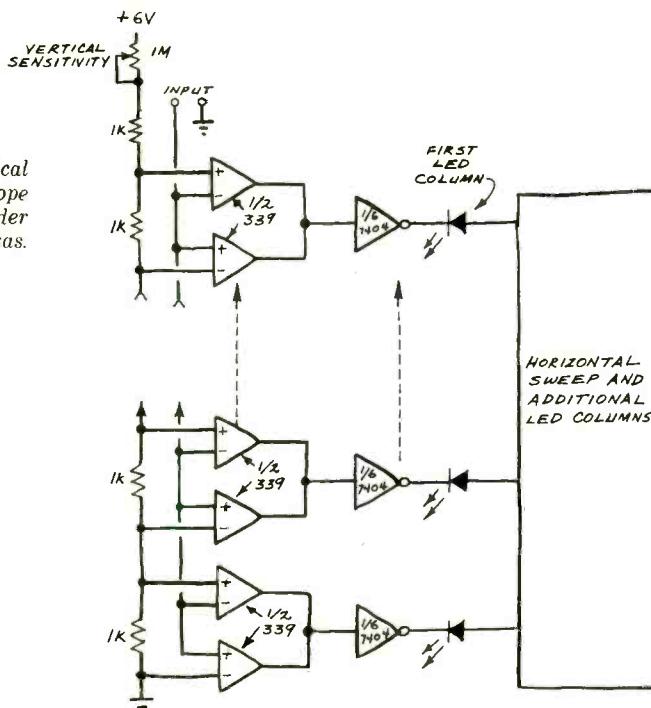
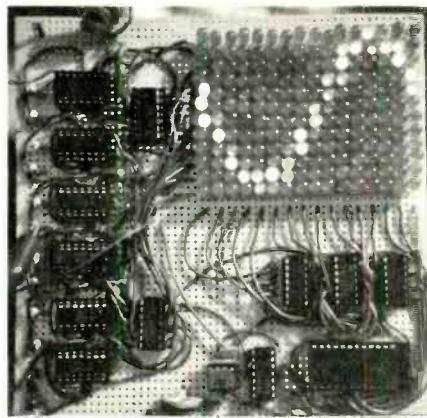


Fig. 5. Vertical section of scope designed by reader Bill Cikas.

Fig. 6. Photo below is of solid-state scope whose circuit is shown in Fig. 5.



living in Rockford, Illinois, has designed a scope with a 12 X 16 element LED display that fits on a 6" X 6" (15.3 X 15.3 cm) perforated board. A portion of the scope's vertical section is shown in Fig. 5, and a photo of the scope displaying a well defined sine wave appears in Fig. 6.

Steven Bolotin, a Chicago high school student, modified the scope described in the April 1979 installment of this column to permit both the negative and positive

halves of a waveform to be displayed. The modification, which is shown in Fig. 7, is inserted between the vertical amplifier and analog-to-digital converter and causes the incoming wave to ride on an adjustable dc level.

Joe Sharp of Orange, Virginia, has worked on the resolution problem caused by the limited number of display elements in the screen of a solid-state scope. He has determined that at least thirty display columns are required for every ten display rows to minimize smearing of the trace. Joe's scope employs three cascaded LM3914s, thirty 10-element LED bar arrays, and provides automatic trigger, ac/dc operation and various other features.

Gregory Kovacs, a student at Eric Hamber Secondary School in Vancouver, British Columbia, has provided details of a sophisticated solid-state scope project he has undertaken. For his half-term electronics project, Greg designed and assembled a scope that can display the waveforms of signals with frequencies of several hundred kilohertz.

A noteworthy feature of Greg's scope is the use of a Siemens UAA170 IC dot generator. Like the more recently introduced

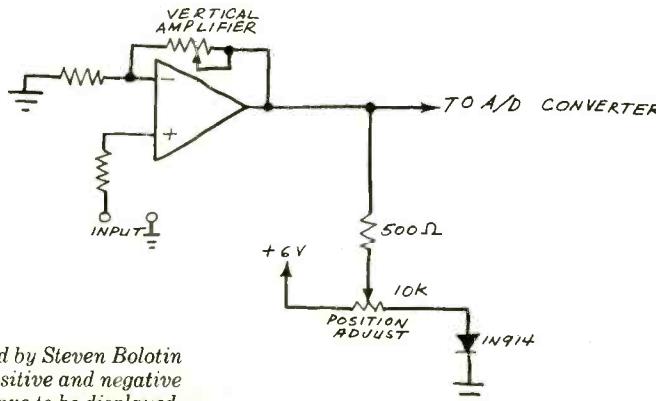


Fig. 7. Circuit designed by Steven Bolotin that permits positive and negative halves of a wave to be displayed.



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LM3914, the UAA170 eliminates the complicated voltage divider/comparator/decoder network that would otherwise be required for the scope's vertical section. In a paper describing his project, Gary observes that a scope using a single UAA170 vertical display driver would be limited to a maximum input frequency of only 50 Hz or so. Therefore, he assembled ten separate vertical display boards, each with its own UAA170 and column of 16 LEDs, and scanned each board with a conventional counter/decoder circuit.

Each display board contains an op-amp sample-and-hold circuit controlled by a Siliconix DG181 analog switch. A horizontal sweep sequentially strobes each display board's sample-and-hold circuit and the sampled voltage level is held until the next strobe pulse arrives. The result is the capability of displaying input waveforms having frequencies of up to 1 MHz.

An important consequence of Greg's decision to use individual sample-and-hold circuits is that his circuit can function as an analog storage scope. It can sample and display on its screen for several minutes any waveform before degradation caused by leakage in the sample-and-hold capacitors occurs. Figure 8 is a photo that shows the high-quality trace the circuit provides.

**Looking Ahead.** Solid-state scopes have a very bright future. Thanks to the LM3914

and similar moving-dot display drivers, experimenters and hobbyists can easily design their own scopes. By cascading vertical and horizontal driver ICs, oscilloscopes with displays containing hundreds of LEDs are possible. Although building such a scope would be tedious (the display board in one of my scopes has more than 650 solder connections), cost is no longer the limiting factor it was before LEDs could be purchased in volume for less than 10¢ each.

Homebrew scopes will become even simpler when manufacturers produce LED dot/bar displays with integral solid-state decoder/drivers. A complete scope could then be assembled in building-block fashion simply by connecting display columns to a standard horizontal sweep circuit. Individual, discrete LEDs are fine for low-resolution scopes, but are for a few reasons unattractive if high resolution is desired. Several alternative display technologies are available, the least costly being liquid crystals. Unfortunately, liquid-crystal displays are too slow for conventional multiplexing techniques.

Recently, however, Ian A. Shanks of the Royal Signals and Radar Establishment in Malvern, England, solved the liquid-crystal addressing problem with a design that continuously applies signals to all elements of the display. Shanks has assembled a prototype storage oscilloscope with a 100 × 100 element display measur-

ing 2.5" × 2.5" (6.45 cm × 6.45 cm). The waveform is displayed as a black line on a light background. It can be projected onto a screen by removing the display's reflective back and using it like a transparency in a slide projector. Shanks is building a new scope with a 128 × 256 element display and believes that a 1,000 × 1,000 element display can be made.

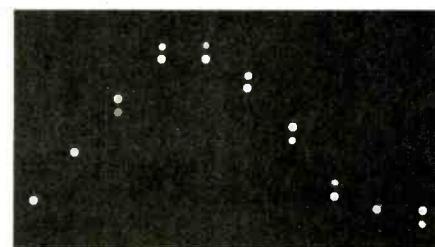


Fig. 8. Photo of waveform displayed on scope designed by Gregory Kovacs.

**In Conclusion.** The oscilloscope is the most important and useful piece of test equipment available. Hopefully, these solid-state scope developments will lead to pocket-size, high-resolution, full-feature scopes affordable by most experimenters and hobbyists. In the meantime, those described here show how you can make contributions to this new technology. ♦

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# Hobby Scene



By John McVeigh, Technical Editor

## FM AND AFC

**Q.** The FM radio in my car does not stay tuned to a station. Rather, it tends to lose that signal and even tune in another station. Is there a circuit you can provide that will remedy this problem?—T.I. Rueth, Jefferson, WI.

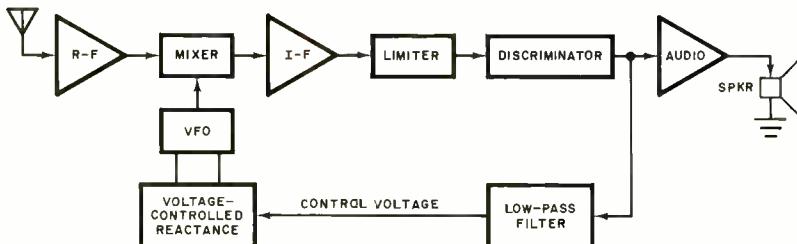
**A.** From what you say, it seems that the culprit is your receiver's afc (automatic frequency control) circuit. Afc is incorporated into FM radios to keep the radio tuned to one station and cancel thermally induced drift. However, afc circuits have their limitations. Perhaps the most troublesome is the tendency to be captured by a signal on an adjacent channel that is stronger than the desired signal.

Some receivers that have afc also include a switch which allows the user to defeat the afc function. This switch is a great aid when an attempt is made to tune

effective way to enhance weak-signal reception. A simplified block diagram of an FM receiver is shown here. Note that a portion of the demodulated signal present at the output of the discriminator is applied to a low-pass filter.

This filter converts the discriminator output into an afc control voltage in the following manner. If the local (variable frequency) oscillator is not operating on the correct frequency, the output of the discriminator will contain both the desired modulation signal and a dc component. The filter output, however, contains only the dc component. The magnitude and polarity of the dc level depend upon the error in the frequency generated by the local (variable frequency) oscillator.

The filtered dc level is applied to a voltage-controlled reactance, usually a voltage-variable capacitance (a Varactor diode). The reactance changes its value,



in a relatively weak station. If the switch is left in the "afc on" position, the afc function will pull the receiver over to the stronger, adjacent-channel signal. Placing the switch in its "afc off" position disables the afc and greatly eases tuning in and holding the desired signal.

If your receiver has such a switch, try placing it in the "afc off" position. This should prevent the receiver from being distracted by strong, off-channel signals. If your receiver lacks such a switch, you can either modify it so that the afc is switchable or employ some means such as a tuneable trap to attenuate the unwanted signal.

Perhaps the principal advantage to the use of an external trap is that it requires no modification of the receiver. However, it is difficult to construct a trap with a high enough Q to adequately attenuate an undesired signal 400 kHz or so away without also attenuating the desired signal. A more realistic way to attenuate the undesired signal is with a directional antenna, but that is not practical in a mobile application such as yours.

Assuming that you have no trepidations about modifying your receiver, adding an afc-defeat switch is perhaps the most ef-

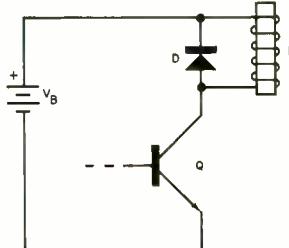
fective way to enhance weak-signal reception. A simplified block diagram of an FM receiver is shown here. Note that a portion of the demodulated signal present at the output of the discriminator is applied to a low-pass filter.

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When base drive is first applied to  $Q$ , current begins to flow through the coil. The voltage transient induced across the coil is positive because the time rate of change of the current through the coil is positive.

Assume now that protective diode  $D$  has not yet been added to the circuit and that base drive is being removed from the transistor. The collector side of the coil becomes positive with respect to the supply side. This second transient increases the voltage drop from collector to emitter as the transistor is coming out of saturation and is going into cut-off. Depending on the electrical parameters



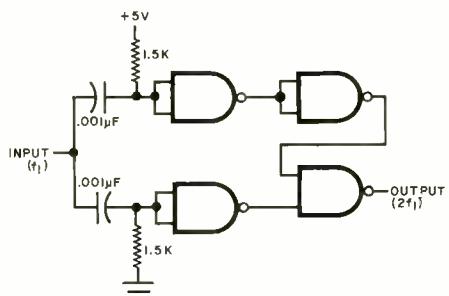
of the relay coil and the circuit to which it is connected, this voltage spike can be quite large—several hundred volts is not uncommon. This overvoltage can spell the doom of a low-voltage switching transistor.

Connecting diode  $D$  as shown in the figure prevents this spike from harming  $Q$ . As the transistor cuts off, the voltage spike forward-biases the diode, clamping the collector-to-emitter voltage drop to one diode drop above the supply voltage. The only disadvantage to diode protection is that the time required for the relay to drop out is extended slightly. This happens because current flows through the diode and the coil during the voltage transient. However, the increase in hold-in time is small enough to be of no consequence in most applications.

## TTL FREQUENCY DOUBLER

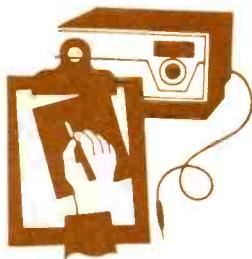
**Q.** Do you have a circuit for a frequency doubler employing TTL digital ICs?—Steve Hillage, Portland, OR.

**A.** The circuit shown here will double the frequency of a square wave applied to its



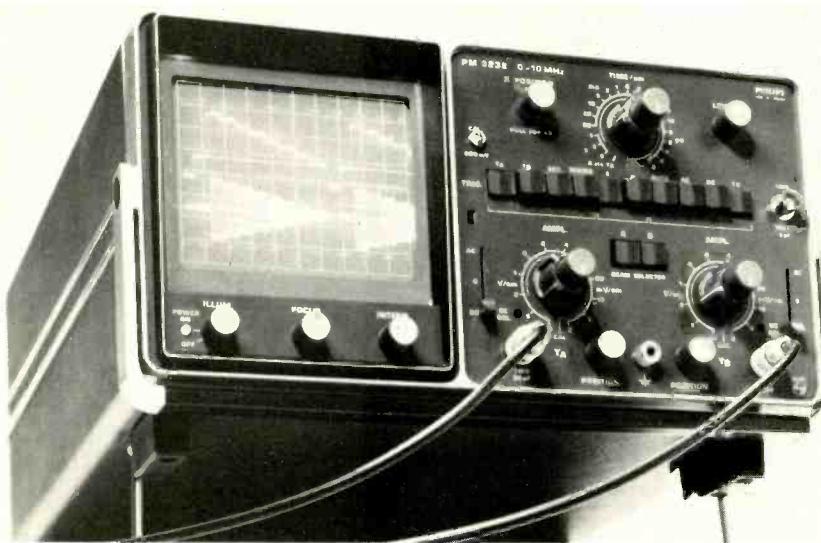
input. It can be assembled using a TTL quad NAND gate such as a 7400. The values of the resistors and capacitors comprising the input differentiators are not especially critical, so reasonable substitutions can be made. Note that this circuit is not intended for use with sine waves and other analog waveforms.

Have a problem or question in circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, N.Y. 10016. Though all letters can't be answered individually, those with wide interest will be published.



# Product Test Reports

## Philips Model PM3232 Dual-Beam Oscilloscope



MOST dual-trace oscilloscopes employ a single set of deflection plates and an electronic switch to "write" the two waveforms on the CRT screen. This approach has some shortcomings (see box), most of which can be eliminated by using a dual-beam system and separate deflection plates for each channel. The dual-beam approach is the one taken by Philips Test and Measuring Instruments in its Model PM-3232 oscilloscope.

The 10-MHz PM3232 oscilloscope has a single electron gun from which two beams are obtained with the aid of two totally separate sets of deflection plates and vertical amplifiers. In effect, then, this scope consists of two independent single-beam instruments, the two sharing a common CRT, sweep circuit, and power supply.

Measuring 20"D X 13"W X 7½"H (50.3 X 32.6 X 18.5 cm), the scope weighs a mere 9.5 kg (21 lb). Price is \$1195.

**General Description.** Each of the scope's vertical amplifiers is rated to respond from dc to 10 MHz in the dc mode (2 Hz to 10 MHz in the ac mode). The specified rise time is 35 ns, while deflection sensitivity is from 2 mV/cm to 10 volts/cm in 12 selectable ranges. Maximum permissible input potential is

± 400 volts dc plus peak. Long-term drift is rated at 0.25 cm/hour. Input impedance is 1 megohm shunted by 20 pF.

The scope is designed so that its two vertical amplifiers can also be used in the X-Y mode. Phase shift between channels is specified at less than 5° at 100 kHz.

The triggered-sweep system has a range of from 0.5 second/cm to 0.2 μs/cm in 20 switchable steps. Triggering can be from either input channel or from an external source. The input level for the external trigger is specified to be less than 1 volt peak-to-peak at 10 MHz at an input impedance of 100 kilohms shunted by 5 pF. The trigger mode is either automatic or normal or from TV-frame or line pulses. (They are sync strapped internally).

Intensity modulation is also provided. This ac coupled input has a 47 kilohms input impedance and requires a drive signal level in excess of 20 volts. The intensity-modulation frequency range is from 20 to 1000 Hz.

Provided is a built-in calibrator that delivers a 600-mV peak-to-peak signal with an accuracy of 1%. The frequency of this signal is approximately 2000 Hz.

The scope's CRT has a 4" L X 3½" H (102 X 82.6 mm) display area. It features a 10-kV

accelerator potential to insure a bright display at fast writing speeds. A metal-backed phosphor is used inside the CRT to prevent burning of the phosphor and to produce a very bright on-screen display.

Housed in a utility-grey metal cabinet, the scope comes with a separate carrying handle and fold-away front tilt stand. A protective cover fits over the entire front of the scope during storage and transport. Compartments inside the molded-plastic cover are provided for storage of the test cables. A locking mechanism built into the cover engages with a slot in the control panel to keep the cover securely in place.

**Testing the Scope.** For our tests, we connected the 10-MHz PM3232 in parallel with a 15-MHz laboratory-grade scope to permit us to observe very fast pulse waveforms simultaneously on both. The 15-MHz scope served as a standard against which the PM3232 was judged. Using this setup, we encountered a few surprises.

During our tests, the two traces on the PM3232's CRT did not waver from the highest down to the lowest sweep speeds. No matter what signals we applied to the two inputs, both traces always lined up properly, with no discernible time displacement between signals. We determined that this scope maintained rock-steady triggering even with pulses of only a few nanoseconds duration and low duty cycle. We also discovered that the PM3232 could trigger from either edge of the very-fast pulses of the test signal. The PM3232 held trigger long after our 15-MHz laboratory scope gave out. The excellent trace visibility, even at very high writing speeds (when the X5 magnifier was switched in), attests to the design of the new CRT and power supply used in the PM3232.

In comparison observations, we noted that both scopes displayed the waveforms clearly. However, the PM3232's display had none of the ringing that was clearly in evidence on the 15-MHz scope's waveforms when we used test signals with very fast rise and fall times. This illustrates why a well-designed 10-MHz scope that has a Gaussian response and no peaking coils (like the PM3232) is more useful for pulse observations than a wider-bandwidth scope whose top end drops sharply.

In an actual frequency-response test, we discovered that the PM3232 considerably exceeded its specified range in both the ac and dc modes. In fact, we had steady, reliable triggering out to beyond 30 MHz. We did not try to determine at just what point the scope failed to yield a usable trace waveform, but it was obvious that it was beyond the 30-MHz point.

Input sensitivity and calibration accuracy were also considerably well within specifications. The two vertical amplifiers performed identically, with no discernible phase shift up to 500 kHz. Triggering was positive and held rock-steady in both the internal and external modes of operation.

**User Comment.** The Philips Model PM3232 oscilloscope was a pleasure to use. Its con-

## Dual-Beam VS Dual-Trace Oscilloscope

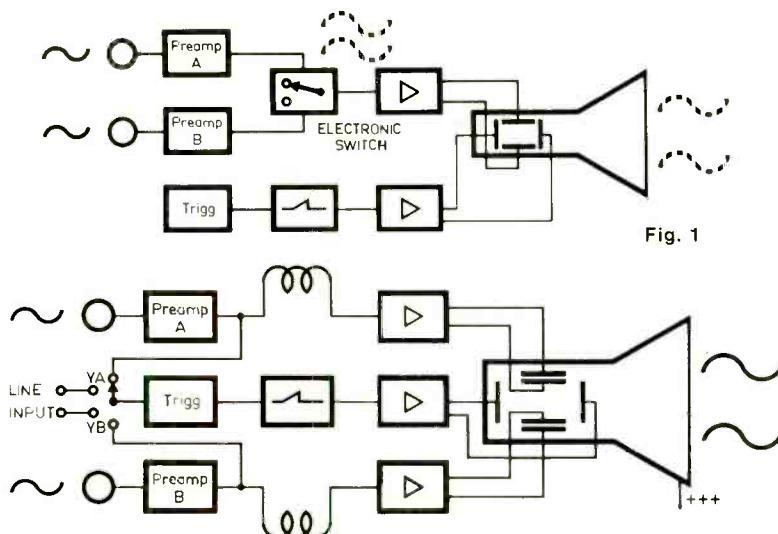
The simultaneous display of two waveforms on an oscilloscope screen is usually performed by what is termed a "dual-trace" system. (Fig. 1) Here, two similar but independent vertical amplifiers are used to influence the trace generated by a single-gun electrostatic cathode ray tube (CRT). An electronic switch built into the scope is used to select one of the two inputs. At that instant, the scope appears to have only one vertical amplifier. (Only one amplifier is activated at any given instant; the other is held in cutoff.)

The trace of the signal on the electronic-switch-selected channel appears on-screen and can be located anywhere on the CRT by operating that channel's vertical position con-

and appear as a series of narrow square waves that can be visually disturbing.

Dual-trace oscilloscope manufacturers avoid this problem by including a second ("alternate") switching mode. In this mode, one input channel is switched in at the beginning of a sweep and remains on-screen for the duration of that sweep. On the next sweep, the second channel is switched on and the first is cut off. At relatively high sweep speeds, the two appear to be on-screen simultaneously.

There are, of course, problems in the alternate mode, just as there are in the chop mode. When low repetition rate signals are viewed, the cut-off channel's trace may disappear from the screen momentarily. The result is a display



trol. Amplitude of the trace depends on where that channel's vertical sensitivity is set.

On the next clock pulse, the electronic switch cuts off the first vertical amplifier and turns on the second identical channel. The input waveform for this channel is then displayed and positioned on the CRT screen in accordance with the setting of its controls.

If the electronic switch operates at a high enough frequency (called "chopping") and there is a correlation between input and switching frequencies, the two images appear on-screen simultaneously and are independently controllable. If there is a correlation between the input and switching frequencies, however, the viewed images can be broken up

that appears to be a single trace that jumps up and down at a low rate on the CRT screen. A companion problem is that the sweep is usually triggered at different times by two related but different frequency signals. Hence, determining time relationships between two signals becomes difficult. This is particularly annoying when a stream of time-related digital signals is being observed.

Philips has overcome the problems inherent in the alternate and chop modes in the Model PM3232 oscilloscope by using a two-beam trace-writing system (Fig. 2). This technique permits two traces to be controlled and displayed simultaneously and eliminates the need for the electronic switch.

control panel is well laid out and easy to read and interpret. Signal, trigger, and mode selection are accomplished via a bank of smooth-operating pushbutton switches. A separate pair of pushbutton switches permits either channel A or channel B (or both) beam selection.

In operation, the PM3232 performed in a manner we normally expect from costlier laboratory-grade oscilloscopes. The controls operated smoothly and positively. Trace waveforms on the CRT were bright and easy to see, even at writing speeds well beyond

the scope's 10-MHz high end. Electrical performance was flawless.

The asking price of the PM3232 is not inexpensive. However, when one considers this instrument's performance, which is on a par with many laboratory oscilloscopes costing several times more, the price is insignificant. If you can afford to spend \$1000 for an oscilloscope, you can't afford not to consider an extra \$200 for the assurance the PM3232 provides in delivering every bit of the performance you pay for.

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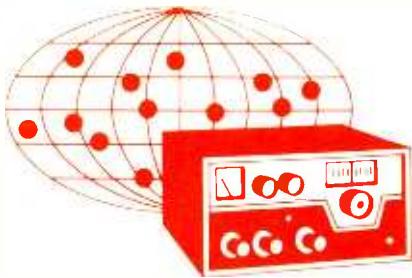
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# DX Listening

By Glenn Hauser

## A WORLD OF NEWS

**I**F YOU rely on domestic radio and TV networks, newspapers and magazines, for news about the world, you are getting only one side of the story. No matter how diligently those who process the news for you may strive to be objective, their points of view inevitably reflect an American bias. Most people aren't even aware they have the alternative of hearing news direct from many countries around the world on shortwave.

On our domestic media, everything has to pass the test of "Is it news in America"? That's why there's so little coverage of Latin America and Africa—except for crises. The truth is, our world is so interdependent that we ignore events elsewhere at our own peril.

Equally as important as getting news from other countries, about other countries, is getting news from other countries about the USA. You may ask, what value can this have? We have a highly developed and extensive free press. The answer is that for once and at last, you will be getting a fresh perspective on events in the USA.

From some stations you will hear lies and distortions; others simply place a different emphasis on the importance of different stories. There really is no one correct order of priority in the day's news, though by comparing ABC, CBS and NBC evening television newscasts, all of which originate within a few blocks of each other, you might conclude that there is.

For a modest investment in a shortwave radio, you will suddenly have access to a world of news, without the intervention of American reprocessors. About 60 countries can be picked up with news in English. The latest times and frequencies appear four times a year in POPULAR ELECTRONICS, with updates almost every month. While we don't give the exact times for newscasts, virtually every transmission listed contains at least one newscast—in most cases on the hour or at the beginning of the broadcast.

**British Newscasts.** Far in front of all others in the objectivity and breadth of its world news coverage is the BBC. The World Service carries news on the hour, but not every hour, to allow some flexibility in scheduling other programmes. There are many other news-related shows, such as "The World Today", "Outlook", "24 Hours" and "Radio Newsreel" carried five or seven days a week at fixed times.

Evidence of the myopia among American domestic broadcasters is the fact that only a handful out of thousands of stations rebroadcast BBC 'network' news on a regular basis. It's safe to say that the idea has not even occurred to most of them, though certainly the idea that they should join an American network has been considered and accepted.

Of course, BBC broadcasts are noncommercial, and its newscasts may not be 'sponsored'. Stations relaying it would be obliged to go nine minutes without a local commercial. So you see the standard BBC newscast has about three times as much news in it as the commercial 'five-minute' newscast.

On the other hand, shortwave listeners can hear news and feature programs from all domestic commercial networks, on one station—AFRTS. The commercials are removed, but replaced with public service announcements. Still, it is enlightening to hear how much news-in-depth programming is available from the networks but seldom heard at a waking hour from affiliates.

Several other shortwave stations are outstanding in their regional news coverage. For Europe, Swiss Radio International's weekday broadcasts of "Dateline" are excellent, as are Radio Nederland's "Newsline."

For Africa, the BBC is again the leader, as it serves as a surrogate 'domestic' station for the continent of Africa, with special programming in English from Britain, but for and about Africa. This is something it does not attempt to do for any other region. Other stations with distinct African services, but without the range of the BBC, are Radio France Internationale, Voice of America and Voice of Germany.

**Other Areas.** Radio Japan is the leader in Asian News, with 10-minute Asian newscasts concluding each of its hours to North America, at 0035 and 0220 GMT. Radio Australia emphasizes the Pacific and Asian angle, and is more easily heard than Radio Japan.

South America does not have any such representative on shortwave. The only countries with international services in English are Argentina, Brazil, Chile and Ecuador. Argentina does not have a commitment to news, the station is hard to pick up, and the country is in a state of chaos. Brazil offers the best potential, if liberalization continues and if its station decides to get off its soft-features-and-music kick. Chile's only interest

is in pushing its anti-communist line. The Ecuadorian station isn't Ecuadorian at all, but American, with the same wire services heard on domestic stations.

Israel is the only country in the Middle East with an effective North American service in English. Its news coverage receives both praise and criticism, which is a sign they're on the right track.

Eastern Europe is a dark area where 'news' has to meet the requirement of portraying the state in a favorable light. Mostly, it's just boring; but if you seek out such programs as "From the Foot of the Column" on Fridays from Radio Budapest, or "News About the Soviet Union" nightly on Radio Moscow, you will begin to get a glimpse of what we would call news—as opposed to the political rhetoric rampant on the stations' regular "newscasts."

You never know where a major news story is going to develop next. With the help of the schedules in POPULAR ELECTRONICS, you can get all kinds of points of view on it—in many cases direct from where it's happening.

**A New Decade.** What will the 1980s bring in the shortwave radio field? The prospect of more and better shortwave receivers seems assured. Digital readout will be the rule rather than the exception. Receivers will be more compact without the drawbacks of reduced selectivity and image rejection.

More and more third-world countries will get into international broadcasting. The Voice of Nigeria is expected to be testing new 500-kW transmitters now, enabling it to begin services to North America and other previously untargeted areas within a few months.

Gabon, a small African nation, began speaking in a big voice last September with tests of "Africa Number One", thanks to French financial assistance. The station was expected to become a relay for Radio France Internationale, which already devotes the lion's share of its efforts to dawn-to-dusk broadcasts in French to Africa on as many as a dozen frequencies at once direct from France—neglecting its friends in North America, for instance.

Venda, one of the South African 'homelands' of questionable independence, announced plans to begin an international broadcasting service audible throughout the world, as soon as funds become available. Thus, "Radio Thohoyandou" may one day become a household word.

Denmark has kept a token shortwave service on the air since foreign languages were dropped in favor of Danish only via an ailing and now puny 50-kilowatt transmitter. It has announced it would activate a 500-kW shortwave transmitter at a new site, Mors, in northern Denmark—but not before 1983 or 1984. It remains to be seen whether legal restrictions on broadcasting in English will be lifted once it is in service. The staff of Radio Denmark has always wanted to maintain broadcasts in English.

Slow-scan television may be tried by shortwave broadcasters. Radio Australia has inquired whether monitors would like to see a picture now and then in addition to listening; and a Radio Japan listener expressed the desire for SSTV accompanying a report on bathing-suit fashions!



**STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION (Required by 39 U.S.C. 3685).**

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# Computer Bits

By Hal Chamberlin

## MICROCOMPUTER POWER SUPPLIES

**N**EXT TO the cabinet enclosure, the dc power supply is probably the most mundane component of a microcomputer system. As a result, it is often overlooked by the prospective purchaser of such a system.

One should know that the power supply has a great deal of influence over the reliability and expandability of the system, as well as size and weight. While a well-designed and constructed power-supply system is usually ignored by the user, a marginal power supply constantly calls attention to itself through unexplained system crashes, overheating or outright failures.

**Changing Power Requirements.** Before discussing the various power supply philosophies and technologies, we will examine the actual power requirements of today's systems.

Early personal computers such as the Altair-8800 and other S-100 bus machines required three or four different power supply voltages (+12, +5, -5, and -12 volts after regulation) at fairly high current levels. These requirements were a result of the microprocessor and memory IC's used by these machines. In particular, the early 1K static semiconductor memory IC's required as much as 1.5 amperes of +5 volts for each 4K. With full memory (64K) installed, up to 24 amperes of current was needed for the memory. The CPU and other peripherals could easily swell this figure beyond 30 amperes! With that kind of current consumption, power distribution and cooling became major design considerations.

Modern microcomputer circuitry requires far less power than the earlier units. The biggest improvement is in memories, where a full 64K of modern dynamic RAM actually consumes less than 1 ampere and fits entirely on a single printed-circuit board.

The introduction of low-power Schottky TTL logic reduced the consumption of other parts of the system to about a quarter of their former levels. In addition, some systems now require only one voltage level (+5 volts) to operate the microprocessor, memory, and miscellaneous logic. Consequently, power supply design and cooling is much less of a problem for them.

**Central vs Local Regulation.** All power-supply voltages used by microcomputer circuitry must be carefully regulated for safe and reliable operation, of course. Two distinctly different approaches to doing this have evolved over the history of microcomputers. The first and most obvious method used one high-current central regulator for each voltage in the system. This was the method used exclusively in the past.

However, some problems arose with power distribution. When dealing with low voltages, such as 5 volts, at high-current levels, even short lengths of heavy wire or a slightly oxidized electrical contact could develop a substantial voltage drop. For example, at 30 amperes a resistance of 0.0016 ohms will create a drop of about 50 millivolts, a 1-percent loss at 5 volts. Keep in mind that TTL logic can only tolerate a 5% loss before malfunctioning!

Another problem with central regulation is that the heavy power supply wiring from board to board also transmits digital noise generated on one board to all other boards in the system. Elaborate systems of chokes and bypass capacitors on each board were needed to prevent such noise coupling.

Many microcomputer systems today, notably S-100 systems, use local regulation on each board. The main power supply in such systems provides rectified and filtered (but unregulated) voltages that are about 50% higher than

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REACT is a tax exempt non-profit organization whose only mission is to bring help immediately when there is trouble through the use of CB radios.

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REACT is recognized by law enforcement, public service and other governmental organizations at all levels. It maintains a formal cooperative working agreement with the American National Red Cross, providing local disaster communications for Red Cross Chapters. REACT works closely with the U.S. Department of Transportation and state police in highway safety and communications affairs. As Col. Sam Smith, retired head of Missouri's Highway Patrol puts it:



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REACT is a volunteer association. Its 50,000 members are organized into more than 2,000 highly disciplined, autonomous REACT teams throughout the country coordinated, supported and represented by their International Headquarters in Chicago, Illinois. REACT members donate their time, energy and even their personal finances to organized monitoring of CB radio channel 9. This is the channel officially designated by the Federal Communications Commission to be used for emergencies and assistance to travelers only. When a call is heard by a REACT monitor, he immediately telephones the proper authorities to rush necessary assistance.

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*Ruffy Joe Higgins*  
National Safety Sheriff

REACT volunteers are from all walks of life, every race and religion, every trade or profession—truckers, doctors, firemen, housewives, businessmen, students.



REACT volunteers are thoroughly trained. They know the best, most efficient communications procedures—just like a police radio dispatcher. They keep complete monitor records, lists of authorities and service organizations. They know who to call and when.

## How do you benefit?

Last year alone, REACT volunteers were instrumental in bringing help faster to the victims of more than a million automobile accidents alone—seventeen minutes faster than accidents not reported by CB, according to research conducted in Detroit, Michigan, by Wayne State University. Over three million motorists received valuable highway or city directions that cut literally millions of miles—and thousands of gallons of fuel—from their driving.



## ... but REACT serves its communities in many other important ways.

If your community has ever suffered the agonies of tornadoes, floods, or other natural disasters it's almost a certainty that your REACT teams played a vital role, providing local emergency communications when power and phone lines were down . . . assisting the Red Cross in disaster relief by delivering emergency food and medical supplies . . . transporting the injured . . . helping police with crowd control. In a hundred other ways REACT teams serve the public in community projects such as March of Dimes drives, communications for parades,

scout activities and county fairs. All in the spirit of public service that is so uniquely American.

## How is REACT financed?

Funds to operate and administer REACT International have come to us in the solid, traditional American way—100% from private contributions and the dues from the members themselves.

Through the years, about 30% of REACT International's operating budget has been provided by contributions and grants from a variety of public spirited corporations, and the balance by REACT members themselves through annual dues of \$5.00 per member.

These funds are used entirely to provide vital training programs; identification materials; a quarterly newspaper that communicates ideas and experiences to improve REACT team operations; inter-team communications; a Junior REACT program to train future REACTers in both citizenship and emergency procedures; and liaison with public safety and other government organizations.



Each individual, autonomous REACT team may also charge local dues and accept tax deductible contributions from local businessmen, to pay the cost of local meetings, training sessions and miscellaneous team expenses. But in its entire seventeen year history, no REACT team has ever charged the public for its services.

## Why a financial crisis now?

For the first time in its history, REACT is appealing directly to the American public—the true beneficiaries of REACT volunteer emergency services—for financial support. We do so reluctantly, realizing that skyrocketing costs are hitting every citizen where it hurts. But inflation is not REACT's most serious problem. Through the years, REACT has relied heavily on the generous contributions of manufacturers, particularly those in the communications industry to help us provide the tools necessary for effective volunteer emergency communications. However, even our modest goals for industry support for 1979 have not been realized.



Our combined income for 1979 is below our minimum operating forecast by nearly 20%. Some vital services already have been curtailed. International Headquarters staff and facilities have been cut to the bone. But it's not enough. Without your direct tax deductible support . . . unless the public now comes to the aid of REACT . . . the effectiveness of the program will be further and seriously jeopardized.

We cannot, and will not, ask our REACT members for additional dues or assessments. They should not be forced to pay additionally for the privilege of serving the public! In fact . . . we have pledged to our membership that any public funds generated by this appeal in excess of our immediate budgeting needs and the financial safety of REACT International will be returned to the membership in the form of reduced dues for 1980.

## How much is needed? How much should you give?

REACT needs are truly modest for such a large organization. We are not out to impress anyone—except with the quality and value of our volunteer emergency services.

So whatever you send will be a godsend. \$5.00 . . . \$10.00 . . . more if you can.

All contributions will be acknowledged and are fully tax deductible. If you send us \$5.00, we will send you, as a token of our appreciation, a "Help" flag for display on your vehicle if you are stalled on the highway . . . plus a list of all REACT team locations so you can call directly for help on CB channel 9. If you send us \$10.00 or more, we'll also send you a beautiful 1979 Road Atlas which includes both CB information and a useful national mileage chart.

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the final regulated voltages required by the boards. For example, 8 volts is usually supplied for the 5-volt line and 16 volts for the 12-volt line.

Each board contains an IC regulator for each different voltage required by that board. Although the cost of 30 amperes worth of 1-ampere regulators may be more than a single 30-ampere central regulator, the small regulators can be purchased one at a time, along with the expansion boards.

Local voltage regulation overcomes many of the problems associated with centrally regulated power distribution. Voltage drops in the main power distribution are of little consequence as long as it is not so great as to exceed regulation capability of the local regulators. Ground wiring, though, must remain heavy because voltage drops along ground leads either add to or subtract from the logic signal voltages. This might lead to the possibility of a zero being interpreted as a one or vice-versa. Local regulators also prevent noise coupling both forward and backward through them, thus reducing the need for noise-filtering components. Again, this does not help ground noise, which must still be controlled through the use of heavy ground wiring and multiple ground connections to the boards.

Local regulation is not without its problems, however. The most severe of these is that the local regulators dissipate a lot of heat, in many cases as much as the board logic itself. This causes a considerably greater buildup of heat around sensitive logic components than would occur in an equivalent centrally regulated system. Here, all of the regulator heat is in the power supply area. As a result, locally regulated boards should not draw much more than 1 ampere from the unregulated supply unless a fan is present in the system to remove the 10 or more watts of heat that this represents. The 1-ampere restriction, however, is much less of a problem now than it was in the past.

Another problem with local regulation that concerns some people is fail-safe operation. All local and most central regulators are *series* elements which control the output voltage by acting as a variable series resistance. If the regulator element should fail as a short circuit, the twice-as-high unregulated voltage directly enters the logic circuitry, perhaps causing severe damage. A large centrally regulated power supply can absorb the cost of elaborate crowbar overvoltage protection circuitry, but

the cost of adding such circuitry to each board in a locally regulated system would be prohibitive. Although integrated-circuit regulators have only modest overvoltage protection circuitry built-in (usually a zener diode across the output), other internal protection makes short-circuit failures very rare.

Perhaps the most insidious problem with local regulators is over-reliance on their regulation capabilities. For proper operation, most IC regulators require an unregulated input at least 2 volts higher than the regulated output voltage. With any less input, the device simply stops regulating and passes ripple and noise directly to the logic circuitry. The problem is insidious because, although a voltmeter may indicate sufficient unregulated voltage (such as +7.5 volts into a 5-volt regulator), the superimposed ripple voltage may momentarily drop below the critical 7-volt level. Use a dc-coupled oscilloscope to check this problem.

**Power Conversion Systems.** Ignoring the exact method of regulation, most of the bulk and cost of a microcomputer power supply is in the power conversion system, which takes 117-volt ac power and produces rectified and filtered low-voltage dc for the regulators. Three methods of power conversion are used.

The first, which is probably the most common, is the classic iron-core transformer and bridge or center-tapped rectifier system, with a bulk capacitor filter. While conceptually simple and inexpensive, this method has many pitfalls for the inexperienced designer. The most serious of these is the extremely poor voltage regulation which must be overcome by the regulator. It is not unusual for the low-load/high-line output voltage to be double that of the full-load/low-line output voltage. If the regulator is to function under the latter condition, normal conditions will mean a very high unregulated input voltage and, consequently, a lot of heat dissipation in the regulators. Marginally designed power supplies of this type will drop out of regulation during momentary low-line conditions, and possibly cause malfunction of the microcomputer.

The second, although more expensive, approach is to use a *constant voltage transformer* (CVT). This type of transformer has two winding "windows" in the core, with the primary in one window and the secondary in the other. A large ac capacitor is connected across one of the secondaries that resonates

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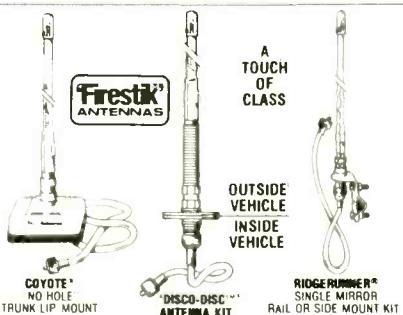
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# Software Sources

By Leslie Solomon  
Technical Director

**Apple Things.** Amongst this firm's software for the Apple II is Typesetter (\$22.95) a high-resolution graphics character system with scaling colors, upper and lower case, PET-style graphics, and an extra character set; Data Handler (\$49.95) a file handling and manipulating system with disk-oriented data base management; Text Editor/Word Processor (\$99.95) a character-oriented editor and operating system; Linfit (\$6.95) a linear regression forecasting analysis and plotting package; Hires Tic-Tac-Toe (\$4.95) four dimensional "tic-tac-toe" using high-resolution graphics, and a series of program packs. Hires programs, and a line of business programs. Andromeda Computer Systems, P.O. Box 19144, Greensboro, NC 27410 (Tel: 919-852-1482).

**Computer Mail.** PCNET is now making available software for the PET (other computers will be forthcoming) to provide mail support for personal computer users with the conventional telephone system. It is hoped that a combination of the PAN software (\$12 on cassette) and a modem will provide this service. Contact People's Computer Company, 1263 El Camino Real, Box E, Menlo Park, CA 94025 (Tel: 415-323-3111).

**6809 Operating System.** PSYMON (Percom System Monitor) is a 1K operating system for Percom's SS-50 bus compatible 6809 control computer and other 6809 systems. It includes 8 monitor-type commands and 15 callable utilities. Firmware is available in five ROM versions: Percom SBC/9 (\$39.95), Percom 6809, Creative Micro Systems EXORcisor, Percom-adapted SWTP MP-2A, and SWTP MP-09 6809 system. The latter four are \$69.95 each. A user manual that includes a listing is \$9.95. Percom Data Company, 211 N. Kirby, Garland, TX 75042 (Tel: 1-800-527-1592).

**Apple Text Editor.** APPLE-WRITER is a powerful text editor for Apple II that includes merging, full text control such as insertion and deletion, text rearrangement, auto search and replacement, text justification, upper and lower case. With a 48K machine, 12 full pages of text can be stored. The package consists of two diskettes (working and backup) with one diskette including a full

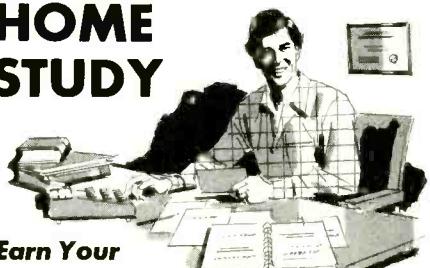
interactive tutorial that the user can call on-screen for quick learning or review. Available from Apple dealers at \$75.

**PET/CBM Programs.** Three new PET/CBM software packages: "Checkbook" assists in balancing a checkbook, selects and displays checks by person, purpose or date, and sums checks by category or person. "Accounts" allows creation of data base for names, addresses, invoice and purchase order numbers, and amounts of purchase. It locates specific companies, determines amounts owned and displays past-due accounts. "Calendar" keeps track of appointments, schedules social engagements and is an all-purpose datebook. Each program: \$9.90 for cassette, \$12.95 diskette. Specify computer. TIS, Box 921, Los Alamos, NM 87544.

**Apple Word Processing.** SUPER-TEXT is a multi-paging system that allows viewing two pages simultaneously. You can keep notes on one screen while you edit the other. It is a character-oriented editor with complete cursor control, has built-in floating-point math and auto tab, you can add or insert a character, word or line; features auto LFCR to eliminate word breaking at end of line, right and left justification, scrolling, move to block marker, copy, delete or save on disk. It also has print controls, single or double line spacing, variable page length and width, and automatic page numbering. Underscoring, line centering and auto link and printing of multiple text files are also included. \$99.95. Muse Co., 7112 Darlington Drive, Baltimore, MD 21234 (Tel: 301-661-8531).

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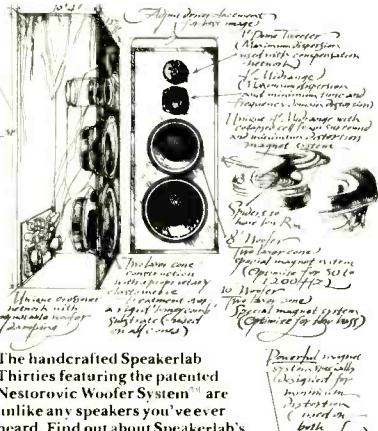
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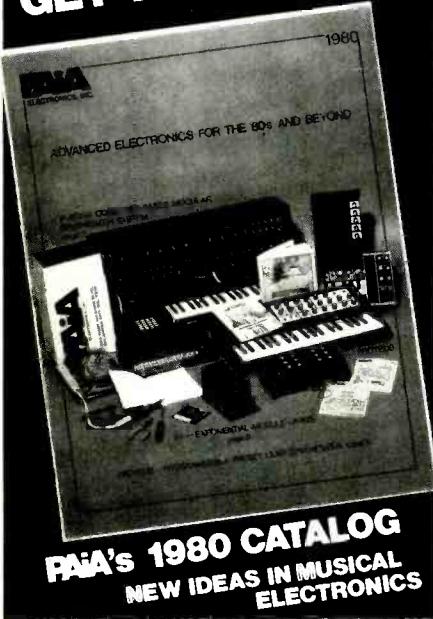
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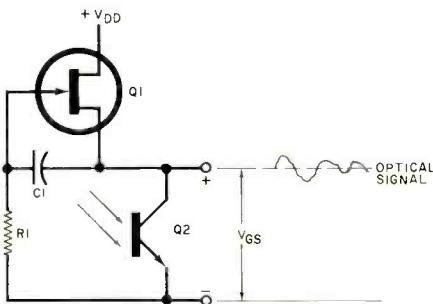
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### TIPS continued

its destruction. However, there is a simple way to prevent overheating. Simply spray the IC with an aerosol coolant before soldering its pins. Take care in doing this—lowering an IC's temperature too much can cause cold solder joints. This technique can also be used when unsoldering and removing IC packages.—Robert Apel, Newark, NJ.

### A SIMPLE SECURITY SYSTEM

The simple and inexpensive circuit shown here can be employed as a security alarm. If the normally open sense switch is closed, the buzzer or relay will be activated and the SCR will turn on. After the sense switch has reopened (or the burglar has cut the wires running to it), the buzzer will be silenced but the lamp will remain



glowing. This lamp can be used to activate a central alarm or simply to indicate which entry point was being used if more than one entrance is equipped with a sense switch. Just about any components can be used, with the SCR chosen to handle the current through the lamp and resistor  $R$  chosen to limit gate current to an acceptable value.—Kenneth B. Blois, APO San Francisco

### ETCHING BRASS

Metal name or call letter plates really dress up a radio shack. You can readily make them using the process of electro-etching, even if you have no etching experience. The brass is connected to the positive terminal of a six-volt storage battery or line-operated dc power supply. A strip of copper flashing is attached to the negative terminal. Both are hung in a glass or plastic container filled with a copper sulphate (blue vitriol) solution. The brass plate becomes etched at any point where the solution contacts it. Any portion of the metal protected by a substance resistive to the etchant will remain intact. Wax is a suitable etch resistor.

Prepare a brass blank for etching by dipping it in hot paraffin. Then, using any pointed tool, scribe the lettering you want to etch. To make the solution, stir one quart of copper sulphate crystals into a quart of water until dissolved. The solution will take on a clear blue color. Then place the metal strips in the etchant and connect them to the power supply terminals. Incidentally, the process can be employed in reverse if raised lettering is desired. Blue vitriol crystals are readily available. They are commonly used to discourage the growth of roots in sewers and drain pipes.—Harry J. Miller, Sarasota, FL.

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# PROJECT OF THE MONTH

## Digital Stopwatch

BY FORREST M. MIMS

HERE'S a two-digit counter with a crystal-controlled timebase that you can either use as a stopwatch or modify for other timing applications. The timebase (see Fig. 1) uses an MM5369 crystal-controlled oscillator/divider. This chip generates a stable 60-Hz reference when connected to a standard 3.58-MHz color TV oscillator crystal. A miniature trimmer capacitor ( $C_2$ , 1.5 to 20 pF or similar) permits you to tune the oscillator to precisely the right frequency. For best results, connect an accurate frequency counter to pin 7 and adjust  $C_2$  until the counter indicates a frequency of 3.579545 MHz.

If you don't have a miniature trimmer capacitor, substitute a 5-pf capacitor for  $C_2$ . Then twist two lengths (approximately 2" or 5.1 cm long) of wrapping wire together and solder one end of each wire to each lead of  $C_2$ , leaving the other end of each wire unconnected. The two leads form a "gimmick" capacitor in parallel with  $C_2$ . Now you can trim the oscillator by snipping off short sections at the free ends of the twisted wires until the desired frequency is obtained.

The 60-Hz output of the MM5369 is divided down to 10 Hz by a 4017 CMOS counter and is further divided to 1 Hz by a second 4017. These two output signals are the project's timebase.

Figure 2 is the schematic of the counter portion of the Digital Stopwatch. Depending on the position of  $S_3$ , either 1-Hz or 10-Hz square waves are applied to the input of the 4518 CMOS dual BCD up-counter. To prepare the project for the timing of an event, place  $S_2$  in its STOP position and toggle  $S_1$  from CLEAR to READY. Then place  $S_2$  in its START position at the beginning of the interval to be timed. When the event is over, place  $S_2$  in its STOP position. The elapsed time will be frozen and displayed on the LED readout.

This circuit can be modified to take advantage of the latch built into the 4511 CMOS decoder/driver ICs. When a logic one is applied to pin 5 of these chips, the data present at their BCD inputs are stored. This permits the continuing display of the result of one timing sequence while the dual counter is timing a later event.

The basic two-digit counter shown in Fig. 2 will increment from 0.0 to 9.9 seconds in 0.1-second steps when the 10-Hz timebase is selected, and from 0 to 99 seconds in 1-second steps when the 1-Hz pulse train is routed to the counter. To in-

crease the maximum timing intervals, you can add more counter/decoder/display stages. For more resolution (e.g., time measurements to the nearest one hun-

dredth of a second), design a circuit that will multiply the frequency of the 10-Hz pulse train by a factor of ten. Then use the 100-Hz output as the timebase. ◇

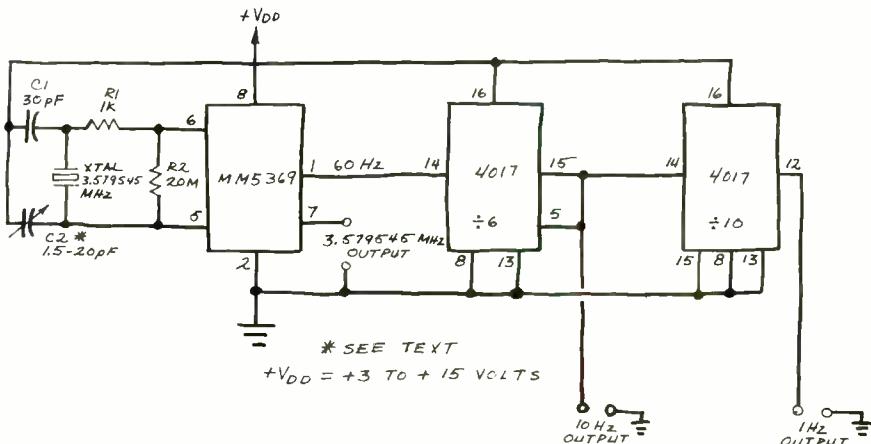


Fig. 1. Schematic of a precision crystal-controlled timebase.

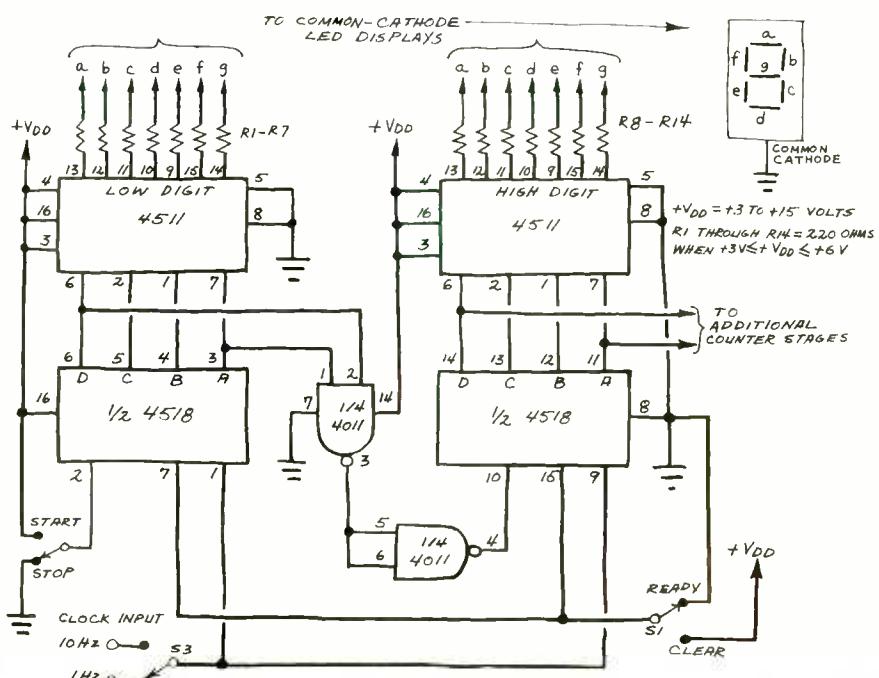


Fig. 2. Circuit for a two-digit digital counter/stopwatch.





















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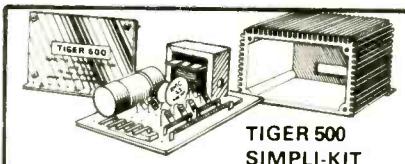
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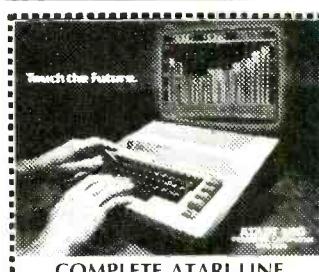
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# Personal Electronics News

**VIDEO DISK INTERCHANGEABILITY** may soon be achieved as a result of a five-year patent-exchange agreement between N.V. Philips and Sony Corp. The agreement allows the two companies to use each other's patent rights on a wide range of products, including optical audio and video disks. Philips and Sony have both been conducting independent research and development on video systems.

**WORLD'S FIRST COMPUTERIZED GUITAR** is what Castle Toy Co. calls its \$45 "Superstar Guitar" with built-in microprocessor. A child or adult can pick up the guitar for the first time and instantly play 12 different prerecorded popular tunes, it is claimed. Users can also compose and record their own tunes and play them back at will.



**A PERSONAL STRAP-ON STEREO SYSTEM** designed to provide hands-free operation has been made available by Aspen Recreational Products, Ltd. for skiers, bikers, hikers, and other sporting types. The "Audiopac" consists of a Pioneer KP373 stereo cassette player housed in a heavily padded chestpack case that has ample room for cassette storage and matching headphones whose earcups can be removed for easy mounting in a motorcycle helmet. The player has locking fast forward and reverse, a loudness button, and automatic play after rewind. It can deliver 10 hours of play from built-in rechargeable batteries. For AM-FM stereo radio listening, the 15-oz. "Bone Fone" from JS&A (312-564-7000), which wraps around your neck like a scarf and doesn't require headphones, is used for the same applications.

**ELECTRONIC GAME PURCHASES** will increase 22% per annum through 1983, according to a forecast made in a "Home and Coin-Operated Electronic Games" study by Frost & Sullivan, Inc., New York City. The \$518-million market in 1978 is expected to jump to \$802 million this year and increase to \$1.4 billion within five years. The submarkets to generate the greatest growth will include programmable-games cartridges (539%), programmable-games consoles (178%), and nonvideo electronic games (150%).

**D.C. RADAR-DETECTOR LAW** is unconstitutional, according to a landmark ruling by a District Superior Court. It was ruled that the law violated the First, Fourth, Fifth, Ninth, and Tenth Amendments to the Constitution and went far beyond even prior restraint in anticipation of wrongdoing. The decision sets the stage for a pending appeal in Michigan, where a 1929 police radio law has been stretched by state police to include radar detectors. Last April, a Michigan Appeals Court ruled radar detectors exempt from the police radio law. The case has recently been reopened by the court and a concurrent action is pending in federal court. Virginia, the only other state ever to have a radar detector law, had the enforcement provision of its statute struck down in 1978 as unconstitutional.

**SATELLITE-TO-HOME BROADCASTS** have begun in Canada in an experimental program, conducted by Canada's Department of Communications. Designed to test the feasibility of direct-home broadcasting to remote and rural areas via small, low-cost earth stations, the project involves some 12 hours of daily programming over Telsat, Canada's Anik B domsat (domestic satellite). Selected families in Ontario, British Columbia, and perhaps the Yukon and Northwestern Territories will participate in the program with earth stations on loan to them.

**A NAVIGATION COMPUTER** with an accuracy of one-tenth nautical mile was announced by William A. Davis (Castro Valley, CA). To use it, one simply enters two altitudes, the two declinations of class-A stars, and two G.H.A.s of the stars. Then in about 40 seconds, the computer calculates longitude and latitude of the two possible positions or fixes—even if the navigator has no idea where he is! The computer also calculates distances between any two points on earth and gives the true bearing between them.

**A COMPUTERIZED MUSIC TYPESETTING SYSTEM** developed by Dataland of Denmark solves the problem of converting a composer's handwritten manuscript into printable form. Called the "scannote" system, it is reported to produce a music masterprint automatically and at considerably less cost than other existing methods. The system employs a special piano keyboard to play in, note by note, the voices in a score, which are then computer-processed and "played back" in a digital plotter to produce finished copy for offset printing.

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