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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Popular Electronics

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 T.M.

Here's how an exciting new micro-electronic breakthrough will make your children heros 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 elses.

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.

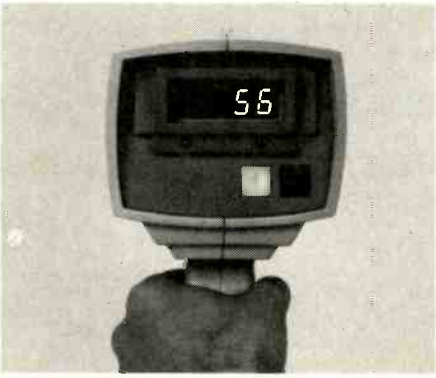
The gun can be mounted on a tripod so that the person taking the measurements can also catch the ball.

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 out perform 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.

JS&A ® PRODUCTS THAT THINK®

Dept. PE One JS&A Plaza
Northbrook, Ill. 60062 (312) 564-7000

Call TOLL-FREE 800 323-6400
In Illinois Call .... (312) 564-7000

JANUARY 1980

25TH ANNIVERSARY

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 tpes of radioactive sources.

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Feature Articles

Construction Articles

Columns

Julian Hirsch Audio Reports

Electronic Product Test Report

Departments

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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 Salsberg

www.americanradiohistory.com

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 electrosensitive printers in "How to Buy a Computer Printer." Electrosensitive paper for our Comprint 912 is not "very fragile" and does not require handling with "utmost care to prevent wrinkling and soiling." And electrosensitive paper is not "impossible to photocopy." Finally, this paper costs about half that of plain paper and reusable ribbons.—*Harlan E. Dybdahl, Computer Printers Intl., Inc., Mountain View, CA.*

The drawbacks noted about electrosensitive 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 I, 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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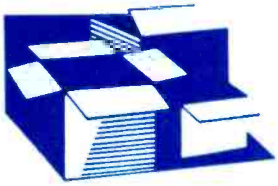


New Products

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.

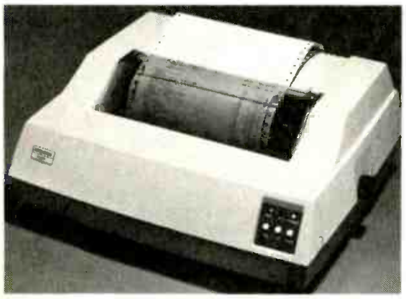
Budget FM Tuner

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 indicators 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

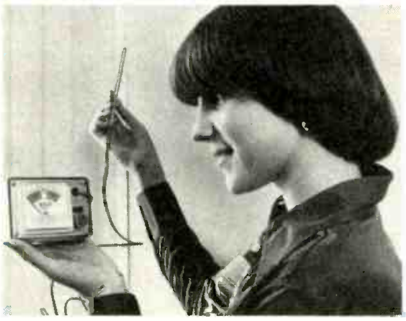
Microtek's MT-80 series bidirectional impact printer features 80- and 120-column printing at a rate of 125 characters per second. It has the full 96 upper- and lower-case ASCII character set in three software-selectable fonts (5, 10, and 15 characters/inch) on original plus three copies. The 10-cpi font uses a 7 × 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" × 17.7" × 14.8" (185 × 450 ×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, ineffective weatherstripping, cracks in siding, etc. It can also be used to check the effectivensss 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.



CIRCLE NO. 92 ON FREE INFORMATION CARD

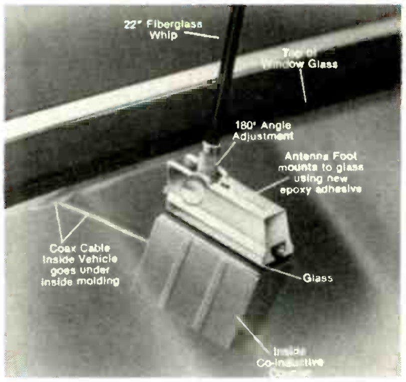
Hitachi 5-inch Dual-Trace Scope

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, ×10 sweep-time magnifier, and 5" (127-mm) CRT with 8 × 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 directionality 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.

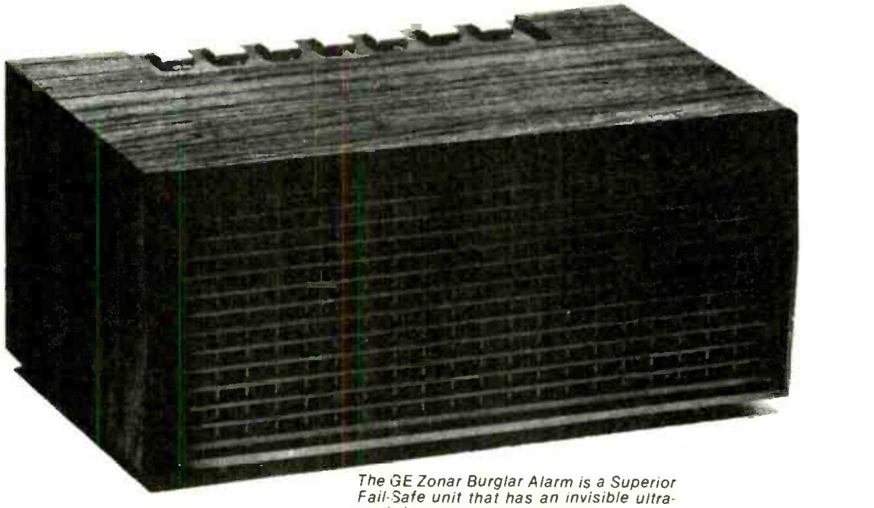
CIRCLE NO. 95 ON FREE INFORMATION CARD

Electronic Ruler Computer

Chafitz, Inc., has announced that it will be the exclusive distributor of an advanced

The Protectors

The two products shown below are the latest in Space-Age Electronic Home Security. Do you know which one is right for you?



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

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

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 worlds 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 personalyzed 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 noticable. It measures only 7" × 4" × 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 1½" × ½" 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 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.

The Micro FM Wireless Mike can be ordered by calling our 24-hour toll-free number below or by sending your check for **$29.95** for one or **$58.00** for two. Please add $1.25 each for postage and handling and Virginia residents add 4% sales tax.

OUR OPINION

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

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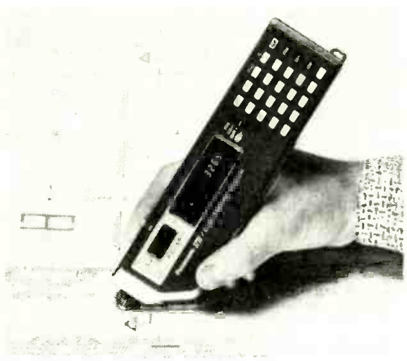

Ruler/Computer developed by Panasonic Co. The "Ruler That Thinks" employs a small displacement measuring wheel to directly measure lengths, distances, areas, volumes, etc., in linear, square, or cubic units in any scale from any document. A multifunction calculator is integrated into the ruler to permit 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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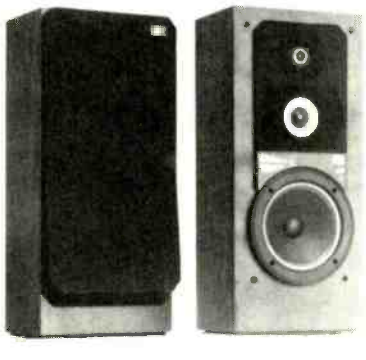
The Model AR92 occupies the economy end of Acoustic Research's line of vertical speaker systems. The three-way, floor-standing system features a specially designed 10″ (254-mm) acoustic-suspension woofer, 1½″ (38-mm) liquid-cooled dome



midrange semihorn driver, and ¾″ (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 31⅜″ × 14″ × 11 7/16″ D (797 × 356 × 291 mm). $300.

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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

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.

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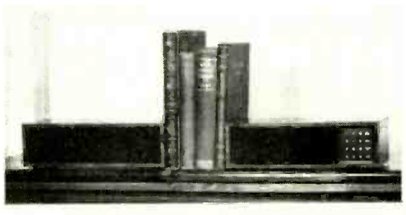
The MassaSonic Ultrasonic Intrusion Alarm uses a microcomputer system said to distinguish real targets from moving air and thus eliminate false alarms. The unit plugs into any normal ac outlet and is rat-



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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,® Marantz® and Fisher.® The important thing is . . . they didn't!

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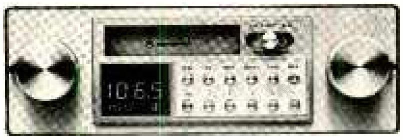
ed at 120° of coverage in any room up to 1,000 sq. ft. Control is via a touch keyboard through which one of more than 1700 three-digit codes can be entered to disarm the unit. When tripped, the system sounds a siren rated at 105 dB SPL at 1 ft for four minutes and rearms automatically. An optional battery/siren 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_2 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.

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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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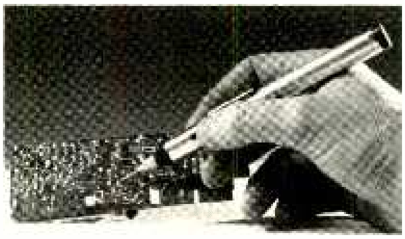
Transtronics Continuity Checker

The "Electronic Workmate" is a new leadless continuity checker from Transtronics. 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. Transtronics Co., 13101 N.E. Hwy. 99, Vancouver, WA 98665.

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[tm] 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 applications 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.

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SYSTEM FIVE

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?

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

To place your order now just send a check for **$74.95** plus $3 shipping for System Five. Or send $159 plus $4 shipping for System Four. Tell us your full street address as we cannot ship to Post Office boxes.

Our unit is dependable and trouble-free, but if by rare chance any problems occur our service-by-mail center sends off your unit within 24 hours of receipt or sends a replacement so you are not without fresh air and can enjoy your dust-free environment. And each Air Energizer is backed by a full one year limited warranty.

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Credit card holders can call our toll-free number below. Order a unit now and if you are not satisfied with its effects within 10 days simply return it for a full cash refund. Order your Air Energizer today.

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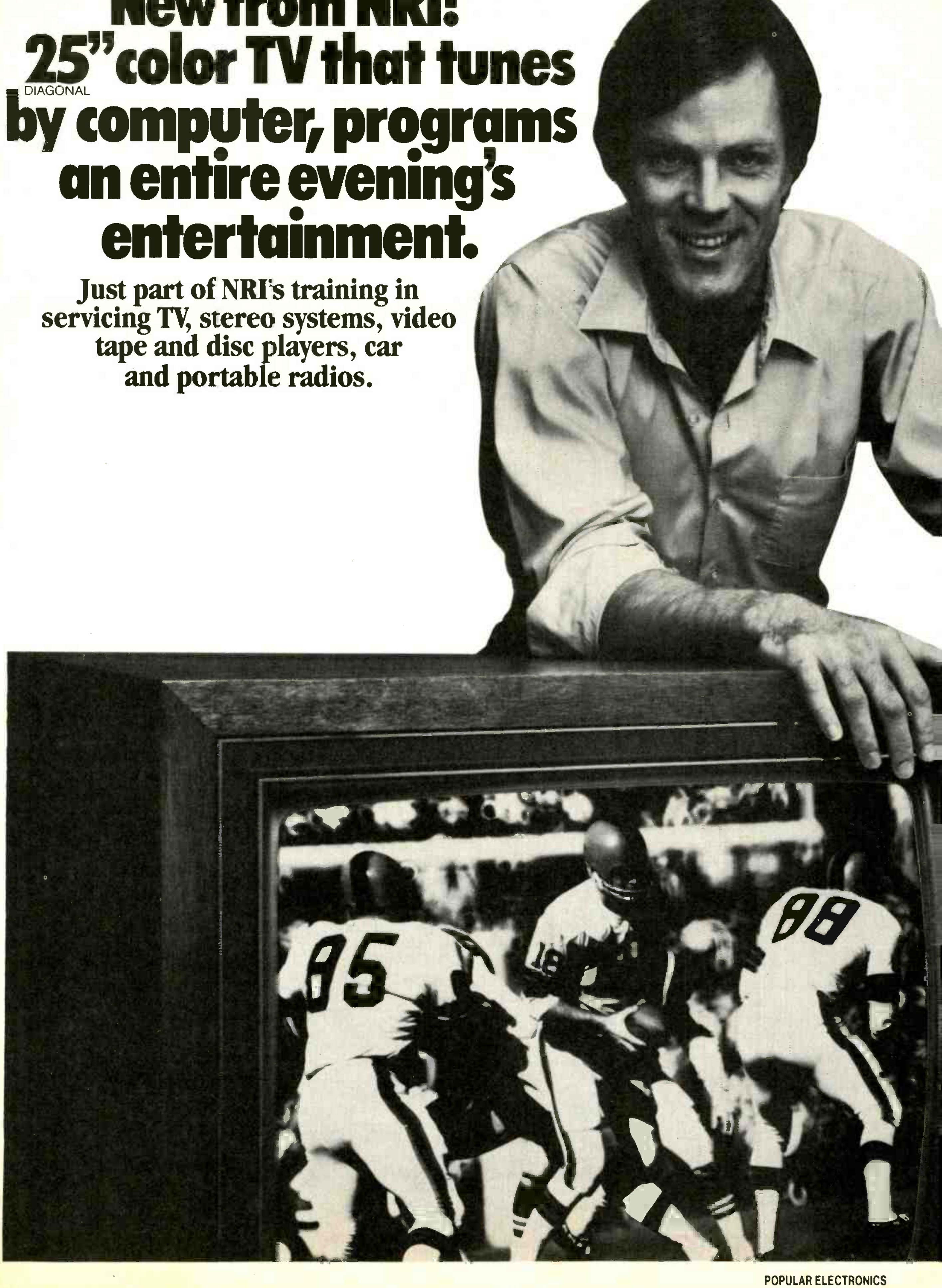
New from NRI! 25" DIAGONAL color TV that tunes by computer, programs an entire evening's entertainment.

Just part of NRI's training in servicing TV, stereo systems, video tape and disc players, car and portable radios.



Only NRI home training prepares you so thoroughly for the next great leap forward in TV and audio...digital systems. Already, top-of-the-line TV's feature digital tuning, computer programming is appearing, and new digital audio recording equipment is about to go on the market.

NRI is the only home study school to give you the actual "hands-on" training you need to handle servicing problems on tomorrow's electronic equipment. Because only NRI includes this designed-for-learning, 25" diagonal color TV with electronic tuning, built-in digital clock, and computer programmer as part of your training. With this advanced feature, you can pre-program an entire evening's entertainment... even key lock it in to control children's viewing.

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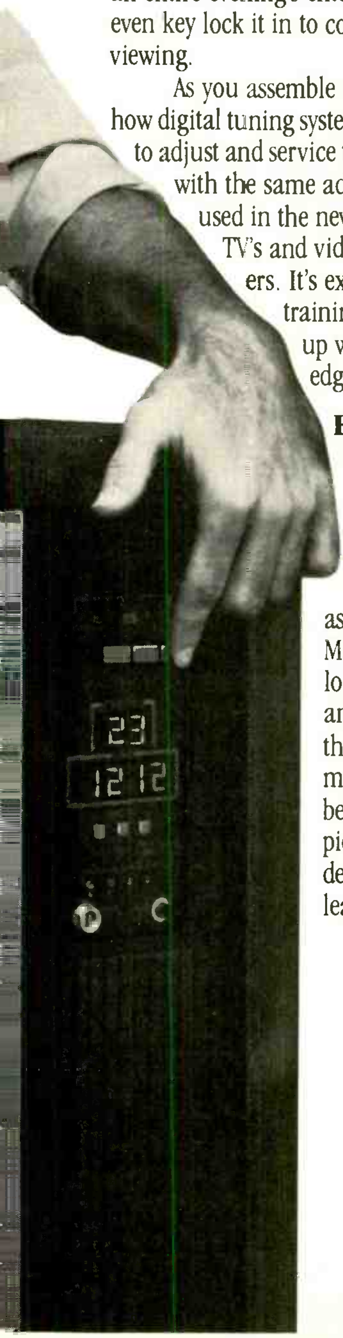

Exclusive Designed-for-learning Concept

The color TV you build as part of NRI's Master Course looks, operates, and performs like the very finest commercial sets. But behind that pretty picture is a unique designed-for-learning chassis...

the only such unit in the world. Rather than retrofit lessons to a hobby kit or an already-built commercial set, NRI instructor/engineers have designed this television so each step of construction is a learning experience.

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Using NRI's exclusive methods, you learn far more than TV servicing. You'll be prepared to work with stereo systems, car radios, record and tape players, transistor radios, short-wave receivers, PA systems, musical instrument amplifiers, electronic TV games, even video tape recorders and tape or disc video players. Your training covers just about every kind of electronic entertainment equipment available now or in the near future.

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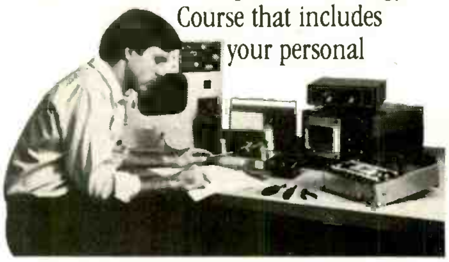

microcomputer. Or Complete Communications with 2-meter transceiver that gets you ready for opportunities in broadcasting, 2-way radio, microwave, and other growing fields. If card has been removed, write to:

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Stereo Scene

By Harold A. Rodgers
Senior Editor

SHORT SUBJECTS

ON 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 preface my account of what happened by admitting 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 Rørbæk 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:

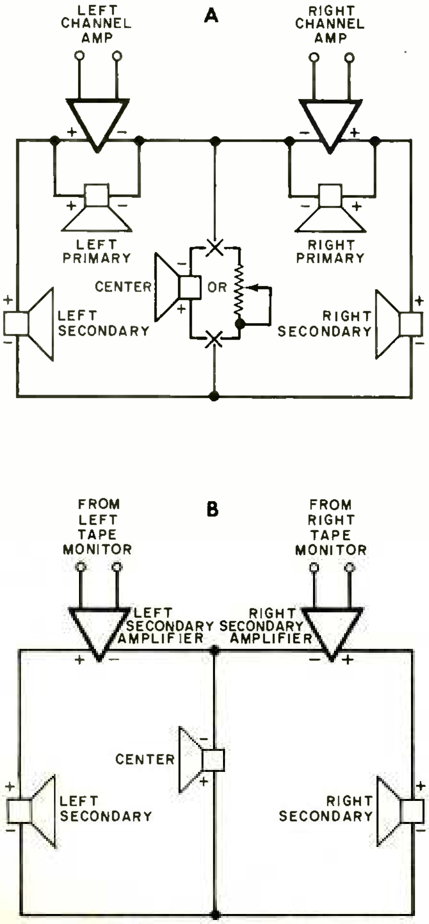


Fig. 1. Variations on speaker arrangements given in October 1979.

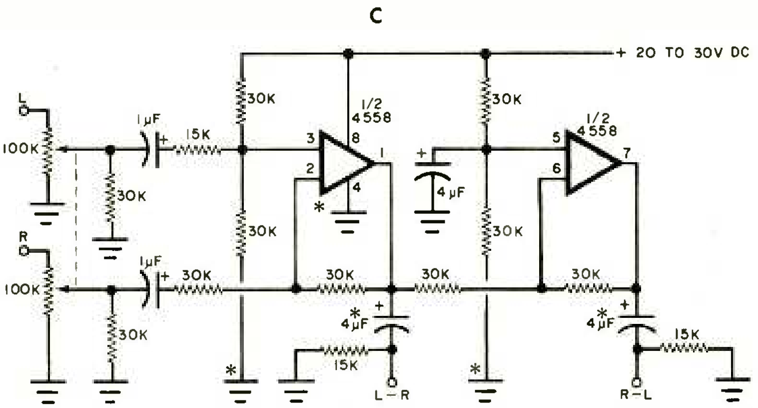
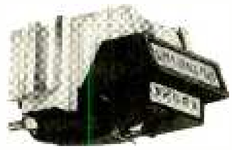
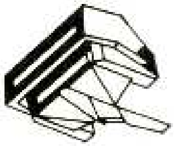
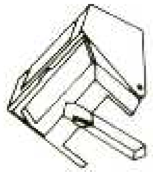
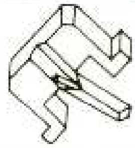


Fig. 2. A practical version of the circuit shown at C in the October 1979 issue.

fact: a Genuine Shure upgrade stylus is unquestionably the biggest bargain in hi-fi

We strongly urge you to check your stylus for wear at least once a year to protect your records and maintain the highest standards of listening pleasure. Regardless of when (or where) you purchased your Shure cartridge, there is a Genuine Shure replacement stylus available which will bring your cartridge right back to its original specifications. Even better, *you may actually be able to improve its performance significantly over the original* with a Genuine Shure upgrade stylus . . . at surprisingly low cost! For example:

IF YOU OWN:	UPGRADE WITH:	THIS IS THE RESULT:
 **V15 Type III SERIES**  **M95 SERIES**	**VN35HE** Hyperelliptical stylus  **N95HE*** Hyperelliptical stylus 	A dramatic reduction of harmonic and intermodulation distortion (formerly available only to owners of the incomparable V15 Type IV) is now possible with the V15 Type III and the M95 Series of cartridges simply by replacing the stylus. The Hyperelliptical stylus configuration contacts the record groove in a "footprint" that is longer and narrower than the popular Biradial tip design, making it pre-eminent for reproduction of the stereo-cut groove.
 **M70 SERIES**	**N72EJ** Biradial (Elliptical) stylus **N72B** Spherical stylus 	Improved trackability, especially at high frequencies, due to a new, redesigned low-mass N72 stylus assembly.
ANY M91, M92, M93	**N91ED*** stylus	Much improved trackability due to the lower effective tip mass of the nude Biradial (Elliptical) stylus tip. Less tracing distortion compared with a Spherical stylus tip.
ANY M71, M73, M75	**N75 TYPE 2*** Series styli	Improved trackability at higher frequencies due to a stylus assembly with a lower effective tip mass.
ANY M44 Series	**N55E*** stylus	Lower tracking force with a Biradial (Elliptical) stylus, lower distortion, lower effective tip mass.
M3D, M7D	**N21D*** stylus	Improved performance at lower tracking forces.

***Before purchasing any replacement stylus be certain your turntable is compatible with the tracking force of the stylus you select.**

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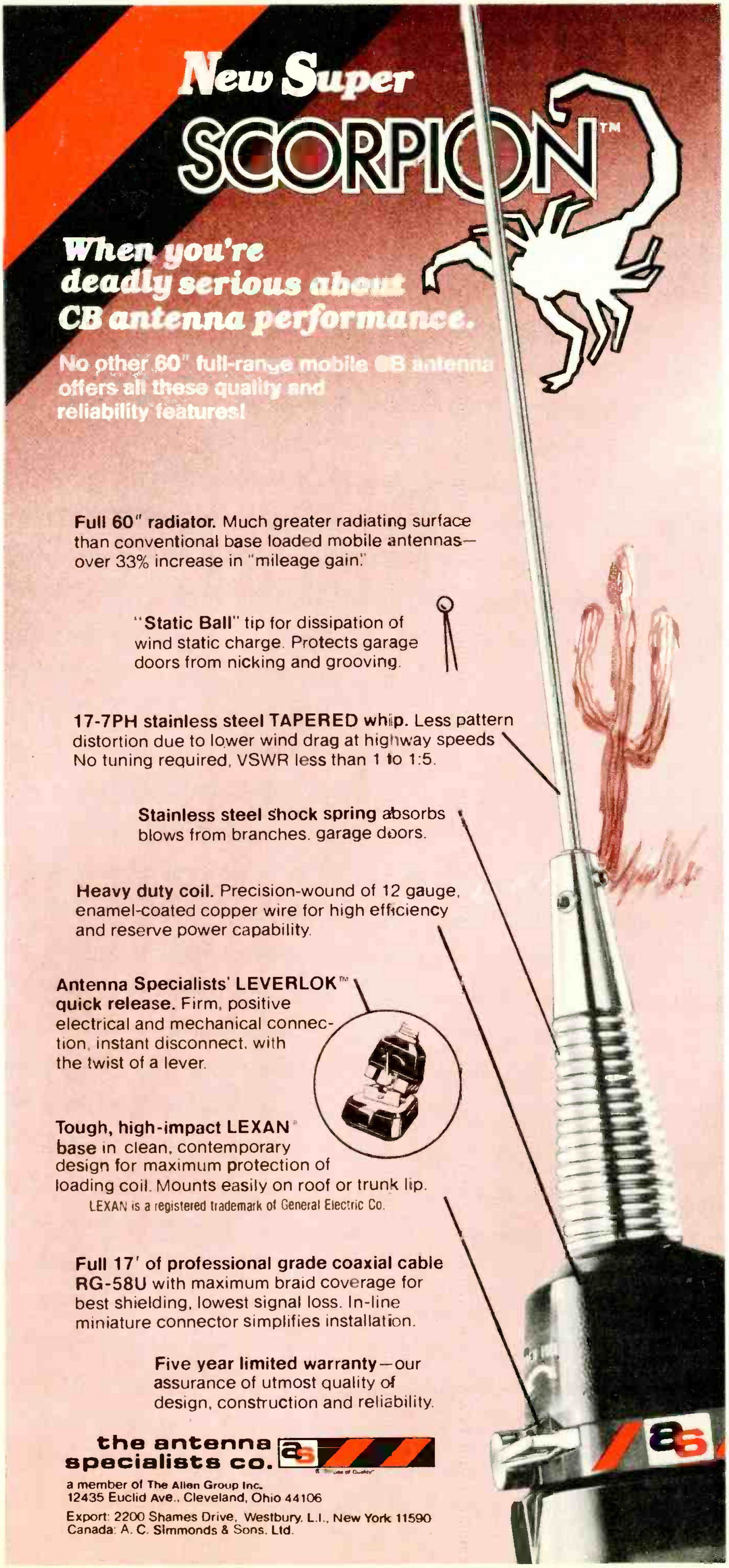

substitute an additional loudspeaker for the control. This speaker would carry an L R signal and should be located halfway between the primary pair to solidify the center image. Circuits A and B, originally given in October, are both candidates for this treatment as shown in Fig. 1.

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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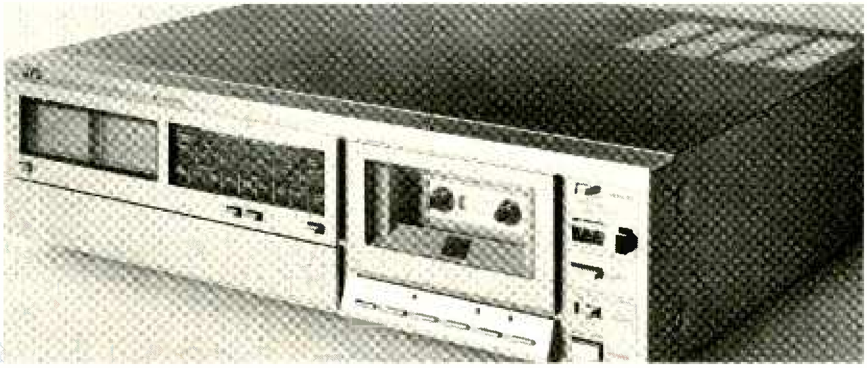
CIRCLE NO. 33 ON FREE INFORMATION CARD

Julian Hirsch Audio Reports



JVC Model KD-A8 cassette deck has computerized tape optimization

HIRSCH-HOUCK LABS REPORT

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 17¾"W × 15⅜"D × 4⅞"H (450 × 390 × 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_2, 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 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.

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

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)

(Continued from page 24)

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.)

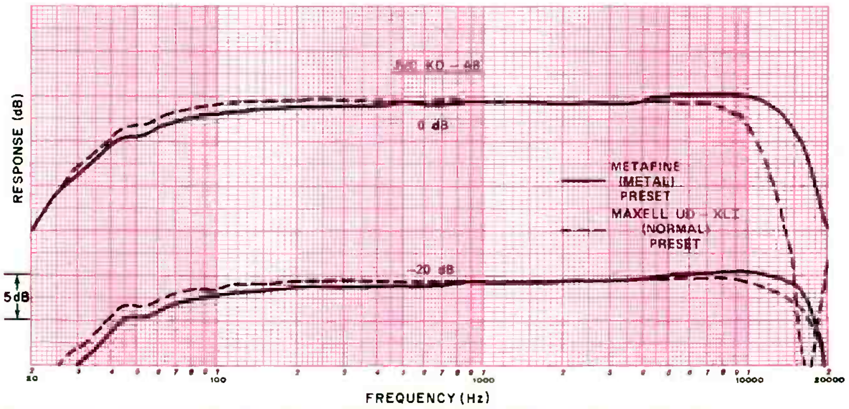
If for any reason, such as an incorrect setting of the TAPE SELECT switch, the computer cannot find appropriate settings, it repeats the test cycle. If the problem persists, the PRESET LED comes on and an ERROR LED blinks. (This latter LED can be extinguished only by pressing the PRESET button.) When 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_2, Sony Duad 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 ±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 intersect 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 Duad tape had even better resistance to saturation, especially with B.E.S.T., which kept the two curves 10 dB apart to 20 kHz.



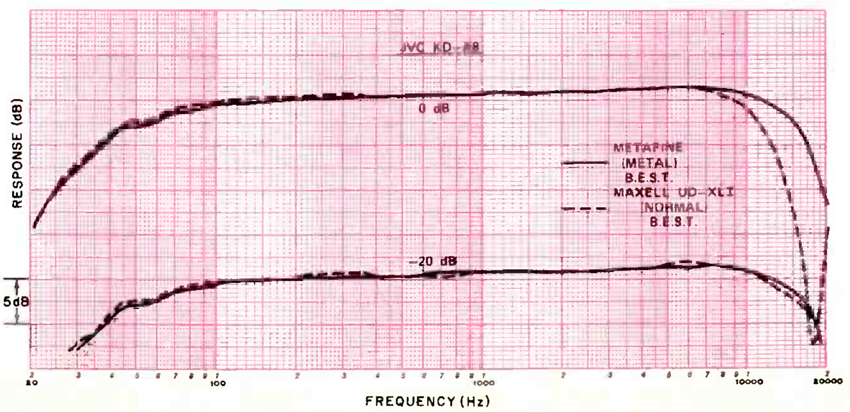
Frequency responses for two types of tape with preset bias and equalization.

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 7½ 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 preamplifier 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



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

(Continued on page 28)

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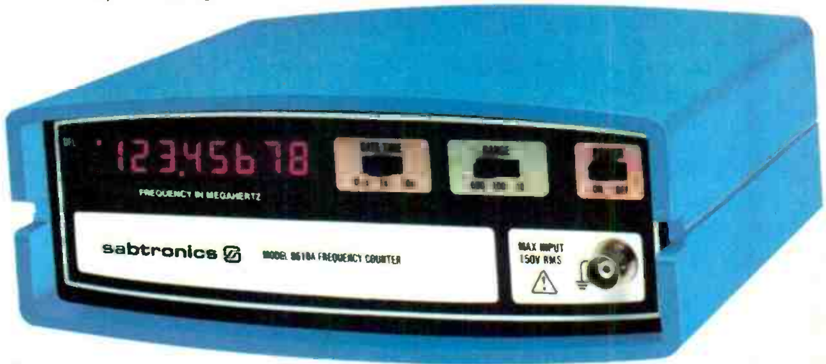
Brief Specifications: Freuuency Range, switch selectable, 10 MHz, 100MHz, 600 MHz • Sensitivity, ± 10mV RMS to 100 MHz, ±50mV RMS, 100 MHz to 450 MHz; 90mV RMS 450 MHz to 600 MHz • Impedance, 1 MΩ, 10 MHz and 100 MHz ranges; 50Ω, 600 MHz range • Gate time (switch selectable) 0.1 sec, 1 sec, 10 sec • Temperature stability, 0.1 ppm/°C • Ageing rate < ±5 ppm/yr • Accuracy, 1 ppm or 0.0001% • Input protection, 150V RMS to 10 kHz (declining with frequency) • Power Requirement, 4.5 to 6.5V DC @ 300mA (4 "C" cells) or optional AC adapter/charger (7.5 to 9V DC @ 300mA).

Also available Model 8110A, same as 8610A except maximum frequency is 100MHz and without battery charging circuit: $59.95 kit



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(Continued from page 26)

±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 +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.

Performance Specifications

Specification	Rating	Measured
R/P frequency response		
−20-dB level	Metafine: 25-17,000 Hz ±3 dB	44-17,500 Hz ±3 dB
	TDK SA: 25-17,000 Hz ±3 dB	40-18,500 Hz ±3 dB
	Maxell UD-XL I:25-16,000 Hz ±3 dB	34-17,500 Hz ±3 dB
0-dB level	Metafine: 25-12,500 Hz ±3 dB	38-16,000 Hz ±3 dB
	TDK SA: 25-8,000 Hz ±3 dB	40-12,000 Hz ±3 dB
With B.E.S.T., −20 dB for all tape types	40-12,500 Hz ±1 dB	100-13,000 Hz ±1 dB (MET) 100-13,800 Hz ±1 dB (SA) 75-12,000 Hz ±1 dB(XL-I) 75-11,500 Hz ±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
	0.12% DIN	0.04% DIN/CCIR
Harmonic distortion (1 kHz, metal tape)	0.4% 3rd harmonic at 0 dB	0.7%
FF/rewind time (C60)	85 seconds	70 seconds
Input sensitivity	MIC 0.2 mV	0.16 mV
	LINE 78 mV	70 mV
Outputs	LINE 0-300 mV	Max. 260 to 287 mV
	PHONES 0.5 mW max, 8-1,000 ohms	Not measured

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 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.

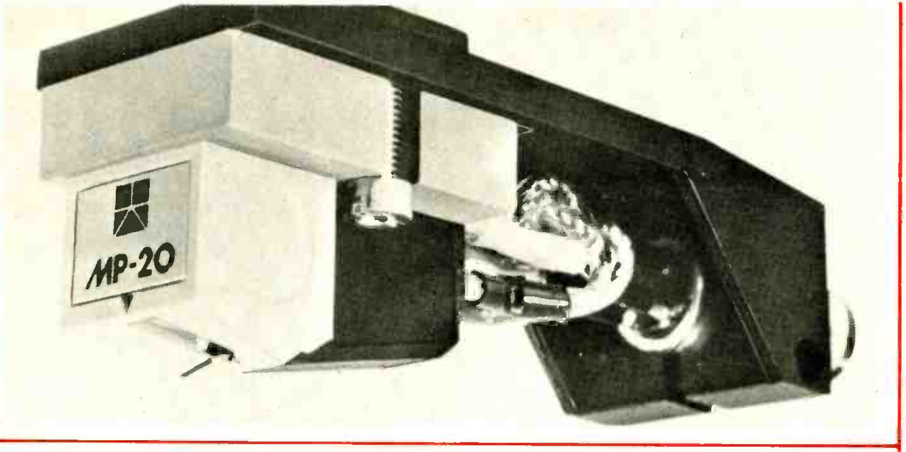
Our only criticism concerns the exposed COMPUTER CAL buttons. Although the manual warns against touching START while the tape is in motion, as it will then be erased, it is too easy to make this mistake. We feel it would have been preferable had these buttons been located behind the hinged door.

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)



Osawa Model MP20 induced-magnet stereo phono cartridge

HIRSCH-HOUCK LABS REPORT

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 × 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 records.

smooth, flat response with no coloration of any kind

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 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.

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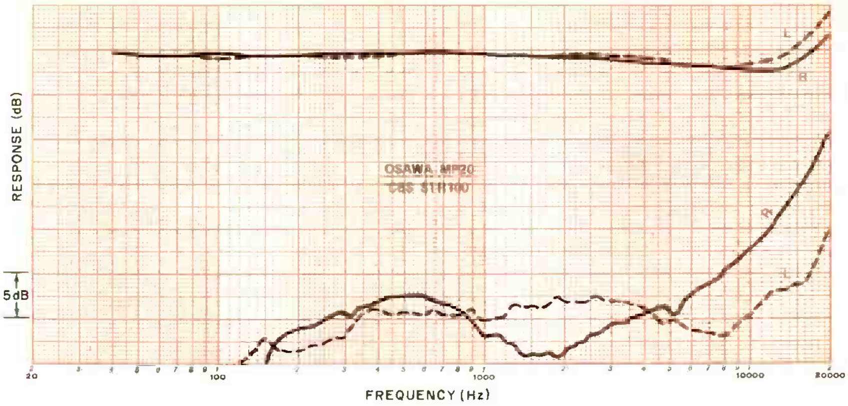


Frequency response and crosstalk for left and right channels.

Celestion Ditton 662 three-way speaker system with passive radiator

HIRSCH-HOUCK LABS REPORT

THE 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 ±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 41⅝"H × 15¾"W × 11¾"D (1057 × 400 × 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

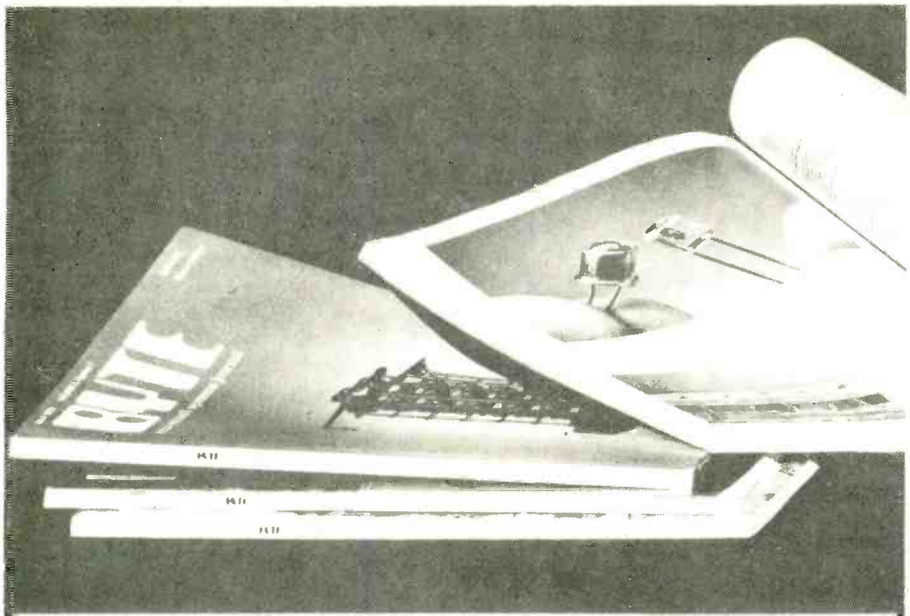
General Description. More than half the 90-liter volume of the cabinet is devoted to the bass radiators. The two heavy 12" cones appear to be superficially identical, but the lower ABR lacks a voice coil and magnet structure and has an 18-Hz resonant frequency. Combined with the driven radiator, the 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 ¾" (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



55 Hz. Splicing the bass curve to the midrange and high-frequency curve, we obtained an overall frequency-response variation of ±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.

This is one speaker system we would be happy to live with on a long-term basis. Its excellent musical properties are sufficient to overcome our reluctance to make room for a pair of large, heavy boxes.

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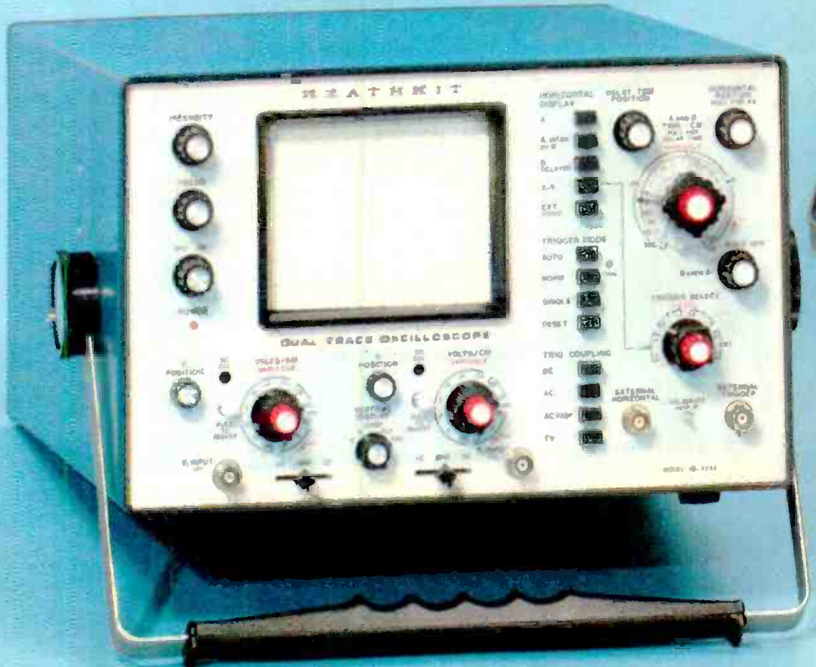

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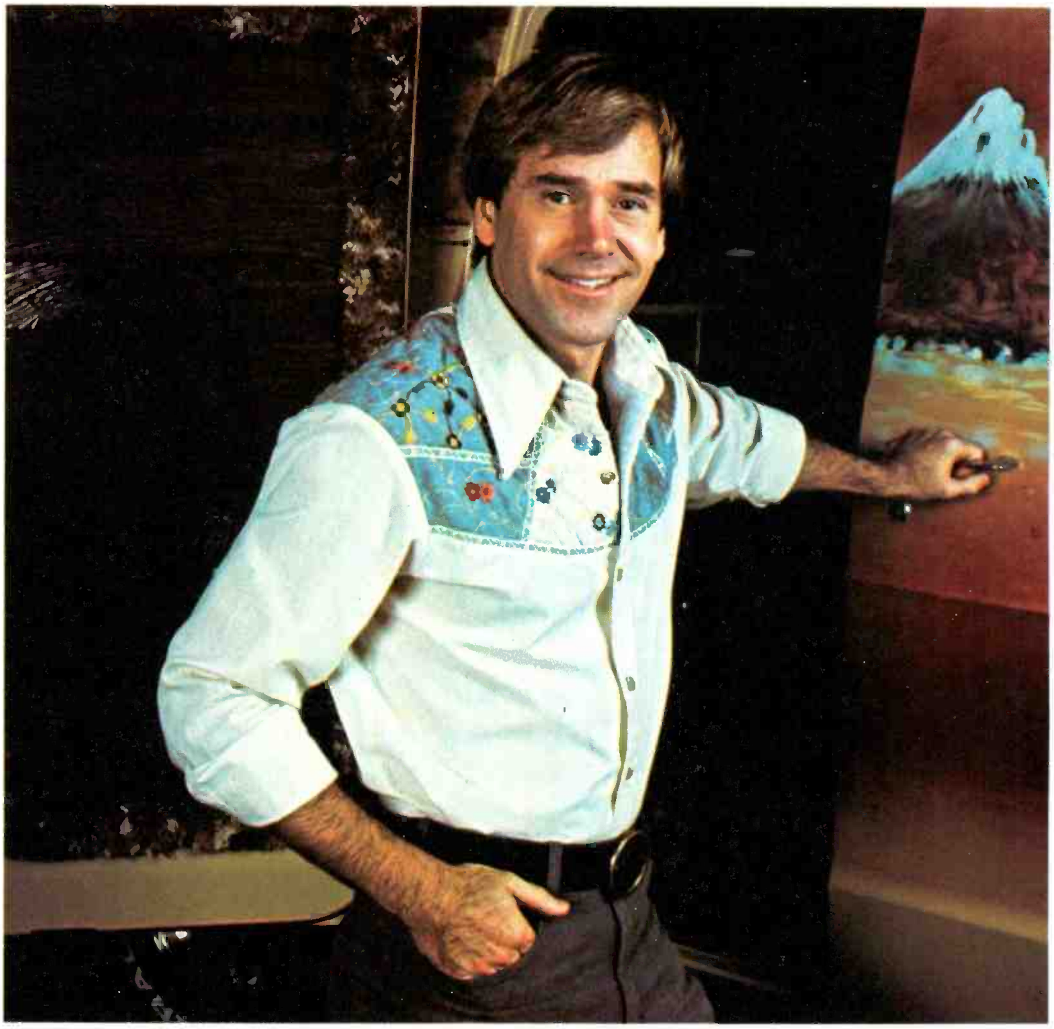

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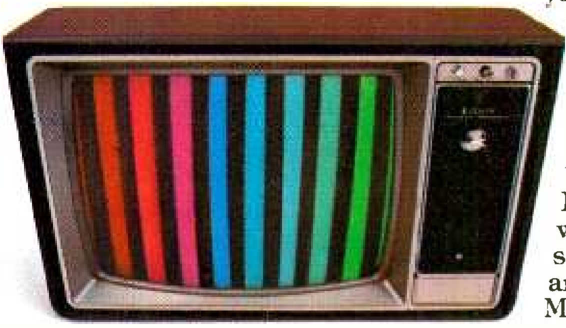

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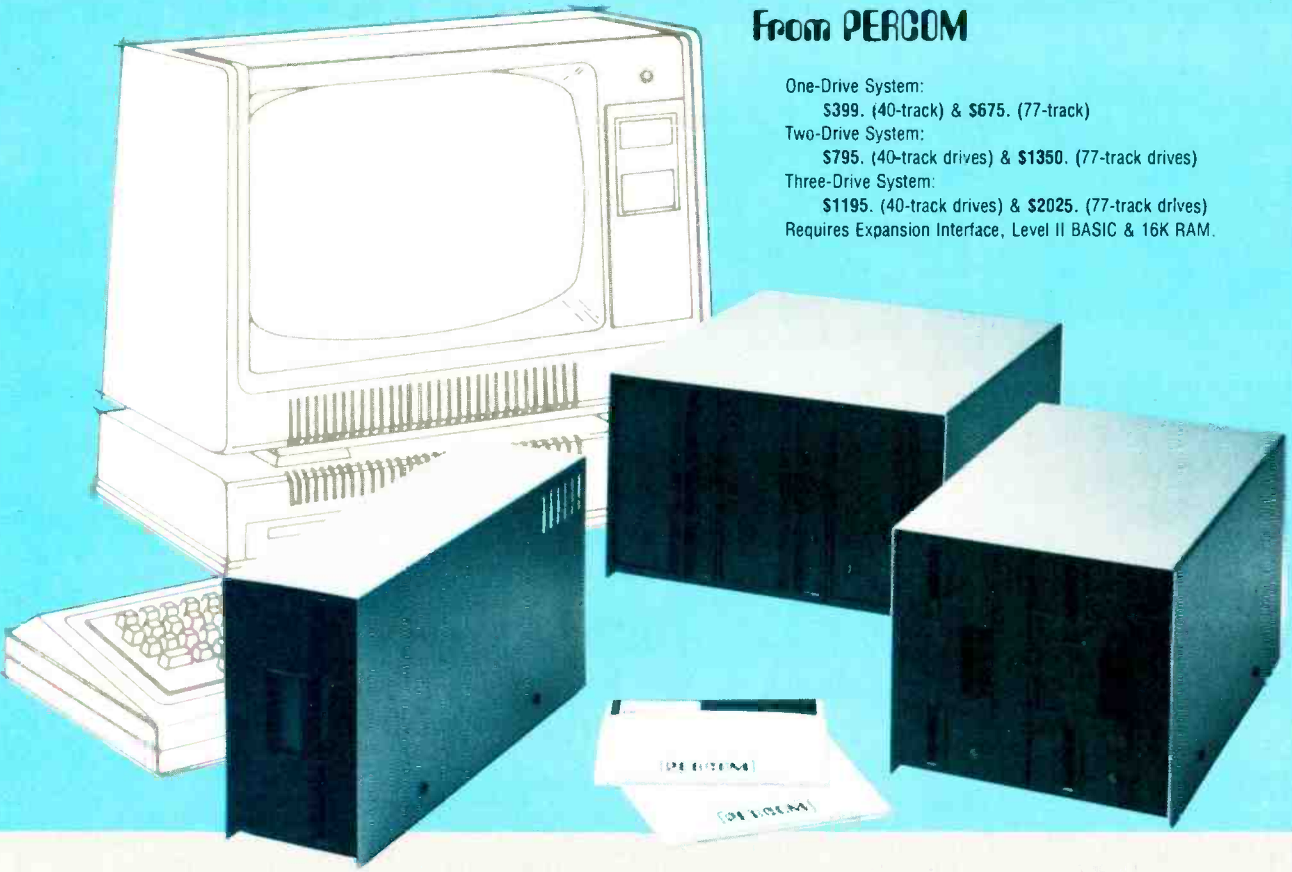

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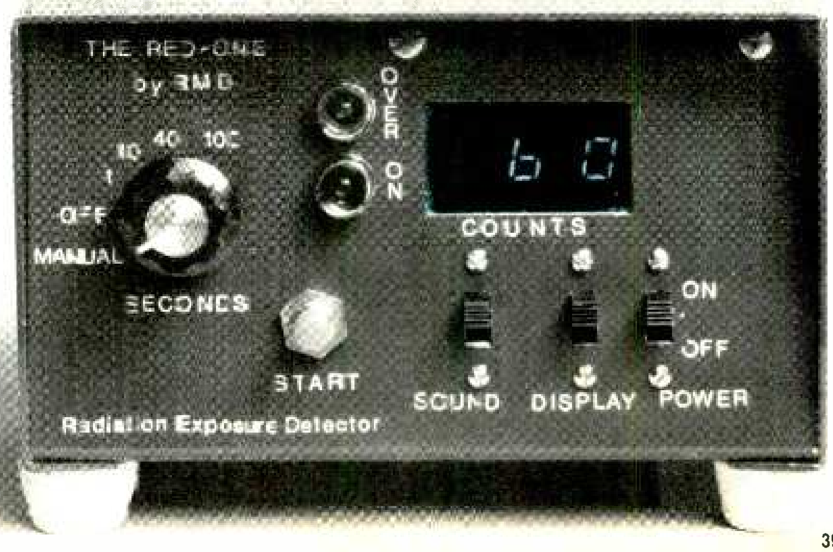
CIRCLE NO. 47 ON FREE INFORMATION CARD

Popular Electronics
JANUARY 1980

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



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-

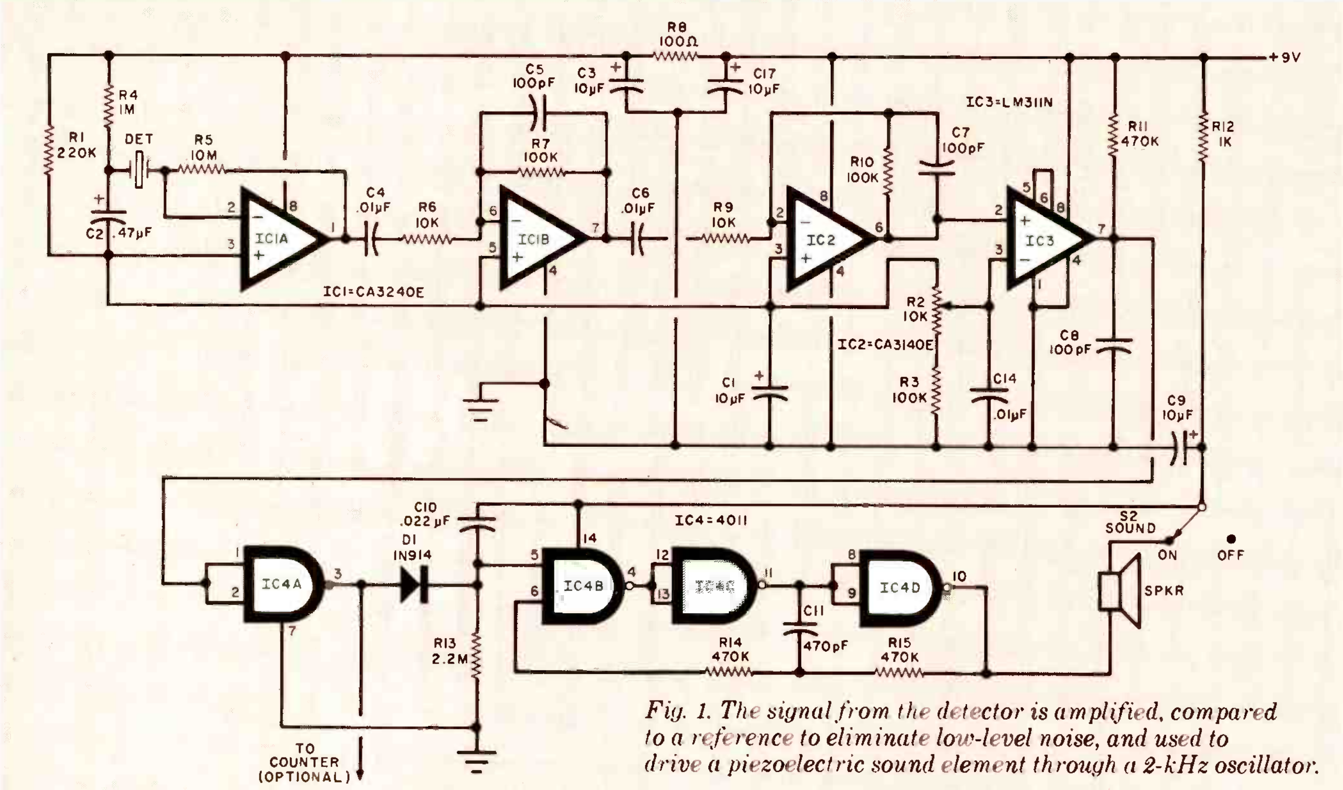


Fig. 1. The signal from the detector is amplified, compared to a reference to eliminate low-level noise, and used to drive a piezoelectric sound element through a 2-kHz oscillator.

PARTS LIST—FIG. 1

C1, C3, C17—10-μF, 16-V tantalum
C2—0.47-μF, 35-V tantalum
C4,C6,C14—0.01-μF disc ceramic
C5,C7,C8—100-pF disc ceramic
C10—0.022-μF 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 ¼-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 μs 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-µF disc ceramic
C13—0.1-µF disc ceramic
C15—0.01-µF disc ceramic
C16—10-µF, 35-V tantalum
DISP1,DISP2,DISP3—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 ¼-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 noncommercial 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.

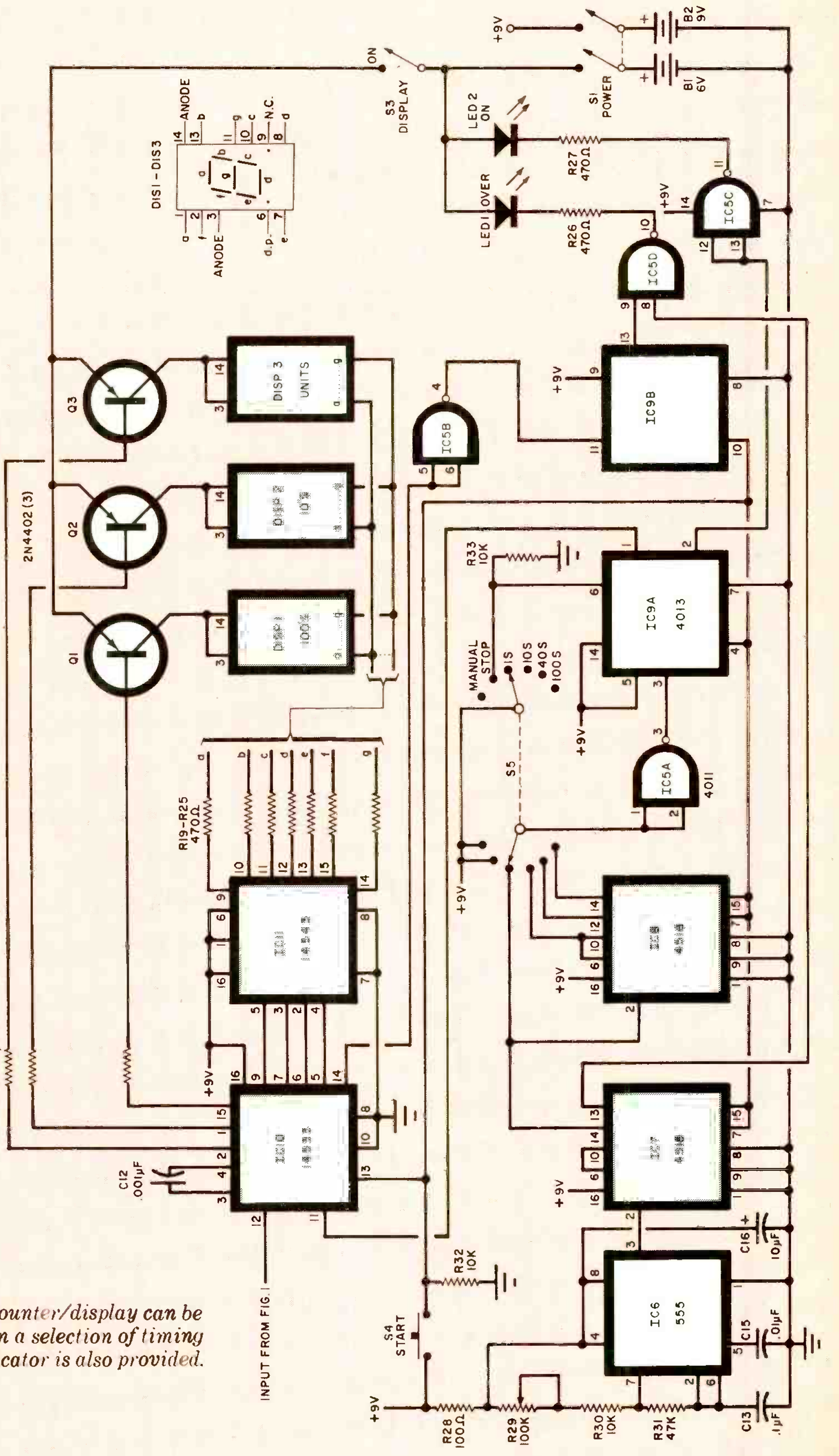


Fig. 2. The conventional 3-digit counter/display can be enabled either manually or from a selection of timing signals. A blinking overrange indicator is also provided.

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.

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.

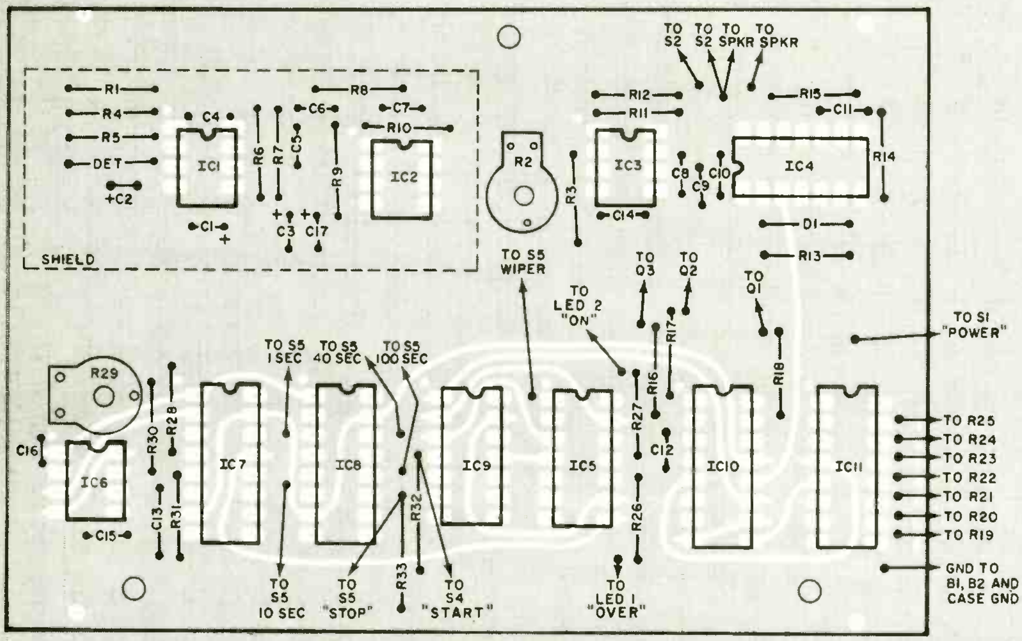
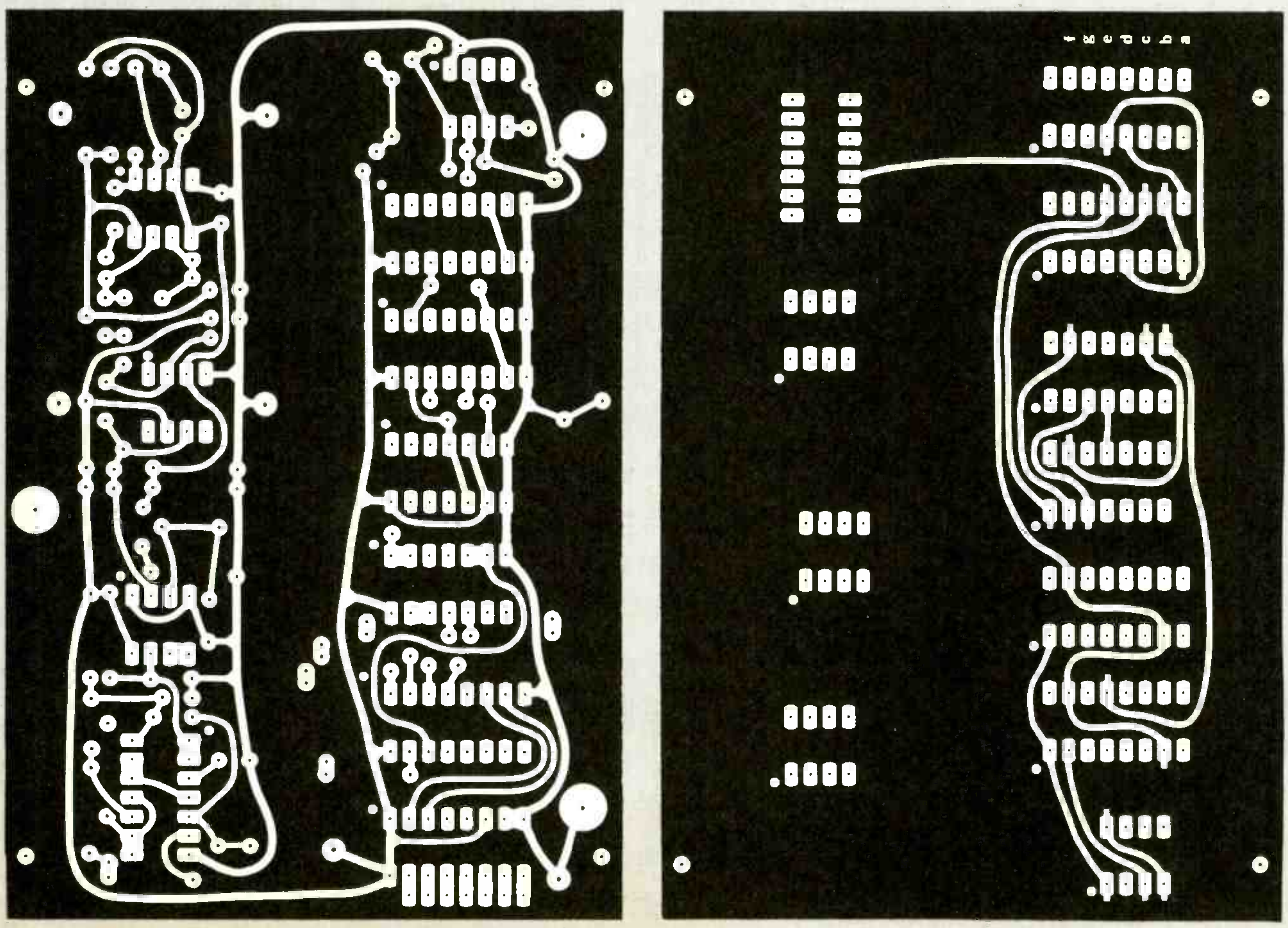


Fig. 3. Actual-size etching and drilling guides for the two-sided pc board are shown below. Component mounting on the top is at left. Note that the upper portion of the board (containing the audible circuit shown in Fig. 1) can be detached if only that circuit is to be used.



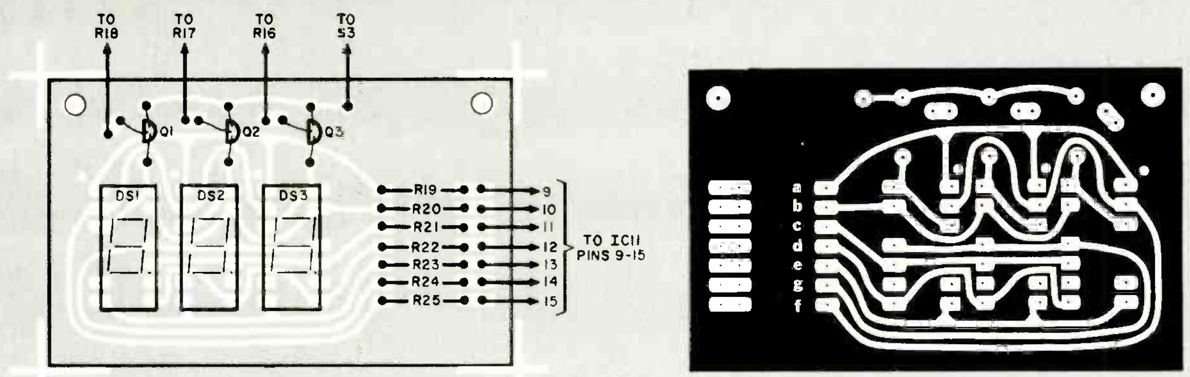


Fig. 4. Actual-size etching and drilling guide and component layout for the display board.

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 ⅛" (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 2½" × 1" × ½" (63.5 × 24.5 × 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)

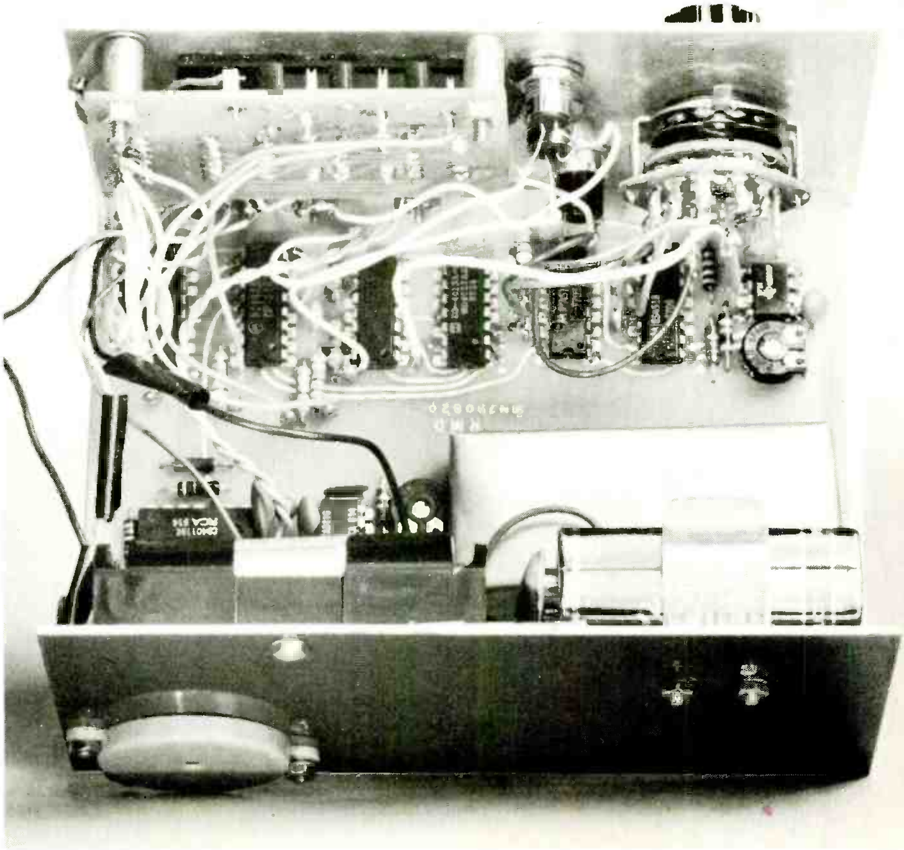


Photo of the author's prototype shows the main pc board mounted on chassis bottom with sound element on back and display on front.

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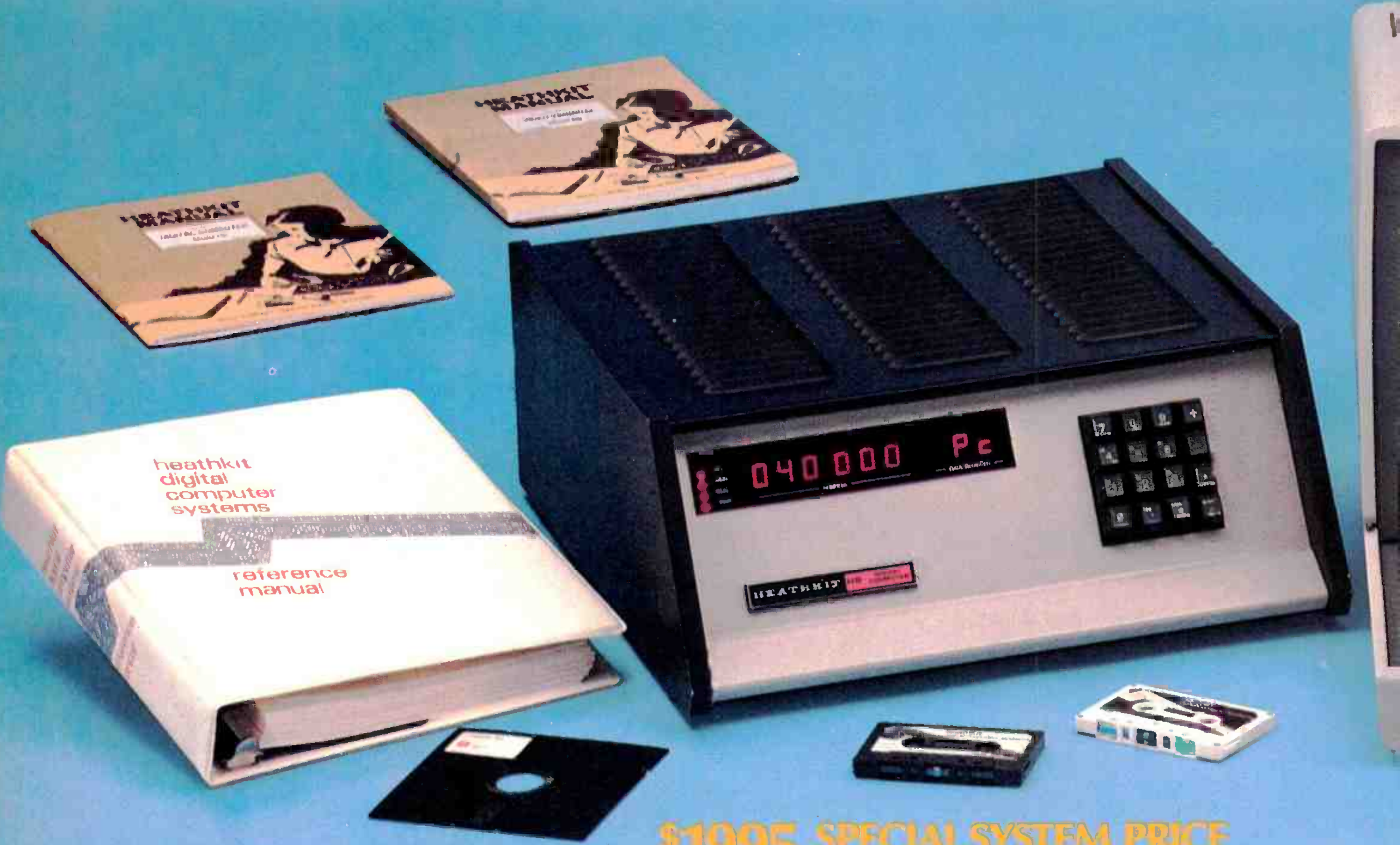

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0367 CIRCLE NO. 28 ON FREE INFORMATION CARD the main pc board.) Rubber cement a 4" × 2½" × ⅜" (102 × 63 × 9.5 mm) piece of foam-rubber carpet pad to the bottom of the main pc board. Assemble the display board, if used.

All components should be mounted inside a prepared metal case that measures 5"W × 3¾"D × 2¾"H (127 × 92.3 × 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 ⅜" (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.

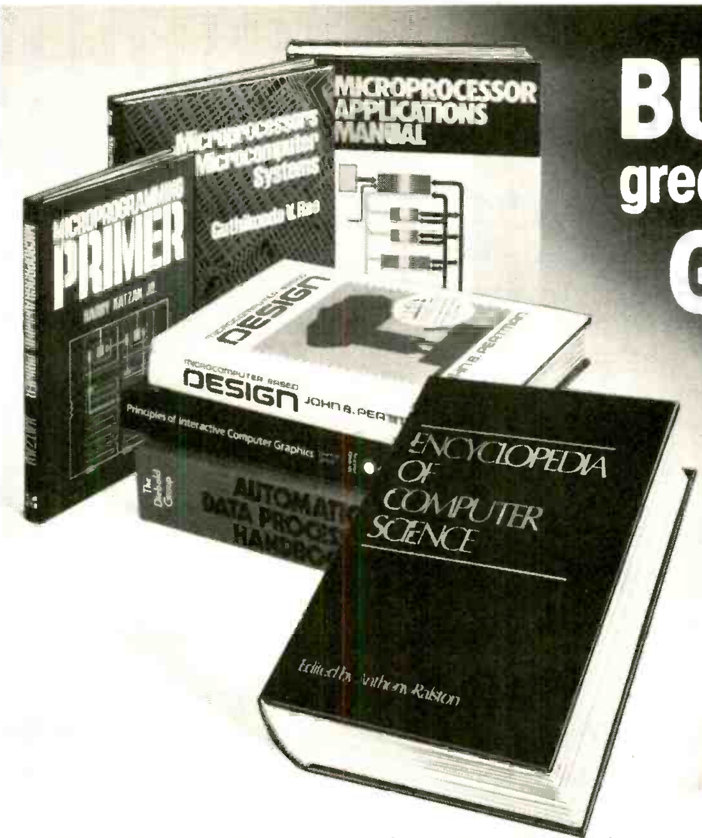
Calibrate the timing chain by adjusting *R29* and observing total ON time of *LED2* with *S5* in one time position. With a little patience, you can adjust *R29* to obtain accuracy within a fraction of a second. Gross adjustment can be made in the 10- and fine adjustment in the 100-second periods. Accuracy 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 ± 10 counts, a display of 120 counts as 120 ± 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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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-

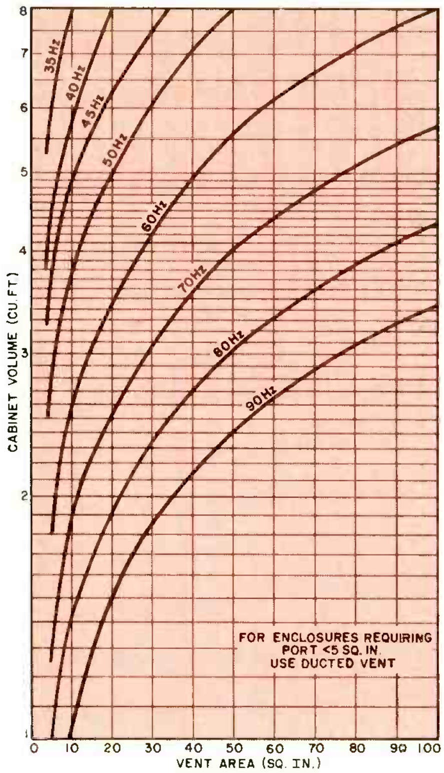

Fig. 1. Design chart to be employed for enclosures with simple vent.

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 opening 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-

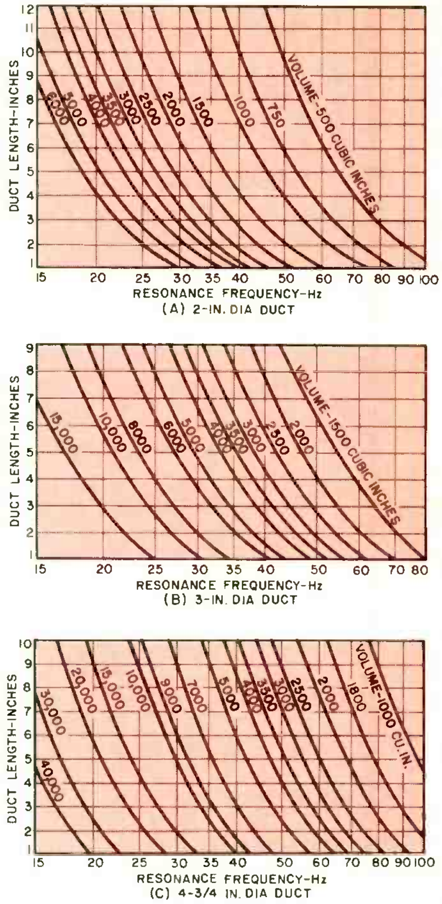

Fig. 2. Design charts for cardboard tube-ducted enclosures. Tubing diameters are inside measurements; duct length is measured from cabinet front.

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 alignment 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.

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_3	—	2.68	2.000	0.0954	0.180	—	—
2	QB_3	—	2.28	1.730	0.1337	0.209	—	—
3	QB_3	—	1.77	1.420	0.2242	0.259	—	—
4	QB_3	—	1.45	1.230	0.3390	0.303	—	—
5	B_4	—	1.000	1.000	0.7072	0.383	—	—
6	C_4	—	0.867	0.927	0.9479	0.415	—	—
7	C_4	0.13	0.729	0.829	1.372	0.466	—	—
8	C_4	0.25	0.641	0.757	1.790	0.518	—	—
9	C_4	0.55	0.600	0.716	2.062	0.557	—	—
9.5	C_4	1.52	0.520	0.638	2.60	0.625	—	—
—	—	—	—	—	—	—	—	—
15	B_6	—	1.000	1.000	0.366	0.299	+6.0	1.07

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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	Butterworth—alignments with flat response down to cutoff.
C	Chebychev—alignments with some degree of ripple in response.
QB	Quasi-Butterworth alignments.
f_S	Frequency of driver's free-air resonance.
Q_{TS} or **Q**	Q of driver at f_S.
Q_T	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.
V_{AS}	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.
V_B	Volume of air in box.
f_3	Cutoff frequency, response down 3 dB from mid-band level.
f_B	Frequency of box resonance, determined by internal volume of air and vent characteristics.
f_{PK}	Frequency of peak lift produced by auxiliary equalizer.

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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 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.

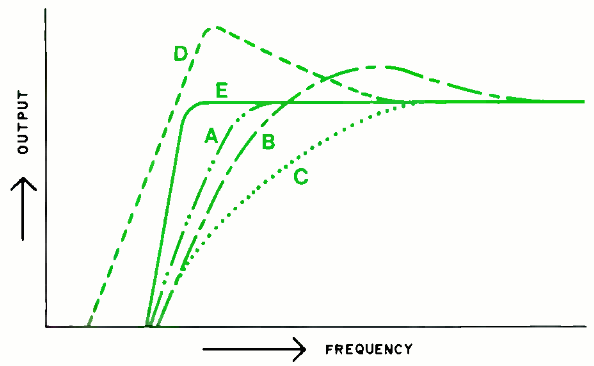


Fig. 3. Characteristic response curves for various reflex systems: (A) Fourth-order Butterworth; (B) relfex box with f_B too high; (C) reflex box with f_B too low, similar to system before equalization; (D) equalizer output to complement B_6 speaker; (E) response of system that combines detuned box (C) 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.

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

TABLE III—THIELE/SMALL PARAMETERS FOR SEVERAL TYPICAL DRIVERS

Brand	Model	Advertised diameter (in.)	f_S (Hz)	Q_{TS}	V_{AS} (cu ft)	V_{AS} (liters)
Electro-Voice	SP12C	12	45	0.67	5.9	165
	SP15C	15	40	0.45	9.9	280
JBL (Prof. Series)	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
Speakerlab	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 cutoff 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 B_6 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. ◇

BY HOWARD BERENBON

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

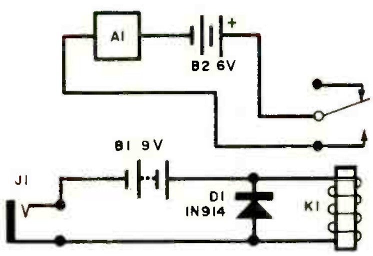
A SIMPLE "REAL TIME" TRS-80 TIMER

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. ◇



Control circuit is activated by cassette relay at line 590.

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.

IF 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 μ 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 μ A; 0 to 5 μ A; and 0 to 50 μ A. The circuit can be powered by a supply furnishing as little as ±2 or +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 μ Meter is shown in Fig. 2. Switch *S2* selects the range and determines the feedback resistance of the stage. When the switch is in its center (off) position, the feedback resistance is *R3*, one megohm. An input current of 0.5 μ A will cause the output of the op amp to be 0.5 volt above ground when only *R3* is in the feedback loop.

This output voltage will cause full-scale deflection of 0-to-50-microammeter *M1* 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 *R4*. 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 *S2* 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 μ A. Higher-current ranges are obtained by shunting *R3* with other resistors to lower the overall feedback resistance. This is accomplished by placing *S2* in one of its two other positions. When the range switch is placed in its 5 μ A position, the parallel combination of *R1* and *R3* causes the meter to deflect to full scale if the input current is five microamperes. Similarly, placing *S2* in its 50 μ A position shunts *R3* with *R2* and causes full-scale deflection of the meter movement when an input current of fifty microamperes exists.

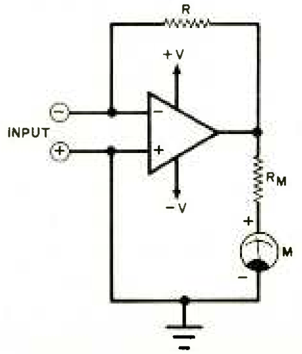


Fig. 1. Schematic of simple current-measuring circuit.

Two shorting switches are included in the circuit. Switch *S1* shorts the input of the project. It is used in conjunction with potentiometer *R5* to zero the meter movement. The other switch (*S3*) is used to short the terminals of *M1* when the meter is not being used. This minimizes mechanical shocks to the meter movement when the project is being transported. Diodes *D1* and *D2* protect the project from excessive input voltages. Jack *J2* provides access to *M1* 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, *M1*, 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 *J1* and illuminated so that the Sensitive μ Meter indicated a current of 50 μ A. The cell was then connected to *J2* and its output current measured using *M1* alone. It indicated a current of 1 μ A.

The reason for this discrepancy between the two readings is that *M1* 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 *M1* or a similar meter alone) in the measurement of currents up to 50 μ A.

There is another significant advantage to the use of the Sensitive μ Meter as opposed to a microammeter alone. Due to the clipping action of protective diodes *D1* and *D2*, the maximum output voltage of the op amp on any of the three ranges is

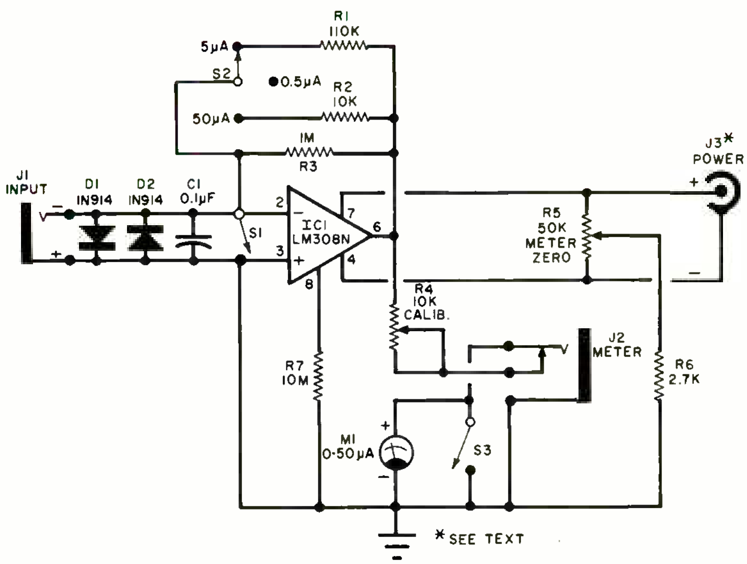


Fig. 2. The gain of the operational amplifier and, hence, the range of the meter are determined by the amount of resistance in the feedback circuit.

PARTS LIST

C1—0.1-μF 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-μA meter movement (Radio Shack No. 22-051 or equivalent)
The following are ¼-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.

approximately 0.7 volt. This corresponds to less than a 50% overload of meter movement *M1*, 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 *J3*. Note that the shell of this power jack must be insulated from chassis ground. The operational amplifier specified for use as *IC1* is an LM308, a precision op amp that can be used with supply voltages ranging from ±2 to ±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 μ Meter. Potentiometer *R5* is connected across the supply to allow zeroing of the meter movement under no-input conditions (*S1* 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" × 2" × 1½" (10.2 × 5.1 × 3.8 cm) aluminum utility box. A Radio Shack No. 22-051 0-to-50-microammeter was used for *M1*. 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 *IC1* 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-μF 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 *J3*, observing polarities. Then close *S1*, place *S2* in its 0.5 μA position, and open *S3*. Set the wiper of *R4* halfway between the two extremes of its travel and adjust potentiometer *R5* for a zero reading on meter movement *M1*. Then open *S1* and place *S2* in its 50 μA 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 *J1* or the voltage at the output of the operational amplifier. Adjust the amplitude of the input current so that it equals 50 μA. 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 *R4* to obtain a full-scale (50 μA) reading on *M1*.

The Sensitive μ 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 *R5*. 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 *D1* and *D2*, 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 *S3* 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

Parlor game displays random, digitally generated answers to your questions

BY MICHAEL J. FRIESE

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 $\overline{\text{OUTPUT}}$ $\overline{\text{ENABLE}}$ 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

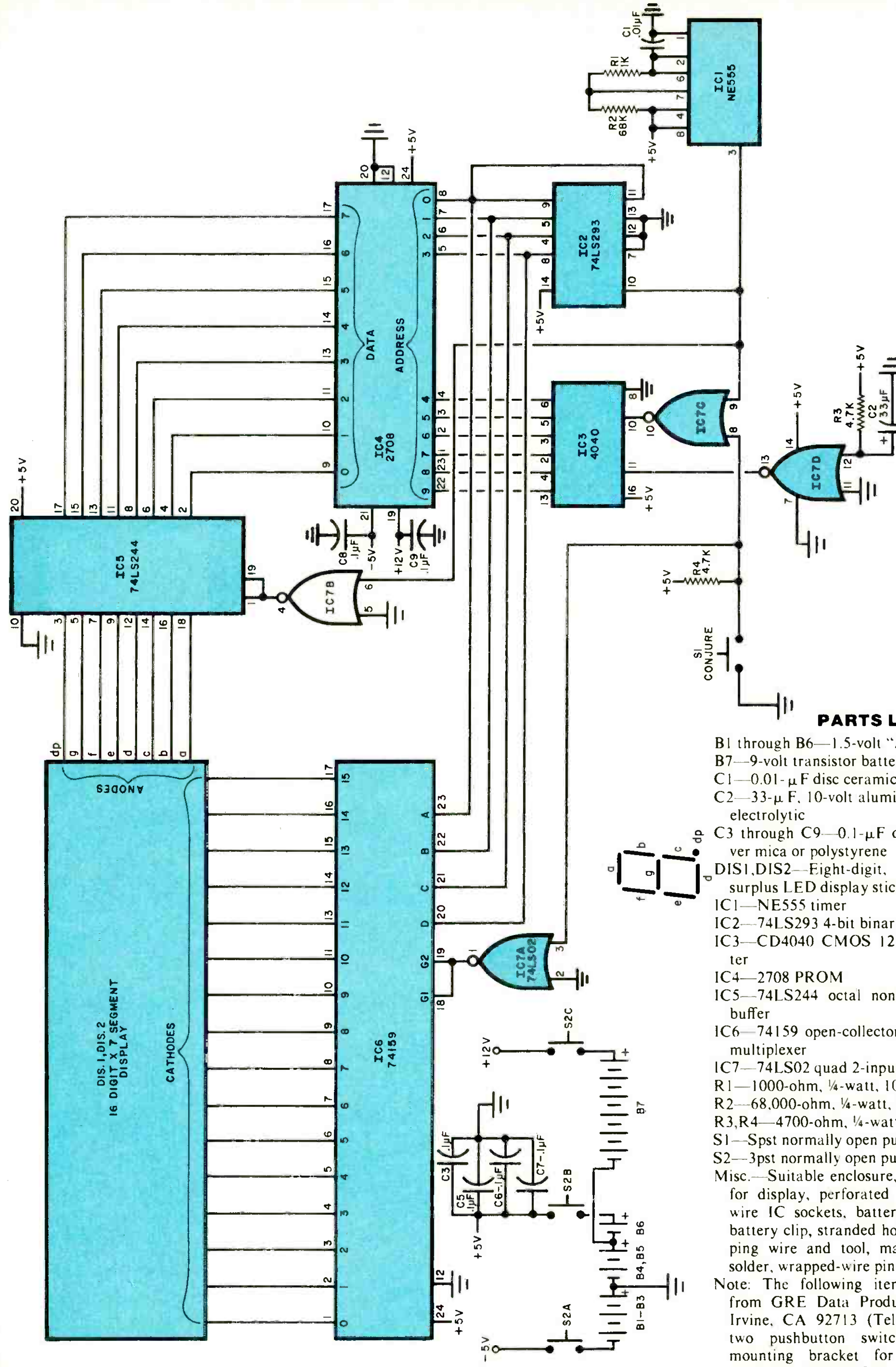


Fig. 1. Schematic diagram of the Magic Box. Answers are stored in the preprogrammed PROM IC4 and supplied to the display when called for.

PARTS LIST

B1 through B6—1.5-volt "AA" cell
B7—9-volt transistor battery
C1—0.01-µF disc ceramic
C2—33-µF, 10-volt aluminum or tantalum electrolytic
C3 through C9—0.1-µF 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, ¼-watt, 10% resistor
R2—68,000-ohm, ¼-watt, 10% resistor
R3,R4—4700-ohm, ¼-watt, 10% resistor
S1—Spst normally open pushbutton switch
S2—3pst 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 (*B1*, *B2*, *B3*) generate −5 volts (actually −4.5 volts) for the V_{BB} line of ROM *IC4*. Three additional AA cells (*B4*, *B5*, *B6*) 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 (*B4* and *B5*, which are also used to generate +4.5 volts for the logic ICs) and *B7*, a nine-volt transistor battery. The various supply lines are bypassed by capacitors *C3* through *C9* to enhance circuit stability. Power is applied to the Magic Black Box by depressing three-pole pushbutton switch *S2*.

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

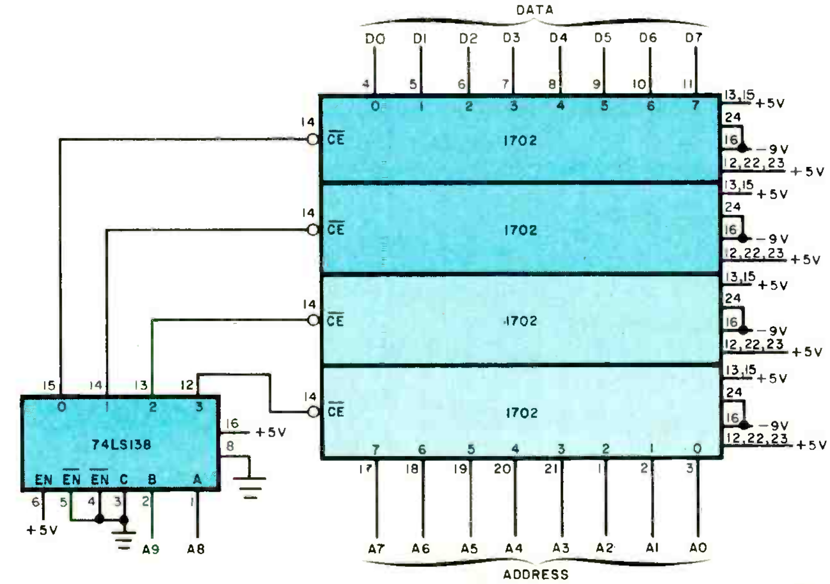
TABLE I— MAGIC BLACK BOX MESSAGE REPERTOIRE

```
PHRASE 1  | your qUEstION? |
PHRASE 2  |   I CANt sAy    |
PHRASE 3  |I sHAll not sAy |
PHRASE 4  |  I CANt 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 |   lEts sEE      |
PHRASE 13 |      yEs        |
PHRASE 14 |yEs yEs yEs yEs |
PHRASE 15 |Is dECIdEdly 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 | dECIdEdly 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 no|
PHRASE 53 |the stars sAy no|
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.



burned into the PROM. Now load the program and run it. Your computer will inquire as to the address of the first of the memory slots that have been set aside for the storage of encoded messages. Reply in decimal notation, e.g., 16384 decimal is equivalent to 4000 hex-encoded binary. The computer will then reply, "PHRASE 1?", signalling that it is ready to receive the first of the messages to be burned into the PROM.

Type in the first message and hit RETURN. Then enter the next one and again depress the RETURN key. Repeat this procedure for each of the remaining messages, for a maximum of 64 responses. To go back and edit any particular phrase, type its identifying number and hit RETURN. The necessary correction can then be made. To list all the remaining phrases from the current identifying number through the sixty-fourth, type LIST and hit RETURN. When you have entered all 64 messages and have edited them to your satisfaction, you can transfer the data stored in the 1K block of RAM into the PROM. Don't forget to save the data you obtain in tape or disk form.

TABLE II—HEXADECIMAL ROM LISTING

@

4000	00	6E	5C	1C	50	00	67	3E	79	6D	70	06	3F	37	53	00
4010	00	00	00	06	00	39	77	37	70	00	6D	77	EE	00	00	00
4020	06	00	6D	76	77	38	38	00	54	5C	70	00	6D	77	EE	00
4030	00	00	06	00	39	77	37	70	00	70	7B	38	B8	00	00	00
4040	50	79	73	79	77	70	00	67	3E	79	6D	70	06	3F	B7	00
4050	00	06	00	39	77	37	00	54	5C	70	00	70	7B	38	B8	00
4060	00	06	00	39	77	37	00	54	5C	70	00	6D	77	EE	00	00
4070	00	06	70	00	06	6D	00	3E	37	39	38	79	77	D0	00	00
4080	00	00	00	70	50	6E	00	77	3D	77	06	B7	00	00	00	00
4090	6D	3E	50	79	38	6E	00	6E	3F	3E	00	1E	79	6D	F0	00
40A0	06	00	39	77	37	70	00	70	7B	38	38	00	6E	3F	BE	00
40B0	00	00	38	79	70	6D	00	6D	79	79	80	80	80	00	00	00
40C0	00	00	00	00	00	00	6E	79	ED	00	00	00	00	00	00	00
40D0	6E	79	6D	00	6E	79	6D	00	6E	79	6D	00	6E	79	ED	00
40E0	06	6D	00	5E	79	39	06	5E	79	5E	38	6E	00	6D	BF	00
40F0	00	00	73	50	5C	7C	5F	7C	38	6E	00	6D	BF	00	00	00
4100	00	00	73	50	5C	7C	5F	7C	38	6E	00	6E	79	ED	00	00
4110	00	5E	79	71	06	37	06	70	79	38	6E	00	6D	BF	00	00
4120	00	5E	79	71	06	37	06	70	79	38	6E	00	6E	79	ED	00
4130	00	77	6D	6D	79	50	70	79	5E	38	6E	00	6D	BF	00	00
4140	00	77	00	73	3F	6D	6D	06	7C	06	38	06	70	EE	00	00
4150	00	06	00	39	77	37	00	6D	79	79	00	70	74	5F	F0	00
4160	00	00	3D	5C	5C	5E	00	39	76	77	37	39	F9	00	00	00
4170	00	00	3D	50	7B	5F	70	00	39	76	77	37	39	F9	00	00
4180	00	06	70	00	06	6D	00	73	50	5C	7C	5F	7C	38	FB	00
4190	00	77	6D	6D	7B	50	70	7B	5E	38	6E	00	6E	79	ED	00
41A0	00	06	70	00	06	6D	00	73	3F	6D	6D	06	7C	38	F9	00
41B0	70	74	7B	00	6D	70	5F	50	6D	00	6D	77	6E	00	6D	BF
41C0	00	00	00	06	00	76	3F	73	79	00	6D	BF	00	00	00	00
41D0	00	00	00	3F	71	00	39	3F	3E	50	6D	F9	00	00	00	00
41E0	00	06	70	00	06	6D	00	73	3F	6D	6D	06	7C	38	F9	00
41F0	00	00	00	00	54	5C	00	5E	5C	1C	7C	F0	00	00	00	00
4200	00	00	73	3F	6D	6D	06	7C	38	6E	00	6D	BF	00	00	00
4210	5E	79	71	06	37	06	70	79	00	39	76	77	37	39	F9	00
4220	00	00	00	00	00	1C	74	40	74	1C	F4	00	00	00	00	00
4230	00	00	71	77	06	50	00	39	76	77	37	39	F9	00	00	00
4240	00	00	6D	5C	1C	54	5E	6D	00	3D	5C	5C	DE	00	00	00
4250	00	06	02	38	38	00	7C	7B	70	00	5C	54	00	04	F0	00
4260	00	00	00	00	00	00	00	37	DC	00	00	00	00	00	00	00
4270	00	37	5C	00	37	5C	00	37	5C	00	37	5C	00	37	DC	00
4280	00	5E	79	39	06	5E	79	5E	38	6E	00	54	5C	F0	00	00
4290	00	00	73	50	5C	7C	5F	7C	38	6E	00	54	DC	00	00	00
42A0	00	00	73	50	5C	7C	5F	7C	38	6E	00	54	5C	F0	00	00
42B0	00	5E	79	71	06	37	06	70	79	38	6E	00	54	DC	00	00
42C0	00	5E	79	71	06	37	06	70	79	38	6E	00	54	5C	F0	00
42D0	00	00	00	06	00	5E	5C	1C	7C	70	00	04	F0	00	00	00
42E0	00	00	00	37	3F	00	39	76	77	37	39	F9	00	00	00	00
42F0	06	00	5E	5C	54	70	00	6D	79	79	00	70	74	5F	F0	00
4300	7C	5F	50	7B	38	6E	00	73	50	5C	7C	5F	7C	38	FB	00
4310	00	00	54	5C	70	00	5F	00	39	76	77	37	39	F9	00	00
4320	00	38	04	70	70	38	79	00	39	76	77	37	39	F9	00	00
4330	1C	54	71	5C	50	70	1C	54	5F	70	7B	38	6E	00	54	DC
4340	70	74	7B	00	6D	70	5F	50	6D	00	6D	77	6E	00	54	DC
4350	00	77	7C	6D	3F	38	3E	70	7B	38	6E	00	54	5C	F0	00
4360	00	3F	71	00	39	3F	3E	50	6D	79	00	54	5C	F0	00	00
4370	00	00	70	06	37	6E	00	39	76	77	37	39	F9	00	00	00
4380	00	00	00	71	77	70	00	39	76	77	37	39	F9	00	00	00
4390	00	00	73	3F	6D	6D	06	7C	38	6E	00	54	5C	F0	00	00
43A0	00	00	00	00	00	00	37	3F	73	F9	00	00	00	00	00	00
43B0	00	37	5C	70	00	5C	54	00	6D	3E	37	5E	77	EE	00	00
43C0	00	37	5C	00	73	3F	6D	6D	06	7C	06	38	06	70	EE	00
43D0	00	6D	38	06	3D	76	70	00	39	76	77	37	39	F9	00	00
43E0	06	00	7C	7B	70	00	77	3D	77	06	37	6D	70	00	04	F0
43F0	73	3E	6D	76	00	70	74	7B	00	7C	1C	70	70	5C	D4	00

Construction. The circuit of the Magic Black Box is not very complicated, so any appropriate assembly technique can be employed. The author assembled his prototype using wrapped-wire connections, and mounted all components except for the batteries and their holders on a piece of perforated board measuring 5″ × 3″ (12.7 cm × 7.6 cm). He installed all components except *C3* through *C8*, *DIS1*, and *DIS2* in Wire-Wrap sockets. A photograph of the prototype circuit board with key components called out appears in Fig. 2.

Easily one of the best bargains in optoelectronics on today's market, surplus seven-segment LED calculator display sticks are employed as the project's readouts. The largest units commonly available have eight or nine digits and are priced at less than $2 each. Two such displays are required for the Magic Black Box's 16-digit readout. Ideally, the two will be able to be butted together to form one continuous 16-digit display. Most display sticks are not designed to do this, however, so a little custom craftsmanship is in order.

Carefully grind down one end of each display stick. If your displays are like most, you will destroy some of the printed circuit foil traces along the edge of the stick when you do this. Carefully rewire the affected connections using No. 30 or thinner wire. Test each display stick to verify that it performs the same as it did before the modification. Then solder wrapping-wire pins to the 16 foil pads along the bottom of each display

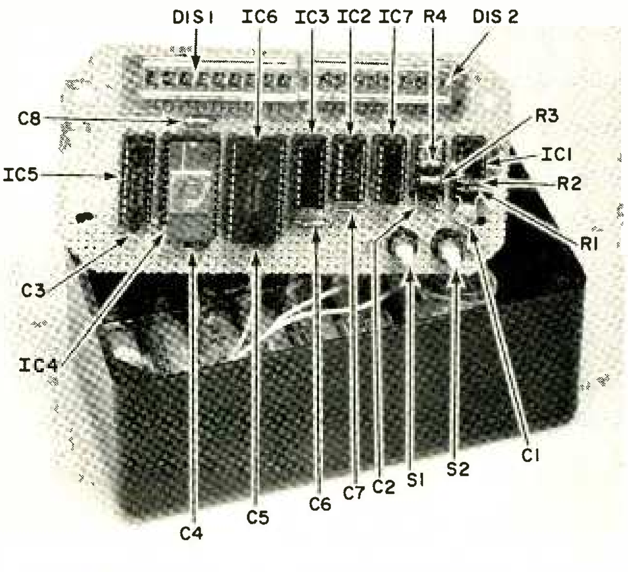


Fig. 2. Photo shows interior of author's prototype.

stick. Mount the display sticks side by side on the perforated board; and, using eight wrapping wires, interconnect the corresponding segment and decimal-point pins of each stick.

Drill holes at the lower right portion of the perforated board and mount push-button switches *S1* and *S2*. Mount eight wrapped-wire IC sockets as was done on the prototype's circuit board (Fig. 2). From left to right, the sockets are of the following sizes: 20 pins; 24 pins; 24 pins; 16 pins; 14 pins; 14 pins; 14 pins; and 14 pins. The socket at the extreme right will accommodate *IC1*, *R1*, *R2* and *C1*. The next socket can hold *R3*, *R4*, and *C2*.

Select a suitable enclosure for the Magic Black Box. The author chose a Bakelite box measuring 6″ × 3⅛″ × 2¼″ (15.2 × 7.9 × 5.7 cm) with a ⅛-inch (3.2-mm) thick red acrylic cover. Drill the necessary holes for battery holders for *B1* through *B7* and install the holders. If you don't want to drill the enclosure, secure the battery holders to it with double-sided adhesive tape. Now wire all power connections, referring to the schematic for the power terminals associated with each IC. Use 4-inch (10.2-cm) lengths of stranded hookup wire to interconnect the battery holder terminals and power switch *S2*.

Connect *S2* to the perforated board's power busses and install bypass capacitors *C3* through *C8*. Install the remaining resistors and capacitors in the extreme right and next-rightmost IC sockets using Fig. 2 as a guide. Take care to orient polarized capacitor *C2* correctly. Then make wrapped-wire connections to complete the balance of the circuit shown in Fig. 1.

Install *B1* through *B7* in their holders and close power switch *S2*. Using a voltmeter, check the polarities of the +5-, +12- and ±5-volt supply lines. If they are correct, open *S2* and install *IC1*, *IC2*, *IC3*, *IC5*, *IC6* and *IC7*. Observe standard MOS handling procedures when installing *IC3*. Once again close power switch *S2*. All segments of each digit should glow, forming 8s, and all decimal points should glow as well. If only one digit glows, chances are that the 555 timer being used as *IC1* cannot tolerate the combination of low supply voltage and high duty cycle. Replace this IC with other 555s until you find one that oscillates properly.

Keep *S2* depressed and close CONJURE switch *S1*. The display should blank out. Open *S1* but keep *S2* closed. Double-check the voltages at pins 12, 19, 21 and 24 of the socket that will accommodate *IC4*. If the readings are correct, open *S2* and install PROM *IC4* in its socket. Observe MOS handling procedures when mounting the PROM in its socket. Now depress *S2* again. The display should read, "Your question?". Keep *S2* depressed and momentarily close *S1*. The readout should briefly blank out and then display a randomly selected message.

Once you are satisfied that the project is functioning properly, install it in the enclosure you have selected. As mentioned earlier, the author housed his prototype in a small Bakelite box (hence the project's name) with a red acrylic top plate. This red cover serves to enhance display legibility. The perforated circuit board was bolted to it using 6-32 machine hardware and suitable spacers. Finally, the acrylic top plate was secured to the enclosure using four 4-40 machine screws, resulting in a compact, sturdy package.

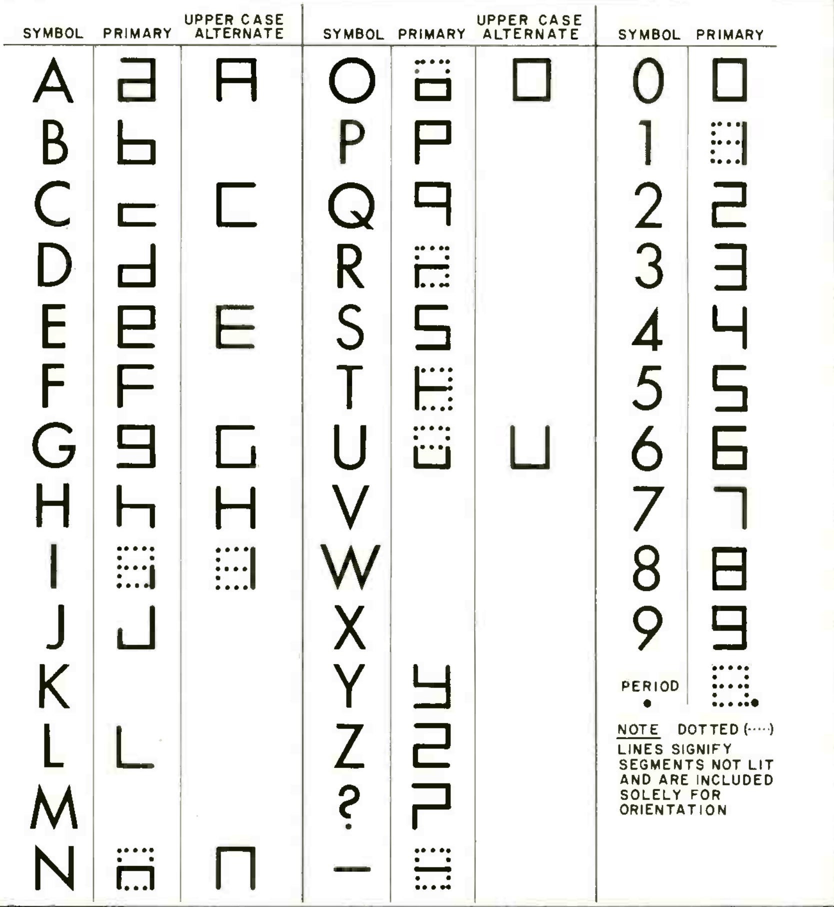
(Continued on page 66)

TABLE III—OCTAL ROM LISTING

0 000	000	156	134	034	120	000	147	076	171	155	160	006	077	067	123	000
0 020	000	000	000	006	000	071	167	067	160	000	155	167	356	000	000	000
0 040	006	000	155	166	167	070	070	000	124	134	160	000	155	167	356	000
0 060	000	000	006	000	071	167	067	160	000	160	173	070	270	000	000	000
0 100	120	171	163	171	167	160	000	147	076	171	155	160	006	077	267	000
0 120	000	006	000	071	167	067	000	124	134	160	000	160	173	070	270	000
0 140	000	006	000	071	167	067	000	124	134	160	000	155	167	356	000	000
0 160	000	006	160	000	006	155	000	076	067	071	070	171	167	320	000	000
0 200	000	000	000	160	120	156	000	167	075	167	006	267	000	000	000	000
0 220	155	076	120	171	070	156	000	156	077	076	000	036	171	155	360	000
0 240	006	000	071	167	067	160	000	160	173	070	070	000	156	077	276	000
0 260	000	000	070	171	160	155	000	155	171	171	200	200	200	000	000	000
0 300	000	000	000	000	000	000	156	171	355	000	000	000	000	000	000	000
0 320	156	171	155	000	156	171	155	000	156	171	155	000	156	171	355	000
0 340	006	155	000	136	171	071	006	136	171	136	070	156	000	155	277	000
0 360	000	000	163	120	134	174	137	174	070	156	000	155	277	000	000	000
1 000	000	000	163	120	134	174	137	174	070	156	000	156	171	355	000	000
1 020	000	136	171	161	006	067	006	160	171	070	156	000	155	277	000	000
1 040	000	136	171	161	006	067	006	160	171	070	156	000	156	171	355	000
1 060	000	167	155	155	171	120	160	171	136	070	156	000	155	277	000	000
1 100	000	167	000	163	077	155	155	006	174	006	070	006	160	356	000	000
1 120	000	006	000	071	167	067	000	155	171	171	000	160	164	137	360	000
1 140	000	000	075	134	134	136	000	071	166	167	067	071	371	000	000	000
1 160	000	000	075	120	173	137	160	000	071	166	167	067	071	371	000	000
1 200	000	006	160	000	006	155	000	163	120	134	174	137	174	070	373	000
1 220	000	167	155	155	173	120	160	173	136	070	156	000	156	171	355	000
1 240	000	006	160	000	006	155	000	163	077	155	155	006	174	070	371	000
1 260	160	164	173	000	155	160	137	120	155	000	155	167	156	000	155	277
1 300	000	000	000	006	000	166	077	163	171	000	155	277	000	000	000	000
1 320	000	000	000	077	161	000	071	077	076	120	155	371	000	000	000	000
1 340	000	006	160	000	006	155	000	163	077	155	155	006	174	070	371	000
1 360	000	000	000	000	124	134	000	136	134	034	174	360	000	000	000	000
2 000	000	000	163	077	155	155	006	174	070	156	000	155	277	000	000	000
2 020	136	171	161	006	067	006	160	171	000	071	166	167	067	071	371	000
2 040	000	000	000	000	000	034	164	100	164	034	364	000	000	000	000	000
2 060	000	000	161	167	006	120	000	071	166	167	067	071	371	000	000	000
2 100	000	000	155	134	034	124	136	155	000	075	134	134	336	000	000	000
2 120	000	006	002	070	070	000	174	173	160	000	134	124	000	004	360	000
2 140	000	000	000	000	000	000	000	067	334	000	000	000	000	000	000	000
2 160	000	067	134	000	067	134	000	067	134	000	067	134	000	067	334	000
2 200	000	136	171	071	006	136	171	136	070	156	000	124	134	360	000	000
2 220	000	000	163	120	134	174	137	174	070	156	000	124	334	000	000	000
2 240	000	000	163	120	134	174	137	174	070	156	000	124	134	360	000	000
2 260	000	136	171	161	006	067	006	160	171	070	156	000	124	334	000	000
2 300	000	136	171	161	006	067	006	160	171	070	156	000	124	134	360	000
2 320	000	000	000	006	000	136	134	034	174	160	000	004	360	000	000	000
2 340	000	000	000	067	077	000	071	166	167	067	071	371	000	000	000	000
2 360	006	000	136	134	124	160	000	155	171	171	000	160	164	137	360	000
3 000	174	137	120	173	070	156	000	163	120	134	174	137	174	070	373	000
3 020	000	000	124	134	160	000	137	000	071	166	167	067	071	371	000	000
3 040	000	070	004	160	160	070	171	000	071	166	167	067	071	371	000	000
3 060	034	124	161	134	120	160	034	124	137	160	173	070	156	000	124	334
3 100	160	164	173	000	155	160	137	120	155	000	155	167	156	000	124	334
3 120	000	167	174	155	077	070	076	160	173	070	156	000	124	134	360	000
3 140	000	077	161	000	071	077	076	120	155	171	000	124	134	360	000	000
3 160	000	000	160	006	067	156	000	071	166	167	067	071	371	000	000	000
3 200	000	000	000	161	167	160	000	071	166	167	067	071	371	000	000	000
3 220	000	000	163	077	155	155	006	174	070	156	000	124	134	360	000	000
3 240	000	000	000	000	000	000	067	077	163	371	000	000	000	000	000	000
3 260	000	067	134	160	000	134	124	000	155	076	067	136	167	356	000	000
3 300	000	067	134	000	163	077	155	155	006	174	006	070	006	160	356	000
3 320	000	155	070	006	075	166	160	000	071	166	167	067	071	371	000	000
3 340	006	000	174	173	160	000	167	075	167	006	067	155	160	000	004	360
3 360	163	076	155	166	000	160	164	173	000	174	034	160	160	134	324	000

OK

TABLE IV—DISPLAY CHARACTER SET



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 DIMA(90):FORX=0TO90:READA(X):NEXT:P=0
40 PRINT"PHRASE";P+1;:INPUTL$:IFLEN(L$)>16THENPRINT"LINE TOO LONG":
     GOTO40
45 IFVAL(L$)<>0THENP=VAL(L$)-1:GOTO40
46 IFL$="LIST"THEN90
50 A=S+P*16:FORX=0TO15:POKEA+X,0:NEXT:X=INT((16-LEN(L$))/2)
60 FORY=1TOLEN(L$):Z=A(ASC(MID$(L$,Y,1))-32):IFZ=1THENPRINT"ERROR ";:
     GOTO40
70 POKEA+X,Z:X=X+1:NEXT:POKEA+X-1,PEEK(A+X-1)+128:P=P+1:GOTO40
90 PRINT"PHRASE";P+1;:IFP<9THENPRINT" ";
95 PRINT"!";:A=S+P*16:FORX=0TO15:Z=PEEK(A+X)AND127:FORY=90TO0STEP-1
100 IFZ<>A(Y)THENNEXTY
110 PRINTCHR$(Y+32);:NEXTX:PRINT"!":P=P+1:IFP<64THEN90
120 GOTO40
200 DATA0,1,34,1,1,1,1,2,1,1,1,1,1,64,128,1,63,6,91,79,102,109,125,1,127
210 DATA111,1,1,1,72,1,83,1,119,124,57,94,121,113,61,118,6,30,1,56,1,55
220 DATA63,115,103,80,109,112,62,1,1,1,110,91,1,1,1,1,1,1,95,124,88,94
230 DATA123,113,111,116,4,30,1,56,1,84,92,115,103,80,109,112,28,1,1,1
240 DATA110,91
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

THE 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 ±1 to ±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 (fanout 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-

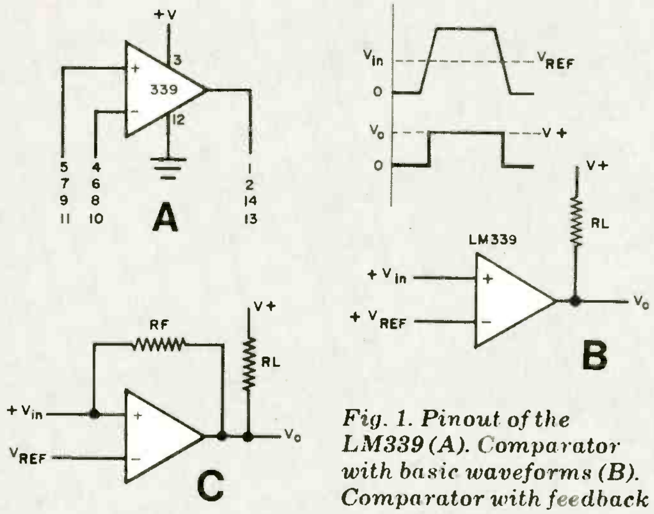


Fig. 1. Pinout of the LM339 (A). Comparator with basic waveforms (B). Comparator with feedback resistor for faster switching action (C).

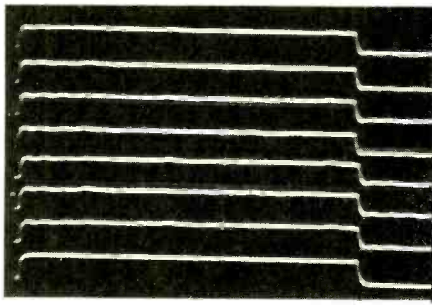


Fig. 3. Outputs of two separate 339 packages (four at top, four at bottom) show excellent matching.

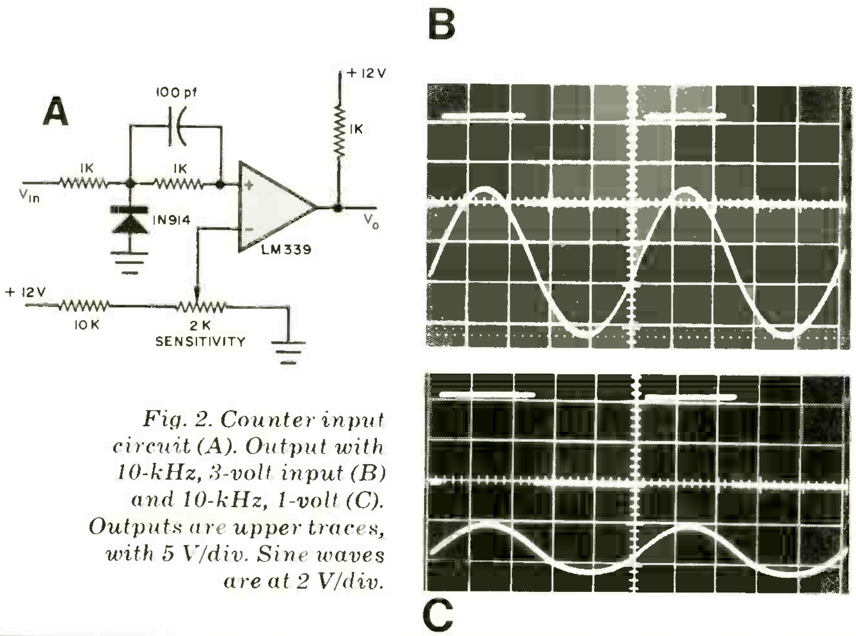
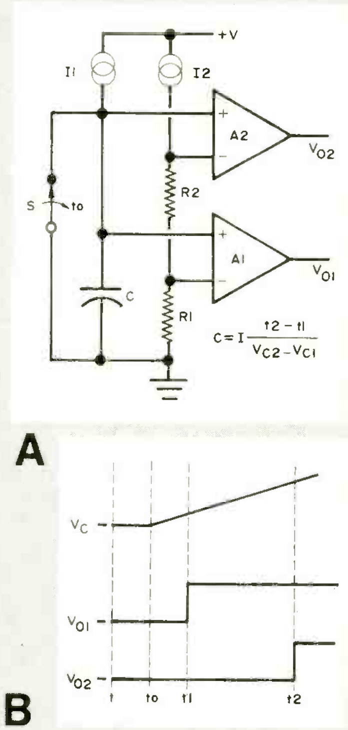


Fig. 2. Counter input circuit (A). Output with 10-kHz, 3-volt input (B) and 10-kHz, 1-volt (C). Outputs are upper traces, with 5 V/div. Sine waves are at 2 V/div.



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.

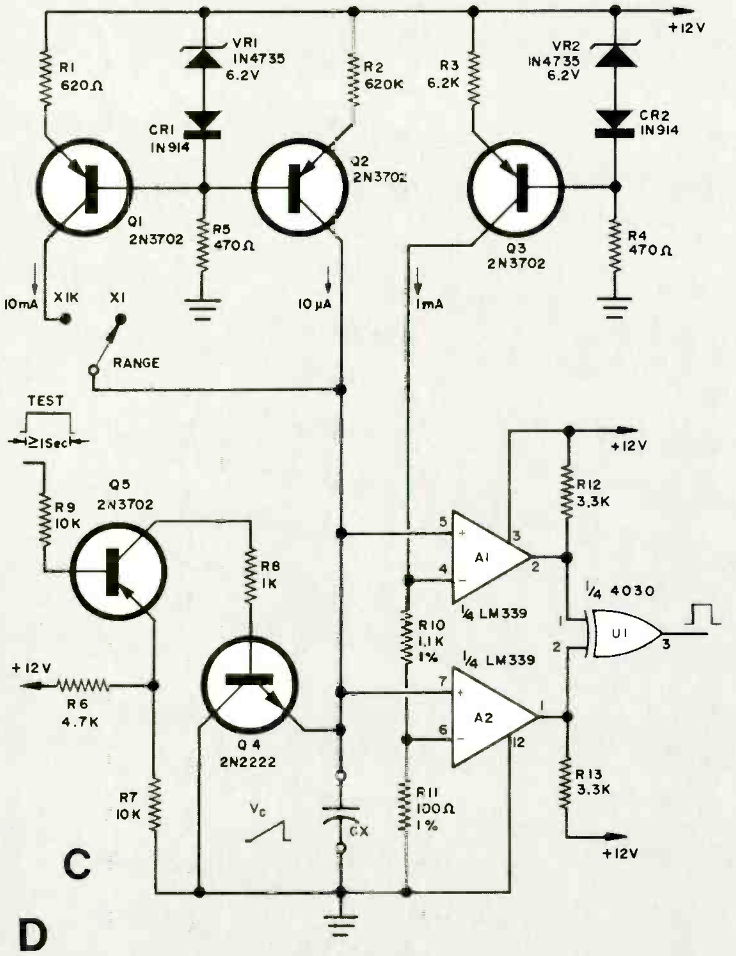
During the design of an 8-input oscilloscope circuit, the author connected eight such circuits, with all eight inputs connected to a source having a pulse 8-microseconds wide. The upper four traces of Fig. 3 came from one 339 package, while the lower four traces came from another 339 package. Actual 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 (*I1*). 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 value 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



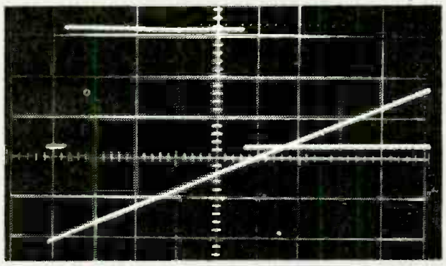


Fig. 4. Basic capacitance measuring circuit (A) and timing diagrams (B). Complete circuit (C) and output for 4.7 µF (D).

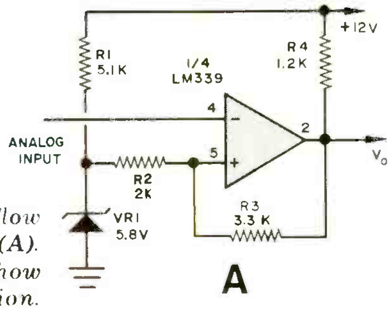
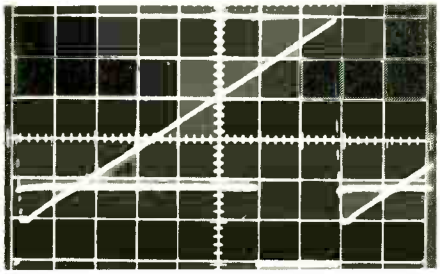
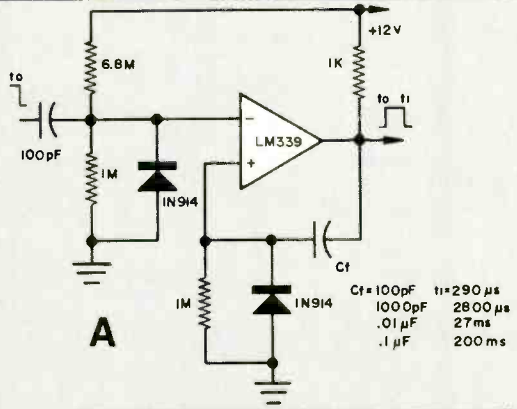
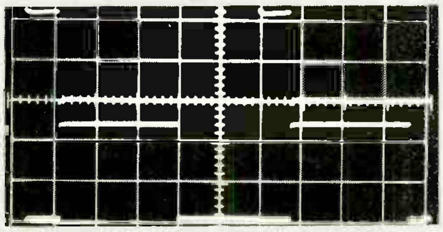


Fig. 5. High/low limit detector (A). Waveforms (B) show switching action.



B





B

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

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 *R1* for 5 to 10 mA of zener current.

When the 339 output is low, some of the current through *R1* flows through *R2* and *R3* 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 *R4*, *R3* and *R2* 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.

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 mono stable. ◇

BUILD A

Metal Locator

BY ROBERT KRIEGER

Low-cost, high-sensitivity unit for searching out metal objects

WHETHER 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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FREQUENCY COUNTER STRAIGHT TALK

There are only three functional requirements for a frequency counter: 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 10 PPM accuracy would read to ± 4500 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 500 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 ± 100 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 ± 460 Hz maximum. Not bad for $99.95. You really need that 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.

The outstanding sensitivity of the 5500, the result of its unique engineering design, and built-in preamp assures stable, accurate readings every time you key up your transmitter.

If you are tired of receiving a plastic bag of sometimes surplus, sometimes defective material only to spend all night trying to solder both sides of the PC Board because the manufacturer chose to use low cost PC Boards without plated-thru holes; if you chose a kit because you only budgeted a hundred dollars for a frequency counter, then the DSI 5500 Counter is the answer. It is 100% factory assembled and tested. DSI strives to purchase the highest quality, prime materials imposing the most rigorous quality requirements possible. Every PC Board that DSI manufactures is plated-thru solder re-flowed, and 100% factory assembled, tested and burned-in in the USA, assuring years of trouble-free service. DSI has worked hard to achieve our worldwide reputation for the best price to quality features ratio in the industry. DSI's 5500 now makes it possible to buy a 100% factory assembled accurate 8-digit frequency counter for under $100.00. Buy quality — Buy performance — Buy cost effectiveness — Buy DSI.

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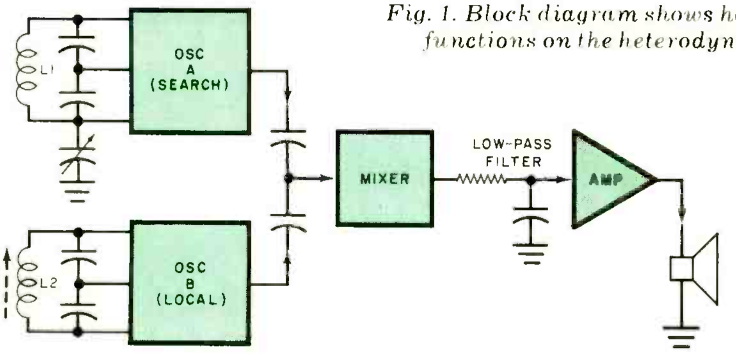


Fig. 1. Block diagram shows how the locator functions on the heterodyning principle.

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 *L1*, 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 *L1* acting as one of the frequency-determining components of oscillator A, the variation in *L1* 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 *L1* 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 *L1* as the inductive element and the other has small tunable inductor *L2*.

For operation, *C1* is set at its midpoint and then *L2* is adjusted so that both oscillators are at zerobeat (same frequency). Varying *C1* will then tune oscillator *Q1* out of zerobeat and cause an audio tone to be heard. Note that source resistor *R4* in the *Q2* circuit is greater in value than *R3* in the *Q1* circuit. Since the *Q1* circuit produces a low level of oscillation, it is necessary to damp the *Q2* oscillator

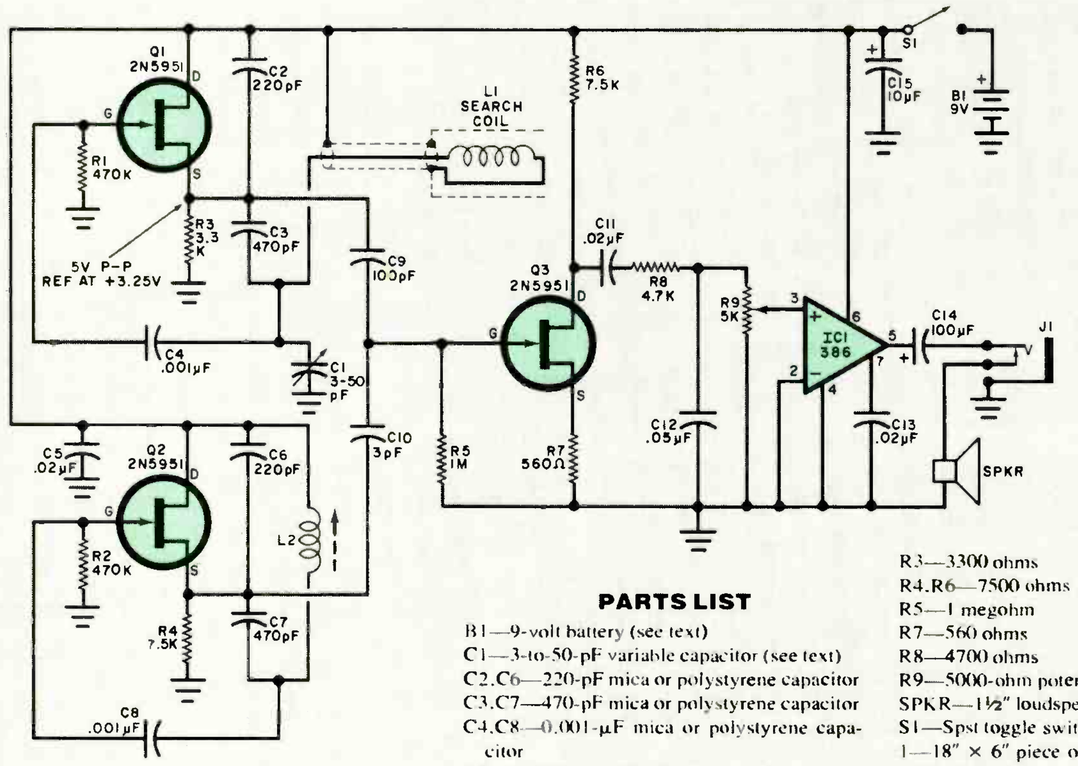


Fig. 2. Two stable Colpitts oscillators (Q1 and Q2) are tuned to operate in the 650-kHz range. They are essentially identical except for the two inductors.

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-µF mica or polystyrene capacitor
C5,C11,C13—0.02-µF capacitor
C9—100-pF mica or polystyrene capacitor
C10—3-pF capacitor
C12—0.05-µF capacitor
C14—100-µF, 16-volt electrolytic
C15—10-µF, 16-volt electrolytic
IC1—LM386 ½-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 ¼-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—1½″ loudspeaker
S1—Spst toggle switch
1—18″ × 6″ piece of ¼″ plywood for search-head coil form
1—36″ length of ¾″ 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; ½″ foam insulation tape; plastic cement; two small brass screws; machine hardware; spacers; hookup wire; solder; etc.

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 5¾" (146-mm) and one 5" (127-mm) disks from a sheet of ¼" (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-

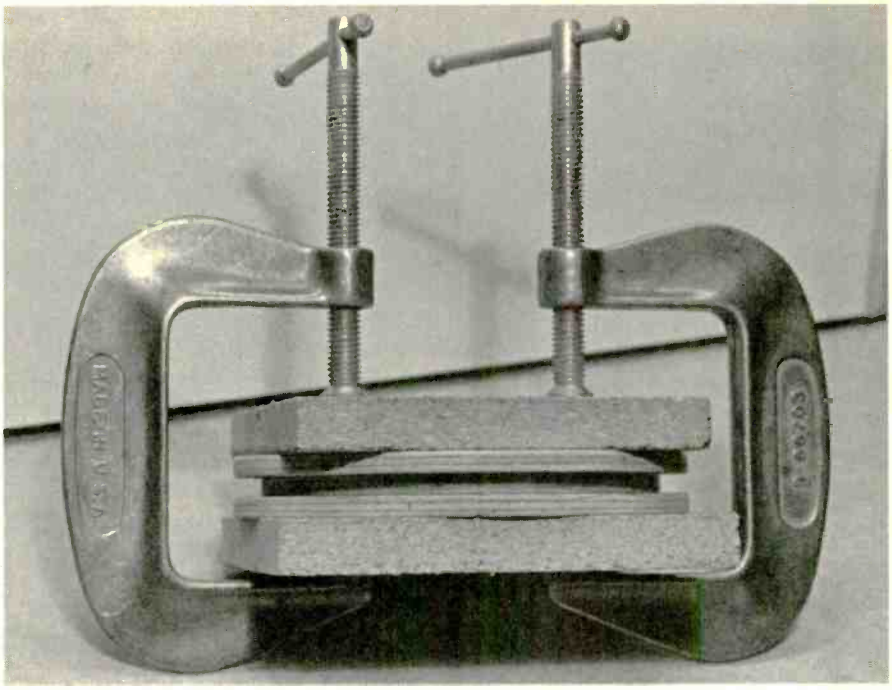


Fig. 3. Glue three plywood discs together with the smaller one in the middle. Use clamps or weights to ensure proper bonding.

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

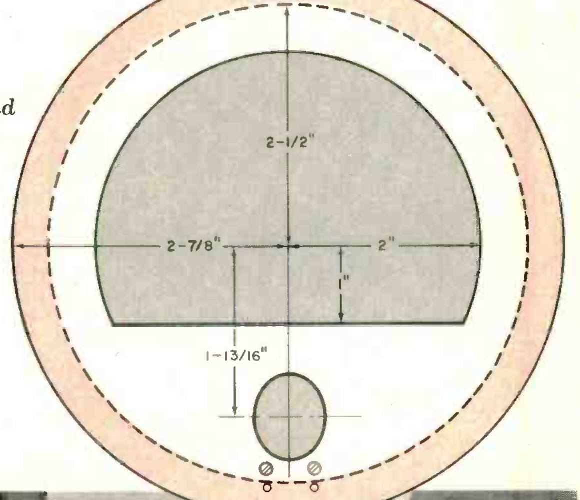


Fig. 5. Use a coping or sabre saw to cut out the form drawn on disc in Fig. 4.

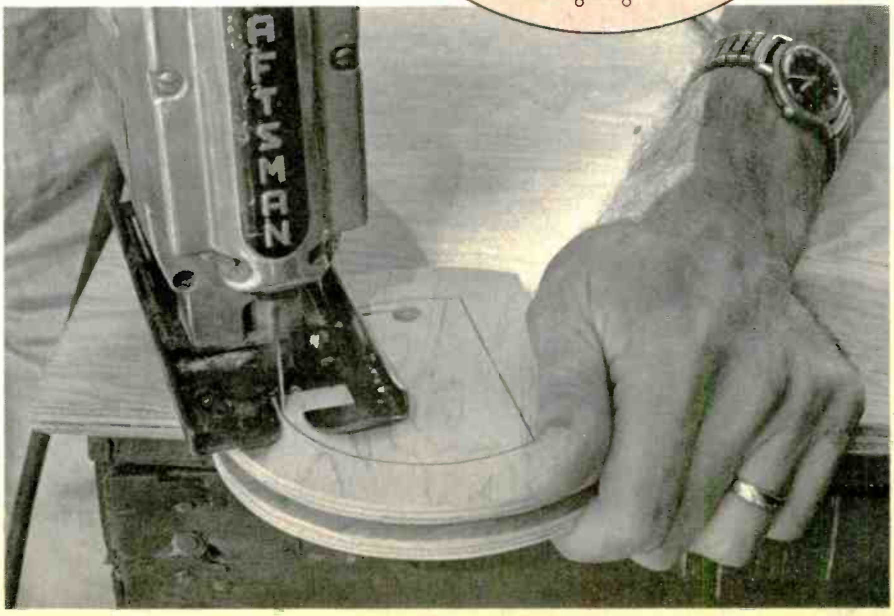


Fig. 6. Drill shaft hole with wood bit, tilting it away from D cutout by about 18 degrees.

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

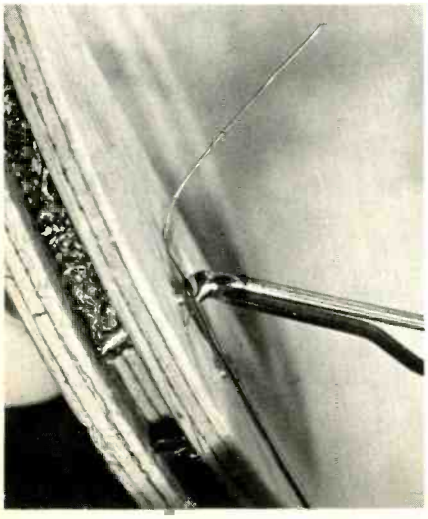


Fig. 8. Bring free end of braid up through plywood sandwich and solder to an adjacent screw.

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 ¾" (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 ⅜" (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 hook-up 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 ½" (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 ⅜" 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 ¼" wide polyfoam weather stripping.

Several inches up on the aluminum shaft, drill a ¼" hole through which to pass the coaxial cable that interconnects electronics package with search coil. On the other end of the shaft, measure down ½" and 1½" and drill ⅛" holes directly in line with the ¼" 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 ¼" 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 ¼" 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 *L2, SPKR, S1, J1, C1, R9, B1*'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 ¾" hole at one end of the box and is held in place with two sets of 6-32 × 1¼" machine screws, nuts, and lockwashers through one wall of the box.)

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.

Next, mount the speaker, *C1, J1, S1, R9*, and *L1* 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 (*Q1*) oscillator first and then the local (*Q2*) oscillator to the same frequency, adjusting *L2* 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 *C1* for zerobeat 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 zerobeat.

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 *B1* to provide superior service, since this type of battery maintains a relatively constant voltage over a longer period than can ordinary carbon-zinc batteries.

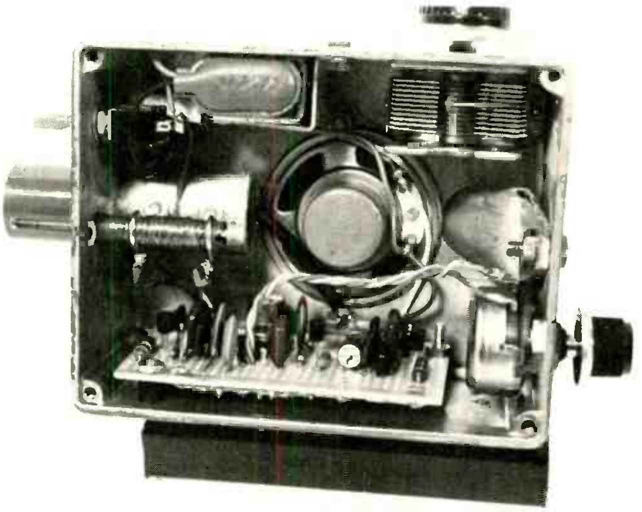


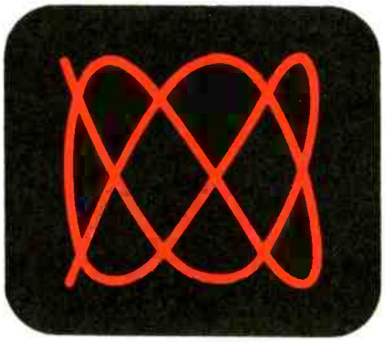
Fig. 11. Photo showing inside of author's prototype. The shaft fits through hole at left. Handle and speaker are shown on the back of enclosure here.

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. ◇

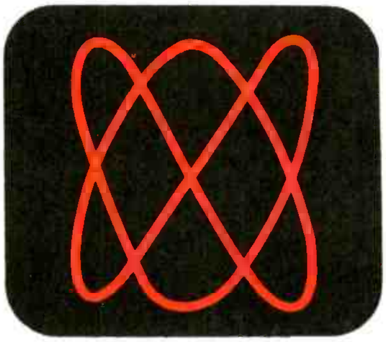
LISSAJOUS PATTERN QUIZ

BY ROBERT P. BALIN

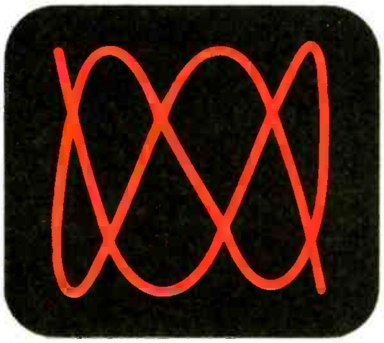
An unknown frequency can be determined by applying it to a scope's vertical terminals, while a signal of known frequency is applied to the horizontal. The resulting display, a Lissajous pattern, can then be analyzed to find the unknown. The ratio between the frequencies is equal to the ratio of the number 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.



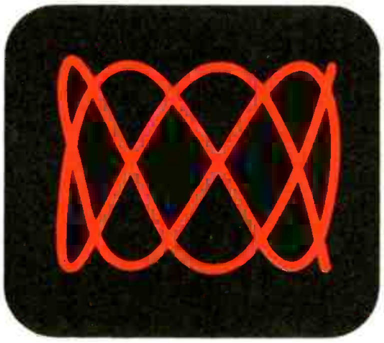
1. V = 2800 Hz. H = ______



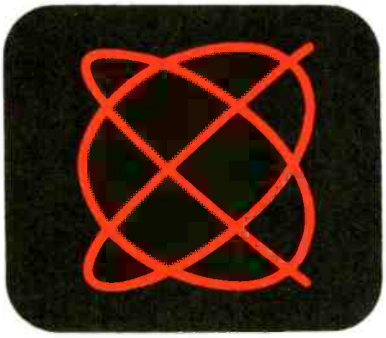
2. H = 500 Hz. V = ______



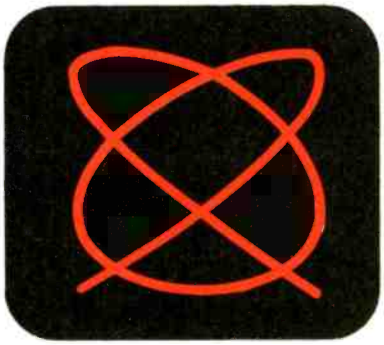
3. V = 1400 Hz. H = ______



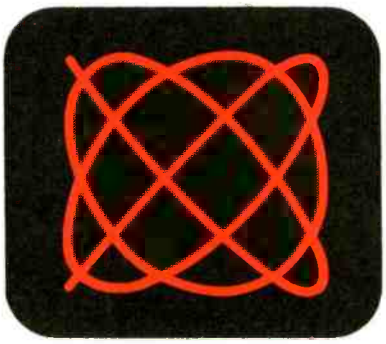
4. H = 240 Hz. V = ______



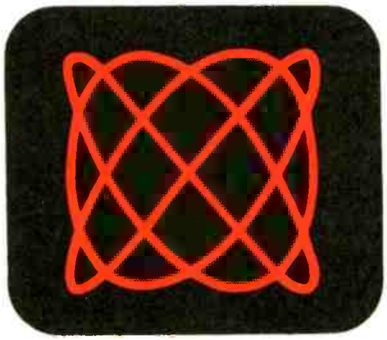
5. V = 1000 Hz. H = ______



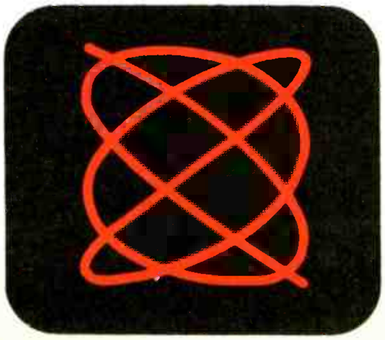
6. H = 60 Hz. V = ______



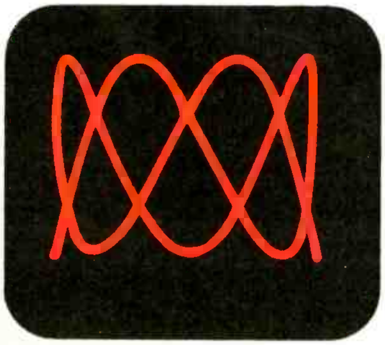
7. V = 4200 Hz. H = ______



8. H = 120 Hz. V = ______



9. V = 3500 Hz. H = ______



10. H = 900 Hz. V = ______

ANSWERS:

1. 7:4; 1600 Hz.
2. 3:2; 750 Hz.
3. 7:3; 600 Hz.
4. 9:4; 540 Hz.
5. 5:6; 1200 Hz.
6. 4:5; 48 Hz.
7. 7:6; 3600 Hz.
8. 4:3; 160 Hz.
9. 5:7; 4900 Hz.
10. 8:3; 2400 Hz.

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 diagram 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.

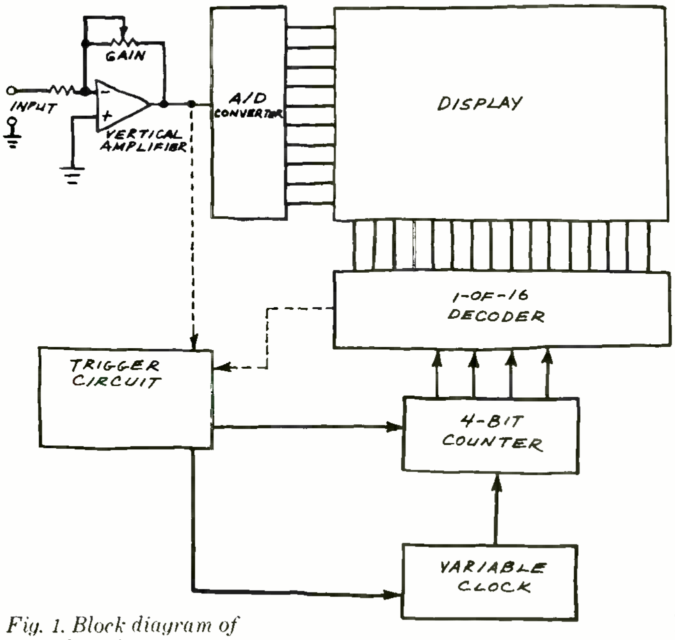


Fig. 1. Block diagram of typical solid-state scope.

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.

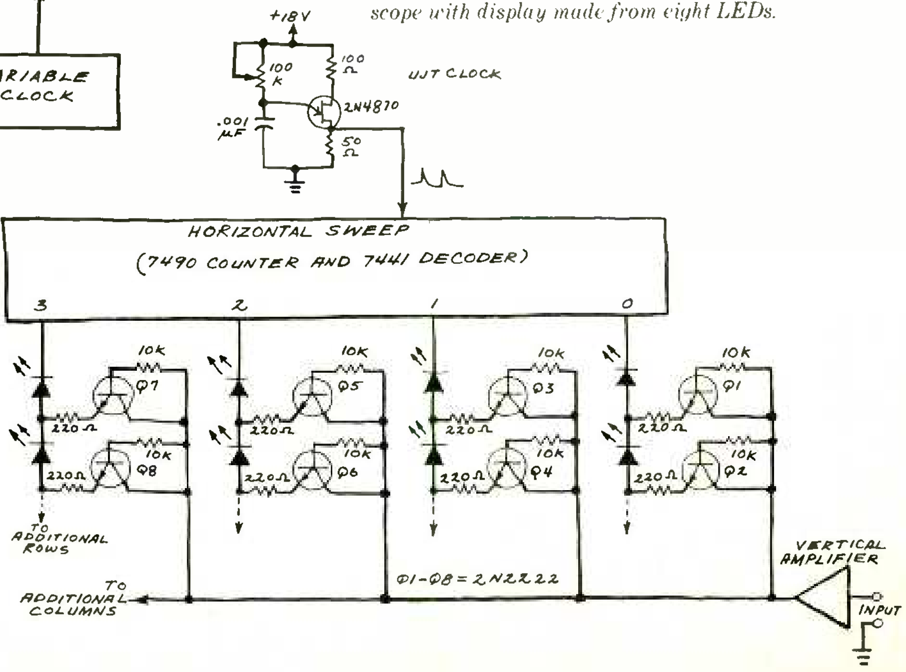
Early Solid-State Scopes. The development of visible LEDs in the early 1960's made possible compact graphic displays that could serve as the screens of solid-state scopes if teamed up with suitable driving and scanning circuitry. Back then, however, LEDs cost $10 *each* and the necessary drive circuits 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.



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

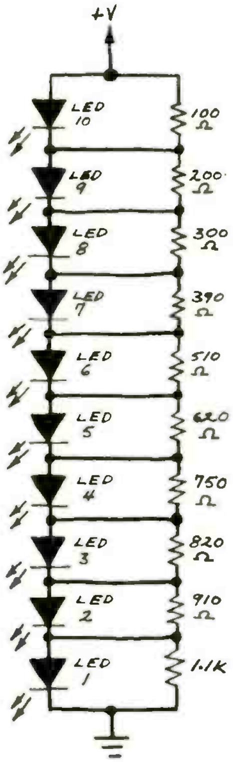


Fig. 3. Voltage-divider LED bargraph display.

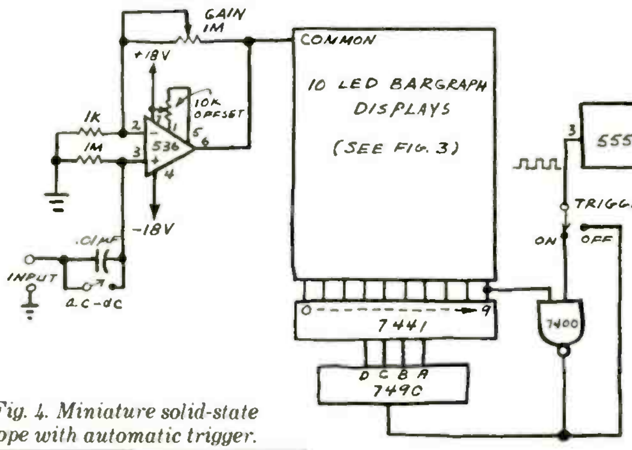


Fig. 4. Miniature solid-state scope with automatic trigger.

A few years ago, Vernon Boyd described 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 × 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

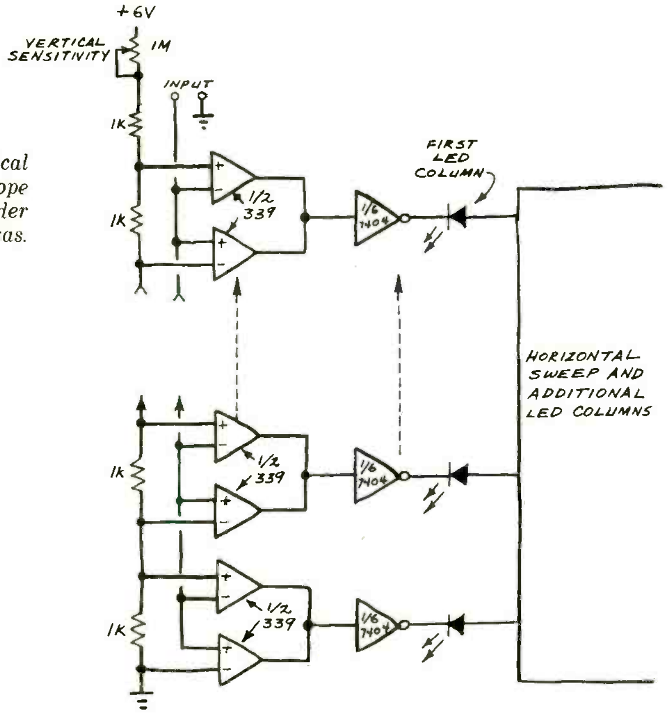
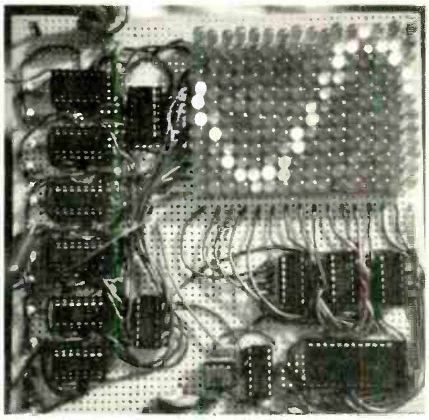


Fig. 5. Vertical section of scope designed by reader Bill Cikas.

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 × 16 element LED display that fits on a 6″ × 6″ (15.3 × 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

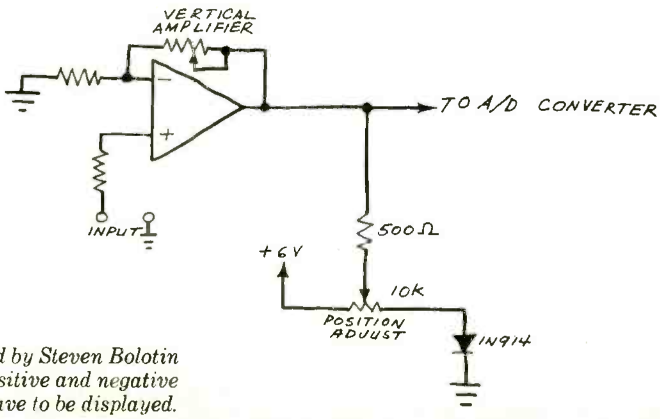


Fig. 7. Circuit designed by Steven Bolotin that permits positive and negative halves of a wave to be displayed.

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 measuring 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.

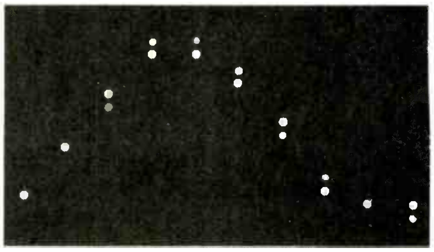


Fig. 8. Photo of waveform displayed on scope designed by Gregory Kovacs.

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.

Hobby Scene Q&A

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 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.

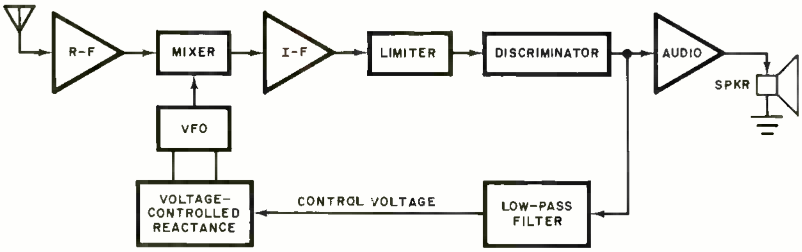
Perhaps the principal advantage to the use of an external trap is that it requires no modification of the receiver. However, it is difficult to construct a trap with a high enough Q to adequately attenuate an undesired signal 400 kHz or so away without also attenuating the desired signal. A more realistic 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 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, shifting the output of the vfo toward its optimum frequency. If the vfo starts to drift, the control loop brings it back into line.

It can thus be seen that the loop must be opened if the afc is to be defeated. Perhaps the best way to do this is to insert an spst switch between the tap at the discriminator output and the low-pass filter or between the filter output and the voltage-controlled reactance. Many commercial designs employ resistive coupling between the filter and reactance and defeat the afc function by shunting the control voltage to ground.



PROTECTIVE DIODES

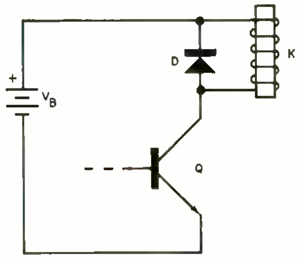
Q. ***Why do many relays that are keyed by transistors have reverse-biased diodes connected across them?—Dennis Barnes, Medford, OR.***

A. A typical relay-driver circuit is shown in the figure. The function of diode *D* is to protect driver transistor *Q* from damage caused by inductive voltage spikes. Relay coil *K* has inductance as well as inherent resistance. Mathematically, the voltage across a coil is equal to its inductance multiplied by the rate at which the current flowing through it changes with respect to time ($V_L = L\,dI/dt$).

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 cutoff. 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.

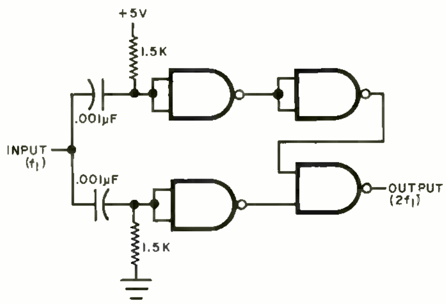
Connecting diode *D* as shown in the figure prevents this spike from harming *Q*. As the transistor cuts off, the voltage spike forward-biases the diode, clamping the collector-to-emitter voltage drop to one diode drop above the supply voltage. The only disadvantage to diode protection is that the time 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 × 13″W × 7¼″H (50.3 × 32.6 × 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 $\pm$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 stripped 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 × 3¼″H (102 × 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 control. 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 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 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.

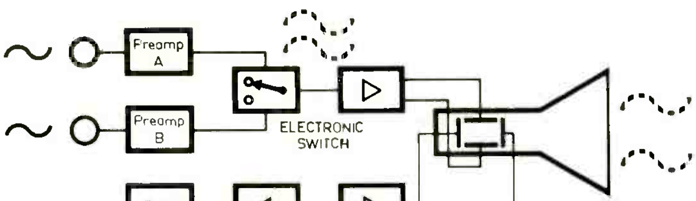


Fig. 1

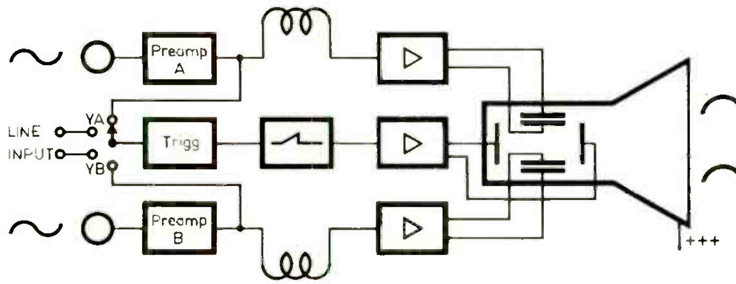


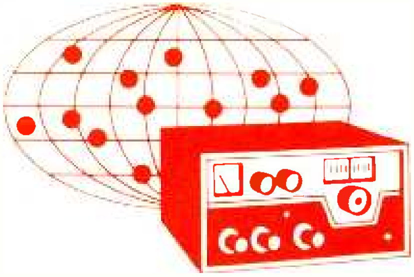
Fig. 2

trol 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.

CIRCLE NO. 105 ON FREE INFORMATION CARD



DX Listening

By Glenn Hauser

A WORLD OF NEWS

IF 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!

Updating Listings. The following changes and additions should be made in the "English Broadcasts" listings that appeared in the December issue.

GMT/UTC	Station	Frequencies
0900-0930	NSB, Tokyo	6115
1000-1500	R. Moscow (via Cuba)	9600, ex-1300
1100-	TWR-Bonaire	15255, not 15225
1130-1400	CBC North. Serv.	6065, not 6195
1200-1230	Kol Israel	25640, 17605, 17560, not 25625, 15600
1200-1230	R. Tashkent	11785, not 5975
1200-1255	R. Peking	9820, ex-15520
1220-1250	R. Ulan Bator	9574, not 9553 (varies)
1230-1551	WYFR	21525, 17785 (Sun only)
1300-1500	R.Australia	17795, not 11705, and 9770
1515-1530	V. of Greece	17710, 15125, not 17830
1530-2200	R. Moscow (via Havana)	11860, ex-11840; ex-1330
1600-1630	R. Norway	not 15345
1600-1745	BBC	17885, not 17880
1705-1755	R. France, Int.	21675, 21620, 17860, 17850, 17795, 17720, not 21705 and 21595
1700-1800	NCJB, Ecuador	17790, ex-17825
1700-1800	WYFR	17845, 21615
1709-1745	BBC	17830, 15260 (Sat & Sun only)
1745-1830	BBC	21710
1840-1900	WYFR	21615, 17845, 15440, 15130
1815-1845	Swiss R. International	17760, ex-17730
1900-2000	HCJB, Ecuador	17890, 15295, ex-17895, 15225
1900-2000	WYFR	21615, 15130
2000-2030	AWR, Andorra	6215
2000-2030	R. Algiers	add 11810
2000-2030	Kol Israel	9815, 7412.5, not 17645, 15415,
2000-2100	WYFR	15130, 11805
2000-2245	BBC	Not 21710
2010-2140	R. Havana Cuba	11920
2100-2145	R. Nacional, Venezuela	15400 (time and frequency vary; irregular), not 2200-
2115-2430	BBC	not 15420
2100-2350	WYFR	11805, 9605
2130-2200	HCJB, Ecuador	17890, 15295, ex-17895, 15225
2200-2215	R. Japan (via Portugal)	11735, ex-15305
2200-2300	CBC Radio	Mon-Fri only; 9760, not 9575
2230-2300	Kol Israel	15300, possibly additional broadcasts later in evening.
2245-2300	UN Radio	11830, not 11920
2300-2330	R. Vilnius	7215, 7150
2300-0200	R. Moscow	15455, 15180, 11780, 9765, 9685, 9610, 9530, 9490, 7165, not 15425, 7205, 7195, 7130, 7115, 7105, 6125, 5940
2335-2355	SODRE, Uruguay	11885, 9515
0000-0500	R. Moscow (Via Havana)	6115
0030-0100	R. Kiev	15240, not 15180, 6020, 5980
0000-0200	VOA	17730, 9640, ex-9650
0030-0230	BBC	not 15070
0030-0500	HCJB, Ecuador	11910, ex-11915
0145-0215	Swiss R. Int.	15305, not 9660
0200-0255	R. Peking	15600, not 17855
0230-0445	BBC	not 11910
0230-0600	HCJB, Ecuador	add 15115
0300-0315	Austrian Radio	delete
0300-0330	R. Kiev	11690, 9735, 9505, 7400, 7150, not 9580, 7320, 7260, 7175, 5970
0300-0330	R. Portugal	11925, ex-11935
0300-0350	V. of Free China	15270
0330-0400	R. Finland	9645, ex-9675
0400-0430	R. Norway	6185, not 11850, 5965
0500-0530	R. Portugal	11925, ex-11935

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10. Extent and nature of circulation	Average no. copies each issue during preceding 12 months	Actual no. copies of single issue published nearest to filing date
A. Total No. Copies Printed (Net Press Run)	505,078	483,931
B. Paid Circulation		
1. Sales through Dealers and Carriers, Street Vendors and Counter Sales	81,906	85,000
2. Mail Subcriptions	325,616	303,900
C. Total Paid Circulation (Sum of 10B1 and 10B2)	407,522	388,900
D. Free Distribution by Mail, Carrier or Other Means Samples, Complimentary, and Other Free Copies	11,032	10,207
E. Total Distribution (Sum of C and D)	418,554	399,107
F. Copies not distributed		
1. Office Use, Left Over, Unaccounted, Spoiled After Printing	3,142	4,732
2. Returns from News Agents	83,382	80,092
G. Total (Sum of E, F1 and 2 — should equal net press run shown in A)	505,078	483,931

11. I certify that the statements made by me above are correct and complete.

WILLIAM L. PHILLIPS,
Assistant Treasurer

12. For Completion by Publishers Mailing at the Regular Rates: *(Section 132.121, Postal Service Manual)*

39 U.S.C. 3626 provides in pertinent part: "No person who would have been entitled to mail matter under former section 4359 of this title shall mail such matter at the rates provided under this subsection unless he files annually with the Postal Service a written request for permission to mail matter at such rates."

In accordance with the provisions of this statute, I hereby request permission to mail the publication named in item 1 at the phased postage rates presently authorized by 39 U.S.C. 3626.

WILLIAM L. PHILLIPS,
Assistant Treasurer

Computer Bits

By Hal Chamberlin

MICROCOMPUTER POWER SUPPLIES

NEXT 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

An urgent appeal to the 76,000,000 Americans whose emergency calls for help on the highway were answered by *REACT.*

For 17 years now, REACT volunteers—ordinary folks just like you and me with CB radios and a powerful desire to help their neighbors—have been helping motorists in trouble on the highway. Now they need your help. I ask every responsible citizen to read this appeal carefully and then give your support to this great American Institution.

Sheriff Joe Higgins
National Safety Sheriff

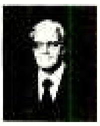
In less than the time it will take you to read this appeal, REACT teams all over the U.S. and Canada will have answered about 80 such calls for help with their CB radios—one emergency every 7½ seconds, 24 hours a day, seven days a week, an average of *more than 4.4 million emergencies per year!*

What is REACT?
Most of the 25 million Americans who own CB radios, and a great many who don't, have heard of REACT and know something about the *tremendous free emergency* services these volunteers perform, for the American public. Very few know the extent to which REACT has been instrumental in saving lives, helping their neighbors save valuable time in a thousand ways, and *saving America's precious fuel.* Here's what you should know about REACT.

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.

REACT International's Board of Directors is a distinguished group of American citizens, *also serving on a volunteer basis,* each with special background and experience in areas that contribute to the strength and stature of REACT—a former head of the Federal Communications Commission . . . an executive of the American National Red Cross . . . a staff member of the International Association of Chiefs of Police Over one-third of the directors have personal experience in the actual operation and training of a REACT team.

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:



"The contribution to highway safety and service to the public made by these REACT volunteers is incredible—at no cost to the taxpayer. There is no way government could provide such outstanding service at any price. The public owes REACT a tremendous debt of gratitude."

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.

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.

Please do not send cash. A check or money order is safer and it provides you proof of contribution for income tax deduction purposes.

Emergency Fund
REACT International, Inc.
75 E. Wacker Drive, Chicago, IL 60601

Dear REACTers: **It's my turn to help!** Here's my tax deductible contribution to keep REACT strong, and continue its voluntary emergency communications service to the public.

Amount $______ check ☐ money order ☐ enclosed.

Name______

Address______

City______ State____ Zip____

CIRCLE NO. 50 ON FREE INFORMATION CARD

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.

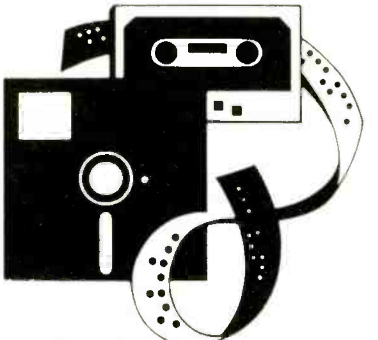
The first, which is probably the most common, is the classic iron-core transformer and bridge or center-tapped rectifier system, with a bulk capacitor filter. While conceptually simple and inexpensive, this method has many pitfalls for the inexperienced designer. The most serious of these is the extremely 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 the winding with the 60-Hz input and thus provides a good deal of regulation. Such transformers are also called *ferroresonant* because of the resonating capacitor. When combined with a conventional rectifier and filter, such a transformer can hold unregulated voltage variations to less than 10%, which reduces regulator dissipation and increases immunity to line-voltage variation. Also, since the transformer puts out an approximately square waveform, a smaller-valued filter capacitor can be used to partially counteract the higher cost and bulk of the CVT. Some of the better S-100 mainframes use CVTs.

There is yet a third power-conversion method that is finding increased acceptance as costs decline. This is the direct off-the-line switching power supply. Such a unit first rectifies and filters line voltage directly without a transformer to provide about 150 volts dc. This high voltage then operates a power oscillator in the 15-to-30-kHz range. The resulting high-voltage, high-frequency ac is stepped down to lower output voltages with a lightweight ferrite-core transformer. The lower-voltage, frequency ac is then rectified and filtered again to provide the final output voltages. Usually the oscillator is constructed so that feedback from one of the output voltages, typically +5 volts, controls its frequency or waveform. It therefore provides sufficient regulation for direct operation of logic. The primary advantages of switching power supplies are small size and light weight for their output capability and a high regulation efficiency, lower heat dissipation, and inherent central regulation.

Safety Approval. Safety testing of a microcomputer's power supply can be a long and expensive process for its manufacturer. When 117 volts is present in the cabinet of a computer, the whole unit must be subjected to a number of stringent tests, some of which are destructive. One solution to this problem is to provide the step-down transformer as a separate unit, much like a calculator battery eliminator, and only have low voltages in the microcomputer. If this is done, only the transformer must be tested, which is a much simpler process. Although limited to smaller machines with low-power consumption, modern low-power ICs make viable.

In sum, one should be aware of the importance of power supplies in microcomputers and add this consideration when making buying judgments.



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).

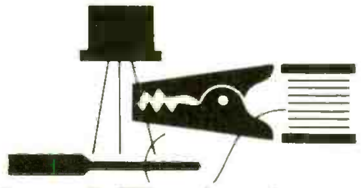
Computer Mail. PCNET is now making available software for the PET (other computers will be forthcoming) to provide mail support for personal computer users with the conventional telephone system. It is hoped that a combination of the PAN software ($12 on cassette) and a modem will provide this service. 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.

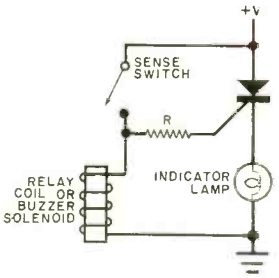
Apple Word Processing. SUPER-TEXT is a multi-paging system that allows viewing two pages simultaneously. You can keep notes on one screen while you edit the other. It is a character-oriented editor with complete cursor control, has built-in floating-point math and auto tab, you can add or insert a character, 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).



Tips & Techniques

AMBIENT LIGHT COMPENSATION

A problem common to most photosensor circuits is their inability to cope with wide variations in the intensity of ambient light. The circuit shown here provides ambient light compensation and makes an ideal



front end for optical signal and position sensing systems. Field effect transistor *Q1* behaves like a variable resistor which automatically adjusts its resistance to hold phototransistor *Q2*'s collector at a constant dc level. The FET will not try to compensate for, correct or cancel the ac (optical) signal as long as the gate rises and falls with the source. The time constant *R1C1* should be chosen to be several times greater than the period of the lowest frequency optical signal to be received. The FET can adjust the phototransistor's response over the many decades of light levels from near darkness to bright sunlight. The 2N5484 FET, whose gate-to-source voltage is nominally 1.5 to 2.5 volts, is suited for this application and the FPT120B is a very responsive and sensitive phototransistor. *—P.D. Wesley, Marion, IN.*

PROBE CHOPSTICKS

When testing components or measuring circuit parameters with a VOM or other instrument employing test probes, try holding the probes as if they were chopsticks. With a little practice, you'll be able to maintain excellent control over the probes and still have one hand free to hold the object under test, adjust knobs, etc. *—Will Hobbs, Portland, OR.*

KEEPING IC'S COOL

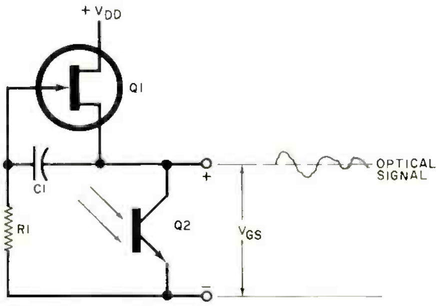
Integrated circuits are notoriously heat sensitive. Unless a minimum of heat is used, soldering an IC in place can result in

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 Appel, 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 electroetching, 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.*

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 (*C2*, 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 *C2* 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 *C2*. 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 *C2*, leaving the other end of each wire unconnected. The two leads form a "gimmick" capacitor in parallel with *C2*. 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 *S3*, 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 *S2* in its STOP position and toggle *S1* from CLEAR to READY. Then place *S2* in its START position at the beginning of the interval to be timed. When the event is over, place *S2* 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 decorder/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 increase the maximum timing intervals, you can add more counter/decoder/display stages. For more resolution (e.g., time measurements to the nearest one hundredth 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. ◊

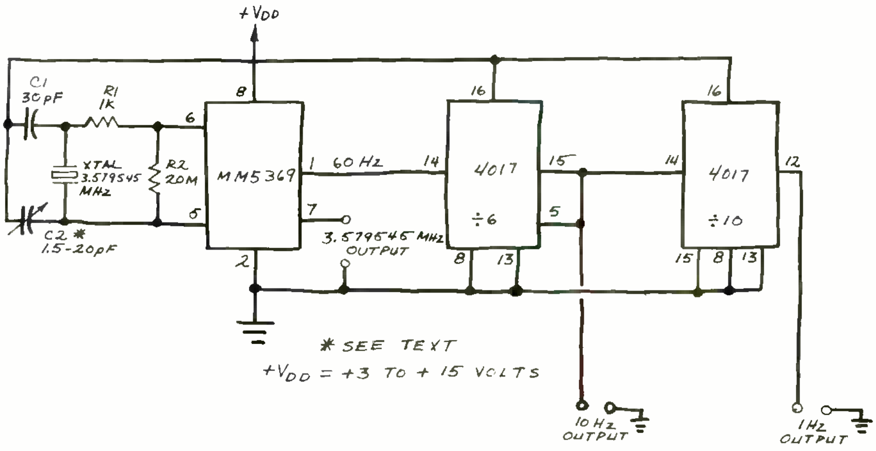


Fig. 1. Schematic of a precision crystal-controlled timebase.

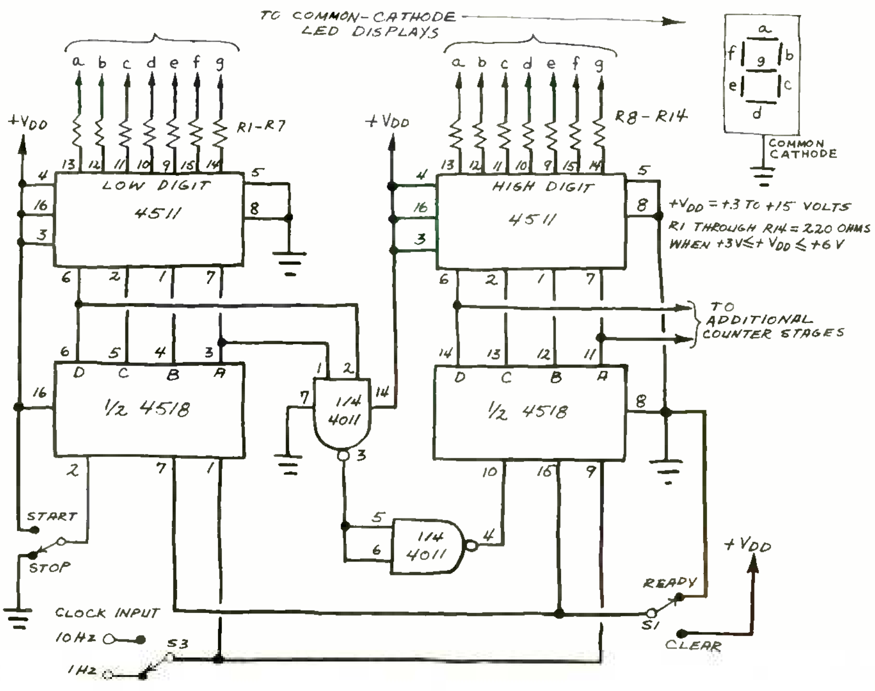


Fig. 2. Circuit for a two-digit digital counter/stopwatch.

NEW PRODUCTS!

Super Color S-100 Video Kit $99.95

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

Gremlin Color Video Kit $59.95

32 x 16 alpha/numerics and graphics; up to 8 colors with 6847 chip; 1K RAM at E000. Plugs into Super Elf 44 pin bus. Not expandable to high resolution Graphics.

Elf II Adapter Kit $24.50

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

1802 16K Dynamic RAM Kit $149.00

1802/S-100 expandable to 32K, Hidden refresh w/clocks up to 4 MHz w/no wait states Addl. 16K RAM **$79.00.**

Quest Super Basic

Quest, the leader in inexpensive 1802 systems announces another first. Quest is the first company worldwide to ship a **full size Basic** for 1802 systems. A complete function **Super Basic** by **Ron Cenker** including floating point capability with scientific notation (number range ±.17E[38]), 32 bit integer ±2 billion; Multi dim arrays; String arrays; String manipulation; Cassette I/O, Save and load, Basic, Data and machine language programs; and over 75 Statements, Functions and Operators.

Easily adaptable on most 1802 systems. Requires 12K RAM minimum for Basic and user programs. Cassette version in stock now. ROM versions coming soon with exchange privilege allowing some credit for cassette version.

Super Basic on Cassette **$40.00**

Tom Pittman's 1802 Tiny Basic Source listing now available. Find out how Tom Pittman wrote Tiny Basic and how to get the most out of it. Never offered before. **$19.00**

S-100 4-Slot Expansion **$ 9.95**

Super Monitor VI.I Source Listing **$15.00**

Coming Soon: Assembler, Editor, Disassembler, DA/AD, Super Sound/Music, EPROM programmer.

RCA Cosmac Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded with additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

Before you buy another small computer, see if it includes the following features: ROM monitor; State and Mode displays; Single step; Optional address displays; Power Supply; Audio Amplifier and Speaker; Fully socketed for all IC's; Real cost of in warranty repairs; Full documentation.

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

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select** and **single step**. Large, on board displays provide output and optional **high and low address**. There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for **all** IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game.

Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and research and development.

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** Expansion Cabinet with room for 4 S-100 boards **$41.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested.

Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year.

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

Super Expansion Board with Cassette Interface $89.95

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

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

Other on board options include **Parallel Input and Output Ports with full handshake**. They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $15.50 for easy connection between the **Super Elf** and the **Super Expansion Board.**

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

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7414N	.70
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7422N	.39
7430N	20
7442N	50
7445N	69
7447N	60
7448N	69
7450N	18
7474N	35
7475N	49
7485N	88
7489N	1 85
7490N	43
7492N	43
7493N	43
7495N	69
74100N	.90
74107N	35
74121N	34
74123N	59
74125N	45
74145N	69
74150N	95
74151N	69
74154N	1 00
74157N	69
74161N	87
74162N	87
74163N	87
74174N	96
74175N	90
74190N	1 15
74192N	87
74193N	85
74221N	2.00
74298N	1 65
74365N	66
74366N	66
74367N	66

74LS00 TTL	
74LS00N	35
74LS02N	35
74LS04N	35
74LS05N	.35
74LS08N	35
74LS10N	.35
74LS13N	55
74LS14N	1 10
74LS20N	35
74LS22N	35
74LS28N	41
74LS30N	35
74LS33N	75
74LS38N	55
74LS74N	1 25
74LS75N	1 00
74LS90N	85
74LS93N	70
74LS95N	1 10
74LS107N	45
74LS112N	45
74LS113N	35
74LS132N	89
74LS136N	45
74LS151N	85
74LS155N	85
74LS157N	85
74LS162N	1 15
74LS163N	1 15
74LS174N	2 00
74LS190N	1 06
74LS221N	1.95
74LS258N	.67
74LS367N	1.35

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CA3045	90
CA3046	1 10
CA3081	1 80
CA3082	1 90
CA3089	2 95
LM301AN/AH	35
LM305H	87
LM307N	35
LM308N	89
LM309K	1 50
LM311H/N	90
LM317T/K	3 75
LM318	1 35
LM320K-5	1 50
LM323K-5	5 95
LM320K-12	1 50
LM320K-15	1 50
LM320T-5	1 60
LM320T-8	1 60
LM320T-12	1 50
LM320T-15	1 60
LM324N	1 15
LM339N	1 55
LM340K-5	1 35
LM340K-8	1 35
LM340K-12	1 35
LM340K-15	1 35
LM340K-24	1 35
LM340T-5	1 25
LM340T-8	1 25
LM340T-12	1 25
LM340T-15	1 25
LM340T-18	1 25
LM340T-24	1 25
LM343H	4 50
LM350	7 50
LM370	1 15
LM377	3 00
LM379	5 00
LM380N	1 00
LM381	1 60
LM382	1 60
LM703H	40
LM709H	28
LM723H/N	50
LM733N	67
LM741CH	35
LM741N	32
LM747H/N	.75
LM748N	35
LM1303N	1 75
LM1304	1 10
LM1305	1 27
LM1307	2 00
LM1310	2 75
LM1458	47
LM1800	1 75
LM1812	7 50
LM1889	3 00
LM2111	1 75
LM2902	1 50
LM3900N	60
LM3905	1 75
LM3909N	89
MC1458V	50
NE540H	3 75
NE550N	1 00
NE555V	39
NE556A	85
NE565A	1.00
NE566V	1 50
NE567V	1 00
NE570B	5.00
78L05	60
78L08	.60
78M05	85
75108	1 75
75491CN	50
75492CN	.55
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LD130	9 95
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CD4002	28
CD4006	1 10
CD4007	28
CD4008	28
CD4009	45
CD4010	45
CD4011	.28
CD4012	28
CD4013	39
CD4014	1 00
CD4015	1 00
CD4016	45
CD4017	1.05
CD4018	.94
CD4019	45
CD4020	1 02
CD4021	1.25
CD4022	1.10
CD4023	28
CD4024	75
CD4025	28
CD4026	2 00
CD4027	66
CD4028	85
CD4029	1 02
CD4030	45
CD4035	1 02
CD4040	1 02
CD4042	85
CD4043	85
CD4044	85
CD4046	1.67
CD4049	45
CD4050	49
CD4051	1.13
CD4060	1 42
CD4066	71
CD4068	.40
CD4069	40
CD4070	50
CD4071	.28
CD4072	.28
CD4073	28
CD4075	28
CD4076	1 45
CD4078	40
CD4081	.28
CD4082	28
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CD4515	2.52
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CD4518	1.02
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CD4527	1.51
CD4528	.79
CD4553	3.50
CD4566	2.25
CD4583	4 50
CD4585	1 10
CD40192	3 00
74C00	28
74C04	40
74C10	28
74C14	2 10
74C20	28
74C30	28
74C48	1 95
74C74	75
74C76	1 40
74C90	1 15
74C93	1 40
74C154	3 00
74C160	1 44
74C175	1 35
74C192	1 65
74C221	2 00
74C905	6 00
74C906	75
74C914	1 95
74C922	5 50
74C923	5 50
74C925	6 95
74C926	6 95
74C927	6 95

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

MOS/MEMORY RAM	
2101-1	3 95
2102-1	95
2102AL-4	1 25
2102AN-2L	1 60
21L02-1	1.18
21F02	1.25
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14	14	24	35
16	16	28	.42
18	27	36	.58
20	29	40	57

2 level 14 pin ww 20

WIRE WRAP LEVEL 3

PIN		PIN	
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16	33	28	1.00
18	.57	40	1.23

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4 MHz	4 25
5 MHz	4.25
10 MHz	4 25
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20 MHz	3.90
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2N3904	18
2N3906	18
2N3055	69
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2N4402	20
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FND359	CC	.357	70
FND500/507	CC/CA	500	1 35
FND503/510	CC/CA	500	90
FND800/807	CC/CA	800	2 20
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4 digit Bubble			80
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DG10 Fluorescent			1 75
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7520 Clairex photocells			39
TIL311 Hex			9 50
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MAN4610	CA	40	1 20
MAN4640	CC	40	1 20
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Music & Sound Inc., model DMS6-FM A, AM/FM intercom. Need schematic or description of 6+ drop resistor. Paul Wojcik, 207 N. 18th St., Barrington, IL 60010.

Fisher model 203 and 180 AM/FM receiver. **Jackson** model 648-S tube transistor tester. Need manual, schematic and recent charts. Avery Comarow, 524-B Springvale Rd., Great Falls, VA 22066.

Hallicrafters model S-38A receiver. Need schematic and service manual. Robert P Meagley, 5909 Jefferson Blvd., Frederick, MD 21701.

Pearce-Simpson model 550 AM marine transceiver. Need schematics, operation manual, and crystal information. Charles C. Boehnke, Box 223, Los Gatos, CA 95030.

Raytheon model 402-2M10 P/N 348086 data terminal. Need operation manual, and schematics. J. Nowinsky, 3167B Congress Hill AFB, UT 84056.

Tektronix type 531 oscilloscope. Need service and operations manual. Henry Schanding, W3RRF, 1250 Saunders Dr., Elizabeth City, NC 27909.

Wurlitzer model 518 amplifier. Need schematic. Russell Campbell, Box 141, Thessalon, Ontario, Can.

Acoustiflex model 200 stereo AM/FM receiver. Need schematic. Wayne Hill, 7704 E. Michigan Ave., Jackson, MI 49201.

Bell & Howell model 2423 stereo tape recorder. Service manual and schematic needed. Daniel Kluth, 805 N. Chatsworth, St. Paul, MN 55104.

Sylvania type 216 signal generator. Schematic and operating instructions needed. D.C. James, 15037 E. LaDonna, Hacienda Hts., CA 91745.

Hickok model 6000A tube tester. Need schematics, operating manual and tube chart. **Elan** model 2 ignition scope. Need schematic and operating instructions. Guy Edwords, 104 Hancock, San Francisco, CA 94114.

Zenith model 5M-191 radio. Need schematic and parts list. Raymond Friend, 236 W. Pearl St., Butler, PA.

Precision Manufacturing Co., model 78 VTVM. Need schematic and operating manual. Steve Lind, Box 1171, Athens, OH 45701.

Hallicrafters radio model SX62 and **Stromberg Carlson Co., Ltd.**, model 5788 triggered time base oscilloscope. Need any information available. John Greeland, Box 138, Helligrews, Nfld. AOA 2T0.

Jackson model 634 dynamic tube tester. Need chart listings, schematic and instruction manual. Donald Godward, 415 W. Dickerson, Bozeman, MT 59715.

Knight model KG-790 AM/FM stereo tuner and **Zenith** model 6-G-601M AM radio. Need maintenance, service instructions and schematics. C. T. Huth, 146 Schonhardt St., Tiffin, OH 44883.

Silvertone model 1434, chassis #185.10501 and model 1484, chassis 185.11040 musical amplifiers. Need schematics, operating manuals and any other information. Carl J. McCormick, 6723 Old Mooringsport Rd., Shreveport, LA 71107.

Magnavox model MX 1620 4-channel receiver. Need schematic and parts list. Michael J. Murphy, 3245 Braeburn Circle, Ann Arbor, MI 48104.

Tektronix model 909 scientific desk calculator and model 926 cartridge programmer. Need schematics and operator's manual. Kurt Inman, 350 Nelson Rd., Scotts Valley, CA 95066.

Solar model CF capacitor analyzer. Need schematic and instruction manual. E. J. Homa, 2936 5th St., Muskegon Hts., MI 49444.

Varo model R-748 TRC-47 receiver. Need schematic and service manual. S. Korb, 807 N. 8th St., Burlington, IA 52601.

RCA model 151 cathode ray oscillograph. Need schematic and operating manual. R. E. Fields, R2, Box 5, Rush, CO 80833.

Superior Instruments Co., model 777 VTVM. Need instruction manual, schematic, calibration and service information. Jacob Landy, 11 Gardenia Lane, Hicksville, NY 11801.

Motorola model FMRU16V(A) FM receiver. Need schematics, parts list, technical service manuals and operation manuals. Charles J. Rainey, 9590 N. Range Line Rd., River Hills, WI 53217.

Century model CT-1 in-circuit condenser tester and **Lafayette LSG-10** signal generator. Need owners manual and schematics. Jack Wise, 1229 Rapids Road, New Braunfels, TX 78130.

RCA Victor model T62 radio. Need schematic, service manual or any information available. David Weisenthal, 29 Northview Ave., Montclair, NY 07043.

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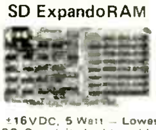

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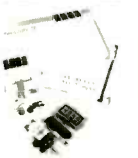

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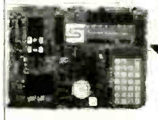

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5.1	–	13-51007	–	15-51020	1100	–	13-11307	–	15-11320	240K	–	13-24507	–	15-24520
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6.2	–	13-62007	–	15-62020	1300	–	13-13307	–	15-13320	300K	–	13-30507	–	15-30520
6.8	12-68007	13-68007	14-68020	15-68020	1500	12-15307	13-15307	14-15320	15-15320	330K	12-33507	13-33507	14-33520	15-33520
7.5	–	13-75007	–	15-75020	1600	–	13-16307	–	15-16320	360K	–	13-36507	–	15-36520
8.2	12-82007	13-82007	14-82020	15-82020	1800	12-18307	13-18307	14-18320	15-18320	390K	12-39507	13-39507	14-39520	15-39520
9.1	–	13-91007	–	15-91020	2000	–	13-20307	–	15-20320	430K	–	13-43507	–	15-43520
10	12-10107	13-10107	14-10120	15-10120	2200	12-22307	13-22307	14-22320	15-22320	470K	12-47507	13-47507	14-47520	15-47520
11	–	13-11107	–	15-11120	2400	–	13-24307	–	15-24320	510K	–	13-51507	–	15-51520
12	12-12107	13-12107	14-12120	15-12120	2700	12-27307	13-27307	14-27320	15-27320	560K	12-56507	13-56507	14-56520	15-56520
13	–	13-13107	–	15-13120	3000	–	13-30307	–	15-30320	620K	–	13-62507	–	15-62520
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16	–	13-16107	–	15-16120	3600	–	13-36307	–	15-36320	750K	–	13-75507	–	15-75520
18	12-18107	13-18107	14-18120	15-18120	3900	12-39307	13-39307	14-39320	15-39320	820K	12-82507	13-82507	14-82520	15-82520
20	–	13-20107	–	15-20120	4300	–	13-43307	–	15-43320	910K	–	13-91507	–	15-91520
22	12-22107	13-22107	14-22120	15-22120	4700	12-47307	13-47307	14-47320	15-47320	1.0M	12-10607	13-10607	14-10620	15-10620
24	–	13-24107	–	15-24120	5100	–	13-51307	–	15-51320	1.1M	–	13-11607	–	15-11620
27	12-27107	13-27107	14-27120	15-27120	5600	12-56307	13-56307	14-56320	15-56320	1.2M	12-12607	13-12607	14-12620	15-12620
30	–	13-30107	–	15-30120	6200	–	13-62307	–	15-62320	1.3M	–	13-13607	–	15-13620
33	12-33107	13-33107	14-33120	15-33120	6800	12-68307	13-68307	14-68320	15-68320	1.5M	12-15607	13-15607	14-15620	15-15620
36	–	13-36107	–	15-36120	7500	–	13-75307	–	15-75320	1.6M	–	13-16607	–	15-16620
39	12-39107	13-39107	14-39120	15-39120	8200	12-82307	13-82307	14-82320	15-82320	1.8M	12-18607	13-18607	14-18620	15-18620
43	–	13-43107	–	15-43120	9100	–	13-91307	–	15-91320	2.0M	–	13-20607	–	15-20620
47	12-47107	13-47107	14-47120	15-47120	10K	12-10407	13-10407	14-10420	15-10420	2.2M	12-22607	13-22607	14-22620	15-22620
51	–	13-51107	–	15-51120	11K	–	13-11407	–	15-11420	2.4M	–	13-24607	–	15-24620
56	12-56107	13-56107	14-56120	15-56120	12K	12-12407	13-12407	14-12420	15-12420	2.7M	12-27607	13-27607	14-27620	15-27620
62	–	13-62107	–	15-62120	13K	–	13-13407	–	15-13420	3.0M	–	13-30607	–	15-30620
68	12-68107	13-68107	14-68120	15-68120	15K	12-15407	13-15407	14-15420	15-15420	3.3M	12-33607	13-33607	14-33620	15-33620
75	–	13-75107	–	15-75120	16K	–	13-16407	–	15-16420	3.6M	–	13-36607	–	15-36620
82	12-82107	13-82107	14-82120	15-82120	18K	12-18407	13-18407	14-18420	15-18420	3.9M	12-39607	13-39607	14-39620	15-39620
91	–	13-91107	–	15-91120	20K	–	13-20407	–	15-20420	4.3M	–	13-43607	–	15-43620
100	12-10207	13-10207	14-10220	15-10220	22K	12-22407	13-22407	14-22420	15-22420	4.7M	12-47607	13-47607	14-47620	15-47620
110	–	13-11207	–	15-11220	24K	–	13-24407	–	15-24420	5.1M	–	13-51607	–	15-51620
120	12-12207	13-12207	14-12220	15-12220	27K	12-27407	13-27407	14-27420	15-27420	5.6M	12-56607	13-56607	14-56620	15-56620
130	–	13-13207	–	15-13220	30K	–	13-30407	–	15-30420	6.2M	–	13-62607	–	15-62620
150	12-15207	13-15207	14-15220	15-15220	33K	12-33407	13-33407	14-33420	15-33420	6.8M	12-68607	13-68607	14-68620	15-68620
160	–	13-16207	–	15-16220	36K	–	13-36407	–	15-36420	7.5M	–	13-75607	–	15-75620
180	12-18207	13-18207	14-18220	15-18220	39K	12-39407	13-39407	14-39420	15-39420	8.2M	12-82607	13-82607	14-82620	15-82620
200	–	13-20207	–	15-20220	43K	–	13-43407	–	15-43420	9.1M	–	13-91607	–	15-91620
220	12-22207	13-22207	14-22220	15-22220	47K	12-47407	13-47407	14-47420	15-47420	10M	12-10707	13-10707	14-10720	15-10720
240	–	13-24207	–	15-24220	51K	–	13-51407	–	15-51420	11M	–	13-11707	–	15-11720
270	12-27207	13-27207	14-27220	15-27220	56K	12-56407	13-56407	14-56420	15-56420	12M	12-12707	13-12707	14-12720	15-12720
300	–	13-30207	–	15-30220	62K	–	13-62407	–	15-62420	13M	–	13-13707	–	15-13720
330	12-33207	13-33207	14-33220	15-33220	68K	12-68407	13-68407	14-68420	15-68420	15M	12-15707	13-15707	14-15720	15-15720
360	–	13-36207	–	15-36220	75K	–	13-75407	–	15-75420	16M	–	13-16707	–	15-16720
390	12-39207	13-39207	14-39220	15-39220	82K	12-82407	13-82407	14-82420	15-82420	18M	12-18707	13-18707	14-18720	15-18720
430	–	13-43207	–	15-43220	91K	–	13-91407	–	15-91420	20M	–	13-20707	–	15-20720
470	12-47207	13-47207	14-47220	15-47220	100K	12-10507	13-10507	14-10520	15-10520	22M	12-22707	13-22707	14-22720	15-22720
510	–	13-51207	–	15-51220	110K	–	13-11507	–	15-11520					

DIGITAL INTEGRATED CIRCUITS

74xx													
7400	$0.15	74150	$0.89	74LS54	$0.27	74LS266	$0.38	74S341	$4.10	74C908	$1.19	4060	$1.49
7401	0.17	74151	0.59	74LS55	0.27	74LS279	0.58	74S342	1.20	74C909	1.78	4066	0.78
7402	0.17	74152	0.59	74LS73	0.38	74LS283	0.99	74S343	4.95	74C910	6.00	4068	0.39
7403	0.17	74153	0.59	74LS74	0.38	74LS290	0.64	74S346	1.25	74C914	1.19	4069	0.26
7404	0.18	74154	0.99	74LS76	0.38	74LS295	0.99	74S362	2.15	74C918	1.49	4070	0.49
7405	0.18	74155	0.69	74LS78	0.38	74LS365	0.66	74S387	4.70	74C925	7.80	4071	0.22
7406	0.24	74156	0.69	74LS83	0.78	74LS366	0.66			74C926	7.80	4073	0.22
7407	0.24	74157	0.64	74LS85	0.97	74LS367	0.66	74Cxx		74C927	7.80	4075	0.22
7408	0.20	74158	0.64	74LS86	0.38	74LS368	0.66			74C928	7.80	4076	1.29
7409	0.20	74160	0.87	74LS90	0.56	74LS386	0.38	74C00	$0.24			4077	0.59
7410	0.17	74161	0.87	74LS93	0.56	74LS390	1.69	74C02	0.24	4xxx		4078	0.39
7411	0.20	74162	0.87	74LS95	0.87	74LS490	1.49	74C04	0.26			4081	0.22
7412	0.24	74163	0.87	74LS107	0.38	74LS670	2.33	74C08	0.25	4000	$0.22	4085	0.69
7413	0.25	74164	0.87	74LS109	0.38			74C10	0.24	4001	0.22	4089	2.75
7414	0.70	74165	0.87	74LS112	0.38	74Sxx		74C14	0.90	4002	0.22	4093	0.99
7416	0.24	74166	1.20	74LS113	0.38			74C20	0.25	4006	1.19	4099	2.10
7417	0.24	74167	1.95	74LS114	0.38	74S00	$0.35	74C30	0.24	4007	0.22	4503	0.98
7420	0.19	74170	1.55	74LS123	0.98	74S02	0.35	74C32	0.25	4008	0.78	4507	0.99
7423	0.25	74173	1.20	74LS125	0.48	74S03	0.35	74C42	0.94	4009	0.43	4510	1.13
7425	0.25	74174	0.88	74LS126	0.48	74S04	0.36	74C48	1.27	4010	0.43	4511	1.04
7426	0.24	74175	0.78	74LS132	0.80	74S05	0.36	74C73	0.71	4011	0.22	4512	0.98
7427	0.25	74176	0.78	74LS136	0.38	74S09	0.38	74C74	0.48	4012	0.22	4516	1.22
7430	0.19	74177	0.78	74LS138	0.93	74S10	0.35	74C76	0.71	4013	0.39	4518	1.13
7432	0.24	74179	1.80	74LS139	0.93	74S11	0.38	74C83	1.37	4014	0.95	4519	0.62
7437	0.24	74180	0.69	74LS151	0.74	74S15	0.38	74C85	1.37	4015	0.95	4520	1.13
7438	0.24	74181	1.95	74LS152	0.74	74S20	0.35	74C86	0.49	4016	0.39	4527	1.67
7439	0.29	74182	0.78	74LS153	0.84	74S22	0.36	74C89	3.95	4017	1.04	4528	0.86
7440	0.19	74184	1.95	74LS154	1.09	74S30	0.35	74C90	0.97	4018	1.04	4539	1.10
7441	0.88	74185	1.95	74LS155	0.74	74S40	0.35	74C93	0.97	4019	0.39	4555	0.67
7442	0.48	74188	3.25	74LS156	0.74	74S64	0.38	74C95	1.09	4020	1.13	4556	0.88
7443	0.69	74190	0.95	74LS157	0.74	74S65	0.38	74C107	0.69	4021	1.13	4582	0.88
7444	0.69	74191	0.95	74LS158	0.74	74S74	0.58	74C151	1.89	4022	0.95	4584	0.74
7445	0.69	74192	0.80	74LS160	1.01	74S76	0.58	74C154	2.90	4023	0.22	4702	7.10
7446	0.69	74193	0.80	74LS161	1.01	74S78	0.58	74C157	1.89	4024	0.79	4703	8.25
7447	0.62	74194	0.87	74LS162	1.01	74S86	0.58	74C160	1.17	4025	0.22	4704	7.30
7448	0.69	74195	0.87	74LS163	1.01	74S112	0.58	74C161	1.17	4027	0.39	4705	9.25
7450	0.19	74196	0.87	74LS164	1.01	74S113	0.58	74C162	1.17	4028	0.88	4706	9.75
7451	0.19	74197	0.87	74LS168	1.13	74S114	0.58	74C163	1.17	4029	1.13	4720	6.95
7453	0.19	74198	1.45	74LS169	1.13	74S133	0.38	74C164	1.09	4030	0.29	4723	0.93
7454	0.19	74199	1.45	74LS170	1.72	74S134	0.38	74C165	1.09	4031	2.97	4724	1.29
7459	0.19	74251	1.09	74LS173	1.33	74S135	0.49	74C173	1.29	4034	2.75	4725	3.95
7460	0.19	74283	2.20	74LS174	1.05	74S140	0.47	74C174	1.15	4035	0.99	40014	0.90
7470	0.29	74290	0.89	74LS175	0.83	74S151	0.69	74C175	1.15	4040	0.99	40085	1.37
7472	0.29	74293	0.89	74LS181	2.50	74S153	0.75	74C192	1.37	4041	0.78	40098	0.54
7473	0.29	74298	0.92	74LS190	1.17	74S157	0.75	74C193	1.37	4042	0.78	40106	0.90
7474	0.29	74365	0.62	74LS191	1.17	74S158	0.75	74C195	1.08	4043	0.69	40160	1.17
7475	0.48	74366	0.62	74LS192	0.97	74S206	3.75	74C200	7.50	4044	0.69	40161	1.17
7476	0.31	74367	0.62	74LS193	0.97	74S258	1.15	74C221	1.89	4046	1.79	40162	1.17
7480	0.49	74368	0.62	74LS194	0.87	74S280	2.25	74C901	0.48	4047	1.99	40163	1.17
7482	0.55			74LS196	0.85	74S287	3.20	74C902	0.48	4048	0.95	40174	1.15
7483	0.59	74LSxx		74LS197	0.85	74S300	1.60	74C903	0.59	4049	0.39	40175	1.15
7485	0.79	74LS00	$0.27	74LS221	1.90	74S305	1.90	74C904	0.59	4050	0.39	40192	1.37
7486	0.27	74LS01	0.27	74LS253	0.99	74S310	2.85	74C905	6.00	4051	1.19	40193	1.37
7490	0.43	74LS02	0.27	74LS257	0.74	74S312	1.05	74C906	0.59	4052	1.19	40194	1.08
7491	0.58	74LS03	0.27	74LS258	0.74	74S316	2.80	74C907	0.59	4053	1.19	40195	1.08
7492	0.43	74LS04	0.28										
7493	0.43	74LS05	0.28										
7494	0.65	74LS08	0.28										
7495	0.65	74LS09	0.28										
7496	0.65	74LS10	0.27										
7497	2.45	74LS15	0.27										
74107	0.29	74LS20	0.27										
74109	0.32	74LS21	0.27										
74121	0.34	74LS22	0.27										
74122	0.39	74LS26	0.32										
74123	0.49	74LS27	0.27										
74125	0.39	74LS30	0.27										
74126	0.39	74LS32	0.32										
74132	0.65	74LS37	0.32										
74141	0.79	74LS38	0.32										
74145	0.69	74LS40	0.27										
74147	1.60	74LS42	0.66										
74148	1.29	74LS47	0.78										
		74LS48	0.76										
		74LS51	0.27										

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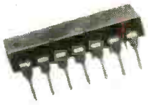
Low-Power Schottky ICs



Low As **49¢**

- *100% Prime*
- *Guaranteed Specs*

Improved 5-volt logic devices use Schottky diode technology for minimum propagation delay and high speed at minimum power.

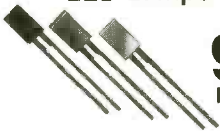
Type	Cat. No.	ONLY
74LS00	276-1900	.49
74LS02	276-1902	.59
74LS04	276-1904	.59
74LS08	276-1908	.49
74LS10	276-1910	.59
74LS13	276-1911	.99
74LS20	276-1912	.59
74LS27	276-1913	.69
74LS30	276-1914	.59
74LS32	276-1915	.69
74LS47	276-1916	1.29
74LS51	276-1917	.59
74LS73	276-1918	.69
74LS74	276-1919	.69
74LS75	276-1920	.99
74LS76	276-1921	.79
74LS85	276-1922	1.29
74LS90	276-1923	.99
74LS92	276-1924	.99
74LS93	276-1925	.99
74LS123	276-1926	1.19
74LS132	276-1927	.99
74LS151	276-1929	.99
74LS157	276-1930	1.19
74LS161	276-1931	1.49
74LS164	276-1932	1.49
74LS175	276-1934	1.19
74LS192	276-1935	1.49
74LS193	276-1936	1.49
74LS194	276-1937	1.49
74LS196	276-1938	1.59
74LS367	276-1835	1.19
74LS368	276-1836	1.19
74LS373	276-1943	2.39
74LS374	276-1944	2.39

4000-Series CMOS ICs

Type	Cat. No.	EACH
4001	276-2401	.69
4011	276-2411	.69
4012	276-2412	.79
4013	276-2413	.99
4017	276-2417	1.69
4020	276-2420	1.69
4021	276-2421	1.69
4023	276-2423	.69
4027	276-2427	.99
4028	276-2428	1.29
4046	276-2446	1.89
4511	276-2447	1.69
4049	276-2449	.79
4050	276-2450	.79
4051	276-2451	1.49
4066	276-2466	1.39
4070	276-2470	.79
4518	276-2490	1.49
4543	276-2491	1.99

All Prime from Major Semiconductor Manufacturers. Specs and Pin Out Diagram Included with Each Device.

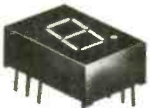
NEW! Rectangular LED Lamps



99¢ Pkg. of 2

High-brightness. Can be stacked vertically or horizontally. Max. forward current: 30 mA. Typical forward voltage: 2.5.
276-070. Red. . . . . 2/99¢
276-071. Green . . . . . 2/99¢
276-072. Yellow. . . . . 2/99¢

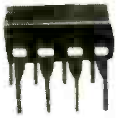
NEW! Pair of LED Digits



1.98

These 10mm 7-segment, red displays are ideal low-cost readouts for any projects. For multiplexed or direct drive. Max. forward current: 45mA/segment.
Common Anode. 276-1643 . . . . . 2/1.98
Common Cathode. 276-1644 . . . . 2/1.98

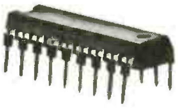
NEW! Oscillator/Divider IC



2.69

CMOS IC with 17 binary divider stages produces a highly stable 60 Hz square wave. Uses a TV 3.58 MHz crystal reference. Very low power operation over wide 3-15VDC range. 8-pin DIP.
276-1769 . . . . . 2.69
3.58 MHz Crystal 2.99

LED Bar/Dot Display Driver



3.49

LM3914N. Features 10 adjustable analog steps, bar or dot display mode. Current-regulated LED ouputs. 8 to 25VDC supply. 18-pin DIP. 276-1707 . . . . . 3.49
LM3915N. As above but with 3 dB log steps.
276-1708 . . . . . 3.49

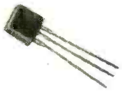
NEW! Silicon Solar Cells

Low As **5.99**

High Efficiency

Convert light to electrical power. All deliver 0.45V at rated current. Use several in series/parallel for higher voltages or current.
276-122. ½ 3" cell. Rated 500 mA . . . 5.99
276-123. Full 3" cell. Rated 1 amp . . . 8.99

Hall-Effect Sensors

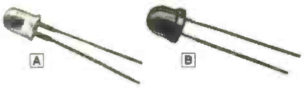


1.98 Pkg. of 3

Open-Collector Output

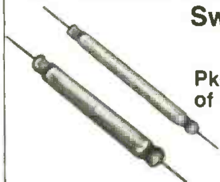
Detects magnetic fields electronically. 750 gauss "on" threshold. Constant amplitude independent of frequency. Similar to type ULN 3006. Ideal for tachs, position sensing, pulse counting. 5 to 16V supply. TO-92 case. With data.
276-1646 . . . . . Pkg. of 3/1.98

Unique LEDs



A **Tri-Color.** Displays red, green, yellow. Uniform light output of 0.6 mcd. Forward voltage: 2.2VDC. Max. current: 25mA. T1-¾ case style.
276-035 . . . . . 1.39
B **Red Flasher.** Operates directly from 5VDC power source. Pulse rate: 3 Hz. Max. current: 20 mA at 5VDC.
276-036 . . . . . 1.29

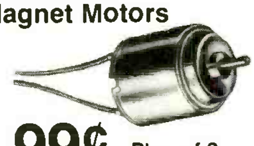
10 Assorted Mini Reed Switches



Pkg. of 10 **1.98**

Hermetically sealed. Gold-plated contacts close when magnetic field is present. Includes mini and micro types.
275-1610 . . . . . Pkg. of 10/1.98

Permanent Magnet Motors



99¢ Pkg. of 2

Up to 10,000 RPM at no load. Long leads for easy hook-up. Motor is 1½x⅞". Shaft, 5/64x¼".
273-206 . . . . . 2/99¢

12/24-Hr. LCD Clock Module

19.95

Actual Size

24-Hour Alarm
Shows Time/Day/Date

Complete clock module — just add switches and battery! 0.25" LCD display has built-in backlight, alarm set, PM and snooze indicators. Operates up to a year on single 1.5V battery. Accuracy: ±13 seconds per month. 277-1005 . . . . . 19.95

Top Octave Synthesizer IC

NEW! **6.99**

S50240. PMOS oscillator/frequency divider chip generates 13 equal-tempered notes from C_8 to C_8 to form the heart of any electronic keyboard instrument. CMOS compatible square wave outputs have 50% duty cycle for driving additional dividers or voice filters. Operates from single supply from 11 to 16 volts. 16-pin DIP.
276-1780 . . . . . 6.99

MC14553 3-Digit BCD Counter IC

2.99

CMOS chip replaces over 8 separate ICs in a digital display circuit. Input pulse shaping. Master reset pin. 16-pin DIP.
276-2498 . . . . . 2.99

RAM Memory ICs

Low As **2.49**

2102 1024 x 1 Array. Low-cost static memory chip. 16-pin DIP. Buy 8 and save!
276-2501 . . . . . 2.49 Ea. or 8/14.95
2114L 1024 x 4 Array. NMOS static RAM. 18-pin DIP. 276-2504. . . . . 10.99

4" Cooling Fan

12.95

Super Quiet Operation

Ideal for cooling power supplies, microcomputers, hi-fi and Ham gear. Delivers up to 70 CFM. Diecast venturi. U.L. recognized motor. For 120VAC, 60 Hz.
273-241 . . . . . 12.95

Dual Analog Delay IC

10.95

Continuously Variable—Many Audio Applications

SAD1024A. "Bucket Brigade" device has 2 separate 512-stage shift registers which can be used independently or in combination. Provides continuously variable electronic delay for complex audio signals to create reverb, echo, phase shift, chorus and vibrato effects. Reliable NMOS design operates from single supply. With applications circuits and data. 16-pin DIP. 276-1761 . . . . . 10.95

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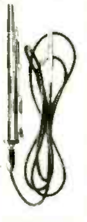
Continuity Tester and Flashlight



Convenient versatile tool for quickly checking continuity of dead circuits, switches, appliances, cords, fuses, motors, control equipment, coils and panel boards. Also tests circuits for low-resistance shorts and helps identify wires in multi-wire cables. Dozens of other uses. Plus the added convenience of a handy, durable flashlight. Uses two AA size penlight batteries (not furnished). Insulated clip prevents accidental shorting to case. Alligator clip has 48" lead with plug.

RT300 .... **$7.95**

Custom Cables & Jumpers

DB 25 Series Cables

Part No.	Cable Length	Connectors	Price
DB25P-4-P	4 Ft.	2-DP25P	$15.95 ea.
DB25P-4-S	4 Ft.	1-DP25P/1-25S	$16.95 ea.
DB25S-4-S	4 ft.	2-DP25S	$17.95 ea.
Dip Jumpers			
DJ14-1	1 ft.	1-14 Pin	$1.59 ea.
DJ16-1	1 ft.	1-16 Pin	1.79 ea.
DJ24-1	1 ft.	1-24 Pin	2.79 ea.
DJ14-1-14	1 ft.	2-14 Pin	2.79 ea.
DJ16-1-16	1 ft.	2-16 Pin	3.19 ea.
DJ24-1-24	1 ft.	2-24 Pin	4.95 ea.

For Custom Cables & Jumpers, See JAMECO 1980 Catalog for Pricing

25 PIN-D SUBMINIATURE CONNECTORS

(Meets RS232)

PART NO.	DESCRIPTION	PRICE
DB25P	PLUG (as pictured)	$2.95
DB25S	SOCKET	3.50
DB51226-1	CABLE COVER for DB25P or DB25S	1.75
DB25P-831	PLUG – Right Angle – P.C. Mount	4.95
DB25S-831	SOCKET – Right Angle – P.C. Mount	5.25

Printed Circuit Connectors

.156 Spacing-Tin-Double Read-Out
Bifurcated Contacts
Fits .054 to .070 P.C. Boards

PART NO.	DESCRIPTION	PRICE
15/30 SE	15/30 Contacts – solder eyelet	$1.95
18/36 SE	18/36 Contacts – solder eyelet	2.49
22/44 SE	22/44 Contacts – solder eyelet	2.95
22/44 WW	22/44 Contacts – wire wrap	3.95
50/100 WW	50/100 Contacts – wire wrap (R681-1) (.125 Spacing)	6.95

Jumbo 6-Digit Clock Kit

* Four .630"ht. and two .300"ht. common anode displays
* Uses MM5314 clock chip
* Switches for hours, minutes and hold functions
* Hours easily viewable to 30 feet
* Simulated walnut case
* 115VAC operation
* 12 or 24 hour operation
* Includes all components, case and wall transformer
* Size: 6¾ x 3⅛ x 1¾

JE747 .... **$29.95**

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

JE701

6-Digit Clock Kit $19.95

Regulated Power Supply

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

JE200 .... **$14.95**

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

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

JE205 .... **$12.95**

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES		
8080A	CPU	$ 7.95
8212	8-Bit Input/Output	3.25
8214	Priority Interrupt Control	5.95
8216	Bi-Directional Bus Driver	3.49
8224	Clock Generator/Driver	3.95
8226	Bus Driver	3.49
8228	System Controller/Bus Driver	4.95
8238	System Controller	5.95
8251	Prog. Comm. 1/0 (USART)	7.95
8253	Prog. Interval Timer	14.95
8255	Prog. Periph. 1/0 (PPI)	9.95
8257	Prog. DMA Control	19.95
8259	Prog. Interrupt Control	19.95

6800/6800 SUPPORT DEVICES		
MC6800	MPU	$14.95
MC6802CP	MPU with Clock and Ram	24.95
MC6810API	128X8 Static Ram	5.95
MC6821	Periph. Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	12.95
MC6830L8	1024X8 Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	7.95
MC6852	Synchronous Serial Data Adapt.	9.95
MC6860	0-600 bps Digital MODEM	12.95
MC6862	2400 bps Modulator	14.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS—MISCELLANEOUS		
Z80(780C)	CPU	$14.95
Z80A(780-1)	CPU	16.95
CDP1802	CPU	19.95
2650	MPU	19.95
6502	CPU	11.95
8035	8-Bit MPU w/clock, RAM, 1/0 lines	19.95
P8085	CPU	19.95
TMS9900JL	16-Bit MPU w/hardware, multiply & divide	49.95

SHIFT REGISTERS		
MM500H	Dual 25 Bit Dynamic	$.50
MM503H	Dual 50 Bit Dynamic	.50
MM504H	Dual 16 Bit Static	.50
MM506H	Dual 100 Bit Static	.50
MM510H	Dual 64 Bit Accumulator	.50
MM5016H	500/512 Bit Dynamic	.89
2504T	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4.95
2522	Dual 132 Bit Static	2.95
2524	512 Static	.99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4.00
2529	Dual 240 Bit Static	4.00
2532	Quad 80 Bit Static	2.95
3341	Fifo	6.95
74LS670	4X4 Register File (TriState)	2.49

UART'S		
A-Y-5-1013	30K BAUD	5.95

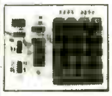
MICROPROCESSOR MANUALS		
M-Z80	User Manual	$7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

ROM'S		
2513(2140)	Character Generator(upper case)	$9.95
2513(3021)	Character Generator(lower case)	9.95
2516	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

RAM'S			
1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024X4	Static 450ns	7.95
2114L	1024X4	Static 450ns low power	10.95
2114-3	1024X4	Static 300ns	10.95
2114L-3	1024X4	Static 300ns low power	11.95
5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4.95
7489	16X4	Static	1.75
74S200	256X1	Static Tristate	4.95
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16 pin 250ns	9.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00

PROM'S			
1702A	2048	FAMOS	$5.95
2716INTEL	16K*	EPROM	59.95
TMS2516 (2716)	16K*	EPROM	49.95
	*Requires single +5V power supply		
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I	16K**	EPROM	29.95
	**Requires 3 voltages, –5V, +5V, +12V		
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

JE600 HEXADECIMAL ENCODER KIT



FEATURES:
* Full 8 bit latched output for micro-processor use
* 3 User Define keys with one being bi-stable operation
* Debounce circuit provided for all 19 keys
* LED readout to verify entries
* Easy interfacing with standard 16 pin 1C connector
* Only +5VDC required for operations

FULL 8 BIT LATCHED OUTPUT—19 KEYBOARD

The JE600 Encoder Keyboard provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8 bit microprocessor or 8 bit memory circuits. Three (3) additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with LED readouts. Also included is a key entry strobe.

JE600 .... **$59.95**

Hexadecimal Keypad only $14.95

DIGITAL THERMOMETER KIT

* Dual sensors—switching control for in-door/outdoor or dual monitoring
* Continuous LED .8" ht. display
* Range: -40°F to 199°F / -40°C to 100°C
* Accuracy: ±1° nominal
* Set for Fahrenheit or Celsius reading
* Sim. walnut case - AC wall adapter Incl.
* Size: 3-1/4"H x 6-5/8"W x 1-3/8"D

JE300 .... **$39.95**

62-Key ASCII Encoder Keyboard Kit

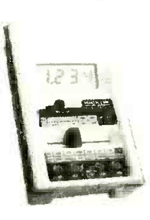
The JE610 62-Key ASCII Encoder Keyboard Kit can be interfaced into most any computer system. The JE610 Kit comes complete with an industrial grade keyboard switch assembly (62 keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and –12V @ 10mA for operation.

FEATURES:
* 60 Keys generate the full 128 characters, upper and lower case ASCII set
* Fully buffered
* 2 user define keys provided for custom applications
* Caps lock for upper case only alpha characters
* Utilizes a 2376 (40 pin) encoder read only memory chip
* Outputs directly compatible with TTL/DTL or MOS logic arrays
* Easy interfacing with a 16-pin dip or 18-pin edge connector

JE610 ..... **$79.95**

62-Key Keyboard only . . $34.95

HICKOK LX303 Portable LCD Digital Multimeter



* Big ½ inch high 3½ Digit Liquid Crystal Display • Over 200 Hours of operation with a 9V battery
* Automatic zero, polarity and overrange indication • 100mV DC F.S. sensitivity • 1% basic accuracy
* 19 ranges and functions • Rugged Cycolac® case and removable cover, stores test lead set
* Full one year warranty

SPECIFICATIONS: DC volts (5 ranges): 0.1mV to 1000V. Accuracy: ±0.5% rdg ±0.5% f.s. Input impedance: 10MΩ. Max. input 1kV except 500V on 200mV range. AC Volts (40Hz to 5kHz): 0.1V to 600V. Accuracy: ±1.0% rdg ±0.5% f.s. (–2dB max. at 5kHz). Max. input: 600V. Resistance (6 Low Power Ranges): 0.1 to 20MΩ. Accuracy: ±0.5% rdg ±0.5% f.s. (±1.5% rdg on 20MΩ range). Input protected to 120VAC all ranges. DC Current (6 ranges): 0.1nA to 100mA. Accuracy: ±1.0% rdg ±0.5% f.s. Dimensions and Weight: 5 7/8" x 3 3/8" x 1 3/4", 8 oz. POWER: 9V battery (not included) or Hickok AC adapter. READ RATE: 3 sec.

LX303 Digital Multimeter $74.95

PART NO.	DESCRIPTION	PRICE
RC-3	115V AC ADAPTER	7.50
CC-3	PADDED CARRYING CASE	7.50
VP-10	X10 DC PROBE ADAPTER (Up to 10K)	14.95
VP-40	40kV DC PROBE	35.00
CS-1	10 Amp DC Current Shunt	14.95

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$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable).
Maximum Data Rate	300 Baud.
Data Format	Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies	2025 Hz for space; 2225 Hz for mark.
Transmit Channel Frequencies	Switch selectable: Low (normal) = 1070 space 1270 mark; High = 025 space, 2225 mark.
Receive Sensitivity	–46 dbm accoustically coupled.
Transmit Level	–15 dbm nominal. Adjustable from –6 dbm to –20 dbm.
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz.
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar).
Power Requirements	120 VAC, single phase, 10 Watts.
Physical	All components mount on a single 5" by 9" printed circuit board. All components included.

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align.

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
* 8 each UPD416-1 (16K Dynamic Rams) 250NS
* Documentation for conversion

TRS-16K **$75.00**

ok JUST WRAP™

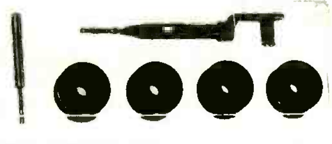
* 30 AWG wire
* .025" square posts
* Daisy chain or point-to-point
* Built-in cut off
* Includes 50 ft. wire
* No stripping or slitting required—just wrap

Part No.	Wire Color	Price
JW-1-B	Blue	$14.95
JW-1-W	White	14.95
JW-1-Y	Yellow	14.95
JW-1-R	Red	14.95

JUST WRAP™ Replacement Wire

Part No.	Color		Price
R-JW-B	Blue	50 ft. roll	$2.98
R-JW-W	White	50 ft. roll	2.98
R-JW-Y	Yellow	50 ft. roll	2.98
R-JW-R	Red	50 ft. roll	2.98

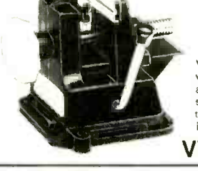
JUST WRAP™ Unwrap Tool $3.49



JUST WRAP™ Kit
* 50 ft. ea.: blue, white, red, yellow wire
* JUST WRAP Tool
* Unwrapping Tool

JWK-6 .... **$24.95**

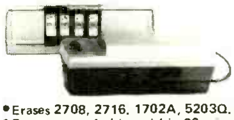
ok Vacuum Vise



Vacuum-based light-duty vise for small components and assemblies. ABS construction. 1½" jaws. 1¼" travel. Can be permanently installed.

VV-1 ...... **$3.49**

EPROM Erasing Lamp



* Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
* Erases up to 4 chips within 20 minutes.
* Maintains constant exposure distance of one inch
* Special conductive foam liner eliminates static build-up
* Built-in safety lock to prevent UV exposure
* Compact – only 7-5/8" x 2-7/8" x 2"
* Complete with holding tray for 4 chips

UVS-11E **$69.95**

Micro-Miniature Joystick

* 2 each 100K pots (Linear Taper)
* Printed Circuit Board Mount
* Size: 1" x 1-3/16" x 1-3/16"

Micro-Miniature Joystick ... **$4.95**

Active Electronic Sales Corp.

Zilog

Z8001	$195.00	16 Bit CPU with segmented address space to 8 Megabytes
Z8002	$150.00	16 Bit CPU with non segmented address space to 64K bytes
Z8000DB	$1500.00	A complete single board Z8000 microcomputer system. Contains the Z8002 microprocessor. 16K words of dynamic RAM. 2K word monitor PROM, dual serial interfaces, four counter/timers and 32 programmable parallel I/O lines

All Products Stocked in Depth
Largest Zilog Inventory

Z80-CPU	2.5 MHz	$ 9.95	Z80-DMA	2.5 MHz	$26.85
Z80A-CPU	4.0 MHz	11.95	Z80A-DMA	4.0 MHz	33.60
Z80-PIO	2.5 MHz	7.20	Z80-SIO/O	2.5 MHz	36.00
Z80A-PIO	4.0 MHz	8.40	Z80A-SIO/O	4.0 MHz	39.50
Z80-CTC	2.5 MHz	7.20	Z80-SIO/1	2.5 MHz	36.00
Z80A-CTC	4.0 MHz	8.40	Z80A-SIO/1	4.0 MHz	39.50
			Z80-SIO/2	2.5 MHz	36.00
			Z80A-SIO/2	4.0 MHz	39.50

MICROPROCESSOR CHIP SETS

Part No.	Price	Part No.	Price	Par No.	Price
8080A	$5.95	6800	$6.95	65C2	$9.95
8085	12.95	6802	11.95	65C4	9.95
				65C5	9.95
8212	3.45	6810	3.95		
8214	3.95	6820	3.95	6520	6.95
8216	3.25	6821	3.95	6522	9.95
8224	2.95	6850	4.25	6532	13.95
8226	2.25	6852	3.95	6551	13.95
8228	3.98				
8238	4.75				
8251	5.75	1802LE	9.95	1854LE	6.95
8253	14.95	1824LE	3.50	1856LE	1.95
8255	5.75	1852LE	1.50	1858LE	1.95
8257	10.95	1853LE	1.45	1859LE	1.50
8259	14.95				

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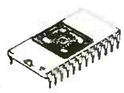
Homotaxial — Best Quality

2N3054	.65	60V	NPN	TO-66
2N3055	.69	70V	NPN	TO-3
2N3442	1.50	160V	NPN	TO-3
2N3771	1.95	50V	NPN	TO-3
2N3772	1.95	100V	NPN	TO-3
2N3773	2.50	160V	NPN	TO-3

Universal SCR

C106D	.34	400V	5.0 AMP	TO-220

EPROM'S



C2708 1K x 8 450 ns	$ 9.95
TMS2716 16K (2K x 8) 450 ns (3 power supplies) T.I. Version	$24.95
C2716/TMS2516 16K (2K x 8) 450 ns (Single 5V supply — Intel version)	$29.95

Special of the Month
4K STATIC RAM

2114 L Low Power **$4.95**
4K (1024 x 4) 300ns

LINEAR I.C.'s

LM324N	.59	LM741CN-8	.29
LM339N	.59	LM747CN-14	.59
LM348N-14	.99	LM748CN-8	.39
LM555N-8	.29	TBA810DAS	1.29
LM556N-14	.59	LM1458N-8	.49
LM723CN-14	.49	LM3403N-14	.39
LM725CN-8	1.25	LM3900N	.59
LM739CN-14	.29	LM4136N-14	.39

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Creates almost any type of sound, from music to gunshots and explosions. High level op amp output. 28 pin DIP. Operates from one 9V battery. With data.

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SN76477N (.600" centers)	$2.49
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MOS MEMORIES

MOS Static RAM's

Part No.	Price
2101 1K (256 x 4) 350ns 22 PIN	$1.95
2102LFPC 1K (1K x 1) Low Power 350ns 16 PIN	1.19
2102LHPC 1K (1K x 1) Low Power High Performance 250ns 16 PIN	1.29
2102-1PC 1K (1K x 1) 450ns 16 PIN	0.94
2102-2PC 1K (1K x 1) 650ns 16 PIN	0.89
P2111-25 1K (256 x 4) 250ns 18 PIN	2.25
P2112-35 1K (256 x 4) 350ns 18 PIN	2.25

MOS Dynamic RAM's

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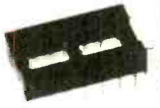

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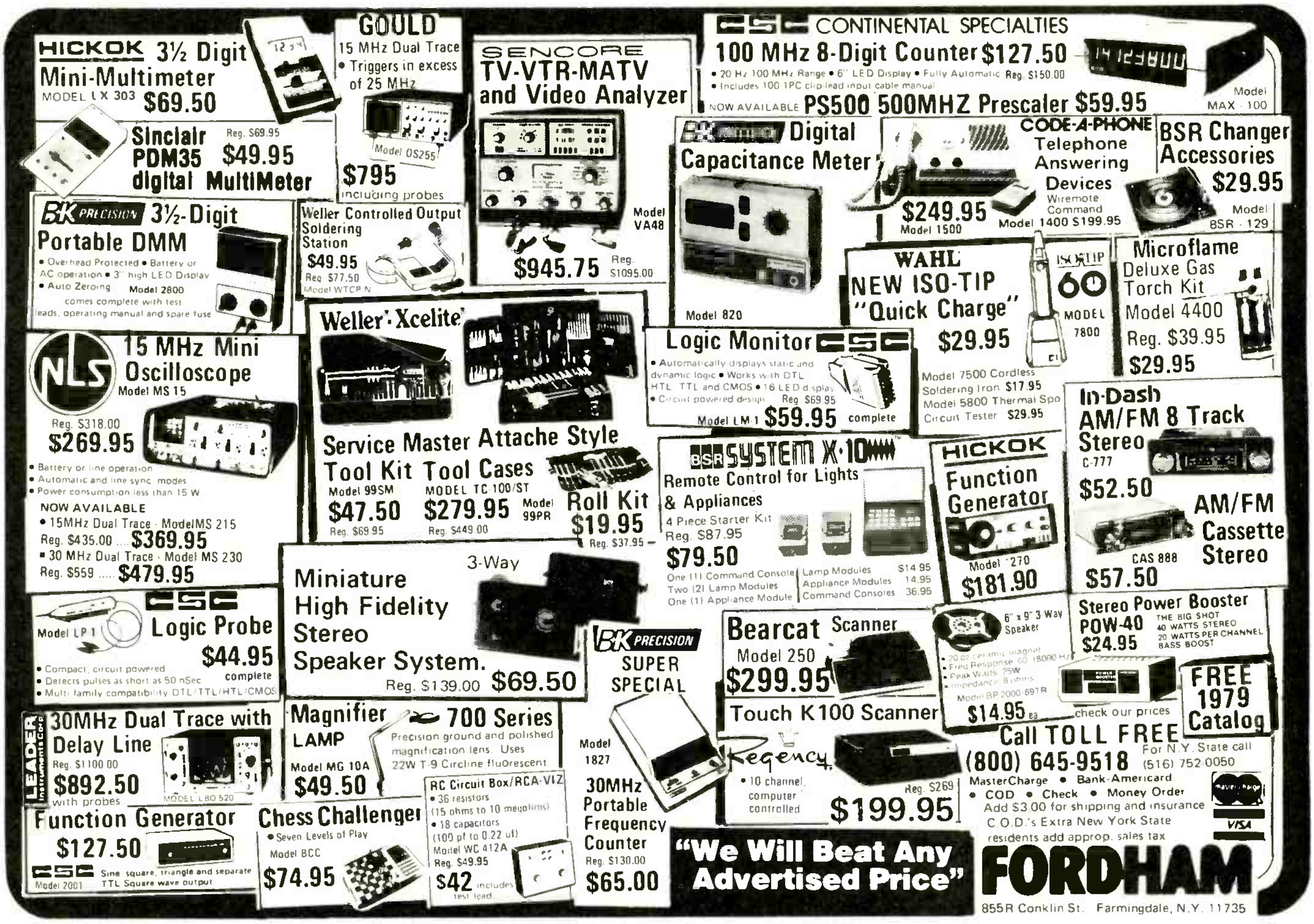

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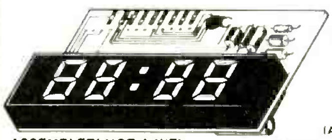

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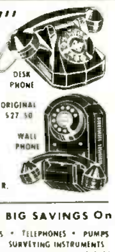

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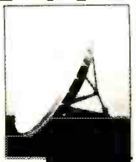

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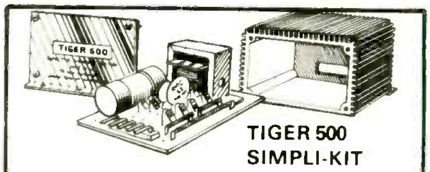

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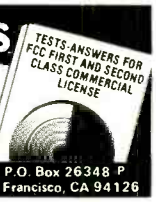

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Personal Electronics News

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 feasability 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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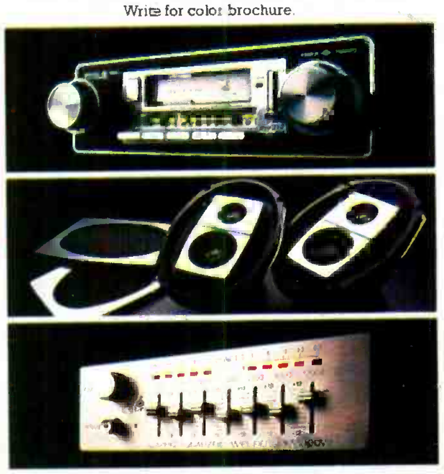

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