FCC PROPOSES NEW CB RADIO CHANGES

# Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE SEPTEMBER 1976/$1

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## Exotic Home Lighting Control Project

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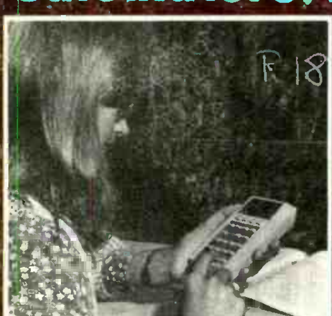


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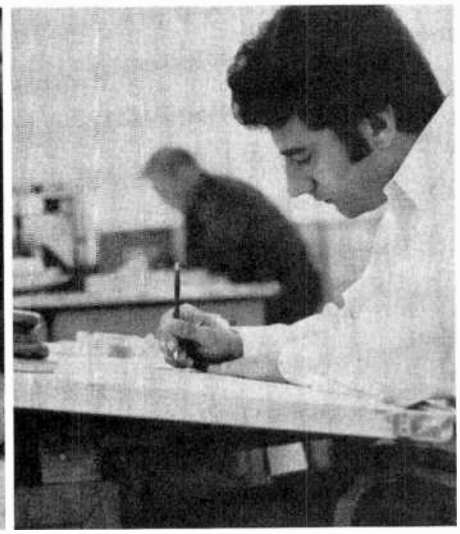

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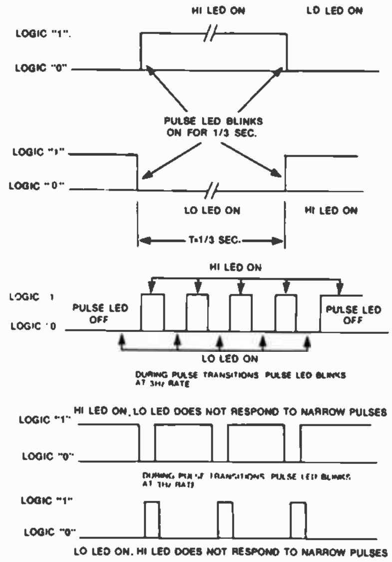


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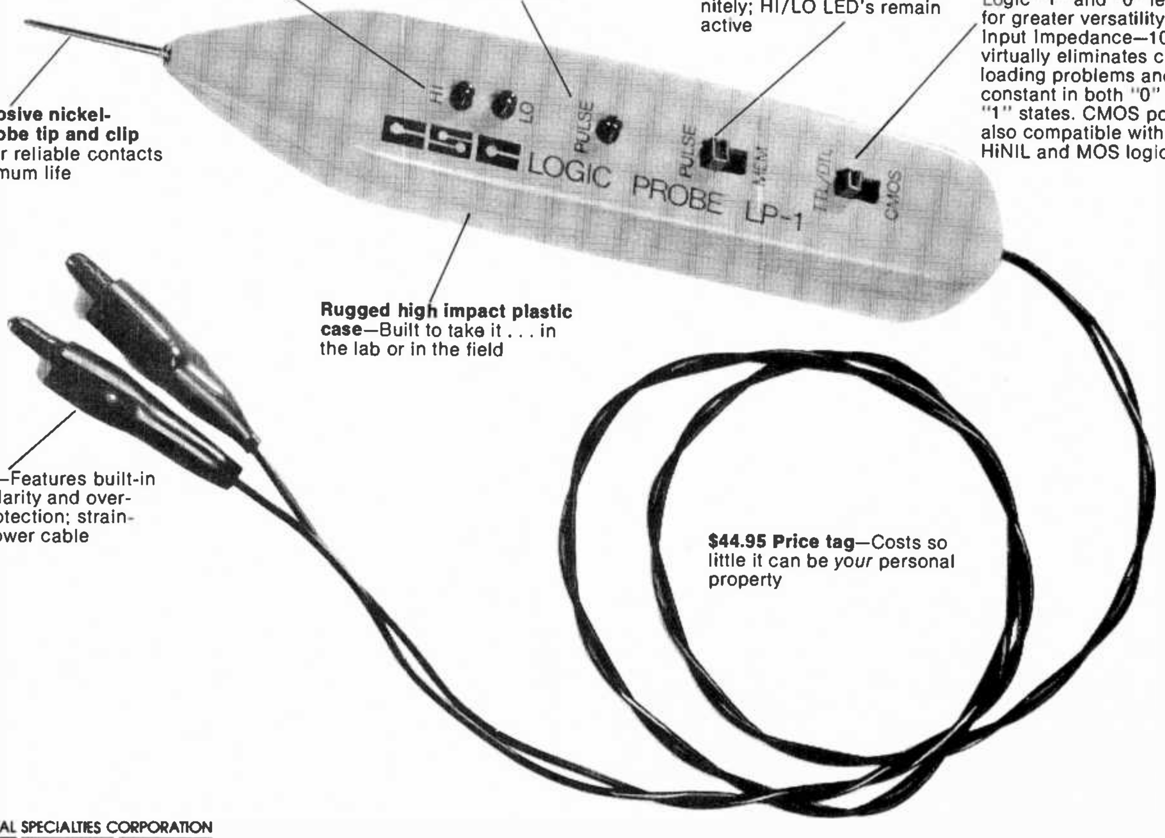




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# Editorial

## CONSUMER "RADIATION" PROTECTION

From time to time we all read about the possibility of biological damage due to "radiation" exposure. The latest "radiation" furor involved the U.S.S.R.'s microwave "spy" beams directed against our embassy personnel in Moscow. But there are some disquieting radiation considerations closer to home. For example, how much radiation exposure is safe? Will there be a damaging cumulative effect from chest X-rays, dental X-rays, color TV receivers, microwave ovens, et al? No one truly knows the answer.

Since 1968, radiological safety standards have been set by the FDA's Bureau of Radiological Health in conjunction with information from industry and interested parties. Establishment of this Federal agency was motivated by General Electric's 1968 recall of more than 100,000 color-TV receivers due to excessive radiation levels. The agency subsequently discovered that many other brands of color TV in the late '60's also had high levels of X-radiation. Today's acceptable TV X-radiation is 0.5 milliroentgens per hour at 5 cm away from the receiver per 10 square cm area.

Microwave ovens, too, exhibit radiation (not X-ray) through a small amount of leakage. The Federal limit, established in October 1971, is 1 milliwatt per $cm^2$ at 5 cm away, at the time of purchase, and 5 milliwatts maximum for the duration of oven use. The military and industry consider 10 milliwatts/$cm^2$ to be the safe limit. However, other countries—namely the U.S.S.R.—have a standard of 10 *micro*watts/$cm^2$ per working day, which is increased to 1 milliwatt for 15- to 20-minute exposures each day.

Obviously, there's a difference of opinion as to which level of microwave "radiation" is safe. Although, there's never been a documented case in the U.S. of harm from exposure to microwave ovens, and I'm confident that the standards are conservative, I still stay more than four feet away from an operating microwave oven (the distance at which leakage becomes unmeasurable with a standard meter).

Assuming that standards are well within safe limits, however, there are other distressing questions. Is there a danger of excessive X-ray exposure from a pre-1969 color TV receiver? How does one know when a microwave oven's door seal is unsatisfactory?

A neon bulb or household fluorescent lamp used as a wand could detect serious microwave leakage by glowing or lighting. But this method is by no means an accurate indicator. Instruments such as Simpson Electric's microwave tester, at $195.00, are too expensive for the general public! The same is true for testers to check color-TV radiation. It was therefore interesting to receive by mail a free sample of a $2.95 color-TV radiation detector kit that includes a film pack with processing chemicals. Developed at home (darkroom not required), it is said to reveal excessive radiation.

I haven't verified the accuracy of the foregoing (available from Dahlco, P.O. Box 19202, So. Minneapolis, MN 55419), but the concept is interesting. It makes me wonder why color-TV and microwave-oven manufacturers haven't developed a simple inexpensive device or material to enable consumers to make home radiation-danger-level tests on their products. But no placebos, please.

Art Salsberg

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Even though you may not have heard of the Sparkomatic name, you've probably been listening to the Sparkomatic sound for the past eight years. That's how long we've been number one in car speakers. And now that we've put that kind of experience into CB, you're going to hear a lot more about us. Because we have everything in CB equipment to fit anything on wheels.

Beginning with converters. If you're just starting out in CB you'll be interested in our CB-10 converter. This easy to install unit converts any AM radio into an all channel CB receiver so you can listen to what CB is all about.

Or, if you're already well into CB, use it to monitor a particular channel while you use your transceiver for the regular action. We also have a CB-11 converter which has the added feature of a 23 channel selector knob.

We make CB transceivers to fit your price range and needs. And whether it's one of our basic mobile rigs like our CB-1123, or a multi-featured base station like the CB-5000, they're all engineered with the same Sparkomatic know-how.

And once you've got a Sparkomatic transceiver, you should back it up with one of the many antennas we make for your specific application.

Like our SA-204. It gives you three full inches of whip adjustment for optimum tuning instead of being limited to the usual 3/4 inch. Other antennas can't give you the lowest SWR (standing wave ratio) like this one can. And because it's pre-wired with a plug-in connector for goof-proof installation, you know you'll get all the performance that's built into your CB radio.

Our motorized SA-301 is the retractable antenna that's completely retractable. It looks like a regular radio antenna so no one will know your car is CB equipped. Yet, it has everything going for it like lock-in tuning and efficient top loaded coil. And it's engineered for AM, FM and stereo, as well as CB.

Our SA-22 is perfect for mounting on station wagons, campers, vans, and cars without conventional trunks. We even have a clip-on (SA-10) or magnet mount (SA-11), which you can easily attach or remove in seconds.

And now that you're all set in CB, you should look into an external speaker. For a few bucks more you can improve greatly on intelligibility.

And nothing is better designed for this purpose than our SK-35CB with the exclusive Sparkomatic Tone Purifier™ slide control which brings in the message the way you want to hear it. And to add another dimension to the fun of owning CB, our Public Address speaker, the SK-50CB is a must.

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# Letters

## CONVERT NATURAL TO COMMON LOGS

Common, or base-10, logarithms are often used in electronics, such as in computing decibel power figures. Unfortunately, a number of electronic calculators that provide natural log (*ln*) functions fail to provide a base-10 log key. Any reader who has such a calculator can easily perform his calculations using the *ln* function simply by multiplying the *ln* figures by the constant 0.434. Hence, the familiar decibel formulas, expressed in natural rather than common logs, become: $G_{dB} = 4.34 \ln (P_2/P_1) = 8.68 \ln (V_2 V_1)$.—*Michael A. Covington, Athens, GA.*

## PRINTERS FOR CALCULATORS

"Here Are the New Programmable Calculators" (May 1974) was timely and informative. I note, however, that there is a need for a low-cost printer for calculators. If an adding machine that sells for \$50 to \$60 can have a numeric printer, it should not be too difficult for a low-priced calculator to have one as well. — *David W. Johnston, Washington, D.C.*

*Electromechanical adding machines use impact-printing mechanisms, whereas calculators use thermal printing heads. Putting an impact printer in a calculator would result in a bulky, power-hungry machine. But you're in luck because some major calculator manufacturers recently introduced small calculators with built-in thermal printing heads. Some will sell for less than \$100.*



## BASE ANTENNAS A HOMER

It was with much enthusiasm that I read "Special Focus on CB Radio" in the April 1976 issue. Your coverage of base station antennas was extremely well presented.— *Arnal A. Cook, Bloomington, IN*

## MORE ON WEATHER ALERTER

The "Severe Weather Warning Alerter" (May 1976) was most interesting. I highly recommend it as an add-on to low-cost vhf weather receivers, but a few comments are in order. Perhaps the National Weather Service Office in author Lloyd's area used a 15-second alert tone at the time the article was prepared, but the new nationwide standard is now a 10-second tone. Therefore, for the Alerter to work effectively under these conditions, the value of *C10* should be reduced.

During severe weather warning conditions, the warning is repeated every couple of minutes, but the alert tone is sent only *once*, with the initial broadcast. If a new warning is required, another warning tone is sent with its initial broadcast. Our latest directive stipulates that tests of the warning signal be conducted every day, including weekends, between 10 AM and 1 PM.

Incidentally, Congress has recently designated the NWS vhf broadcast network as a primary means of disseminating attack warnings. These would also be preceded by an alert tone. — *John R. Hughes, Jr., National Weather Service, Detroit, MI.*

# Out of Tune

In "Learning Electronic Theory With Hand Calculators, Part One" (July 1976), the equation accompanying Fig. 4 should read:

$$R_T = \cfrac{1}{\cfrac{1}{R_1} + \left( \cfrac{1}{\cfrac{R_2 R_3}{R_2 + R_3} + R_4} \right)}$$

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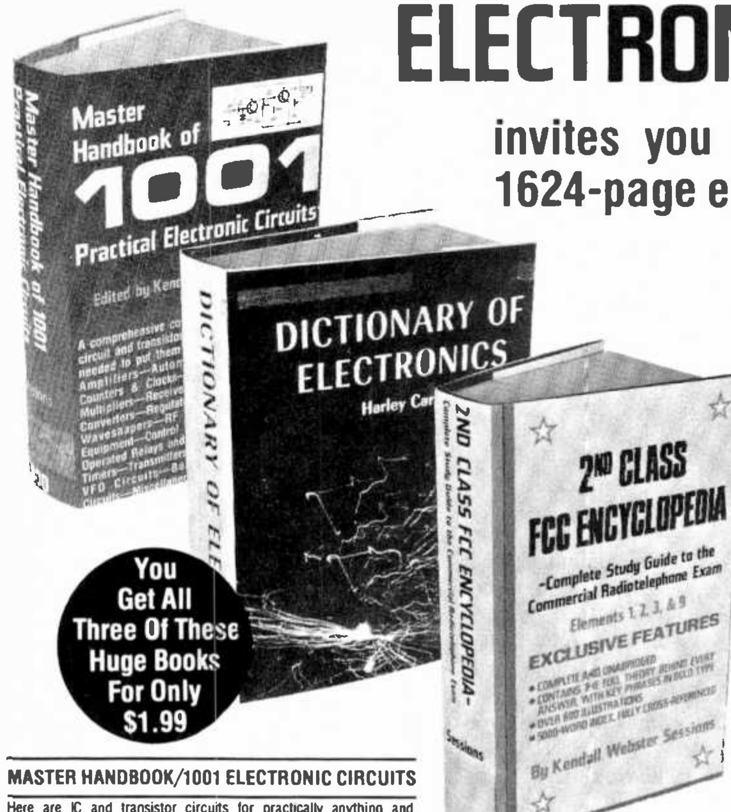


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- The 3 introductory books carry a publishers retail price of $33 85. They are yours for only $1.99 (plus postage and handling) with your Trial Membership.
- You will receive the Club News describing the current Selection, Alternates and other offerings, every 4 weeks (13 times a year).
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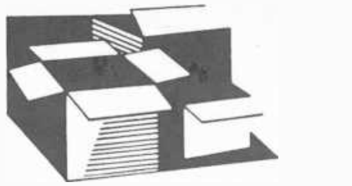


# New Products

*Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.*

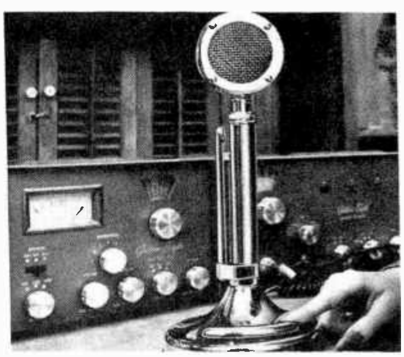
### KENWOOD AM/STEREO FM RECEIVER

Kenwood's Model KR-5600 deluxe stereo receiver is rated at 40 watts/channel into 8 ohms with 0.5% maximum THD from 20 to 20,000 Hz. Its power amplifier section uses direct-coupled complementary-symmetry output stages and has "area of safe operation" circuit and relays that instantly cut output power should safe levels be exceeded. Op amps in the preamp section maintain a high S/N ratio. A MOSFET front end has a rated sensitivity of 1.8 µV. Capture ratio is 1.5 dB, and alternate-channel selectivity is 80 dB. A PLL in the multiplex section provides uniform stereo separation A 25-µs deemphasis switch is provided for Dolby-processed FM signals. ADAPTOR OUT/IN terminals can also accommodate an outboard Dolby unit and a 4-channel conversion adaptor.

CIRCLE NO. 85 ON FREE INFORMATION CARD

### ASTATIC "SILVER EAGLE" MIKE

A new version of the venerable D104 crystal desk microphone has been introduced. Called the D104 Silver Eagle, it features a push-to-talk bar in parallel with the grip-to-talk bar on the desk stand. A slide locking clamp provides "no hands" transmission. Electronic or relay switching transceivers can be used with the microphone,

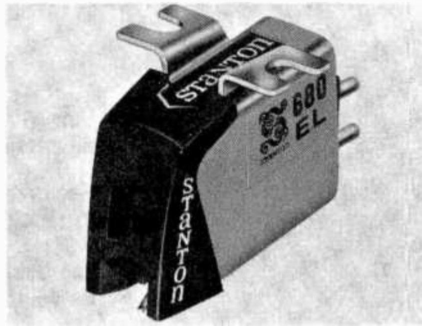


which is wired with an open audio line on receive. Its coiled cable has one shielded conductor and four unshielded. All external parts, including the base, are chrome plated.

CIRCLE NO. 86 ON FREE INFORMATION CARD

### "DISCO DUTY" PHONO CARTRIDGE

The Stanton 680EL has been developed for use in discotheques and radio stations. Its claimed frequency response is from 20 Hz to 18,000 Hz, with a nominal output of 1.1 mV/cm/sec ±2 dB. Channel separation is




said to be 30 dB, and channel balance within 2 dB. Load resistance is 47,000 ohms, and load capacitance is 275 pF. The cartridge's stylus is a 0.4 mil × 0.7 mil elliptical diamond. Tracking force is from 2 to 5 grams, and cartridge weight is 5.5 grams. The Stanton 680EL comes with a replacement stylus. $90.00

CIRCLE NO. 87 ON FREE INFORMATION CARD

### SWTP PRINTER

Southwest Technical's Model PR-40 alphanumeric printer kit is a 5×7-dot matrix impact printer which produces the 64-character upper case ASCII set with 40 characters per line. Print rate is 75 lines per minute on standard 3⅞-inch rolls of adding machine paper. One complete line is printed at a time from an internal 40-character line buffer memory. Printing takes place either on receipt of a carriage return command or automatically whenever the line buffer memory is filled. The unit is available in kit-form only and includes the assembled print mechanism, chassis, pc boards, components, ac power supply, assembly instruction, one ribbon and one roll of paper. $250.00.

CIRCLE NO. 88 ON FREE INFORMATION CARD

### LUXMAN SYNTHESIZED FM TUNER

The new Luxman Model 5T50 is a frequency synthesized FM tuner featuring a four-digit, seven-segment frequency readout with 200-kHz incrementation. An FM dial scale is also provided with a LED pointer that moves across the 88-108-MHz band. Tuning can also be accomplished by means of seven station presets, as well as automatic scan tuning. The preset capability uses a CMOS IC memory, which is maintained by a self-recharging battery, even when line power is turned off. A string of LED's indicates signal strength. Claimed S/N is 72 dB, capture ratio is 1.3 dB, alternate channel selectivity 80 dB, and stereo separation 48 dB at 1000 Hz, 38 dB from 30 to 10,000 Hz. Dolby noise reduction with a 400-Hz test oscillator is built-in. Claimed sensitivity is 1.7 µV (IHF), 9.8 dBf (available power) monaural. Frequency response is 30 to 15,000 Hz, +0.2, −0.5 dB. THD at 65 dBf is 0.08% at 1000 Hz (stereo). A muting switch selects one of two thresholds, or disables this feature. Output voltage is 1.5 V. Balanced (300 ohms) and unbalanced (75 ohms) antenna inputs are provided.

CIRCLE NO. 89 ON FREE INFORMATION CARD

### TURNER MAGNETIC-MOUNT CB ANTENNAS

Turner has added two magnetic-mount antennas to its Signal Kicker® CB antennas line. The antennas use a magnet with a specification strength of of 90 lb (41 kg) of direct pull. The SK900 series come with 18 ft (5.5 m) of coaxial cable. They are factory tuned for low VSWR and are designed to handle up to 500 watts of power. The stainless steel whip measures 46" (122 cm) long. The Model SK900 antenna includes a stainless steel shock spring and sells for $28, while Model SK900 at $25 does not have a shock spring.

CIRCLE NO. 91 ON FREE INFORMATION CARD

### FISHER AM/FM STEREO RECEIVER

Fisher's Model RS1060 receiver features a PLL multiplex decoder, attenuator-type calibrated volume control, a claimed FM sensitivity of 1.7 µV (IHF) or 9.8 dBf (available power), and a continuous power output rating of 100 W rms minimum into 8 ohms from 20 to 20,000 Hz with no more than 0.15% THD. It also has ladder-type filters in its linear phase i-f section, two tuning meters, feedback-type Baxandall tone controls, a tuned bass extender, two

PHONO and AUX inputs and an FM DOLBY mode for use of an external Dolby noise reduction unit with the FM tuner. Two tape monitors are provided, as well as FM muting, a six-position speaker/headphone selector, switchable high and low filters, and a tone defeat switch. Phono preamp input sensitivity is 2 mV at rated output at 1000 Hz. FM capture ratio is 0.8 dBm; alternate channel selectivity, 70 dB. Measures 23¾"W × 16¹⁵⁄₁₆"D × 7⅜"H (60.3 × 43 × 18.7 cm), and weighs 54 lb (24.5 kg).

CIRCLE NO. 92 ON FREE INFORMATION CARD

### DUMONT SINGLE-TRACE OSCILLOSCOPE

A single-trace oscilloscope with a bandwidth of dc to 5 MHz, Model 5040, is available from Dumont Oscilloscope Laboratories. It has triggered sweep,

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**It's Patented, Too . . . U.S. Pat. No. 643485**

***Here's What CB Magazine (May 1976) Has to Say About Our "One-Hander"***

"On the road, it performed beautifully. The 60 dB of adjacent channel rejection was a particular plus in the test area . . . In my opinion, this radio is one of the best innovations in mobile communications in many years. Having all of the operating controls built into the mike frees the driver from having to reach for the next channel or looking for the volume control while paying attention to traffic."

***Handset shown actual size***

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**The 1½x5¼x7" remote section is easily concealed. 3-way switch for its own built-in speaker, handset speaker, external speaker.**

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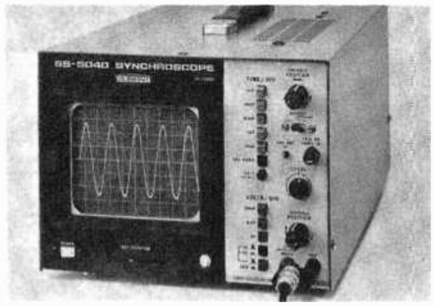


minimum vertical sensitivity of 20 mV/cm, input impedance of 1 megohm paralleled by 32 pF, a horizontal time base of 1 µs/cm to 10 ms/cm in five calibrated steps. The horizontal amplifier accepts external sweep signals from dc to 100 kHz (−3 dB), and has an external sensitivity of 0.5 V/cm. A 5-inch CRT provides a 3.15" × 3.94" (80 × 100 mm) viewing area, and uses a P31 standard phosphor. A built-in calibrator provides a 1-V p-p line frequency reference signal. Measures 16.5"D × 9"W × 6.5"H (41.9 × 22.8 × 16.5 cm), and weighs 15.4 lb. (6.98 kg). $325.

CIRCLE NO. 93 ON FREE INFORMATION CARD

### TEAC HALF-TRACK TAPE DECK

Teac announces its A-3300SX-2T open-reel tape deck with a 2-channel stereo or mono format. Features three motors, three tape heads, and 7½ or 15 ips. Independent left and right channel source/tape selector and VU level averaging meters are included. A manual cue lever facilitates searching and editing. Includes separate bias and equalization selectors, independent left and right channel record mode selectors, and individual input and output level controls. Accommodates 10½-inch reels. Claimed frequency response is 30 to 26,000 Hz ± 3 dB at 15 ips; wow and flutter (NAB weighted) is 0.04% at 15 ips, and THD is less that 1% at 1 kHz, normal operating level. A headphone output jack is built-in. Measures 17⁵⁄₁₆" × 17⁵⁄₁₆" × 8⁵⁄₁₆" (44 × 44 × 21 cm), and weighs 44 lb (20 kg).

CIRCLE NO. 94 ON FREE INFORMATION CARD

### MERIX ANTI-STATIC COATING

Merix Anti-Static #79 is a non-metallic conductive coating that achieves its conductivity chemically after it is diluted with de-ionized water. It can be wiped on to an area, dries quickly, and gives conductivity to an average area of 8000 to 10,000 square feet per gallon. The coating gives readings of 20 to 100 megohms per square inch on plastics, and +100 megohms per square inch on glass surfaces. Merix Anti-Static #79 is stable, clear, neutral pH, nonflammable, and safe to use. Available in large quantities, or in sample gallons for $58 each, or sample quarts for $27 each. Merix Chemical Co., Div. A., Conductive Coatings, 2234 East 75th St., Chicago, IL 60649.

### WEATHERALERT WEATHER RECEIVER

A new weather receiver from Weatheralert offers continuous U.S. Weather Service monitoring and sounds its internal siren when a special signal is received whenever dangerous conditions threaten. During normal operation, the receiver picks up the weather station's continuous reports. The siren trips only when the special signal is transmitted. (Volume need not be turned up to activate the siren.) The receiver is designed to operate within 40 to 50 miles (65 to 80 km) of the transmitter using its built-in telescoping antenna. An optional antenna kit extends reception range up to 80 miles (130 km). Primary ac powered, the receiver automatically switches over to batteries should a power failure occur. $39.95. Address: Weatheralert Co., 639 S. Dearborn St., Chicago, IL 60605.

### SANSUI HIGH-POWER STEREO RECEIVER

The Sansui Model 9090 stereo receiver is rated at 100 watts/channel at 0.2% maximum harmonic distortion with both channels driven into 8 ohms. The direct-coupled amplifier section features two meters with logarithmically compressed scales to cover a power output range of from 0.05 to 200 watts at 8 ohms. The receiver is equipped with zero-center tuning and signal-strength meters, the latter doubling as a multipath indicator during FM antenna alignment for eliminating multipath distortion. A phase-locked-loop IC is used in the FM (stereo) demodulator to minimize multiplex distortion and tuning noise. In addition, the receiver has a circuit to permit mixing mike signals with those from any other source. FM sensitivity is rated at 1.7 µV, capture ratio at 1.5 dB, and selectivity at 85 dB. $750.00.

CIRCLE NO. 96 ON FREE INFORMATION CARD

### EICO MOBILE CB PREAMP

The "Long Ranger" Model LR-3 preamp boosts CB signal 20 dB on receive for increased sensitivity. Although the preamp is


inserted in the transmission line between transceiver and antenna, a carrier detection circuit isolates the preamp on transmit. Requires 12 V dc, positive or negative ground. $29.95

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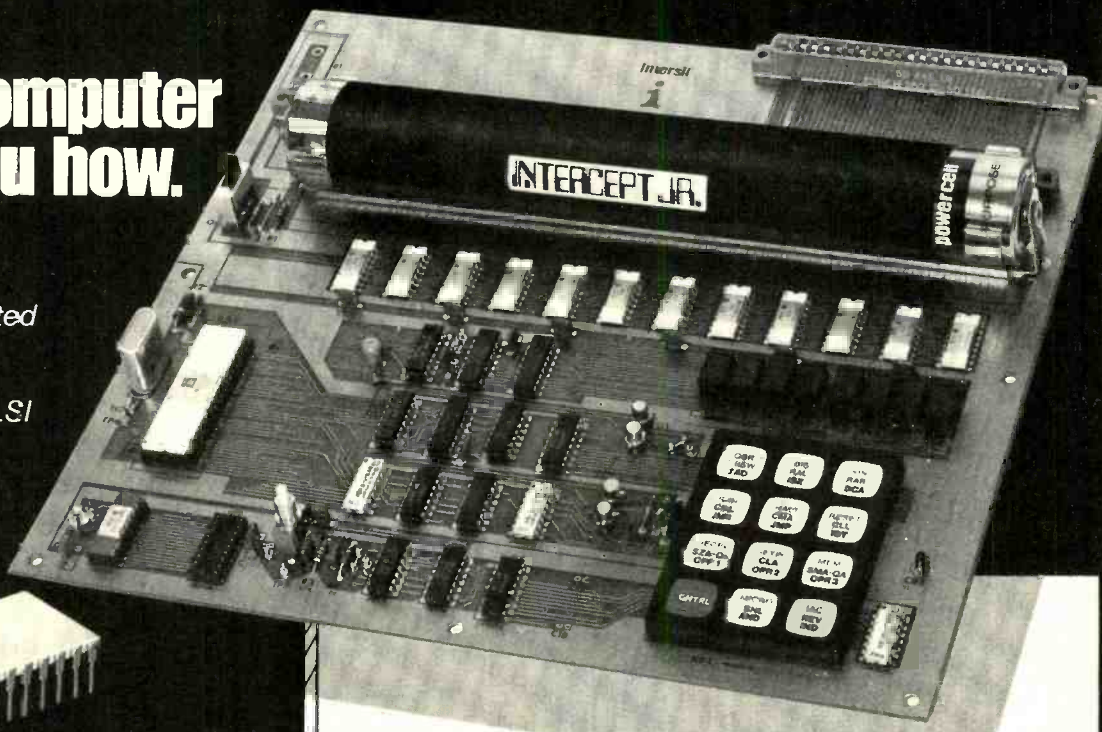
# Learn to use a microprocessor.

## This portable computer teaches you how.




*Low cost, battery operated Intercept Jr. Tutorial System instructs you on todays most advanced LSI semiconductor devices, then serves double duty as an operating solid-state computer!*

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# New Literature

### CB ANTENNA CATALOG

Cush Craft's new 4-page catalog, C-9, includes a full line of monitor antennas; trunk-mount, jiffy mirror-mount and co-phased mirror-mount mobile antennas; omni-base antennas for permanent or temporary use; directional base-station antennas with 3,4 and 5 element beams, including a horizontal/vertical power beam and dual beam stak kit. Antennas are illustrated and complete specifications are provided. A section on related accessories is also provided. Address: Cush Craft Corp., 621 Haywood St., Manchester, NH 03103.

### TECHNICAL BOOKS CATALOG

Tab Books offers a 1976 catalog of technical and do-it-yourself books. The 44-page, fully illustrated catalog describes over 400 current and forthcoming books, plus 14 electronic book kits. Some of the subjects covered are: amateur radio license study; audio; hi-fi; basic electronics; 2-way, shortwave and CB radio; math calculators and computers; electronic music; general electronic servicing; and test equipment. A selection of TV, radio, CB and hi-fi service manuals is also included. Address: Tab Books, Blue Ridge Summit, PA.

### SPEAKER CATALOG

Quam-Nichols announces its new 17-page catalog illustrating its line of loudspeakers for high fidelity, music instruments, sound systems, automotive, general purpose and industrial applications. Technical specifications are given, including dimensions, frequency response, power-handling capacity, voice-coil impedance and diameter, and magnet material. Speakers are illustrated and a section on configurations and mounting dimensions is included. Also available is a 2-page flyer describing Quam's air-suspension speakers. Address: Quam-Nichols Company, Marquette Rd. and Prairie Ave., Chicago, IL 60637.

### SOLDERING AND DESOLDERING EQUIPMENT

A new, 4-page catalog, #76, from Endeco illustrates its line of soldering and desoldering equipment. Included are soldering and desoldering irons, kits, a desoldering head that converts a soldering iron into a desoldering iron, tips, desoldering bulbs, solder paks, and soldering tool stands. Cord size, wattage, voltage and tip temperature information are included. Address: Enterprise Development Corp., 5127 E. 65 St., Indianapolis, IN 46220.

# SwTPC 6800

# #1

**IN PERFORMANCE**

The word is getting around. There is simply no better processor available for general purpose computer work than the Motorola MC6800. This memory oriented processor is easier to program and makes possible more efficient, shorter and faster running programs than the old fashioned bus oriented processors. Have you been convinced that machine language, or assembler programs are only for the experts? Well not with a modern 6800 based computer. Anyone can learn very quickly with this simple straightforward hexidecimal notation processor. When you add to these advantages the unique programmable interfaces and the Mikbug® ROM you truly have a "benchmark" system.

Mikbug® eliminates the tedious and time consuming job of loading the bootstrap program from the switch console each time the computer is turned "On". With Mikbug® this is automatic and you simply don't have switches and status lights. It has been said (not by us) that a switch console is essential for "hardware development," (perhaps they meant "hardware debugging"). Anyway the SwTPC 6800 system has no need for either. This is a fully developed, reliable system with no strange habits. All boards have full buffering for solid noise immune operation. One crystal type clock oscillator drives everything, processor interfaces and all; so there are no adjustments and no problems.

**FOR VALUE**

The SwTPC 6800 in its basic form comes complete with everything you will need to operate the computer except an I/O device. This may be either a teletype of some kind, or a video terminal. You get a heavy duty anodized aluminum case, a 10 Amp power supply large enough to power a fully expanded system, a mother board with seven memory/processor slots and eight interface slots, a 2,048 word static memory and a serial control interface. This kit is now only $395.00. It was introduced at $450.00, but when processor prices went down we reduced the price of the kit accordingly.

As an owner of our 6800 computer you will get copies of our newsletter with helpful information and software listings. We have a library of software including all the common computer games and our fantastic BASIC. This is available to you for the cost of copying, you don't have to buy anything to get this material.

What more could you want? Pay a visit to our nearest dealer and see the 6800, plus our new cassette interface, graphics terminal and printer. He will be happy to demonstrate our system and to supply you with a 6800 that will fit your exact needs.

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**with serial interface and 2,048 words of memory. . . . . . . . . . . . .$395.00**

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Cyberdux, Microcomputer Applications, 1210 Santa Fe Dr., Encinitas, Calif. 92024 (714) 279-4189

The Micro Store, 634 South Central Expressway, Richardson, Texas 75080 (214) 231-4088

ELS Systems, 2209 N. Taylor Rd., Cleveland Heights, Ohio 44112 (216) 249-7820

Microcomputer Systems Inc., 144 S. Dale Mabry Ave., Tampa, Florida 33609, (813) 879-4301

William Electronics Supply, 1863 Woodbridge Ave., Edison, N.J. 08817 (201) 985-3700

Computer Mart of New York, Inc. 314 Fifth, New York, N.Y. 10001 (212) 279-1048

The Byte Shop Computer Store # 1, 1063 El Camino Real, Mountain View, Calif. 94040, (415) 969-5464

The Byte Shop Computer Store #2, 3400 El Camino Real, Santa Clara, Calif. 95051, (408) 249-4221

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Computer Warehouse Store, 584 Commonworth Ave., Boston, Massachusetts 02215 (617) 261-1100

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The Computer Store, Inc., 120 Cambridge Street, Burlington, Mass. 01803 (617) 272-8770

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The Milwaukee Computer Store, 6916 W. North Ave., Milwaukee, WI 53213 (414) 259-9140

Control Concepts, P.O. Box 272, Needham Heights, Mass. 02194

American Microprocessors, Equipment & Supply Corp. at Chicagoland Airport, P.O. Box 515, Prairie View, Illinois 60069 (312) 634-0076

The Computer Room Inc., 3938 Beau D'Rue Dr., Eagan, Minn. 55122, (612) 452-2567

Computerware, 830 First St., Encinitas, Calif. 92024 (714) 436-9119

Atlanta Computer Mart, 5091 B Buford Highway, Atlanta, Ga. 30340 (404) 321-4390



CIRCLE NO. 65 ON FREE INFORMATION CARD

# Stereo Scene

By Ralph Hodges

## GREETINGS FROM NIHON

ALTHOUGH you may not know it, "Nihon" is the name—or at least the likeliest phonetic rendering of the name—that the Japanese people have for their native land. There are many other things that we, and especially I, don't know about Japan, even though I've just returned from my third visit to that country in about as many years. What appears below is an amalgam of what I think I've learned on the trip and what I'm sure I don't as yet understand. The emphasis will of course be on hard information, since rumors and speculation are readily available elsewhere.

**What Is Japan?** For our purposes Japan is perhaps the world's leading producer of sophisticated consumer electronics. It is also one of the world's poorest markets for its own products. Outside of stores that sell them, I have never seen—much less heard—a Japanese transistor radio, except in taxicabs where they have been turned on more for my benefit than the driver's. People do not walk around with such devices, and as nearly as I can tell from brief glimpses of resorts and scenic areas, they do not take them on trips either. Japanese-made TV receivers seem to sell well among those who can afford them, but I've never seen them used for anything other than sports events. The salesman who totted up my copious purchases in a store in the Akihabara (Tokyo's famed retail electronics district) used an abacus instead of an electronic calculator, although his store had at least three different brands of calculators on display.

If this seems to suggest that the urban Japanese consumer is backward and unappreciative of the "finer things," put the idea out of your mind. Notwithstanding a highly complex and difficult language, Japan has managed to achieve a phenomenally high percentage of literacy within its population. Consumer enthusiasm is rampant, technological awareness is acute, and among those able to indulge themselves there is a refined appetite for the arts in all their varieties and origins.

However, the Japanese are given to setting themselves collective *and* individual goals. They wait until they can afford what they want rather than "making-do" with temporary substitutes, and they relish, I think, the anticipation as much as the actual acquisition. Having been an impoverished audiophile for too many years, I respect their attitude and admire their patience. But I think most Westerners, myself included, would consider their buying practices a strange combination of rationality and irrationality.

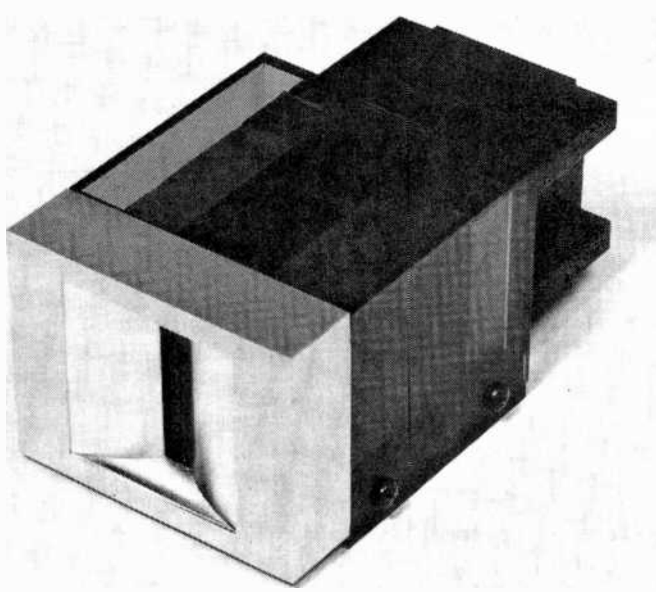
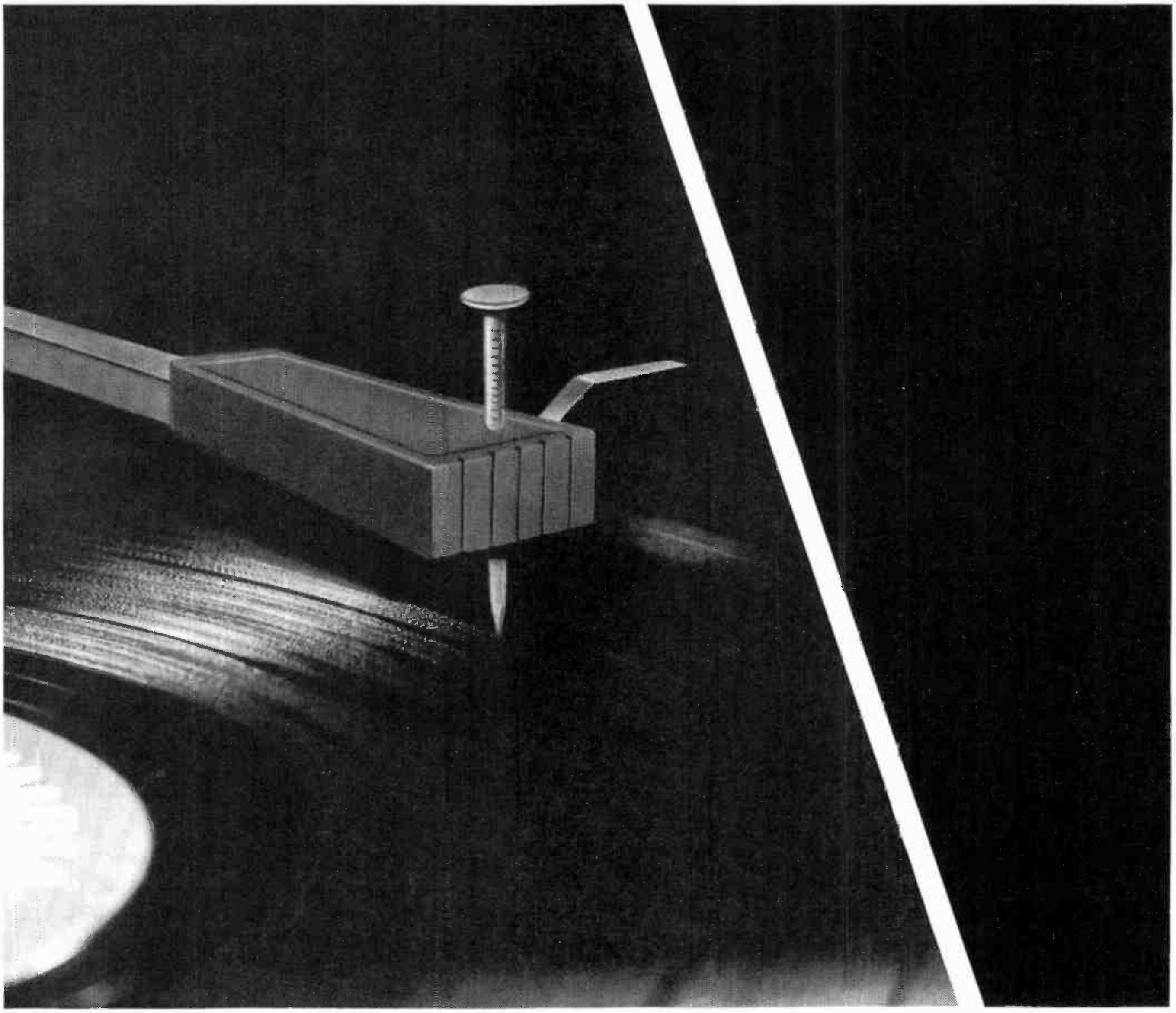


*Fig. 1. The Pioneer ribbon tweeter is down only 10 dB at 100,000 Hz.*

**Hi-fi in Japan.** In the U.S., the staple hi-fi product has been and is likely to remain the receiver, even though the popularity of "separates" is growing. In Japan, the receiver has never been an extraordinarily popular product, and latest reports indicate that it is dying a speedy death.

There is a rational reason for this: Japan's FM broadcasting is extremely sparse, so that a modern receiver's wide-band tuning capabilities and superb interference rejection are largely superfluous. At present, regulations allow a maximum of two broadcasting stations in any given reception area, and these tend to be widely spaced on the dial (the Japanese FM band is centered 10 MHz below that of the U.S., so that there is only a two-thirds overlap between the two; but most Japanese receivers are designed to cover the U.S. band only, and are therefore not really Japanese products at all). I am told that the people in charge are gradually being persuaded that equipment in the hands of the general populace is capable of coping with closer frequency spacings. If this view prevails, Tokyo may suddenly acquire eight or more FM stations in addition to the present two, which would make a stereo FM receiver a more practical product than it has been.

Then there is the irrational side. Receivers may be languishing in Japan, but tuners are not! The world's more widely acclaimed tuners—the classic Marantz 10B and the Sequerra, for example—bring higher prices on the Japanese market than almost anywhere else. But Japanese tuners, as good as some of them are, do not sell



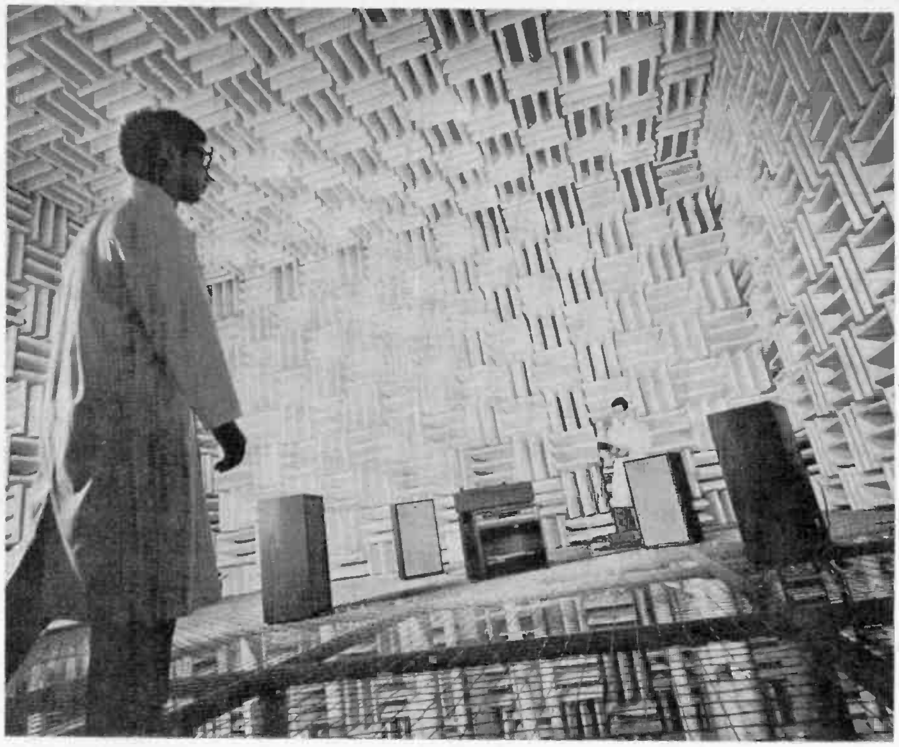


*Fig. 2. JVC's unusually large anechoic chamber.*

remarkably well. I think you can put this phenomenon down to good reasons (these preferred tuners are, after all, excellent) as well as questionable ones. For example, U.S. products are considered exotic by the Japanese in ways that Japanese products are considered exotic in the U.S.

**The Japanese Market.** In the opinion of many people in Japan, the audio market is more sharply and discernibly divided than in the U.S. A large part of the market buys the equivalent of consoles—usually three-piece ensembles—two speakers and a central control and program-source section. All of this is generally enclosed in free-standing furniture. Often, this will all be of Japanese manufacture.

On the next step up you'll find the beginnings of audiophilia. One

*Fig. 3. The JVC sound theater has two enormous horn-loaded speaker systems.*

# Introducing the first pocket programmable that remembers your programs and data even when it's turned off. The new HP-25C. $200.00*


Meet the first Scientific Programmable calculator that lets you take a breather midway through your solution *without* having to start all over again when you get back. The reason: Its memory and storage registers stay ON even when you shut *it* OFF†—during a phone call, a meeting or a weekend.

It's called the HP-25C. (Incidentally, the "C" stands for "Continuous Memory C-MOS" technology.) *Continuous Memory*

Here's what Continuous Memory does for you:

1. It lets you key in your favorite program—debug it—and retain it in memory for repeated use. So you gain accuracy as well as time.

2. You can add additional functions not on the keyboard (hyperbolics, octal/decimal conversions, etc.), simply by writing programs and storing them permanently in memory.

3. It enables you to gather data one place (such as at a survey jobsite) and retain your results until you get back to work with them later (just think of the time you'll save and the accuracy you'll gain because you *won't* have to re-enter information).

4. You don't lose data when you lose battery power. Here's why: when all the decimal points display—indicating a low battery—your data and program will not be lost provided the calculator is turned OFF and the recharger is promptly connected. The HP-25C will even retain your data and program for at least 5 seconds—without *any* battery at all—while you are replacing a discharged battery with a charged one.

But there's more. Aside from Continuous Memory, the HP-25C is identical to our popular HP-25. Both give you a total of 72 pre-programmed functions and operations; complete keystroke programmability; branching and conditional test capability and fixed decimal, scientific and engineering (exponent in multiples of ±3) notations.

You also get our RPN logic system with 4-register stack and 8 storage registers.

And every program written for the HP-25 will work *without modification* for the HP-25C.

The HP-25C. There's never been a Scientific Programmable Calculator like it before.

Best of all, the HP-25C's got HP's name on it. And you know what that means. Design, performance and a back-up support system you just can't get anyplace else.

Why not "test touch" one for yourself? Or, if Continuous Memory is not important to your particular application, try our standard HP-25, $145.00.* For complete HP-25C specs and the name of your nearest dealer, call toll-free **800-538-7922 (in Calif. 800-662-9862).**

### THE HP-25C AT A GLANCE

- Program memory and storage registers stay ON at all times.
- 72 functions and operations.
- Keystroke programmability.
- Full editing capability.
- Branching and conditional test capability.
- 8 addressable memories.
- Fixed decimal and scientific notation—plus engineering notation.
- RPN logic system with 4-memory stack.
- $200.00*

616/10

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*Suggested retail price, excluding applicable state and local taxes—Continental U.S., Alaska & Hawaii.
†The HP-25C's C-MOS memory chips consume only 1/80,000 of the calculator's normal operating power. Thus, a fully charged battery pack can hold your programs and data for a least 1½ months with the HP-25C turned off.

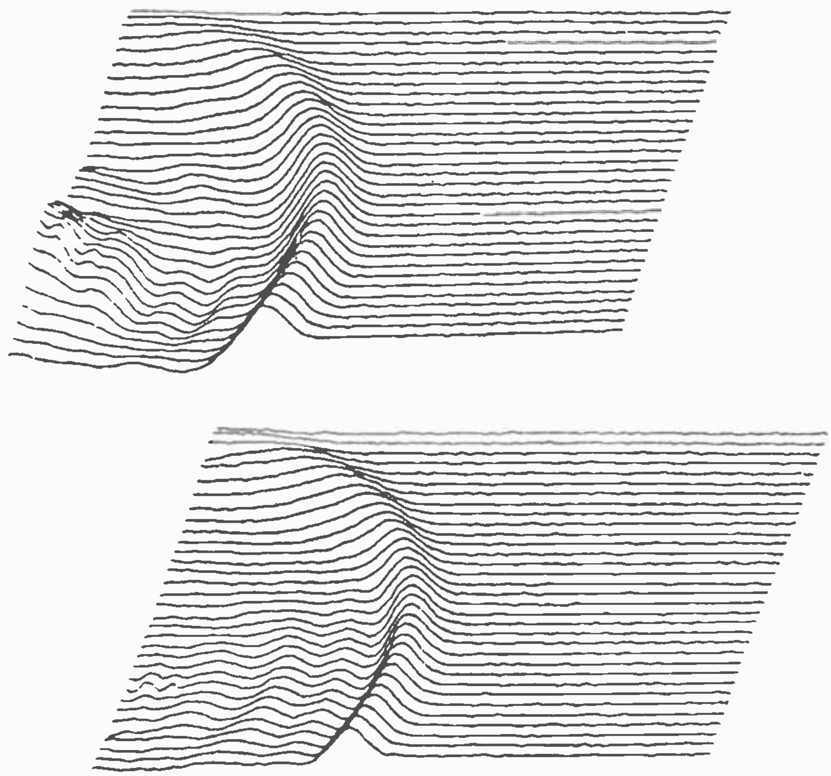

*Fig. 4. Recent work at JCV includes this visual analysis of loudspeaker wavefront propogation. Here hard-dome (top) and soft-dome tweeters are compared.*

Japanese enthusiast I spoke to has KLH speakers, Dynaco amplifiers, an AR turntable, and a Shure cartridge, and this is not an unusual combination. Above that level there are large loudspeaker systems—big JBL's and Bozaks, Tannoys, Klipschorns, and the most expensive Electro-Voices—together with prestige amplifiers of U.S. or European make. You'll notice a dearth of Japanese goods in this lineup, which is one of the peculiarities of the Japanese market on their own home ground.

**The Potential Japanese Market.** It seems to me that what the Japanese have lacked up to now is a succession of products—or even just one product—that is universally recognized as being the *best* available. True, their tape decks are highly regarded, but in the final analysis the real Japanese enthusiast would prefer a professional Ampex, 3M, or Studer machine. Japan is the world's undisputed leader in direct-drive phono turntables, but there seems to be a lingering suspicion that the belt-drive units from western Europe and England might be better. Phono cartridges are manufactured under numerous brand names in Japan, many of which have attracted enthusiasts overseas. But the clear-cut distinction of superiority has eluded all Japanese manufacturers, and those who have striven for it have suffered.

Paradoxically, as Japan struggles to get out of the world-wide recession precipitated by events in the West and Middle East, it may meet the recognition it has long sought, waiting just around the next bend in the road. The moving-coil phono cartridges of Denon (Nippon Columbia), originally designed to fulfill NHK requirements for FM broadcasting in Japan, are belatedly being hailed as superbly qualified contestants for the title of best phono cartridge in the world. (Denon retreated from its first entrance into the U.S. market several years ago, but it is scheduled to return in December.) Nakamichi Research has fully established itself as a manufacturer of "ultimate" cassette decks over a period of several years, so international recognition cannot be far behind. Nakamichi now has a phono cartridge, a preamplifier, and (by the time you read this) a super-power amplifier, all intended to qualify as "best" in the international sweepstakes.

**Japan's Resources.** Throughout its relatively brief history as a technological giant in audio, Japan has strenu-

# Will other CB's catch up with Royce's Wireless?

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Answer: There is a big difference between Royce and *all* other CB makers! Because *only* Royce has the Wireless Module concept!

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Royce has brought computer technology to CB. With wireless modules. Automated—not hand-soldering. Precision assembly. Higher quality components. Computer tuning and testing.


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So, now you have an easy way to decide which CB to buy! And your Royce dealer can show and tell you more about the amazing new Wireless Module CB's and the entire Royce line. Stop by and see him soon! Royce Electronics Corp., 1746 Levee Road, North Kansas City, Mo. 64116.

**Royce Wireless Model 1-655.** 23-channel mobile CB has Amplified Automatic Gain Control circuit (AAGC) to amplify weak signals, reduce nearby overload. Phase Lock Loop (PLL) tuning adds greater reliability. Large S/RF meter. Pushbutton ANL switch minimizes noise static. Pushbutton PA/CB switch activates powerful P.A. Pushbutton RF gain Control prevents overload from nearby stations.

**Royce Wireless Model 1-658.** 23-channel mobile CB Vol-U-Mike allows receiver volume adjustment from mike or front panel. Phase Lock Loop (PLL) provides reliable 23-channel operation with only 3 crystals. Large, readable S/RF meter. Pushbutton PA/CB switch activates powerful P.A. Continuous RF Gain Control prevents overload from nearby stations.

Model 1-655

Model 1-658


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ously sought and won a commanding position in the very center of its overseas markets. But recently (at least in the U.S.) the center has been shifting somewhat, and now tends to favor high power and, to a certain extent, separate components instead of the all-in-one receiver. The Japanese are prepared to follow this and other trends wherever they may lead. Unfortunately, such a policy once again threatens to cast them in the role of follower rather than leader—an unenviable position in an industry where innovation and "breakthroughs" command so much respect.

Too little appreciation, I think, is given to the Japanese audio industry, both as an innovator and a stabilizer in new audio developments. Over the past decade, the Japanese have done some remarkable research and created some superb devices. The Denon phono cartridges are one obvious example; another is the Pioneer PT-R7 tweeter (Fig. 1), a ribbon design with a frequency response that is down barely 10 dB at 100,000 Hz and an almost impeccable transient response. This separate, raw tweeter, alas, is not part of Pioneer's overseas marketing program, and was therefore almost unknown outside of Japan until recently, when a few hardy Westerners began visiting Nihon to ferret out some of its more obscure treasures.

There are, in fact, a number of Japanese manufacturers who retain some very novel and interesting products as domestic sales items only. There are good marketing reasons for doing so. However, Japanese consumers meanwhile await confirmation of these products' excellence from abroad; when none is forthcoming, they lose interest themselves.

**Highlights.** I have high hopes that the image of Japan throughout the audio world will change for the better, and fairly soon. These were boosted considerably by field excursions I was able to make to the headquarters of Nakamichi Research and the research labs of JVC.

E. Nakamichi, for example, is embarking on the construction of his own personal concert hall, which he gleefully anticipates will serve both as a refined development tool for future audio products and the fulfillment of a long-standing personal dream. Nakamichi seems to relish competition, insists on iconoclasm, and does not shrink from controversy. This is hardly the image of the Japanese manufacturer we're accustomed to.

JVC, on the other hand, probably seems rather doctrinaire to most U.S. consumers, although the company's espousal of the ANRS noise-reduction system and CD-4, both of which are JVC developments, sets it somewhat apart. How apart I hadn't realized until I visited the JVC research center.

First of all, the facilities are remarkable for an establishment of this kind. The anechoic room (Fig. 2) is one of the largest in the world, reportedly effective down to about 50 Hz. There is also a large reverberant room with a reverberation time (at mid frequencies) of almost 10 seconds. But one of the biggest showpieces is a 1,277-cubic-meter theater (Fig. 3) that can be drastically altered in acoustical characteristics via a central control console. The slats visible at the left of the photograph, highly reflective as seen, can be rotated along their long axes to expose absorbent glass-fiber backings. Finally, the wall and ceiling panels can be retracted entirely, leaving behind deep glass-wool surfaces that soak up sound like an open field on a windless day.

The mere existence of these facilities wouldn't be at all exciting unless they were being put to good use. Evidently they are. JVC is apparently engaged in deep study of sound-field propagation-researches which led to the stunning video representations of loudspeaker wavefront propagation as presented to the Audio Engineering Society in New York last October (Fig. 4). There has also been some related work on binaural recording, which is intended to be heard exclusively through headphones. On my visit I was treated to a test pressing of a binaural disc that was irresistible in its near-perfect realism. I have heard many binaural recordings and have been impressed by them all, but this was something beyond my previous experience.

In short, Japan has much to offer the worldwide audio community that we're yet to become aware of. We can, I hope, look forward to a remission of the receiver-for-any-amount-of-money-you-have-in-your-wallet syndrom and an assertion of the concept of basic, hard-working research in the interest of better sound. This is an area in which the Japanese shine. All of us would profit from basking in their glow. ◈

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If you take the professional approach to CB
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SIDEBANDER II is noted for having the biggest "talk power punch" in mobile CB. It reaches those 46 SSB channels crisply and clearly with a full power of 25 watts in. And because it's synthesized, it achieves more precise frequency and better stability. Exceptional features include: noise blanker, RF and AF gain controls, clarifier, and squelch.

CONSOLE II brings frequency synthesization to home base. It's a true no-nonsense professional with performance that gets your message through and brings in signals loud and clear. Superb features include "on the air" indicator, triple-function meter, automatic load and gain controls.

Two classic examples why SBE has the answers SSB users like.


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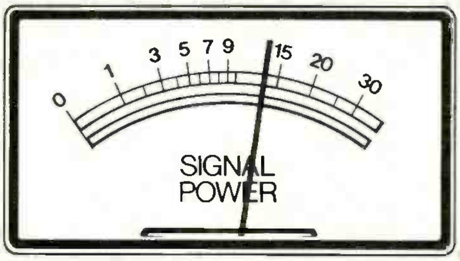
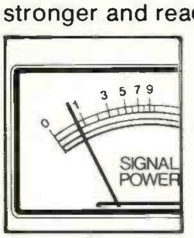
# More miles per pound




## Turner mikes turn ordinary CB sets into heavyweights

Check the channels. You hear Turner mentioned a lot on CB. Most longtime CBers have a Turner mike. They often sound stronger and reach farther. It's easy to understand why:




Even a weak carrier signal can do the job if it has good mike input, while on the other hand a strong signal with poor modulation can be hard to copy. Demonstrate this to yourself by opening up your receiver squelch and listening to a distant station, a signal which barely swings the S-meter. Even though signal power hardly moves the needle, can you still copy through the noise? If so, that's good modulation. And you're probably listening to a Turner mike.


Many Turner models have a built-in pre-amplifier with volume control on the mike.

Mike volume control lets you adjust mike input, which allows the radio to put out a signal with all the voice modulation or "talk power" the set is designed to deliver.

A Turner mike can also add to your set's effective range by keeping input consistently high. The Turner M+3 and Road King 60 include a speech compression circuit to assure constant-level input, regardless of mouth-to-mike distances or natural rising and falling of the voice.

Or to get rid of cab rumble, traffic and

other interfering background noises that reduce effective range, consider the Road King 70, a rugged CB mike that adds noise cancelling to the other Turner features.

Ask a Turner dealer to help you get full performance out of your base or mobile CB. Or start by asking for a communications catalog from Turner, 716 Oakland Road N.E., Cedar Rapids, Iowa 52402.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# Hobby Scene Q&A

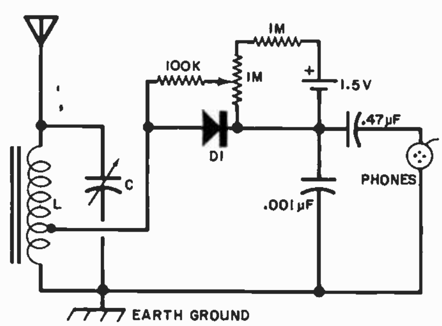
By John McVeigh

### "SUPERHOT" CRYSTAL SET

**Q.** ***I built a crystal set using a ferrite bar antenna, AM tuning capacitor, silicon diode, ceramic caps and crystal earphone. It works, but I can only pick up very close stations. Is there a way to increase the set's sensitivity?***

*—Clane Linn, New Orleans, LA*

**A.** The crystal set isn't very sensitive because you used a silicon-diode detector. For the diode to conduct, you have to exceed the barrier potential (0.7 V)—which only a very hefty signal could do. Germanium, with a barrier potential of 0.2 V, is a better choice. The circuit shown, though, is a rather unique crystal set using a silicon diode. Tuning is accomplished by varying capacitor C. The ferrite loopstick, *L*, has a low-impedance tap. The 1-megohm potentiometer applies a bias voltage across the diode, ranging from 0 to 0.75 volt. Thus, the pot acts as a sensitivity control. At maximum sensitivity (0.7 V forward bias), very weak signals will be able to ride through the diode. When connected to a good antenna (a longwire or rotatable loop), this little set will deliver suprising performance. In operation, you will notice a point where advancing the sensitivity control causes the signal to drop out completely. This happens when the diode turns fully on. Back down slightly for best sensitivity. Use high-impedance crystal headphones or earphones, and an AA or C cell voltage source. The battery will last for a long, long time.




### ELECTRIC MUSIC BOOKS

**Q.** ***Thanks for the recent electronic music series. Do you know of any books on the subject that I can do more research with?***

*—R.M., Rye, New Hampshire*

**A.** There are many books out on electronic music and music synthesis. Here are some: *Electronic Music Circuit Guidebook* by Brice Ward (TAB), *Experimenting with Electronic Music* by Brown and Olsen (TAB), and *The New World of Electronic Music* by Walter Sear (Alfred Publishing).

### HAUNTED TV RECEIVER

**Q.** ***My TV receiver is connected to a master antenna system (75-ohm cable) supplied by the apartment complex in which I live. The signal levels are more than sufficient, but the ghosts are terrible. Is there some sort of broadband network I can use to eliminate these ghosts? I'm using a 75-ohm/300-ohm transformer-balun.***

*—Larry Moore, FPO San Francisco*

**A.** The ghosts are being produced by one of two circumstances. First, there might be a building nearby reflecting the signal. Since the reflection arrives later than the direct signal, a ghost appears. To cure this, the master antenna would have to be pointed so that there is a null in the direction from which the ghost is coming. Note that even if this means pointing the beam somewhat away from the direct path, the beam and distribution amplifier's gain will probably make up for the reduced signal level. Second, there might be an improper termination in one of the apartments. If the termination impedance is not 75 ohms, reflected waves can travel up and down the line, causing a series of closely spaced ghosts. The real cure for that is to correct the termination impedance.

As for a broadband ghost exorcist, the only thing that I can think of is a resistive pad (attenuator) of 75 or 300 ohms impedance, placed before or after the balun, respectively. This would lower the overall signal level, and if the ghosts are much weaker than the desired signal, you could attenuate them into oblivion while retaining a sufficient desired signal strength.

### BROADCAST STATION GUIDE

**Q.** ***Can you provide me with the title of a book that provides the call letters, frequencies, and addresses of commercial broadcasting stations?***

*—Harry Lee Smith, Luray, Virginia*

**A.** Howard W. Sams & Co. (4300 W. 62 St., Indianapolis, IN 46206) publishes a useful book entitled "North American Radio-TV Station Guide," written by Vane A. Jones. It covers AM, FM and television broadcasting, and lists (among other things) frequencies, power output, call letters, and addresses under several listing formats. Canadian, United States, Mexican, and Central American stations are included.

### AMATEUR CODE REQUIREMENTS

**Q.** ***I've heard a rumor that The FCC will either reduce the General Class code requirement to 5 wpm or eliminate it completely? Is this true?***

*—Bruce Levine, Brooklyn, NY*

**A.** I haven't heard that specific rumor, but there are some changes being contemplated for code tests in general. First, the FCC is considering the establishment of a "Communicator Class" Amateur license. It would be a no-code ticket carrying telephony (voice) privileges in the vhf region of the spectrum. Second, the FCC has announced that it will conduct a different type of code test at a few field examination points on an experimental basis. The new test will consist of five minutes of recorded text, and a series of true-false or multiple choice questions based on the transmitted information. However, for the time being, *both* tests (the new and old "one-minute of solid, written copy) will be given. If the results from the two show a high degree of correlation, a new format for the receiving portion of the code test will be adopted. Although there have been many petitions asking for a reduction of the General code test from 13 to 10 wpm, the FCC has not shown much of a reaction.

---

Have a problem or question on circuitry, components, parts availability, etc.? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, NY 10016. Though all letters can't be answered individually, those with wide interest will be published.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**When you've got a Pace, you've got the world by the ears.**

PACE TWO-WAY RADIOS, PRODUCTS OF PATHCOM INC.

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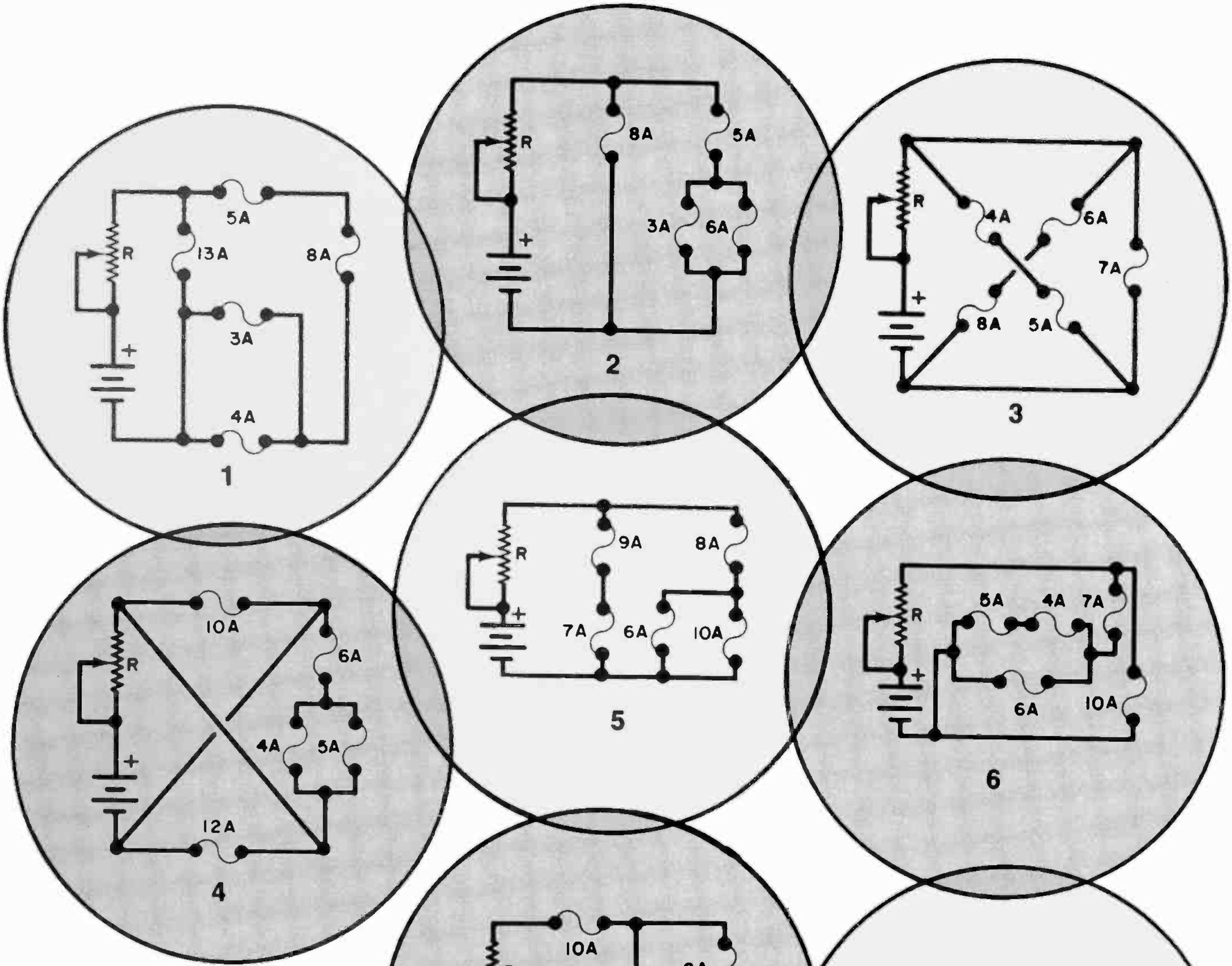
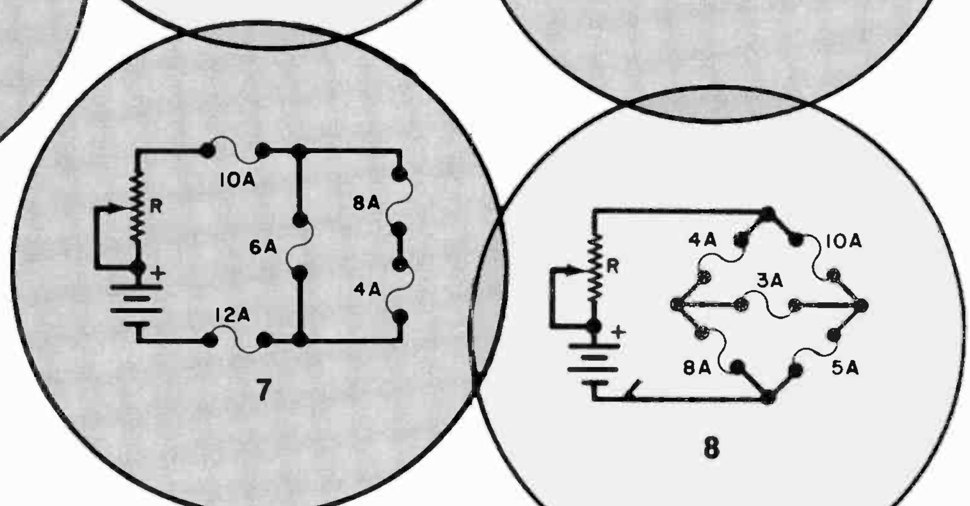
# FUSING QUIZ

One of the most important components in an electronic circuit is the fuse, which protects the entire system from current overload. Circuit designers, technicians, and hobbyists should be acquainted with the various types of fuses and how to use them.

To test your knowledge of fusing circuits, see how many of the following problems you can solve. For each of the circuits shown below, determine the order in which the fuses will blow as resistance *R* is slowly decreased to zero. Assume that the battery can deliver any required amount of current, and that each fuse has an internal resistance of one ohm, regardless of its current rating.



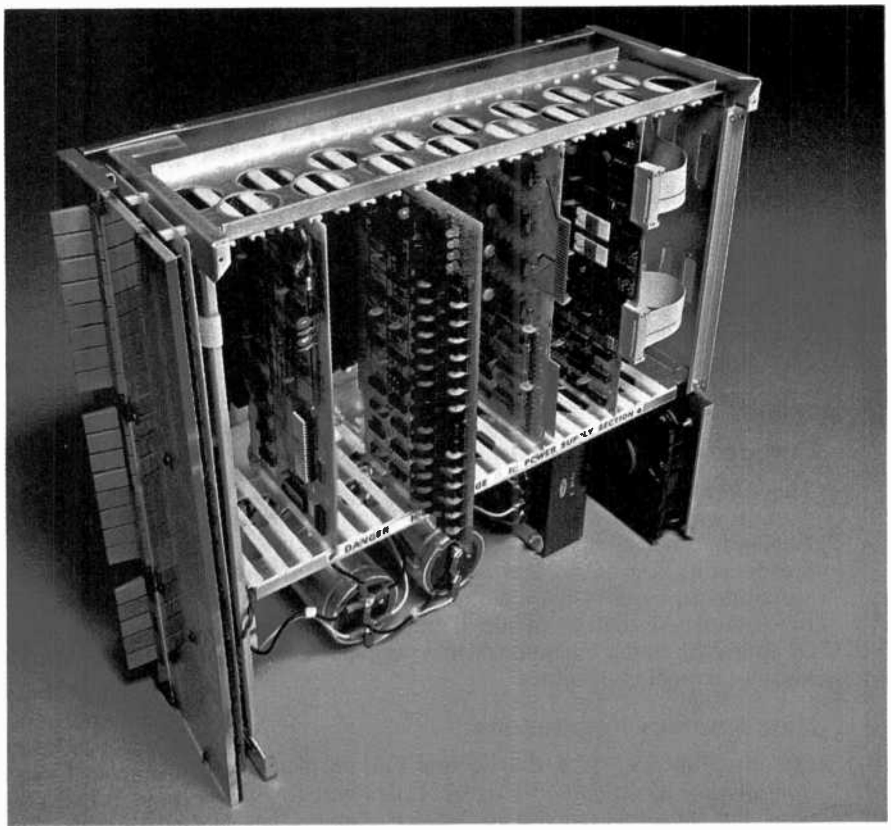




**ANSWERS**

1. 5A, 13A
2. 5A, 8A
3. 7A, 4A, 6A
4. 6A, 10A, 12A
5. 8A, 7A
6. 10A, 7A
7. 6A, 4A
8. 4A, 5A, 3A

# If you thought a rugged, professional yet affordable computer didn't exist,

# think IMSAI 8080.



Sure there are other commercial, high-quality computers that can perform like the 8080. But their prices are 5 times as high. There is a rugged, reliable, industrial computer, with high commercial-type performance. The IMSAI 8080. Fully assembled, it's $931. Unassembled, it's $599. And ours is available now.

In our case, you can tell a computer by its cabinet. The IMSAI 8080 is made for commercial users. And it looks it. Inside and out! The cabinet is attractive, heavy-gauge aluminum. The heavy-duty lucite front panel has an extra 8 program controlled LED's. It plugs directly into the Mother Board without a wire harness. And rugged commercial grade paddle switches that are backed up by reliable debouncing circuits. But higher aesthetics on the outside is only the beginning. The guts of the IMSAI 8080 is where its true beauty lies.

The 8080 is optionally expandable to a substantial system with 22 card slots in a single printed circuit board. And the durable card cage is made of commercial-grade anodized aluminum.

The IMSAI 8080 power supply produces a true 28 amp current, enough to power a full system.

You can expand to a powerful system with 64K of memory, plus a floppy disk controller, with its own on-board 8080—and a DOS. A floppy disk drive, an audio tape cassette input device, a printer, plus a video terminal and a teleprinter. These peripherals will function with an 8-level priority interrupt system. IMSAI BASIC software is available in 4K, that you can get in PROM. And a new $139 4K RAM board with software memory protect. For the ultimate in flexibility, you can design the system for low-cost multiprocessor, shared memory capability.


Find out more about the computer you thought didn't exist. Get a complete illustrated brochure describing the IMSAI 8080, options, peripherals, software, prices and specifications. Send one dollar to cover handling.

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PE-9

# news HIGHLIGHTS

## CB Rip-Offs

With CB radio thefts on a meteoric rise, the new National CB Theft & Recovery Bureau is making an effort to reduce thefts and aid law-enforcement agencies in returning recovered CB rigs to their rightful owners. For a modest fee, a CB radio owner can have his name and address and the serial number of his rig entered into the Bureau's computers. "Rip-Off Strip-Off" identification decals go on his CB radio, antenna, and vehicle windshield. The decals warn potential thieves that the rig is registered and carry a reward offer to $250 for information leading to the arrest and conviction of thieves. To help police identify owners of recovered CB rigs, the Bureau maintains a 24-hour toll-free "hot line" that is said to be available to every law-enforcement agency and insurance company in the country.

## European Quadraphonic Broadcast

The first commercial quadraphonic broadcast in Europe was made over *Radio Picadilly*, Manchester, England, on last April 2. Using a Sansui QSE-5B broadcasting encoder, the station played discrete 4-channel tapes and QS 4-channel records for two days. It is estimated that 2 million homes in the UK are equipped for stereo reception, while perhaps ½ million have 4-channel capabilities.

## New Amateur Regulations

Effective July 23, 1976, the Federal Communications Commission has modified Part 97, Rules and Regulations for the Amateur Radio Service. Novice Class operators will be allowed to run up to 250 watts of input power, a healthy increase over the old 75-watt limit. A Novice reaching the end of his two-year license term need no longer wait one year from the expiration date for reexamination, but can apply for a new Novice exam immediately. *All* licensees using Novice segments of the bands will be limited to 250 watts input power. Technicians will receive full Novice hf privileges. The Novice exam will be the only one administered by mail, unless the applicant can produce a physician's note certifying disability. Then the exam will be administered by a Commission-approved volunteer examiner. Full credit will be granted to examination elements administered in the past by mail. So, Conditionals are "grandfathered" to General Class licenses, Technicians C to Technicians. The number of distinct license classes is reduced to five by this action.

## Hughes Is Alternate Source for RCA Microprocessor

Hughes Aircraft Company has signed an agreement with RCA Corp. to be a nonexclusive alternate source for the RCA CDP1802 CMOS 8-bit microprocessor and related support circuits. RCA will supply Hughes with process outlines, artwork, and tooling. The agreement also includes an option on future-generation CMOS microprocessors, including silicon-on-sapphire versions.

## Engineering Technician Salaries Higher

The Engineers Joint Council, as a result of its biennial survey, says the salaries of engineering technicians increased on the average by 13.6% between 1973 and 1975. The figures were obtained from 630 employers and covered over 61,500 technicians. According to the results, the "average" engineering technician has had about fourteen and a half years of experience since leaving school, is about 34 years old, and is earning $12,200 a year. Graduates of two-year junior college and technical institute programs start out with average salaries about $1700 per year more than nongraduates of the same age.

## Flick-of-the-Wrist Time

"Flick-it" is a new digital wristwatch introduced by Gruen. It displays the hours and minutes on its LED readout with a flick of the wrist. The seconds, month and day can be displayed by touching the Time Command Button. The mechanism which energizes the display with a flick of the wrist is set so that normal movement of the arm will not activate it. Gruen designs and makes its own watch modules.

## New Audio Recording System

Elcaset is the name given to a new audio recording system introduced by Sony, Matsushita, and Teac. The Elcaset is intended to realize the convenience of the Compact Cassette and the sound quality of open-reel tape. It has a tape width of ¼" and tape speed of 3¾ ips (9.5 cm/s). The tape is pulled out of the cassette shell for transport on heads, so that the preciseness of shell construction cannot affect the running of the tape. Extra holes in the shell provide for automatic code selection of proper bias and equalizer.

## Valor International CB Jamboree

In connection with the Pepsi-Cola Syracuse Gold Cup motorcycle race on Sept. 12 at the New York State Fairgrounds, Valor Enterprises will sponsor a 3-day CB jamboree at the site. It will include 250 exhibits by leading manufacturers of CB equipment, motorcycles, snowmobiles, RV's and vans.

## Personal Use Radio Advisory Committee Formed

An Advisory Committee to furnish advice and recommendations on potential means of alleviating the interference and enforcement problems currently being experienced in the Citizens radio service has been created by the FCC. It is expected that the Personal Use Radio Advisory Committee will consist of approximately 15 to 25 non-Commission members, obtained from a cross-section of the Citizens Band industry (manufacturers, importers, dealers), as well as equipment users and the general public.

# HIT THE ROAD WITH THE AUTOMATIC CB. JOHNSON.

"This year, lots of folks are takin' to the road for trips and adventures of all kinds. They're getting more fun out of every mile with the automatic CB from Johnson. And y'all know it's right handy if you're in a heap of trouble, too."

That's right, Sheriff. Johnson's built-in, automatic controls make operation easier and safer, performance better. Exclusive voice tailored audio circuitry automatically drops off signals outside voice frequencies to give you great reception.

Our automatic noise limiter keeps reception clean and built-in gain control prevents blasting and fading.

Johnson's unique electronic speech compression automatically selects and compresses voice frequencies to produce uniform, high-level modulation, maximum range. All automatically.

When you hit the road, go with Johnson CB. We back every Johnson with a full year parts and labor warranty and walk-in service at more than 850 locations. See a Johnson CB dealer and take off on *the great American adventure.*

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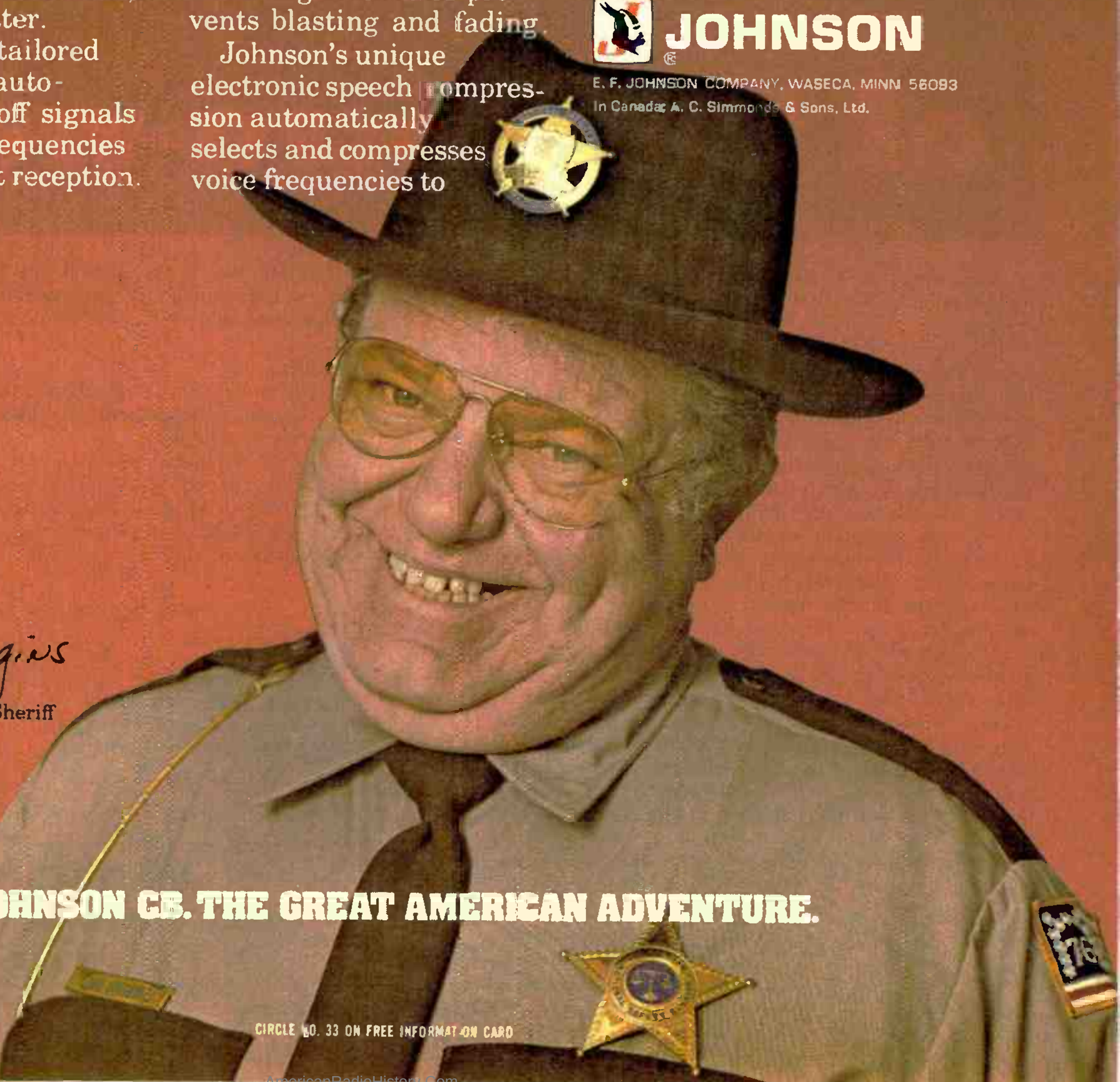

Joe Higgins
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CIRCLE NO. 33 ON FREE INFORMATION CARD

BUILD THE

# COSMAC "ELF"

## A LOW-COST EXPERIMENTER'S MICROCOMPUTER

## PART 2

*Some hardware improvements and more programming details.*

BY JOSEPH WEISBECKER

LAST MONTH, we discussed the construction of the low-cost Elf microcomputer/trainer and gave some examples of simple programming. This month, we will describe hardware and how to make a low-cost LED replacement for the relatively expensive hex display and add a simple 8-bit I/O port. Then we'll add a 16-switch monitor that, among other things, will allow you to use a hex keyboard. We'll finish up the hardware section by showing how to use a 9-volt battery as power for a RAM circuit to hold a program for as long as six months.

When we're finished with the hardware details, it's back to the software, continuing with our programming discussion.

**The Hardware.** The hex displays called for in the original Elf project can be replaced with a discrete LED circuit as shown in Fig. 1. You will need a CD4508 eight-bit register, eight low-current LED's, two 4049 hex inverters, and eight 470-ohm, ½-watt resistors. When the LED circuit is substituted for the hex displays, current consumption will be reduced by about 150 mA. The input comes from the data bus, which formerly went to hex displays *IC4* and *IC5*.

When you use the LED display, you must count the LED's to arrive at the hex number displayed. The upper four LED's form the first digit, the lower four the second digit.

You can mount the LED's on the front panel. Be sure you carefully identify each. Also, when making the conversion, don't forget to modify the RUN switch circuit as shown.

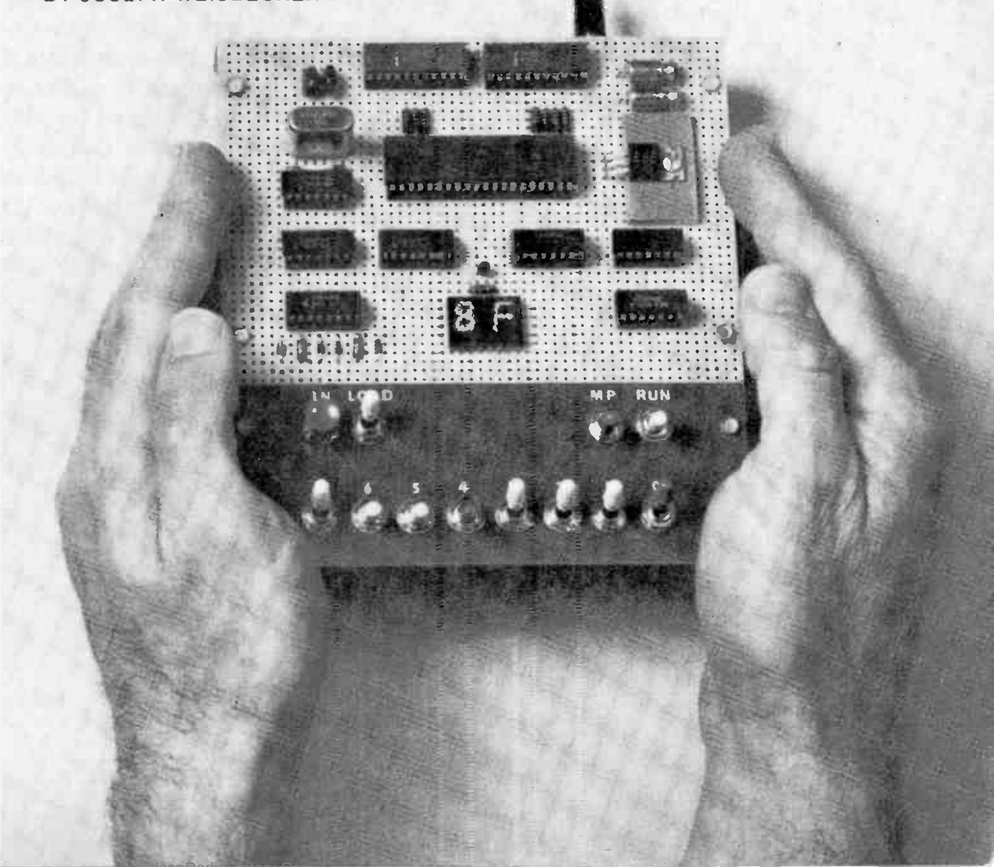
You can connect an inexpensive cadmium-sulfide (CdS) cell between the EF1 line and ground. Be sure to use a photocell that has a dark resistance in excess of 200,000 ohms and a light resistance of less than 10,000 ohms. If you use any other photocell, you may have to increase the value of the resistor to pull up the EF1 line of the 1802 microprocessor. The high input impedance of the CMOS logic eliminates the need for photocell amplification. Also, several photocell inputs can be used, each connected to a different flag (EF) line.

Using a photocell input, you can program the computer to start counting when an object moves past one photocell and stop counting when the object passes a second cell. This technique allows you to determine the speed of a moving object. It can also be used to count people, monitor motor speed, provide targets in a computer-controlled light gun or "eyes" for a computer-controlled robot, etc.

Magnetic reed switches, simple make/break switches, or similar devices can be connected to the computer via the flag-line inputs.

Several inexpensive methods of expanding the number of input and output lines can be used with this computer. One example is shown in Fig. 2. Here, a CD4058 IC is used in both the input and the output positions, while other IC's provide the necessary gating. A 69 instruction will store the values of the eight input lines in memory as a single byte.

In the output port section, a 61 instruction sets a memory byte into this port. The output port can control up to eight output lines, but you will have to add CD4050/CD4049 buffers if you wish to drive TTL loads. You can use



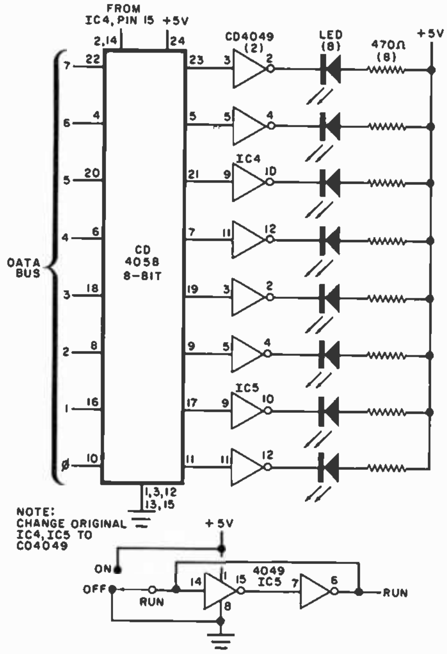



*Fig. 1. Circuit for a discrete LED display.*

these output lines to drive suitable transistors to control relays, lamps or LED's, or battery-powered motors, you can have the computer sequence lights, control animated displays or robots, or control a slide projector in response to tones from an audio tape. You can use the existing Q line output in the same manner for a single operation.

A simple method of controlling up to 16 output lines or monitoring the states of 16 switches is shown in Fig. 3. A 62 instruction will set the low-order digit of a memory byte into the 4-bit CD4515 register. The output line corresponding to this digit will go low, while the other 15 remain high. To make things more interesting, the computer can determine whether the switch attached to the selected output line is closed or not by testing EF2 with a branch instruction.

The following program continuously examines all 16 switches in sequence and stops with the number of any closed switch from 0 to F in the low-order digit of R3.0:

| Step | M | Bytes | Comment |
|---|---|---|---|
| 1 | 0000 | F8 FF A2 | FF→R2.0 (memory pointer) |
| 2 | 0003 | 13 52 E2 | R3 + 1, R3.0→M2, 2→X |
| 3 | 0006 | 62 22 | MX→CD4515 (select switch) |
| 4 | 0008 | 3D 03 | Repeat step 2 if switch is open |
| 5 | 000A | 30 0A | Stop with R3.0 = closed switch number |

The diodes can be omitted if only one switch at a time will be closed. This circuit and an appropriate program could permit data and instruction bytes to be loaded into memory a digit at a time from a hex keyboard instead of toggle switches. Switch debouncing could be performed with a programmed delay following each key depression. A 64-character keyboard could be used by treating it as four groups of 16 keys each, with the common side of each key group connected to a different flag line. In fact, a program to generate the Morse code equivalent of each key could be written using the Q line as the output.

This circuit can also be used to select one of 16 external devices or I/O ports if desired. Using the latter technique would permit up to 128 I/O lines. Cascading CD4515's would permit even larger numbers of I/O lines to be handled.

A low-cost video terminal can be made using the "Scopewriter" (POPULAR ELECTRONICS, August 1974), or you can interface your computer with a cassette data interchange system.

We have only scratched the surface of I/O circuits for the Elf. The real fun (and program training) starts when you think of new things to attach to the output lines and start writing programs to activate them.

The major drawback with a RAM, or memory, system is that data stored in it is erased when the main power source is shut down. (Of course, if you could use a ROM, this wouldn't be a problem. However, ROM's must be preprogrammed with the memory data you wish to save, a costly and time-consuming approach.) Adding a cassette interface doesn't entirely eliminate the problem because a "bootstrap" is still required to be stored in memory to run the cassette.

The use of low-power COSMOS RAM IC's and a 9-volt mercury battery, as shown in Fig. 4, will allow you to save programs in memory for up to six months even with the main power to the computer turned off. The 1822 RAM's shown are pin-compatible with the 2101's specified for the original project, but some of the RAM's must be rewired as shown.

With the COSMOS RAM's installed, you can turn off power to the computer at any time. The mercury battery will supply the required standby power to the memory system so that the program will be ready to run immediately when the computer is again powered up. The newly added STANDBY switch should be turned on (+5 volts) only after power is turned on. It should be off to hold pin 17 of the RAM's at ground potential before removing power from the system.

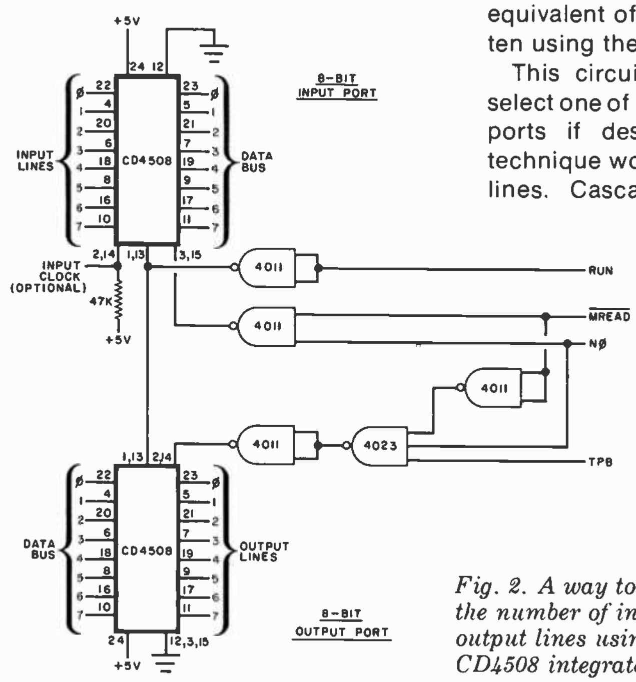



*Fig. 2. A way to expand the number of input and output lines using two CD4508 integrated circuits.*

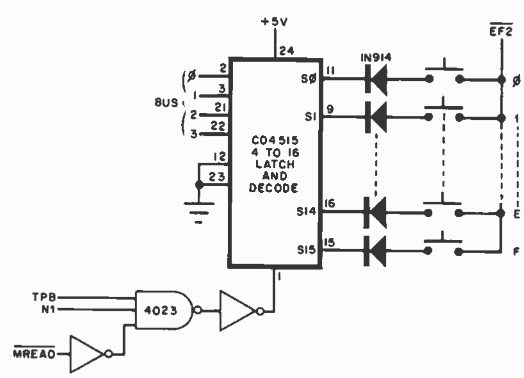



*Fig. 3. A method of controlling up to 16 outputs.*

Periodically check the battery's output; if it should fall too low, the memory system won't be able to hold data.

The last piece of hardware we will discuss here is the simple output driver shown schematically in Fig. 5. This is a conventional driver for almost anything that doesn't require more current than the transistor is capable of safely handling. The diode in the relay circuit removes the reverse transient spike that might otherwise damage the transistor. You can substitute a LED or even a load resistor for driving a power stage.

**More Programming.** The single-line output program shown below is a simple program that will flash the Q LED at a preset rate. It also provides a programmable square wave on the Q line.

| Step | M | Bytes | Comment |
|---|---|---|---|
| 1 | 0000 | 7A | 0→Q |
| 2 | 0001 | F8 10 B1 | 10→R1.1 |
| 3 | 0004 | 21 | R1-1 |
| 4 | 0005 | 91 | R1.1→D |
| 5 | 0006 | 3A 04 | Repeat step 3 if D = 00 |
| 6 | 0008 | 31 00 | Go to step 1 if Q = 1 |
| 7 | 000A | 7B | 1→Q |
| 8 | 000B | 30 01 | Go to step 2 |

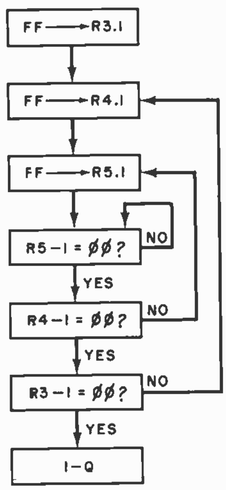
When you run this program, the square-wave frequency depends on the settings of the input switches. You can change frequency at any time. For higher frequencies, change B1 at M(0006) to A1 and 91 at M(0008) to 81. You can now select any of 256 different frequencies by altering the settings of the switches.

To modify the program to sweep the audio frequency range, use the following program:

| Step | M | Bytes | Comment |
|---|---|---|---|
| 1 | 0000 | F8 FF A2 | FF→R2.0 |
| 2 | 0003 | 7A | 0→Q |
| 3 | 0004 | 82 A1 | R2.0→D; D→R1.0 |
| 4 | 0006 | 21 81 | R1-1; R1.0→D |
| 5 | 0008 | 3A 06 | Repeat step 4 if D = 00 |
| 6 | 000A | 31 03 | Go to step 2 if Q = 1 |
| 7 | 000C | 7B 22 82 | 1→Q; R2-1; R2.0→D |
| 8 | 000F | 32 00 | Go to step 1 if D = 00 |
| 9 | 0011 | 30 04 | Go to step 3 |

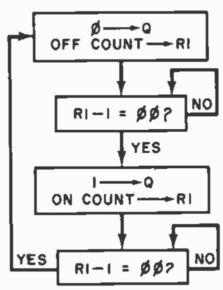
This program can be used in audio test applications. Note that R2 is used as a second counter that causes the square-wave frequency to change after each cycle. You can hear what this sounds like by using the circuit shown in Fig. 5.

Very low frequency square waves, or long-interval timing, can be programmed by cascading counters as illustrated in the following flow chart:




The Q line can then be used to activate a relay (as in Fig. 5), which can control house lights, motors, etc.

Suppose you wish to program a variable-pulse generator instead of square-wave generator. Use separate counts for the pulse off and on times as illustrated in the following flow chart:




This program will flash the Q LED and put a square wave on the Q line at a rate determined by the contents of memory M (0002) from a 10 to some other number. By referring back to the Instruction Subset Table in last month's article, you should be able to interpret the above program.

Note in the program that R1 is used as a 16-bit decrementing counter (steps 3, 4, and 5). When the high-order eight bits of this counter reaches 00, the Q line goes to its opposite stage. Changing steps 2 and 4 to use the low-order byte of R1 increases the Q line's output frequency by a factor of 256.

If you use a 1-MHz crystal in the clock, the above program can generate square waves at frequencies between 0.3 and 80 Hz, depending on the byte in M(0002). By changing the B1 instruction at M(0003) to A1 and the 91 instruction at M(0005) to 81, square waves between 80 and 20,000 Hz can be generated. In this manner, your basic computer becomes a presettable square-wave generator.

We can rewrite the program so that the square wave's frequency becomes a function of the settings of the toggle switches as follows:

| Step | M | Bytes | Comments |
|---|---|---|---|
| 1 | 0000 | F8 FF A2 | FF→R2.0 |
| 2 | 0003 | E2 | 2→X |
| 3 | 0004 | 7A | 0→Q |
| 4 | 0005 | 6C B1 | Switch byte→ MX, D:D→R1.1 |
| 5 | 0007 | 21 91 | R1-1; R1.1→D |
| 6 | 0009 | 3A 07 | Repeat step 5 if D = 00 |
| 7 | 000B | 31 04 | Go to step 3 if Q = 1 |
| 8 | 000D | 7B 30 05 | 1→Q; Go to step 4 |

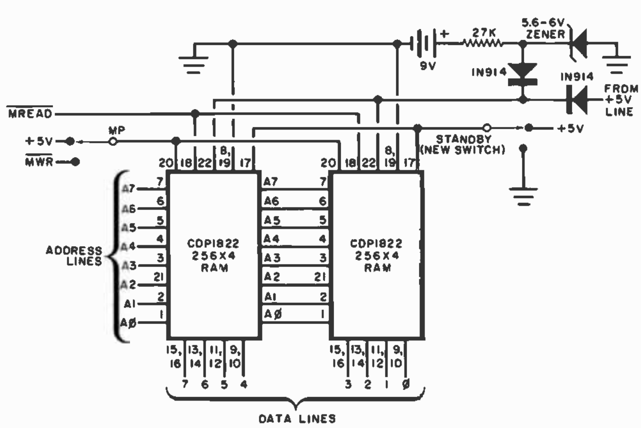



*Fig. 4. Using a low-power COSMOS RAM and a 9-volt battery permits saving programs in memory.*

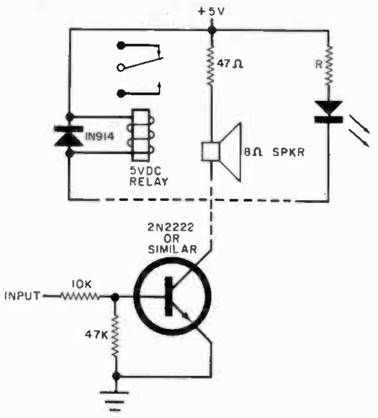



*Fig. 5. Circuit to provide outputs used for testing.*

In a similar manner, you can program bursts of pulses, variable-interval pulse trains, etc. You can even write a program where a list of bytes specifies a sequence of different tones to make a programmable music box.

The following two programs are "games" that demonstrate how the COSMAC instructions can be used. No added I/O circuits are required to run these programs.

Load the following sequence:

| Step | M | Bytes | Comment |
|---|---|---|---|
| 1 | 0000 | E1 | 1→X |
| 2 | 0001 | F8 0F A1 | 0F→R1.0 |
| 3 | 0004 | 64 | MX→display; X + 1 |
| 4 | 0005 | 3F 05 | Wait for INPUT switch to be depressed |
| 5 | 0007 | 6C | Switch byte → MX,D |
| 6 | 0008 | F8 0A F7 | 0A→D; D-MX→D |
| 7 | 000B | 51 64 | D→M1; MX → display; X + 1 |
| 8 | 000D | 30 0D 00 | Stop; 00 |

Set both the LOAD and MP switches to off and then flip RUN to on. Have someone select any digit between 1 and 9 multiply by 10, add the original digit. Then multiply the sum by 9. Have the person who selected the digit tell you the result — but not the original digit. Set the binary code for the least-significant digit of the final answer into switches 3, 2, 1, and 0, and place the other input switches in the down position. When you depress the INPUT switch, the computer will display the unknown digit.

This program illustrates how to set a memory byte into the output display with a 6C instruction. Note the use of R1 as a memory pointer and the use of the binary subtract instruction in step 6.

The following program makes the computer "think" of a byte, which you must guess in no more than seven tries:

| Step | M | Bytes | Comment |
|---|---|---|---|
| 1 | 0000 | 8A AB | RA, 0→RB.0 = secret byte |
| 2 | 0002 | F8 AA A3 | AA→R3.0 = memory pointer |
| 3 | 0005 | 53 E3 | D→M3; 3→X |
| 4 | 0007 | F8 07 A4 | 07→R4.0 = number of turns |
| 5 | 000A | 64 23 | M3→display, 3 +1; 3 − 1 |
| 6 | 000C | 2A 3F 0C | RA + 1 until INPUT is depressed |
| 7 | 000F | 37 0F | Wait for INPUT to be released |
| 8 | 0011 | 6C 8B | Switch byte→M3; RB.0→D |
| 9 | 0013 | F5 33 1A | M3-D→D; Go to step 12 if M3 ≥ RB.0 |
| 10 | 0016 | F8 01 | 01→D |
| 11 | 0018 | 30 22 | Go to step 16 (show D) |
| 12 | 001A | 3A 20 | Go to step 15 if D = 00 |
| 13 | 001C | 53 64 | D→M3; M3→ display; 3 + 1 |
| 14 | 001E | 30 1E | Stop loop |
| 15 | 0020 | F8 10 | 10→D |
| 16 | 0022 | 53 64 23 | D→M3→display; 3 + 1; 3 − 1 |
| 17 | 0025 | 24 84 | R4-1, R4.0→D (turn counter) |
| 18 | 0027 | 3A 0C | Go to step 6 if D = 00 |
| 19 | 0029 | 8B 7B | RB.0→D; 1→Q |
| 20 | 002B | 30 1C | Go to step 13 (show D and stop) |

Place both the MP and LOAD switches in the off position after toggling the program. When you start the program by operating RUN; AA is displayed. Now, try to guess what byte the computer has selected by setting the eight INPUT switches and depressing the main INPUT switch. If 00 is displayed, you guessed correctly; if 01 is displayed, your guess is too low; if 10 is displayed, your guess is too high. You lose after seven wrong tries, at which point, the computer turns on its Q LED and the displays indicate the hidden byte. To try again, set RUN to off and then on.

The subtract instruction in step 9 sets an arithmetic overflow flag (DF) if MX is equal to or greater than D. The COSMAC instruction manual covers a detailed explanation of the use of this overflow flag in arithmetic and shift operations.

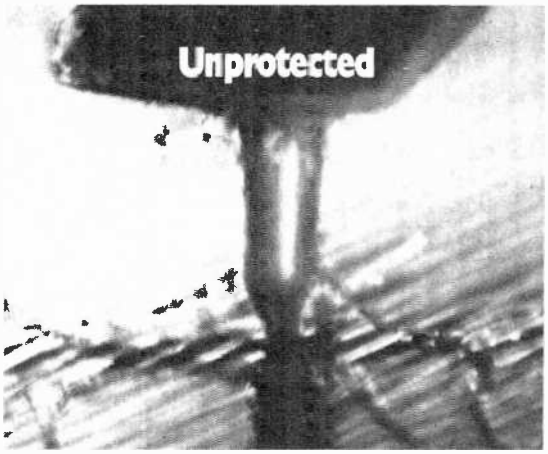
**HEX NUMBER SYSTEM**

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

**In Closing.** Now that you have some familiarity with programming for the Elf, look through your back issues of POPULAR ELECTRONICS for some challenging programs to write. Try the "Logidex" game in the November 1973 issue, "Tug-of-War" game in February 1975, "Electronic Dice" in July 1975, and the "Executive Digital Temper Countdowner" in December 1975. These are just a few of the many electronic games you can *program* instead of building. ◈


*"Uh... About this loaner you sent us while our computer is being repaired..."*

# If you can see a difference, imagine what you'll hear.

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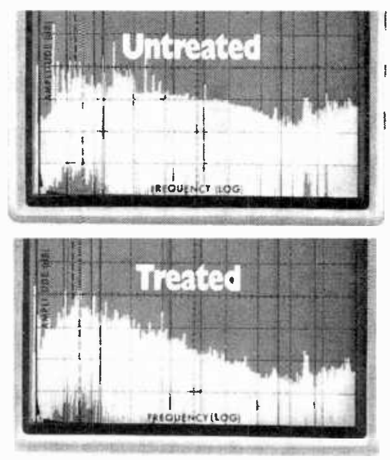


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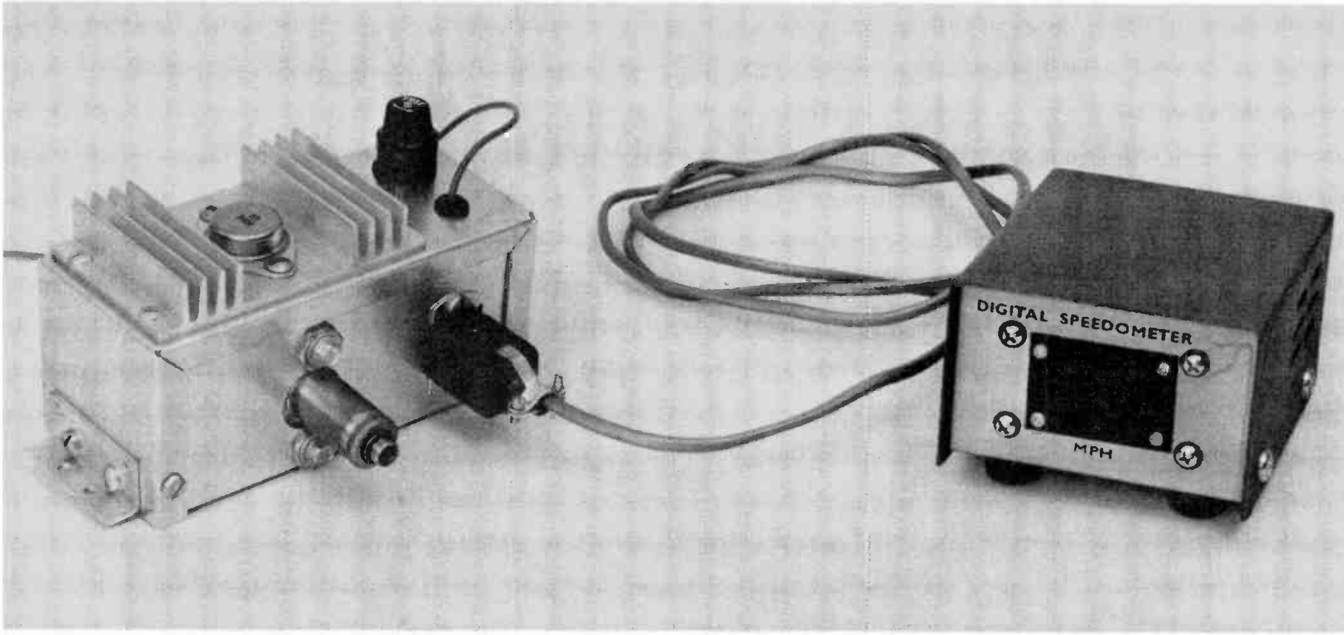
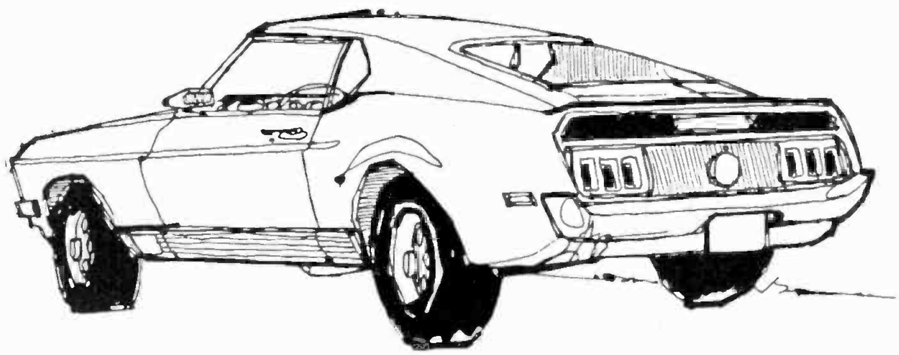



# BUILD A DIGITAL SPEEDOMETER FOR YOUR CAR

BY RICHARD B. FERMOYLE

*Linear readout uses 7-segment LED's.*



HOW accurate is your car's speedometer? Chances are it has some nonlinearities in the upper range due to increasing tension on the needle return spring. To overcome this irregularity and keep within the speed limit, you will want to build this digital speedometer. Besides, it will enable you to see what your exact speed is at a glance. The speedometer simply converts the standard 1000 revolutions per mile of your speedometer cable to an electrical signal to drive a two-digit readout.

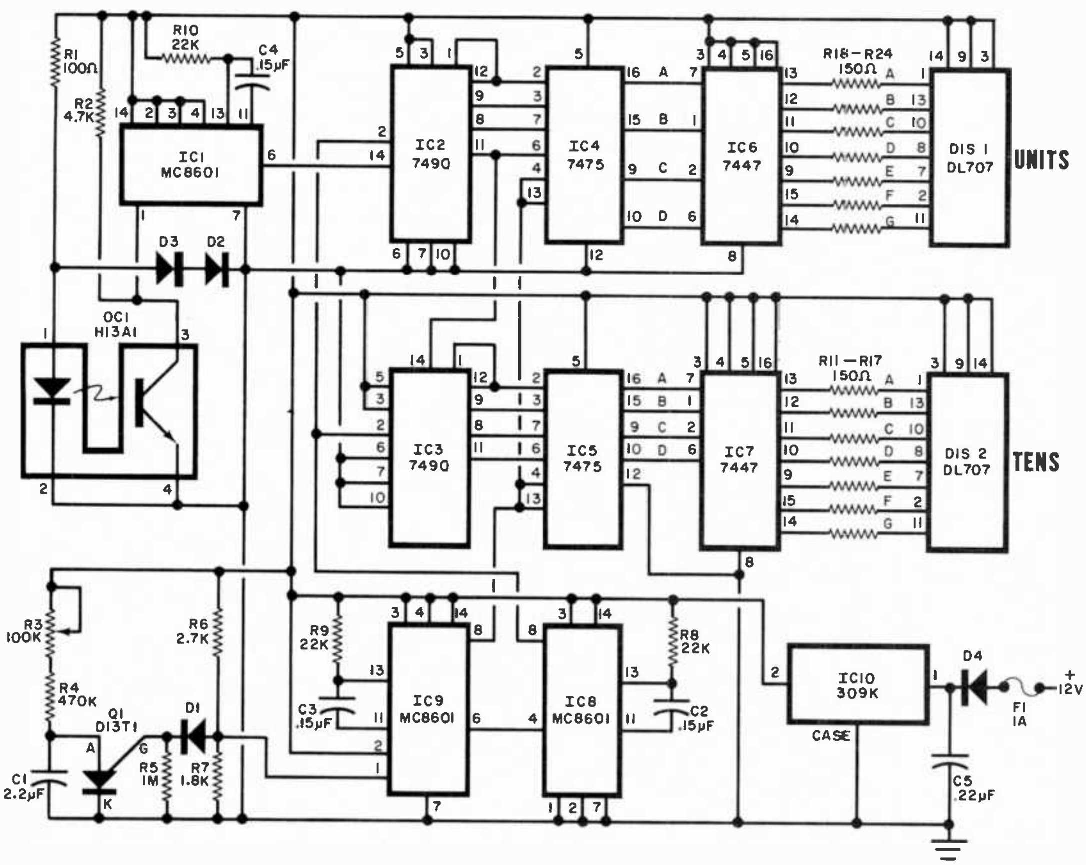
**How It Works.** The key component in the circuit (Fig. 1) is *OC1*, an optoelectronic device consisting of a gallium-arsenide LED and a photosensitive silicon transistor. The two are in an enclosure but are separated by an open space. When the LED is on, and the light (which is not visible) hits the transistor, it turns on. A slotted metal disc attached to the speedometer cable is used to interrupt the light beam activating the transistor.

The voltage across the LED in *OC1* is regulated by *R1* and *D2* and *D3*. The load for the phototransistor is *R2* and its output is applied to *IC1*, which is connected as a monostable (one-shot) multivibrator. Each time the phototransistor conducts, the output (pin 6) of *IC1* changes states (going from high to low) for a period determined by *C4* and *R10*. At the end of the period (about 1 ms), the output of *IC1* returns to its high state. The pulse rate is determined by the rotation of the disc interrupting the light beam in optoisolator, *OC1*.

The pulses from *IC1* are then counted in a conventional decade counter (with latch) consisting of *IC2*, *IC4*, *IC6* and seven-segment readout *DIS1*. The overflow from the counter is totalled by a second decade counter consisting of *IC3*, *IC5*, *IC7* and *DIS2*.

To prevent readout flicker, each decade counter has a latch (*IC4, IC5*). The outputs of the counters (*IC2, IC3*) are stored in the latches. When the latches are strobed, the digital value is passed to the readouts through the drivers (*IC6, IC7*). Thus, the readouts do not "run" as the counters cycle, but flash on with a set of digits each time the latches are strobed.

To understand the counting procedure, assume that your car is going 10 mph. Since the speedometer cable rotates 1000 rev/mile, it will be going 10,000 rev/hour or 2.77 rev/s. The metal disc used with *OC1* has eight slots cut in its edge so 22 pulses per second are generated. For the readouts to display the proper information, decade counters *IC2* and *IC3* are allowed to count for only slightly more than 450 ms before they are reset by a positive pulse at their common zero-reset pins (2). The reset pulse is generated by *IC8*, which is triggered by the latch circuits in *IC9*.




## PARTS LIST

C1—2.2-µF tantalum capacitor
C2,C3,C4—0.15-µF Mylar capacitor
C5—0.22-µF Mylar capacitor
D1 to D4—Silicon diode (1N914 or similar)
DIS1,DIS2—Seven-segment LED readout (Litronix DL707, MAN1, or similar)
F1—1-A fuse and holder
IC1,IC8,IC9—MC8601P
IC2,IC3—7490
IC4,IC5—7475
IC6,IC7—7447
IC10—SD309K
OC1—Optoelectronic coupler (GE H13A1)
Q1—D13T1 programmable unijunction transistor
R1—100-ohm, ¼-W, 5% resistor
R2—4700-ohm, ¼-W, 5% resistor
R3—100,000-ohm, pc-type trimmer potentiometer
R4—470,000-ohm, ¼-W, 5% resistor
R5—1-megohm, ¼-W, 5% resistor
R6—2700-ohm, ¼-W, 5% resistor
R7—1800-ohm, ¼-W, 5% resistor
R8,R9,R10—22,000-ohm, ¼-W, 5% resistor
R11 to R24—150-ohm, ¼-W, 5% resistor
Misc.—Mechanical speedometer, dual drive adapter, length of speedometer cable, suitable chassis (2), epoxy cement, heat sink and socket for IC10, plastic for readout window, metal for interrupter disc, mounting hardward, etc.
Note—Dual drive adapter is available from S. S. White, 151 Old New Brunswick Rd., Piscataway, NJ 08854. Ask for Bulletin 7205.

*Fig. 1. As the interrupter disc passes through the slot on OC1, it causes IC1 to inject a count into the decade counters. Circuit made up of Q1, IC9 and IC8 determines the timing.*

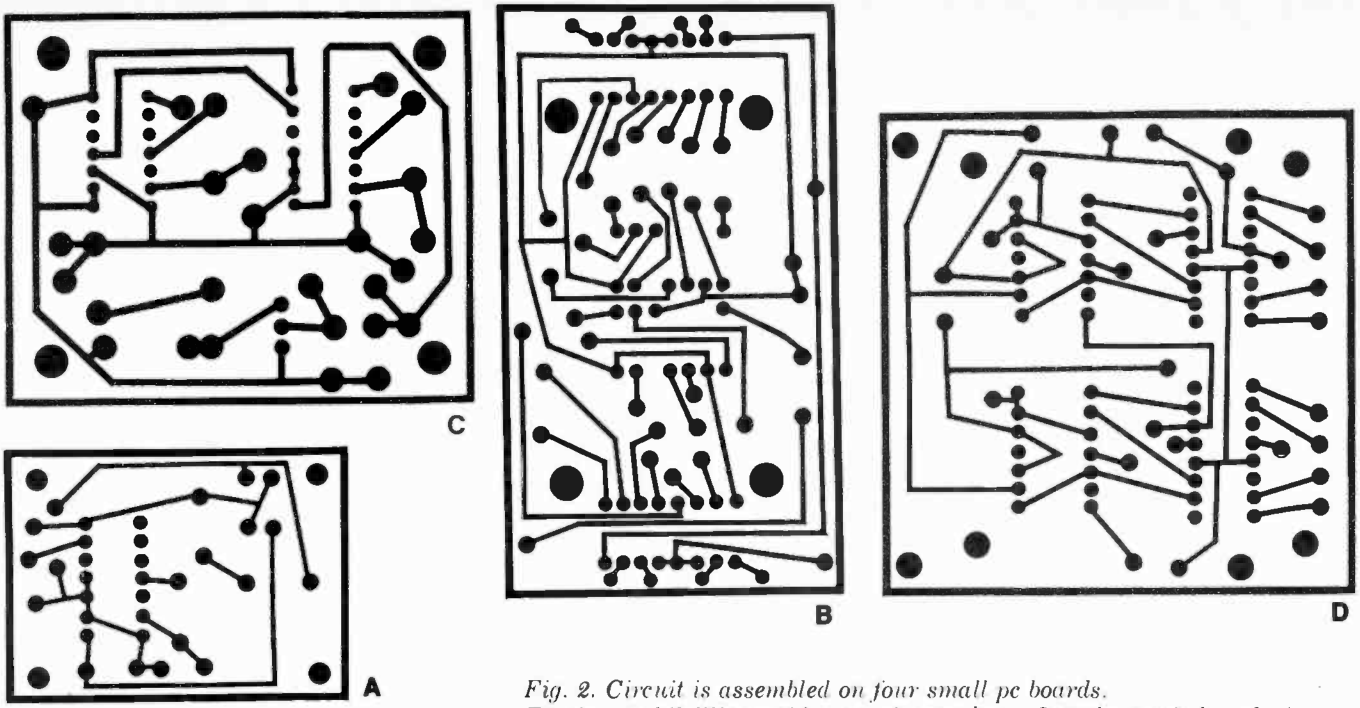
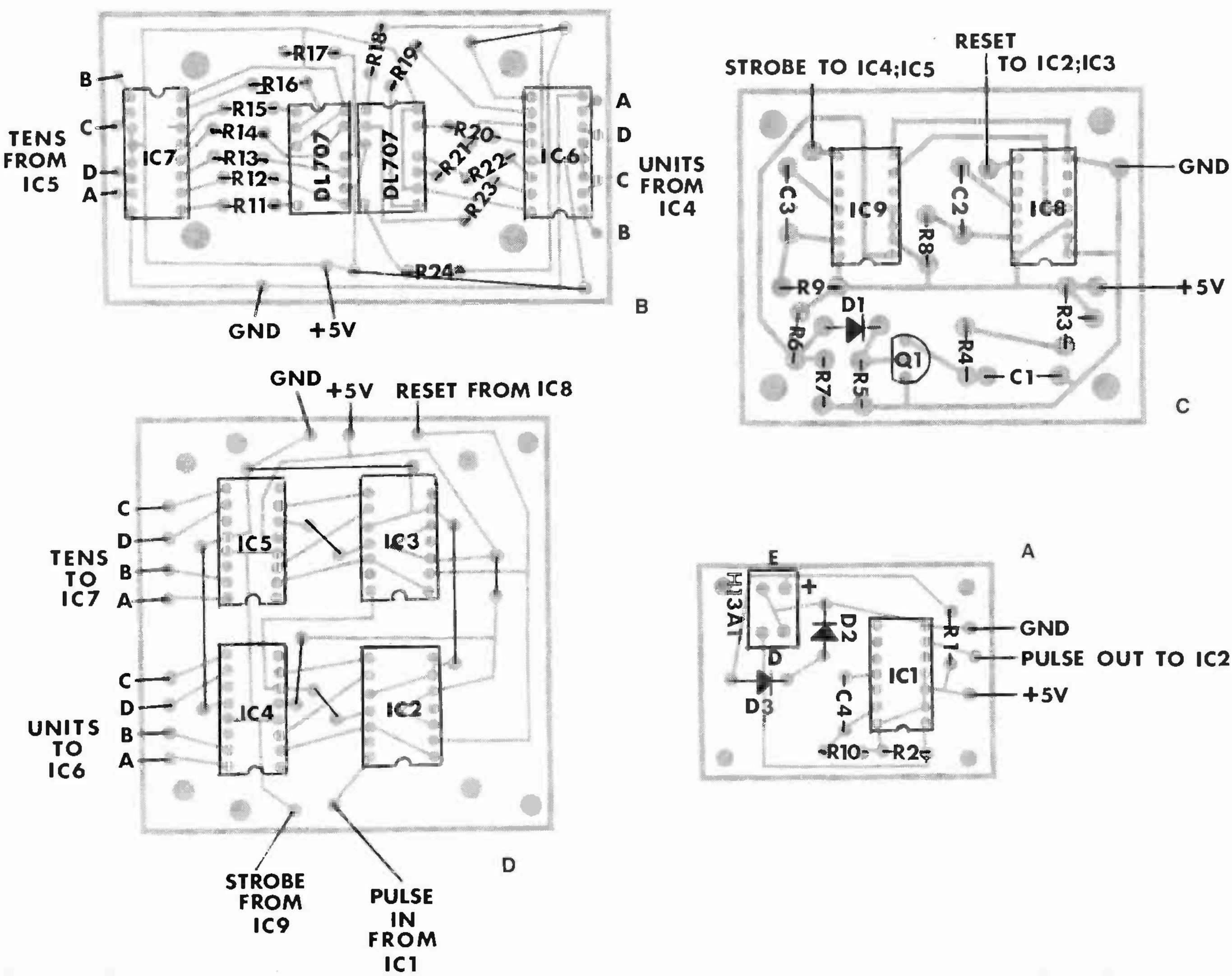



Fig. 2. Circuit is assembled on four small pc boards. Etching and drilling guides are shown above. Optoelectronic board (A) is fitted to the speedometer chassis. Display board (B) is mounted on front panel of display chassis with other two boards (C & D) inside the display chassis. Component layouts are shown below. Solid lines between solder pads are jumpers.



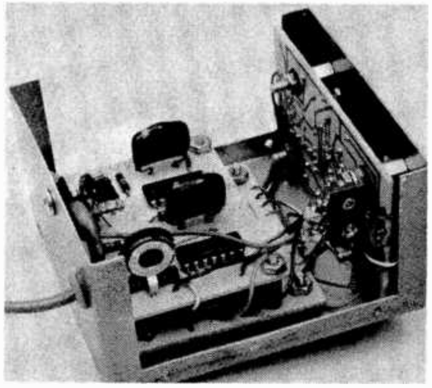


*Fig. 3. This photo shows interior of the display chassis. Cable at left goes to power supply unit.*

The timing for these pulses is provided by a pulse generator consisting of programmable unijunction transistor *Q1* and timing elements *R3, R4,* and *C1*. Each time *Q1* fires (determined by the circuit time constant), a negative-going pulse is generated at the junction of *R6* and *R7* and passed to *IC9*, which is wired as a monostable multivibrator. The output of *IC9* is a one-millisecond pulse applied to *IC4* and *IC5*. When *IC9* times out, pin 6 returns high and triggers *IC8*, also wired as a one-shot, which generates the reset pulses for *IC2* and *IC3*.

Operating power is provided by *IC10,* a 5-volt regulator, with *D4* used as protection against accidental input voltage reversal.

**Construction.** The circuit is assembled on four small pc boards as shown in Fig. 2. Other than the optoelectronic board and the power supply components, two circuit boards and the display board are mounted in a small metal enclosure as shown in Fig. 3. A window for the display must be cut in the front panel with a piece of plastic cemented over the window. The two pc boards are mounted on spacers with the strobe-reset board on top (to provide access to *R3*).

Drill a small hole in the back of the enclosure for a two-conductor shielded cable. The cable carries the +5-volt supply, pulses from *IC1*, with the shield acting as a ground.

Coupling the vehicle speedometer cable to the interrupter disc requires a mechanical fitting that will accept the male fitting presently connected to the cable. These fittings vary with the make of the car so it is necessary to get another speedometer that is a duplicate of the one you now have—either from an auto parts dealer or a junk yard. Disassemble the speedometer you obtain to remove the indicating pointer, the miles-per-hour scale, and the odometer components, as they will not be needed.

Fabricate the interrupter disc as shown in Fig. 4. Cement the disc in exactly the same place as occupied by the old indicating pointer. If your speedometer uses magnetic coupling, it must be defeated to allow the cable rotation to be coupled directly to the disc. In most cases, this can be done by applying a little epoxy between the magnet and its associated drum.

Select a two-part metal chassis to hold the modified speedometer and *IC10* on a heat sink as shown in Fig. 5. Mount the optoelectronic pc board under the interrupter disc so that the slotted edge of the disc passes through the slot in *OC1*. Then firmly secure the board in place. Wire the 5-volt supply to the cable connector and the optoelectronic pc board (using the metal chassis as common ground). Then wire the three leads from the optoelectronic board to the cable connector. Fit the two halves of the enclosure together and secure with appropriate hardware.

So that you don't lose the use of your old speedometer (you'll want to compare the two) and the odometer (which is generally required by law), obtain a dual drive adapter and an extra takeoff cable for the digital speedometer. The adapter, similar to those used in taxicabs for meter takeoff, can be found in auto parts stores, or see the Parts List.

**Adjustment.** The only adjustment necessary is calibration of *R3*. This is done by using an oscilloscope to get the pulses at pin 1 of *IC9* 450 milliseconds apart. If a scope is not available, it is also possible to make the adjustment by driving the car on a measured mile for one minute and setting *R3* so the meter reads 60 mph. To be sure the adjustment does not change due to vibration, secure the rotor of *R3* with a drop of epoxy. ◈

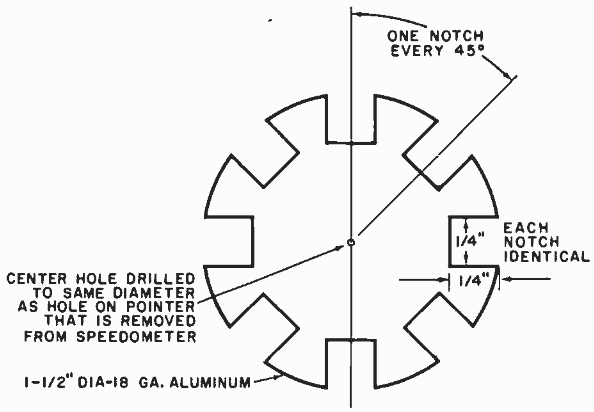



*Fig. 4. Use this diagram to make interrupter disc.*

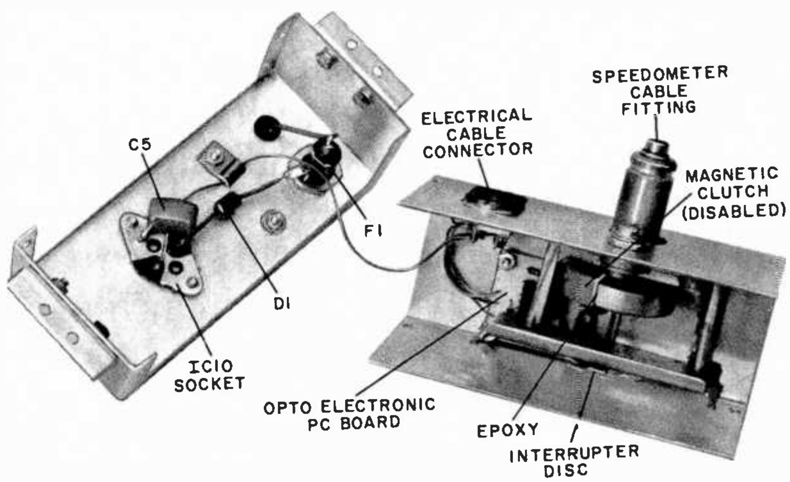



*Fig. 5. Assembly of the speedometer and optoelectronic unit.*

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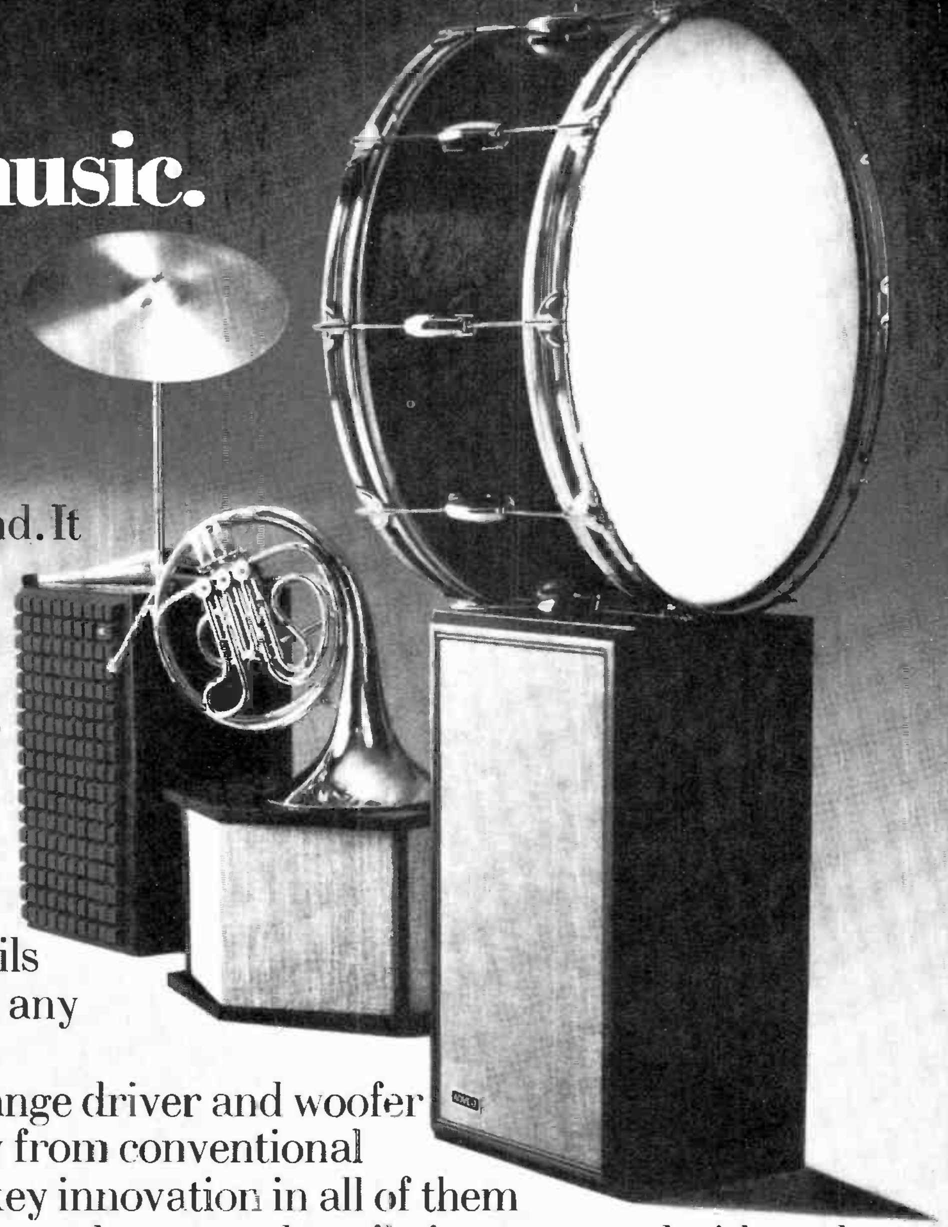

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BY RUSSELL J. BIK

# BUILD DYNADIM II

## DELUXE HOME-LIGHTING CONTROL

***Featuring an automatic dim-to-off mode from a few seconds to a slow 40 minutes, as well as conventional preset-level dimming.***

THE INTRODUCTION of SCR's and triacs into light-dimmer design advanced the state of the art from the dark ages of the giant rheostat to the compact home devices of today. The Dynadim II project described in this article represents the next logical step in dimmer development. It performs all the functions of standard light dimmers and also provides automatic dimming of room lighting at adjustable rates.

As a mood setter at parties, the Dynadim II can dim lighting from full on down to any preset holding level or all the way off at dim rates ranging from a few seconds to an imperceptibly slow 40 minutes. The same slow dimming can serve as a sleep inducer by helping you to relax. It's especially handy to have around when the kids insist that the lights be left on after they are put to bed.

Shorter timing cycles can be applied to applications like providing a professional touch to the presentation of home movies and slides by bringing down the "house" lights while you attend to the projector.

**How It Works.** The Dynadim II circuit shown in Fig. 1 is designed to work in series with the ac power source and the load via the ac input terminals. The power to the load is regulated by triac Q3 that acts as an ac switch that closes at some point during each alternation of the input power and opens automatically each time the voltage passes through the zero point. The point in the alternation where Q3 is triggered into conduction determines how much power is supplied to the load. If triggering occurs early in the cycle, the controlled light glows at a higher average intensity than if triggering occurs later.

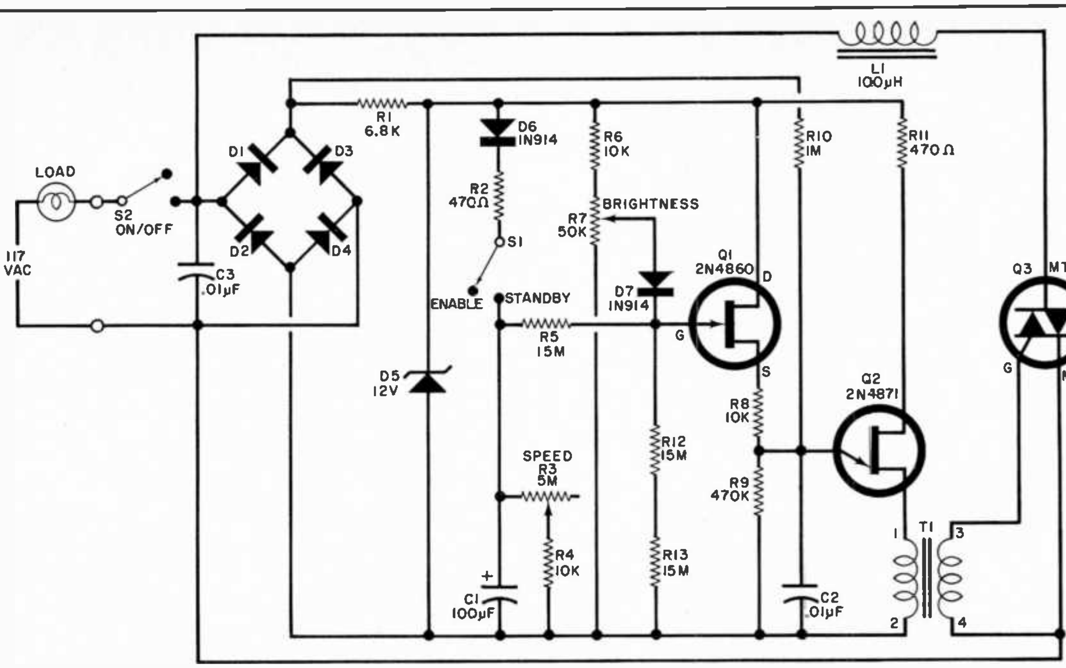


*Fig. 1. Unlike a conventional light dimmer, the triac (Q3) is gated later and later in the power-line cycle as C1 discharges. Dimming time is controlled by varying discharge time to C1*

## PARTS LIST

C1—100-µF, 15-volt electrolytic capacitor
C2—0.01-µF, 50-volt capacitor
C3—0.01-µF, 200-volt capacitor
D1 through D4—1-ampere, 200-PIV rectifier diode
D5—12-volt zener diode (1N4742 or similar)
D6,D7—1N914 diode
L1—Line filter inductor approximately 100 µH at 4-amperes)
Q1—2N4860 field-effect transistor
Q2—2N4871 unijunction transistor
Q3—200-volt, 6-ampere triac ECC Q2006L4
R1—6800-ohm, ½-watt, 10% resistor
R2,R11—470-ohm, ½-watt, 10% resistor
R3—5-megohm slide potentiometer
R4,R6,R8—10,000-ohm, ½-watt, 10% resistor
R5,R12,R13—15-megohm, ½-watt, 10% resistor
R7—50,000-ohm slide potentiometer
R9—470,000-ohm, ½-watt, 10% resistor (see text)
R10—1-megohm, ½-watt, 10% resistor
S1,S2—Spst slide switch
T1—Pulse transformer with 1:1 ratio (Sprague No. 11Z12)
Misc.—Printed circuit board; suitable chassis box with cover; insulator (goes between pc board and box); felt strips; knobs for slide pots; bus wire; machine hardware; solder; etc.
(The following items required only for portable table version of dimmer: 12' "remote-control" extension cord; right-angle strain relief; four rubber feet.)
Note: The following items are available from Celltronix, 1239 Old Bayshore Hwy., San Jose, CA 95112: Etched and drilled pc board for $5.50; complete kit of parts, including chassis box, in wall-mount version for $24.95 and in table version for $26.95. California residents, please add sales tax.

To send *Q3* into conduction, a trigger pulse is applied to the gate of the triac by the discharge of *C2* through *Q2* and the primary of *T1*. The time constant of *C2* and its resistors is rather long compared to the period of a single ac alternation. The values given in Fig. 1 were selected so that the potential across *C2* just barely attains an amplitude sufficient to drive *Q2* into conduction when the voltage across *C1* is zero and *R7* is set for minimum bias on *Q1*.

Closing *S1* causes *C1* to charge through *R2* and *D6*, thereby increasing the bias on *Q1* and allowing *C2* to charge more quickly with each alternation of the ac power cycle. As a result, the *Q2* oscillator circuit produces the triggering pulses for the triac earlier in the cycles, and the controlled lights brighten.

An earlier triggering can also be obtained by adjusting the *R6-R7* voltage divider. The effect on the bias of *Q1* is the same as raising the potential across *C1*, except that a static control over lighting intensity is obtained to set threshold levels.

The automatic dimming feature is obtained by opening *S1* and allowing *C1* to slowly discharge through *R3* and *R4*. This causes the lighting to diminish gradually as the triggering pulses to the triac are produced later and later in each cycle.

The high resistance required to prevent the voltage from being too rapidly shunted away from *C1* is provided by using a field-effect transistor as *Q1* and a very high resistance in its gate circuit.

The rectified power applied to the timing circuit by the diode bridge made up of *D1* through *D4* is maintained at a constant 12 volts, regardless of load, by zener diode *D5*. The filtering network made up of *C3* and *L1* reduces interference to the AM broadcast band caused by triac switching transients.

**Construction.** To keep the dimmer as slim and compact as possible, it is recommended that you build it on a printed circuit board. An actual-size etching and drilling guide and component placement diagram are shown in Fig. 2. Note that the entire circuit, including controls and switches, mount directly on the pc board. To avoid lead breakage from vibration, it is best to epoxy *T1* to the board. It is also advisable to mount *R1* about ¼" (6.4 mm) above the surface of the board to assure good heat transfer.

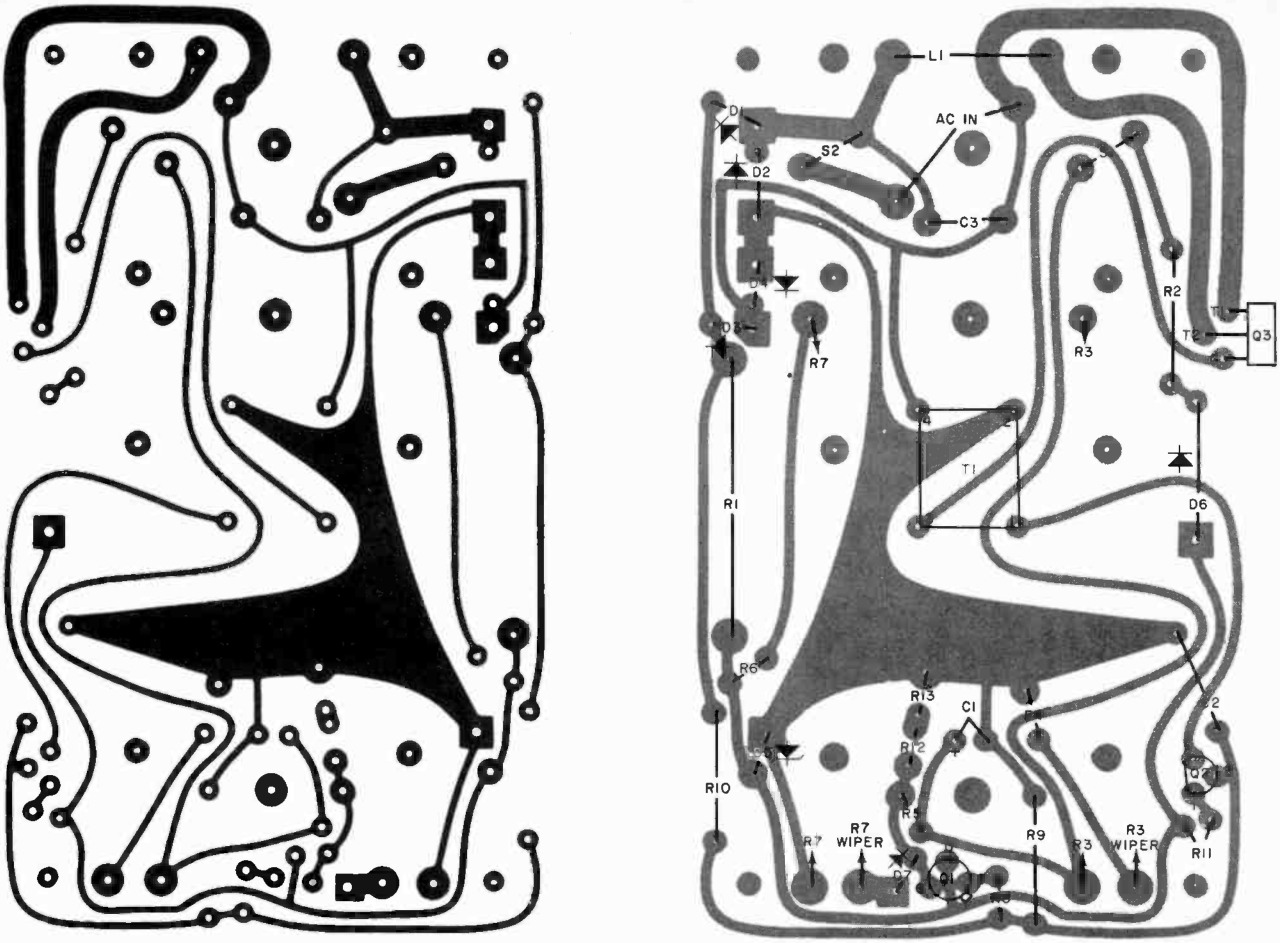


Fig. 2. Actual-size etching and drilling guide is shown above left, with component layout guide above right.

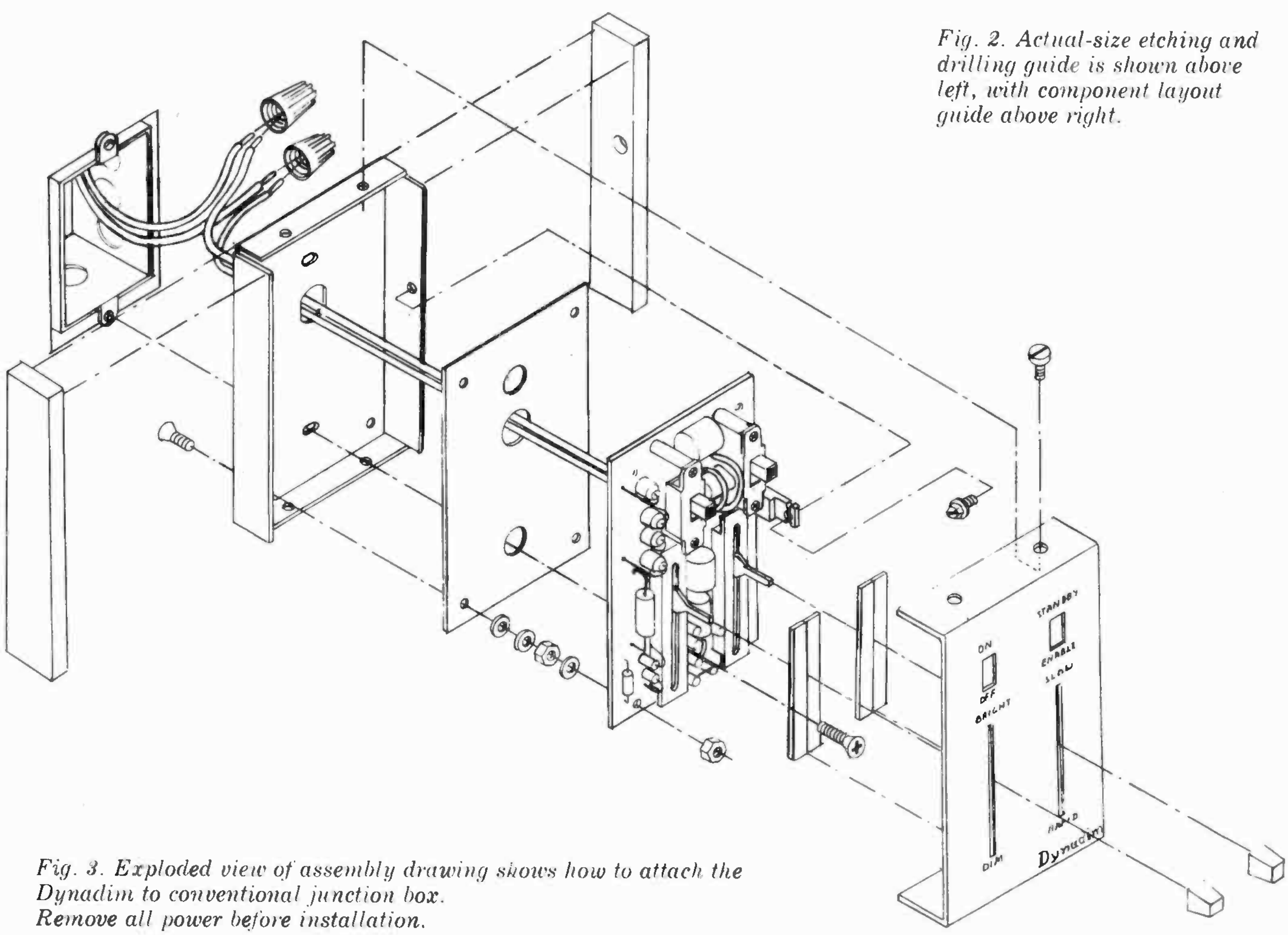


Fig. 3. Exploded view of assembly drawing shows how to attach the Dynadim to conventional junction box.
Remove all power before installation.

The triac (*Q3*) specified in the Parts List has an electrically isolated heat-sink tab that can be bolted to the metal cover to provide good heat sinking. If you use any other type of triac, an insulating mounting kit will be required.

After wiring the board, check it over for possible solder bridges between foil traces and to ascertain that all components are properly installed and polarized. To avoid leakage problems in the high-impedance circuit around the two transistors, remove all rosin and clean the board thoroughly with alcohol.

It is important that the leakage of *C1* be minimized and that *Q1* be properly biased to obtain the full 40-minute time delay. The leakage through an electrolytic capacitor is inversely proportional to the number of hours it is charged. This process is cumulative over the life of the capacitor. A dramatic reduction in leakage will occur during the first few hours of operation; improvement continues into the thousands of hours. (Note: The capacitors supplied with the kit listed in the Note under the Parts List come burned in. If you buy new capacitors locally, you can burn them in once they are mounted in the project simply by leaving the dimmer turned on in the standby mode.)

The value of *R9* was selected to provide optimum bias for the nominal specifications of *Q1*. However, differences in individual transistors may have to be compensated for by changing *R9*'s value. Raising the resistance increases the apparent length of the timing cycle until a point is reached where the controlled light will not turn off even if *C1* is discharged. The ideal value for *R9* is just below the point at which this begins to occur.

You can mount the dimmer in a permanent wall mounting (at a light-switch junction box) or in a separate box for portable table use. The assembly details for the junction-box approach is shown in Fig. 3. Note that the dimmer is connected in *series* with the load. Make sure that all electrical power is removed from the junction box before attempting to install the dimmer.

Mount the pc board assembly inside a form-fitting enclosure, with a thin insulator between the bottom of the board and the metal rear section of the box. The metal cover should have cutouts for the slide shafts of the potentiometers and switch toggles. Short lengths of felt fabric can be used between the inside of the front panel and the tops of the slide pots to keep out dust and other foreign material. Cement these strips in place so that they just touch each other in the two slider hole locations.

When you make the hookup to the ac line in the junction-box installation, be sure to use wire nuts for the connections.

Drill the rear wall of the dimmer's box so that it can be mounted directly on the junction box via the latter's switch mounting screws. (The original junction-box switch will no longer be needed.) In this manner, the complete dimmer can be affixed to the wall to eliminate the crowding that would exist if the entire circuit were to be "squeezed" into the junction box.

If you prefer to make your dimmer a table model, the same four screws that mount the circuit board to the box can be used to secure rubber feet to the bottom of the box in which the project is housed. In this configuration, a 12' (about 4-m) long "remote-control" extension line cord should be used to allow maximum flexibility. The lamp to be dimmed then plugs directly into the cord, which also plugs into the ac receptacle.

**Using the Dimmer.** For conventional control of lighting, it is recommended that the dimmer control be left in the full BRIGHT position and that the lights be controlled with the ON/OFF switch. When the dimmer is left on for long periods of time, a slight warming of the chassis will be noted. This is normal and should cause no apprehensions.

For dimming action, if you wish the lights to be full on and extinguish automatically to a very dim glow over a period of, say, 10 minutes, the procedure would be: First set the timing and dimming controls to DIM and RAPID and the STANDBY/ENABLE switch to ENABLE. The lights will extinguish quickly. Adjust the dimmer control to the position that gives the desired minimum illumination. Set the timing control to a position about four divisions above RAPID, *S1* to STANDBY, and (when ready to initiate the dimming action) switch to ENABLE. The lights will begin slowly to dim to the preset level.

Although the Dynadim II itself draws very little power (about as much as an electric clock), it is advisable to turn it off when convenient. This will ensure maximum component life. ◈


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# Special Focus on AUDIO

**Here is a group of audio-focused articles that touches all the interest bases of PE readers—buying tips, kit building, experimenting & applications.**

*$130 stereo kit features modular design, artificial inductors, and 10-octave control.*

BUILD THE

# "DELTA-GRAPH" OCTAVE-BAND EQUALIZER

PE TESTED

BY BRYAN T. MORRISON

THE Delta-Graph ten-octave-band equalizer described here can solve a number of sound problems for home and professional audio systems. In the home, it can be used to compensate for poor listening-room acoustics and the differences in the responses of phono cartridges, amplifiers, and speaker systems. For serious tape recordists or for professional applications, it can be used to emphasize or de-emphasize one or more instruments during a mix-down session and to modify the input signals to create special sound effects.

Among the equalizer's features are low cost, modular design, the use of op amp gain stages and artificial inductors, flexible interfacing with a variety of audio devices, and very-low noise figures. (See Specifications box.) Universal input/output circuitry with high-level drive capability provides balanced low-impedance inputs as well as standard single-ended outputs for maximum flexibility. The equalizer's ten slide potentiometers, one for each musical octave, are arranged in a horizontal line to provide a graphic display of the adjustments made to the sound system. The controls provide a boost/cut range of 15 dB in each direction for a total of 30 dB of control in each octave. The equalizer can be built for a monophonic, a stereophonic, or a 4-channel system with costs starting at $56 (less power supply) for a one-channel kit.

**About the Circuit.** Many active equalizers offer a limited number of control "bands" (usually five), which means that each control must cover two or more octaves. Although this is better than no control at all, this approach does not permit separate adjustments of all octaves in the audio range. A better approach is to divide the audio band into ten octaves, as is done in the Delta-Graph. Now, each octave can be individually adjusted with high precision.

The control circuits usually found in active equalizers employ expensive and bulky physical inductors to achieve discrete-band control. The Delta-Graph, however, uses special "gyrator" circuits that electronically simulate inductors to keep down cost and size and to obtain precise, predictable band control. By using gyrators in all but the highest-octave band, the equalizer is highly immune to electromagnetic fields, has accurately predictable saturation levels, and can simulate a wide range of inductances without changes in size or appreciable price variations.

The schematic diagram of the basic monophonic equalizer module is shown in Fig. 1. Note that the first nine bands use the gyrator circuits, while the tenth uses a miniature inductor. (Hum pickup and saturation are not important factors in the highest frequency band.)

Additional active stages in the circuit provide the balanced inputs and outputs that are so often used in profes-

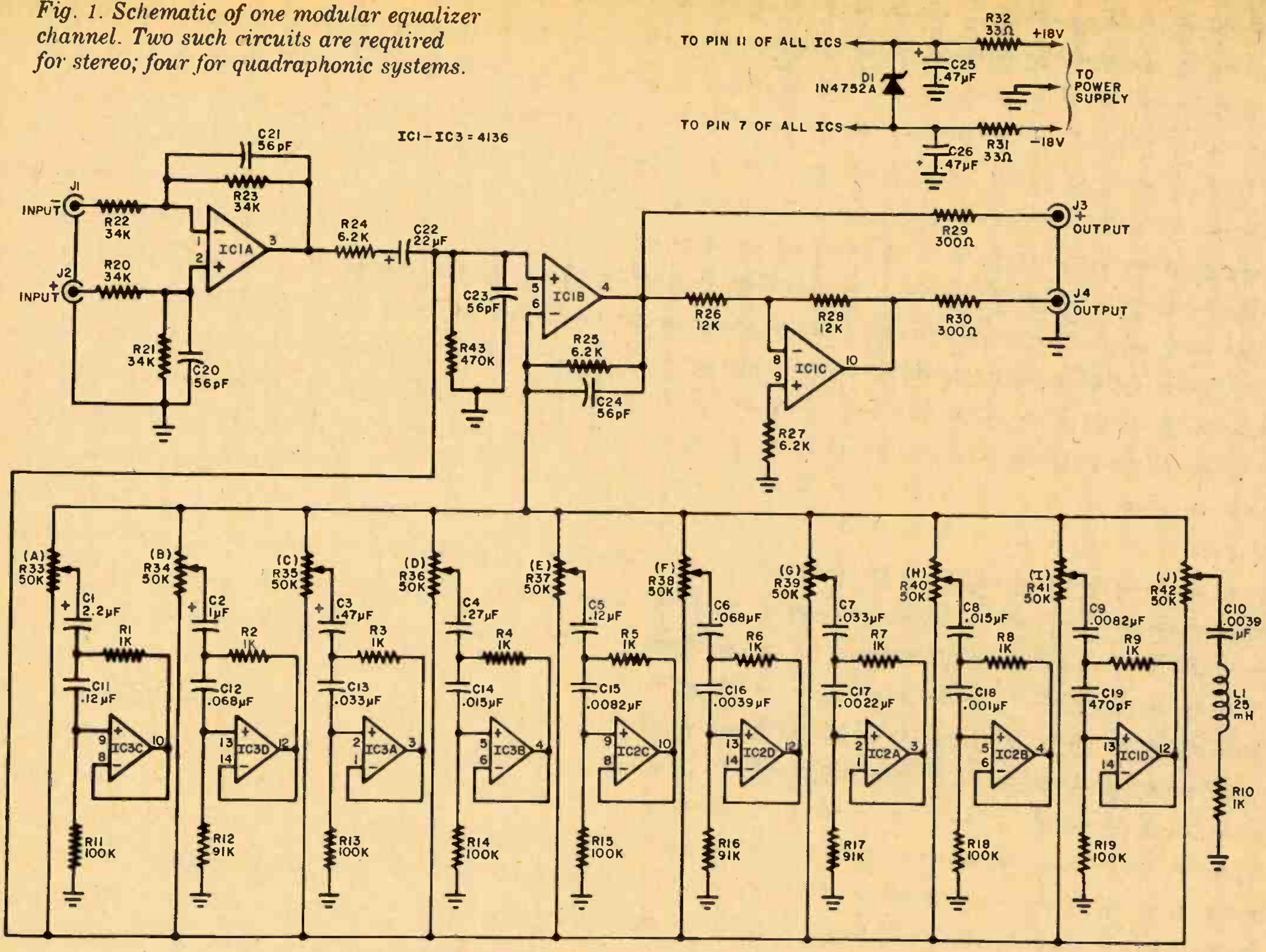



*Fig. 1. Schematic of one modular equalizer channel. Two such circuits are required for stereo; four for quadraphonic systems.*

## EQUALIZER MODULE PARTS LIST (per channel)

The following are 50-volt, 20% tantalum capacitors:
C1—2.2 μF
C2—1 μF
C3,C25, C26—0.47 μF
The following are 50-volt, 10% Mylar capacitors:
C4—0.27 μF
C5,C11—0.12 μF
C6,C12—0.068 μF
C7,C13—0.033 μF
C8,C14—0.015 μF
C9,C15—0.0082 μF
C10,C16—0.0039 μF
C17—0.0022 μF
C18—0.001 μF
The following are 50-volt, 20% disc capacitors:
C19—470 pF
C20,C21,C23,C24—56 pF
C22—22-μF, 16-volt upright aluminum electrolytic capacitor
D1—33-volt, 1-watt zener diode (1N4752A or equivalent)
IC1,IC2,IC3—4136PC quad operational amplifier IC
J1 through J4—Phono jack (optional)
L1—25-mH toroidal inductor
The following are ¼- or ½-watt, 10% resistors
R1 through R10—1000 ohms
R11,R13,R14,R15,R18,R19—100,000 ohms
R12,R16,R17—91,000 ohms
R20 through R23—34,000 ohms
R24,R25,R27—6200 ohms
R26,R28—12,000 ohms
R29,R30—300 ohms
R31,R32—33 ohms
R43—470,000 ohms
R33 through R42—50,000-ohm W-taper slide-type potentiometer with silicone damping and center detent
Misc.—Suitable enclosure; printed circuit board; eight-contact barrier block (Kulka Electric No. 670A-3100-8 or similar); knobs for slide pots; 1/16" thick aluminum stock for rear panel, pot brace, and power supply bracket; plastic standoffs (4); shielded audio cable; hookup wire; machine hardware; solder; etc.
Note: The following items are available from Delta-Graph Electronics Co., Box 741, Pasco, WA 99301: Complete mono kit of equalizer module parts, including pc board, tested IC's, finished case, rear panel, but less power supply, No. EQ10M, for $56.00; Stereo version of No. EQ10M, No. EQ10SP, including power supply, for $130.00; Power supply kit for up to four equalizer modules, No. PS-4, for $20.00; Walnut veneer cabinet that accommodates two equalizer modules and power supply, No. EQ10WC, for $20.00; 25-mH toriodal inductor, No. EQL1, for $1.50. Washington residents, please add 5% sales tax.

sional recording and PA applications. Resistors *R20* through *R23* make up a precision-balanced input stage for true differential, high common-mode rejection in balanced-line systems. When an unbalanced input is desired, as in home audio systems, the module's inverting (−) input can be grounded and the signal applied to the noninverting (+) input.

Capacitors *C21, C24, C25,* and *C26* stabilize operation of the op amps. Capacitors *C20, C22,* and *C23* provide a gentle frequency-response rolloff in the range beyond the top end of the audio spectrum to limit noise and r-f interference. Resistor *R43* ground references the *IC1B* equalizing op amp at its + input.

The output of the equalizer is fixed at 600 ohms balanced or 300 ohms single-ended by *R29* and *R30*, which also provide short-circuit protection. Even though the 4136 op amps have built-in overload protection, this is an added safety factor. (The op amps were also chosen for their high slew rates and superior noise ratings.) The output stage will effortlessly supply enough voltage and current to drive a dozen typical power amplifiers into clipping, even if the amplifiers are connected in parallel with each other. Furthermore, it will drive the amplifiers without an increase in THD or IM and without any loss in the bass register.

Resistors *R26, R27,* and *R28* and *IC1C* form an output that is shifted 180° from the + input. In single-ended applications, an output can be taken from one point while the other point is left open. Both outputs can be used in applications requiring "bridge" driven amplifiers.

Zener diode *D1* protects the op amps from overvoltages and power supply transients and permits operation from high-voltage supplies, with the addition of external current-limiting resistors. Internal current-limiting resistors *R31* and *R32* are optimized for operation with the power supply shown in Fig. 2, while providing extra power supply noise and ripple isolation.

The Fig. 2 power supply is designed to deliver ±18 volts at up to 200 mA. Since the nominal current demand of each equalizer module is 50 mA, the supply will accommodate up to four modules for quadraphonic system equalization.

**Construction.** The equalizer modules and power supply are best assembled on printed circuit boards, the actual-size etching and drilling guides and components-placement diagrams for which are shown in Fig. 3. Use a low-wattage soldering iron and fine solder.

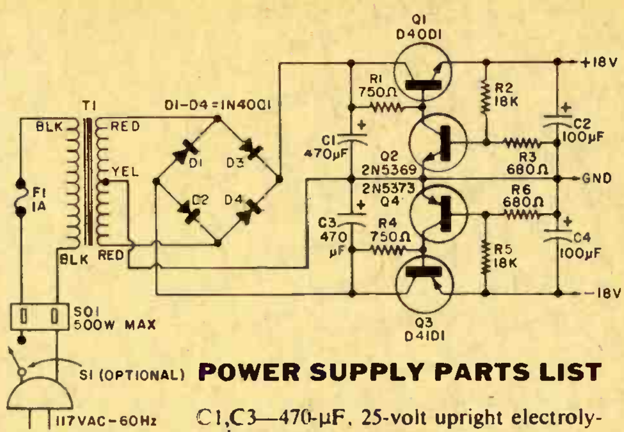
Start by assembling the equalizer module. First install the resistors and capacitors, followed by the diode and toroidal coil (clip off unused leads), then the IC's, and, finally, the slide potentiometers. Be sure to orient all components properly.

The pots should be mechanically tied together to prevent them from shifting, as the sliders are operated, with an 8¾" (22.2-cm) length of ⅜" × 1/16" (9.53 × 1.6-mm) aluminum. Drill ⅛" (3.16-mm) holes ¾" (19 mm) apart, starting ⅜" (9.5 mm) from one end of the strip.

Strip both ends of a 1½" (3.8-cm) length of hookup wire; solder to one end a No. 6 solder lug; and solder the other end to the "ground pot support" pad on the pc board. Place the aluminum strip over the top sections of the slide pots and align the holes in the strip with the threaded holes in the pots. Place a No. 4 washer over a 4-40 × ¼" machine screw, and drive this screw down in the hole of the second pot. Secure the strip to the other nine pots with 4-40 × ¼" screws.

Cut a piece of 1/16" aluminum plate to 8" × 4¾" (20.3 × 12.1 cm) and drill 3/16" (4.8-mm) holes along one of the short ends, locating and spacing them to exactly line up with the input/output and power pads on the pc board. Mount the barrier block so that its solder terminals pass through the holes and do not touch the metal plate. Then drill the holes for the spacers that will be used between the board and rear plate. Use ½" (12.4-mm) spacers and self-tapping 6-32 × ¼" machine screws to fasten the spacers in place. Solder the lugs of the barrier block to the pads on the pc board.

Assemble the power supply board, carefully following the guide for it shown in Fig. 3. Be sure you properly orient the electrolytic capacitors, rectifier diodes, and transistors. Fasten down the small barrier block with No. 6 machine hardware. Note that the transformer, fuse and



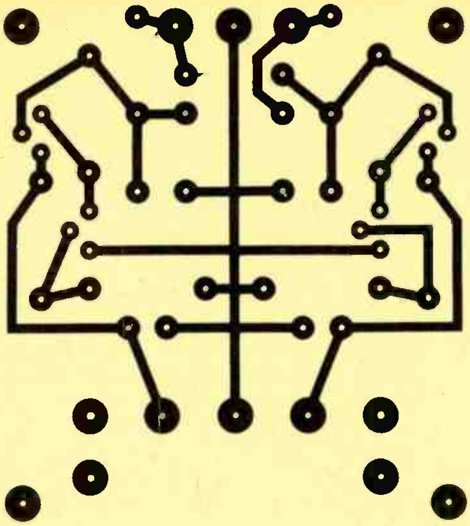

### POWER SUPPLY PARTS LIST

C1,C3—470-µF, 25-volt upright electrolytic capacitor
C2,C4—100-µF, 25-volt upright electrolytic capacitor
D1 through D4—1N4001 rectifier diode
F1—1-ampere fuse
Q1—D43C1 npn silicon transistor (General Electric)
Q2—2N5369 npn silicon transistor
Q3—D42C1 npn silicon transistor (General Electric)
Q4—2N5373 pnp silicon transistor
R1,R4—750-ohm, ½-watt resistor
R2,R5—18,000-ohm, ½-watt resistor
R3,R6—680-ohm, ½-watt resistor
S1—Spst switch (optional)
SO1—Chassis-mounting ac receptacle
T1—28-volt center-tapped, 200-mA transformer
Misc.—Mounting panel; barrier block (Kulka Electric No. 600Y-3); machine hardware; hookup wire; solder; etc.

*Fig. 2. Power supply accommodates up to four equalizer modules.*

### CLAIMED SPECIFICATIONS

**Frequency response:** 20 to 20,000 Hz ±0.5 dB.
**Dynamic range:** Output noise greater than 105dB below maximum output from 20 to 20,000 Hz.
**S/N ratio:** Better than 90 dB referenced to 2-volt rms rated output from 20 to 20,000 Hz.
**Band centers:** 31.25, 62.5, 125, 250, 500, 1000, 2000, 4000, 8000, 16,000 Hz nominal.
**Adjustment range:** ±15 dB maximum (30-dB total range).
**THD:** Less than 0.1% at rated output from 20 to 20,000 Hz.
**IM distortion:** Less than 0.01% at rated output 60/7000 Hz mixed 4:1; typically less than 0.003%.
**Rated output:** 2.0 volts rms into 10,000 ohms.
**Clipping output:** 10.0 volts rms into 10,000 ohms single ended, 20.0 volts rms into 10,000 ohms balanced.
**Input impedance:** 68,000 ohms single ended; externally set with terminating resistor for balanced inputs between 600 and 100,000 ohms.
**Output impedance:** 300 ohms single ended, 600 ohms balanced.
**Note:** *All controls at 0 dB.*



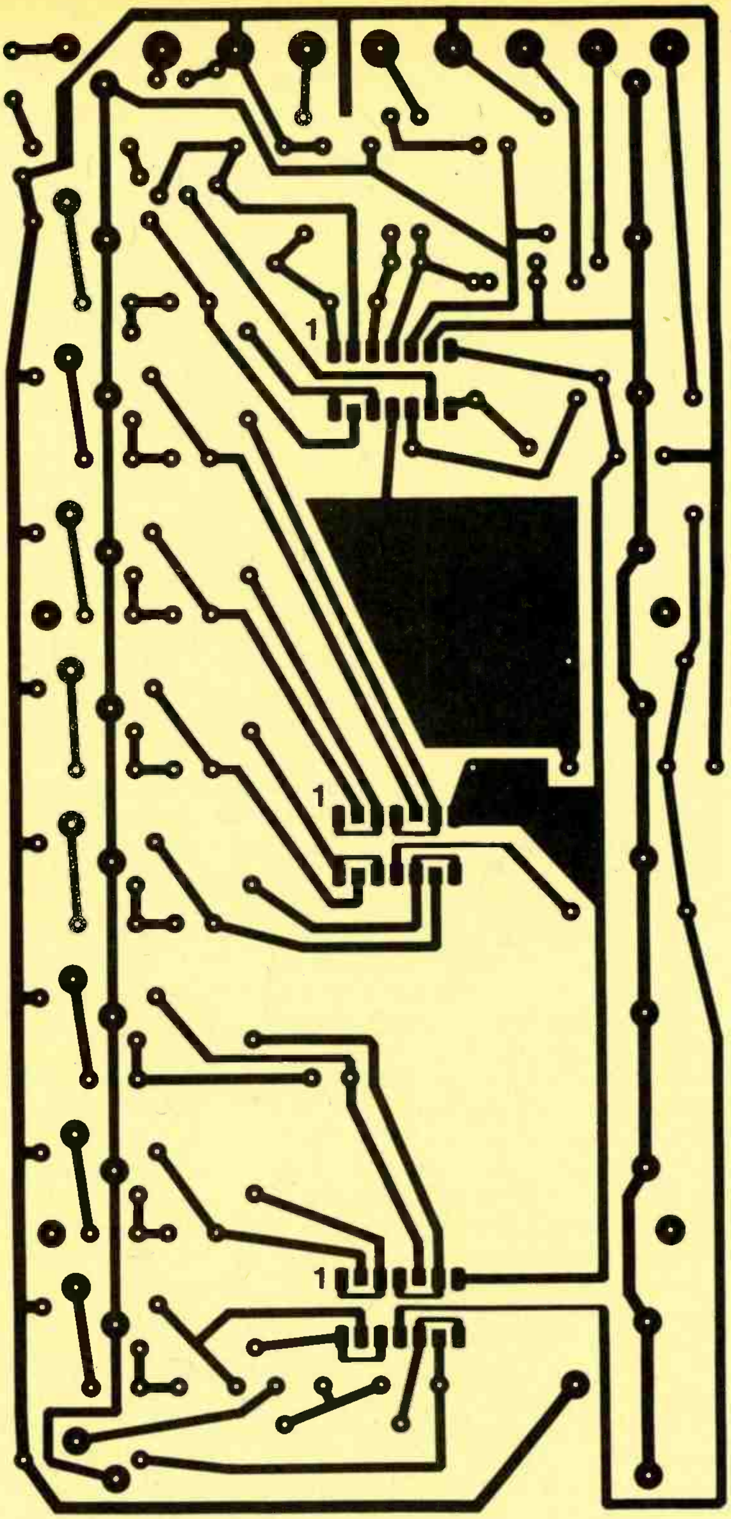
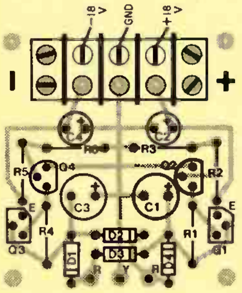
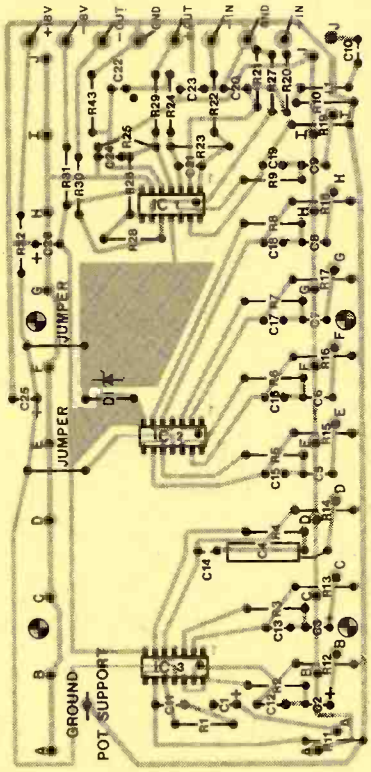


*Fig. 3. Actual-size etching and drilling guides (above and right) and component placement diagrams (below) for equalizer module and power supply.*





holder, and accessory ac receptacle mount off the board. Again, you will need a 1/16" thick aluminum backplate. Cut the plate to 6½" × 2¾" (16.5 × 7 cm) and bend the plate along the short dimension 1¼" (3.2 cm) in from the edge at a right angle. Machine the short upright section of the bracket for the line cord strain relief, accessory ac receptacle, and fuse holder. Then drill the mounting holes for the transformer and power supply board. Mount the receptacle, fuse holder, and transformer in their respective locations. Referring to Fig. 2, wire the primary circuit of *T1* as shown, connecting the ends of the line cord directly across the receptacle if you are not using a power switch. If you plan to use *S1*, modify the circuit as shown and plan to mount the switch on the front panel of the case in which you house the equalizer. Snap a plastic strain relief over the line cord and secure it in its hole in the bracket.

Set the power supply board near the secondary side of the transformer and connect and solder the latter's leads to the appropriate pads on the board. Then use ¼" spacers to mount the board to the bracket.

With the equalizer module(s) and power supply subsection fully wired, you can set them side by side and temporarily interconnect them, following the diagram shown in Fig. 4 to check out their operation. (Note that the dia-

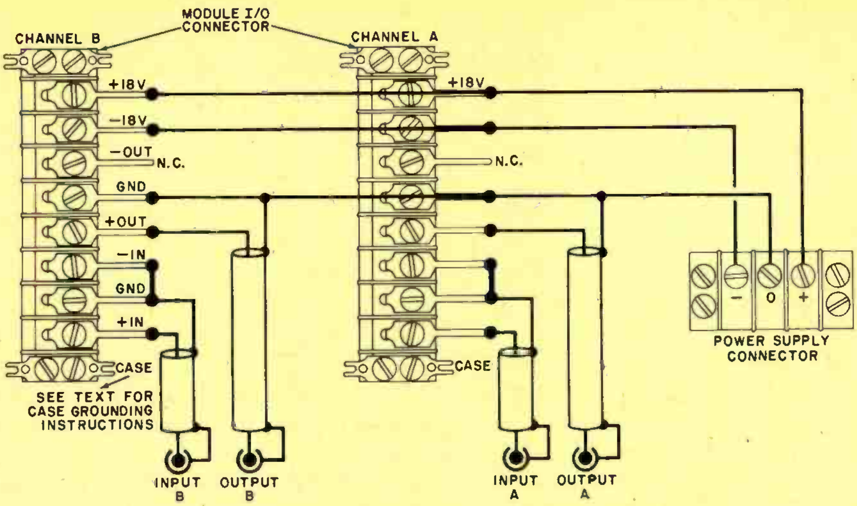



*Fig. 4. Wiring scheme for home audio system is shown here with stereo setup. For mono, eliminate channel B; for 4-channel add channels C and D in same manner as shown for channel B to channel A.*

gram illustrates the wiring scheme for a home stereo system. If you plan to build only a monophonic version, simply disregard everything to the left of the Channel A barrier block. Alternatively, if you are planning to build a quadraphonic equalizer, Channels C and D are added exactly in the same manner as Channel B is shown connected to Channel A.)

During tests (and in actual operation), the equalizer can be installed between the preamplifier and power amplifier in your sound system. Use shielded audio cable when making the signal-line hookups between the equalizer and your sound system. It can also be connected into the system via the tape monitor circuits, which will allow the equalizer to be switched in and out of the system with the TAPE MONITOR switch of your receiver or preamplifier.

**Final Assembly.** Once you are satisfied that your equalizer is operating properly, disconnect it from your sound system. Then mount the module(s) and power supply in a suitable enclosure. (Do not forget to mount the power switch, if you chose to use one, in a convenient location on the front panel of the enclosure.)

As the circuit is designed, the equalizer's audio and chassis (case) grounds are separate and brought out to terminals on the rear panel via the barrier block. If you use a nonconducting enclosure (such as a wood cabinet, plastic box, etc.), simply tie each module's case ground to its input ground. When you mount the modules in a metal enclosure and the module cases are physically grounded to the enclosure, it is wise to leave the case ground terminals floating so that the audio ground path is connected to the enclosure at only one point in the entire system. This will prevent ground loops.

**In Conclusion.** As you use the equalizer in your sound system, you will discover that there is a certain amount of interaction among the controls. This is a normal condition. You will also find that, to obtain the best possible equalized sound from your system, you will have to do considerable experimenting with the settings of the various slide controls. However, once you get your system properly equalized, you need never again touch the controls—unless you change speaker systems, amplifier, or cartridge, or you move your system to a different area. ◈

# The State of Audio Electronics Today

***Latest developments, including class D amplifiers.***

BY LEONARD FELDMAN

HERE ARE the highlights of audio electronics, circa 1976-77. A number of advances have been made, as you shall see.

**Receivers.** With the growing interest in the marketplace on "separates" (high-power basic amplifiers, sophisticated preamp-control units and top-notch tuners), many manufacturers who depend on receiver sales for the bulk of their component business have attempted to cover all bases this year. It is more than two years since the "100-watt-per-channel" barrier was broken by a few daring manufacturers. Now, a new power output level around 160 watts per channel seems to be the plateau for which more and more receiver makers are aiming.

New receiver designs are not concerned with increased power alone, however. Many of them offer increasingly sophisticated tone-control circuits—the type previously found only on separate preamplifiers or the more expensive integrated amplifiers. The appearance of a third tone control, which operates in the mid-frequencies (called a "presence" control in early hi-fi days) has found its way to the front panels of medium- and high-priced receivers. So have selectable turnover frequencies for bass and treble controls, which increase a receiver's versatility and permit the tailoring of the frequency response at the extremes without adversely affecting mid-band response. In deference to audio purists who frown on the use of tone controls entirely, receivers equipped with more versatile tone control systems also include switches which permit bypassing those tone controls entirely.

Historically, the more useful "add-on" electrical/electronic accessories designed for use with hi-fi components are eventually incorporated into the components. A good example is the low-cut or high-cut filter, which started out as a little "black box" accessory and is now standard on nearly every front panel of modern receivers.

This year's newest adoption of an add-on is the graphic equalizer—that *ne plus ultra* of tonal compensation devices. It divides the audio spectrum into many (5 to 24) segments for fine control of overall system frequency response. One manufacturer has incorporated a graphic equalizer with five slide controls into at least three of his popularly priced receivers, thereby eliminating the traditional rotary bass and treble control knobs.

Also borrowing from the advanced features found in "separates," some manufacturers have augmented the usual pair of tuning meters found on most receivers with a second pair whose sole function is to monitor average or instantaneous power delivered to connected loudspeakers. Power meters on receivers are anything but another "gimmick," as they permit visual adjustment of channel balance and even provide a measure of security against overdriving of speaker systems whose maximum power input capability may not be as great as the output capability of the receiver to which they are connected.

Nor are all the new receiver features externally visible. Phase-locked-loop circuitry for more stable operation of stereo multiplex systems in receivers and tuners has become almost standard in all but the very lowest priced units. The use of PLL has given rise to separation specifications of 40 dB or more. These performance figures remain true, by the way, even after years of use of the product since the PLL circuits have no adjustment coils or capacitors to drift out of alignment with time.

The use of completely independent power supplies for each of the two stereo amplification channels is another innovation in stereo receivers that may not be physically apparent from the outside of the receiver. The proponents of this technique credit it with reducing interchannel modulation effects and low-frequency IM and harmonic distortion. The twin power approach may take the form of two completely separate power transformers or may utilize separate secondary windings on a single transformer, each of which is connected to its own rectifier and filter circuits for providing power to one of the two channels. Toroidally wound power transformers are also being used increasingly in high-power receivers because of their more efficient use of space in the chassis and their superior regulation qualities.

Tuning meters have multiple functions in some new receivers. Panel switches alter the purpose of some signal-strength meters so that they display FM deviation (a handy metering technique that is particularly helpful in setting up associated recording equipment when transcribing FM or stereo FM programs on tape). More and more of these meters are also being used as multi-path indicators, which permit optimum orientation of external FM antennas for least interference caused by delayed, reflected signals. One manufacturer has reversed the direction of meter needle deflection and repositioned meter circuitry so that it indicates best signal-to-noise ratio (FM quieting) rather than just greatest signal strength. (The two tuning points may not coincide.)

**Tuners.** The growing number of FM stations which crowd the dial in most major metropolitan areas have created a dilemma for many r-f circuit designers. Ideally, wide-bandwidth response in the r-f and i-f sections of a tuner (as well as in the FM detector circuits) is needed if recovered audio signals are to be as low in distortion as possible. But built-in wide-band response means lower adjacent- and alternate-channel selectivity, defeating the need to separate closely spaced stations on the dial.

A recent tabulation of FM stations lists 67 of them serving a tri-state area. Of this number, no fewer than 18 are only an FM channel width (200 kHz) apart. As many as 24 low-power stations in the area are actually assigned to the same frequency, pointing up the need for excellent capture ratio even though such "paired" stations may be in opposite geographical areas.

A very logical solution to this problem has been incorporated in some better tuners by a few manufacturers. Instead of effecting a compromise between the circuit requirements for good selectivity and low distortion they have designed products which offer selectable bandwidth. If you live in any area which is not plagued with stations that are practically "on top of each other," you can choose the wideband i-f position of the switch and enjoy low distortion figures when listening to stations that transmit good signals. Alternatively, when confronted with a portion of the dial that is overflowing with closely spaced (in frequency) stations, you simply flip a switch to the narrow position and, while distortion becomes somewhat higher, at least you are able to tune to the station of your choice without interference from adjacent- or alternate-channel signals.

Several tuner manufacturers have adopted the most accurate tuning method of all—phase-locked-loop digital circuits. Local oscillator frequencies are divided and compared (in the equivalent of a high-frequency PLL circuit) with a crystal-controlled reference frequency built into the tuner. Since tuning accuracy is then simply a function of crystal frequency accuracy, such tuners may be said to be as accurate in their frequency pin-pointing as the station transmitters themselves. In some variations, frequency is read by means of LED or other numeric readouts.

Since this "super afc" method invariably involves tuning by means of a dc voltage and varactor diodes (which replace the conventional mechanical multi-ganged tuning capacitor), the tuners lend themselves to pre-selection or pre-programming of favorite stations. Long-term "memory" of selected stations is often accomplished by including a low-voltage, long-life battery to supply power to the memory even when the tuner is turned off. Tuning meters are not required with synthesized tuners, of course, but even some of the more conventional tuners have eliminated all meters from front panels, substituting instead LED signal-strength indicators and even pairs of LED's which must glow equally to indicate correct center-of-channel tuning. This latter technique has also been applied to all-in-one receivers in budget-priced categories in the last few months.

**Amplifiers and Preamps.** Not to be outdone by manufacturers of all-in-one receivers, makers of separate amplifiers also have new circuit innovations to offer.

The prematurely announced Class D or switching amplifier, first exhibited nearly three years ago, is still awaited by audio fans who have been tantalized by the promise of a more efficient, cool-running, high-power, solid-state circuit that requires a minimum of heat-sinking and operates by "sampling" audio waveforms at a high-frequency (500 kHz) rate. Class B amplifiers, long the mainstay of solid-state audio electronics, are fairly efficient converters of dc energy when delivering maximum power. However, they are relatively inefficient at typical (music) listening levels. When delivering rated power, a properly designed Class D amplifier can attain efficiency figures of 80% or higher.

In a Class D amplifier, the audio input signal is used to vary the pulse width of a 500-kHz pulse train (Fig. 1). The reduced duty cycle of the amplifier section results in higher efficiency than with Class B operation. An integrating network "reads" the average width of pulses and reconstitutes the audio signal waveshape. The high-frequency "sawtooth" edges of the restored waveform are inaudible.

But Class D amplifiers are not the only ones that promise increased efficiency, reduced weight, and compact construction. Another manufacturer has developed what he calls a "Series E" circuit (also referred to as a Class G amplifier) which, while not as radical a departure as Class D, is also capable of greatly improving the efficiency of audio power amplifiers.

The Series E circuit utilizes two pairs of output transistors for each channel. The first pair, powered by a low dc supply voltage, handles low-level signal waveforms or the ascending first portion of high-level waveforms. When an audio waveform exceeds a predetermined amplitude, the second pair of output devices, powered by a much higher voltage supply, "takes over" in a smooth transition. Since this latter pair of devices is normally "turned off" when not needed, the result of the "pass-along" technique is greater efficiency over each pair of devices' operating range. First examples of the circuit are expected to appear in the form of a receiver.

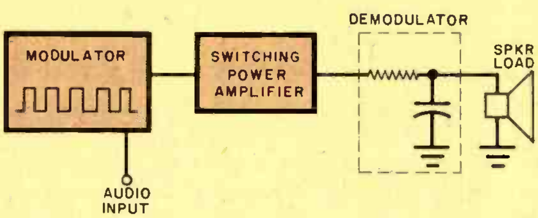



*Fig. 1. With the class D switching power amplifier shown above, signal (A) at left modulates pulse (B) to give pulses of varying width (C). These are then integrated to create replica of the original signal (D).*

Still another amplifier manufacturer has introduced a "current dumping" 100-W/channel power amplifier. It's actually a Class A amplifier with current dumping circuitry that's called upon when current demands are high. It uses error-correction circuits.

In addition to average-power-reading meters, some basic power amplifiers now include a series of LED indicators, each calibrated to fire at 3-dB intervals. The combination of meters plus LED indicators permits users to visually monitor the difference between "average" power delivered by their stereo amplifiers and musical transient peaks which are often 10 to 20 dB higher in amplitude. The latter might overload an amplifier for short periods without being detected by the listener.

Recognizing the wide disparity between average power levels and peak power inherent in today's wide dynamic music program sources, at least one manufacturer has produced a novel power-monitoring circuit that compares instantaneous output signal distortion with the distortion-free input signal. When that comparison discloses a significant difference in waveform between the two signals, the amplifier instantly "limits" power output so that nominally low distortion levels are maintained at all times. An indicator light accompanies the limiting action so the user can back off on the volume setting to restore full dynamic range. As for preamplifier control units and control sections of integrated amplifiers, two divergent trends seem to be evident. For the first, some manufacturers are offering more and more control and switching features on these separates. The popularity of such outboard accessories as graphic equalizers, noise-reduction devices, and dynamic range expanders has given rise to the need for more tape monitor circuits through which these devices can be connected to the audio chain. Thus, while most receivers now boast at least two monitor circuits, preamplifiers and integrated amplifiers often include three or more such circuit-interruption points. Multiple phono inputs are also popular; some of the new preamps make provision for connection of low-voltage-output moving-coil phono cartridges.

The other trend in preamplifiers seems to be *away* from controls, switches and knobs. A variety of control chassis is now available offering just "basic" preamplification and program selection. These most separate of separates concentrate on super-low distortion, high-input signal-handling capability and ruler-flat frequency response, leaving the control frills to less esoteric products. There are even expensive pre-preamplifiers made by a few small firms. These do nothing but provide straight voltage gain (at super-low noise levels) for moving-coil cartridges. Indeed, with the increasing number of separate equalizers available, a basic preamplifier (equipped, perhaps, with some fixed cut-off filter positions, but little else in the way of tone controls) begins to make a lot of sense to the audio perfectionist who can add such separate tone-control devices without introducing system redundancies.

As for phono preamp circuits themselves, there is increased use of high-voltage devices in the front ends of preamps, many operating from dual-polarity supplies to provide the wide, dynamic signal-handling capability now demanded by knowing purchasers of these control units. There are some preamplifiers which claim a signal-handling capability of 500 millivolts and more. This figure is more than 46 dB greater than the nominal 2.5-mV input sensitivities which those same preamp circuits require to deliver full rated output. Add to that the signal-to-noise ratio of around 60 dB (from nominal input to residual noise and hum level) and we have preamplifier circuits with 100-dB capability—far more than the dynamic range capability of any phonograph record ever pressed.

**Accessories.** As the little black boxes of yesterday find their way into the complete component of today, other add-on devices take their places. Two distinct areas of audio research seem to be occupying engineers at this time. The first has to do with increased dynamic range and improved S/N. In this area we already have a host of products available, such as dynamic expanders, single-ended noise reduction devices (that do not require anything to be done to the program source when first recorded, as opposed to two-sided noise-reduction systems such as Dolby, dbx and ANRS) and dynamic noise filters. The second category of add-on device is relatively new and involves an attempt to simulate the acoustics of live concert halls in one's own listening room. Quadraphonic sound's initial premise of accomplishing this may be challenged by purely electronic time delay systems which can be adjusted by the user to vary time delay and decay parameters. Physical placement of speakers is far less critical than with 4-channel arrays.

Two approaches to this goal are already represented by products on the marketplace. One employs a wholly analog system known as "bucket brigade" chips, operating at a delay rate determined by a digital clock. The second approach involves analog-to-digital conversion of the incoming audio signals, followed by application of the digitally encoded pulses to shift registers and, finally, reconversion to delayed audio signals by a digital-to-analog converter. Once in digital form, the signals can by delayed by the amount desired.

We know of serious experiments in which the "space" of the living room is divided into as many as 16 sectors. Computer programs which contain information regarding a particular concert hall are fed into the system and delay times for each sector (as well as other identifying qualities of the signal "reflected" from that sector) are punched up on the 16-channel reproducing system. The system is now used for acoustic studies, but if past history is any indicator, we might find this elegant concert-hall simulator reduced in size and cost sufficiently to become next year's "add on" accessory. ◈

# Guide to "Home Brew" Phono Preamp Design

*Why RIAA signal processing is used, and how it affects preamp design.*

BY DENNIS A. BOHN

AUDIOPHILES continue to rely on the phonograph disc as their principal program source. Because of this, they are very careful to check the phono ratings of commercial preamplifiers. In this article, we will take a look at the almost universally used RIAA equalization system, and how it affects the design of phono preamps. Also included are representative phono preamp circuits employing low-noise IC's, as well as design information for those who like to "roll their own."

Phono preamplifiers differ from other preamplifiers only in their frequency response, which is specially tailored to compensate for (equalize) the recording characteristic. If a fixed-amplitude signal is recorded on a phonograph disc while its frequency is varied from 20 to 20,000 Hz, the result will have a playback response curve similar to that in Fig. 1. This plot of phono cartridge output (amplitude) versus frequency indicates a dramatic alteration of the fixed amplitude input signal. *Playback equalization*, which is performed by the phono preamplifier, corrects this alteration and recreates the applied flat-amplitude signal. To understand why we must go through this procedure, a consideration of the recording process is necessary.

**Recording and RIAA.** The grooves in a stereo disc are cut by a chisel-shaped stylus, which is driven by two vibrating transducers mounted at right angles to each other (Fig. 2). The cutting stylus vibrates from side to side in step with the variations in the signal impressed on the cutter coils. This is called a "lateral cut," as opposed to the older "vertical cut" method. The resulting displacement of the groove back and forth about its center is known as *groove modulation*. The amplitude of this modulation cannot exceed a certain amount, or "cutover" will occur. That is, the

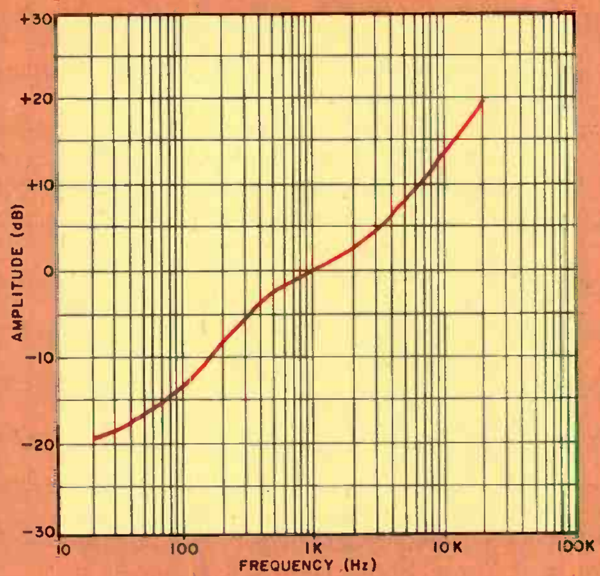



*Fig. 1. RIAA recording characteristic boosts highs and attenuates bass.*

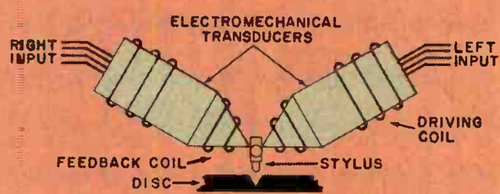



*Fig. 2. A typical stereo cutting head uses negative feedback coils to counteract head resonances.*

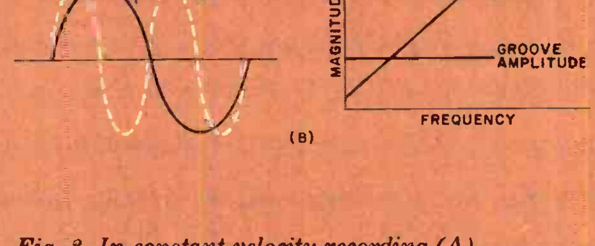



*Fig. 3. In constant-velocity recording (A), groove amplitude varies with frequency. In constant-amplitude recording (B), groove velocity varies with frequency.*

cutting system will break through the wall of one groove into the wall of the preceeding groove. The ratio of the maximum groove amplitude possible before cutover to the minimum amplitude that will provide an acceptable S/N ratio (generally 58 dB) determines the dynamic range of a recording. This has been found to be typically 32 to 40 dB.

The signal-to noise ratio (S/N) is governed mainly by the quality of the vinyl from which a disc is made. The grainy characteristic of the disc surface acts as a noise generator. In the recording process, the cutting stylus is heated to smooth out the graininess, and thus minimize on-disc noise. Of course, if high-quality vinyl (with small grains) is used, the overall noise level will decrease. Interestingly, the level of noise generated by the vinyl tends to be ten times greater than that generated by the preamp. It is not uncommon for wideband (white) noise levels due to surface irregularities to rise to 10 µV.

On the disc, an audio signal's amplitude is deposited in the form of groove modulation amplitude, and its frequency appears as the rate of change of groove modulation. This sounds simple enough, but why isn't the graph of Fig. 1 a straight horizontal line centered on 0 dB? After all, we are applying a signal of fixed amplitude.

The variation results from certain peculiarities of the recording head. Due to its physical construction, the velocity frequency response of the head (that is, how fast the cutting stylus moves in cm/sec when driven by a given input signal) exhibits a resonant peak at about 700 Hz. To counteract this undesirable effect and produce a velocity output independent of frequency, negative feedback coils are added. Therefore, the cutting head is known as a *constant velocity* device.

Figure 1 shows the pre-equalization of signals to be applied to the cutting head. The equalization curve has this particular shape for two reasons. First, low frequencies are attenuated to prevent cutover. Second, boosting the high-frequency content improves the S/N ratio. Because the driving coils of the cutting head are primarily inductive loads, their impedances are frequency dependent. If a fixed input signal causes a constant voltage to be applied across the coils, the resulting current, and thus magnetic field and rate of change of vibration, become frequency dependent. This is called *constant amplitude* recording.

Conversely, if a fixed input signal causes a fixed current to be applied to the driving coils, the resulting voltage and cutting amplitude becomes frequency dependent. This is called *constant velocity* recording. With respect to frequency, for a given input signal amplitude, the cutting head has only one degree of freedom — either vibrating *rate* (constant velocity from current drive) or vibrating *distance* (constant amplitude from voltage drive).

The terms constant velocity and constant amplitude tend to create confusion. But the key idea is that they have meaning only for a *fixed amplitude input signal*, and are used to describe the resulting behavior of the cutting head as a *function of frequency*. Changing the input level results in an *amplitude* change for constant amplitude recording, and a *velocity* change for constant velocity recording. These changes are *independent* of the input signal frequency. For example, if an input level of 10 mV results in a 0.1-mil (1 mil = 1/1000th of an inch) amplitude change for constant amplitude recording, and a velocity of 5 cm/sec for constant velocity recording, then a change of the input level to 20 mV would result in an amplitude of 0.2 mil and a velocity of 10 cm/sec — independent of frequency.

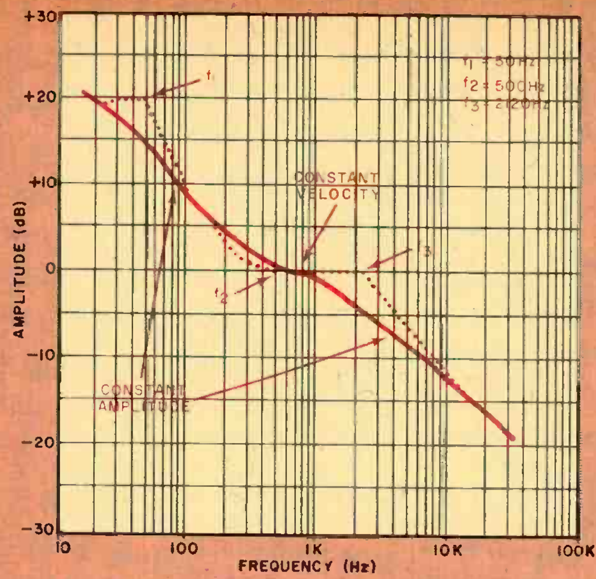



*Fig. 4. RIAA playback equalization compensates for the recording characteristic that was shown in Fig. 1.*

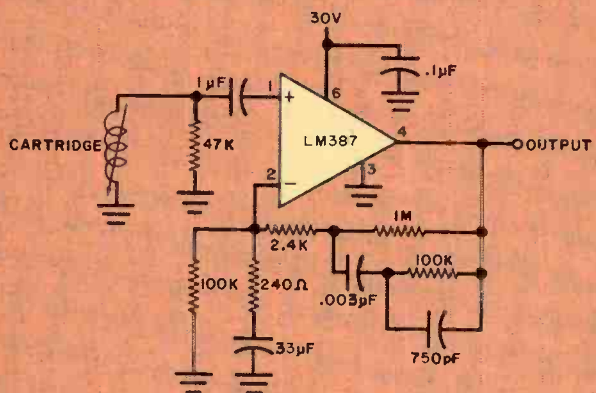



*Fig. 5. Schematic of a one-channel phono preamplifier design that uses the LM387 integrated circuit.*

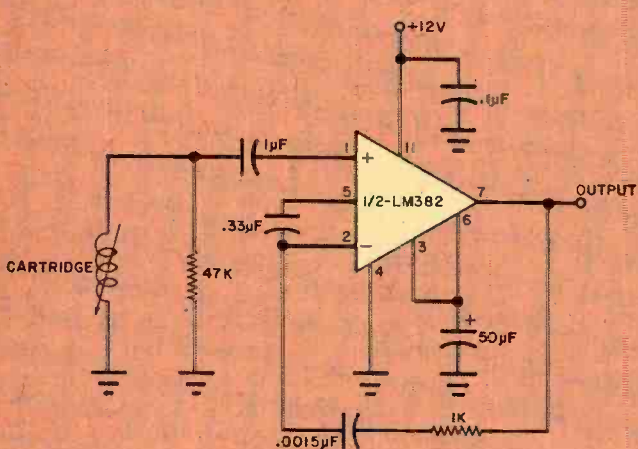



*Fig. 6. This phono preamp uses the LM382 IC and has a minimum parts count.*

Each of these recording methods suffers from dynamic range problems. Constant velocity recording (Fig. 3A) displays two readily observable characteristics. The amplitude varies inversely with frequency, and its slope is constant over the entire frequency range. This makes constant velocity recording ideal when magnetic pickups are used, as they are constant velocity devices. A magnetic cartridge consists of an active generator, such as a magnetic element moving in a coil (or vice versa). Its output is proportional to the speed of movement through the magnetic field, thus varying directly with groove velocity.

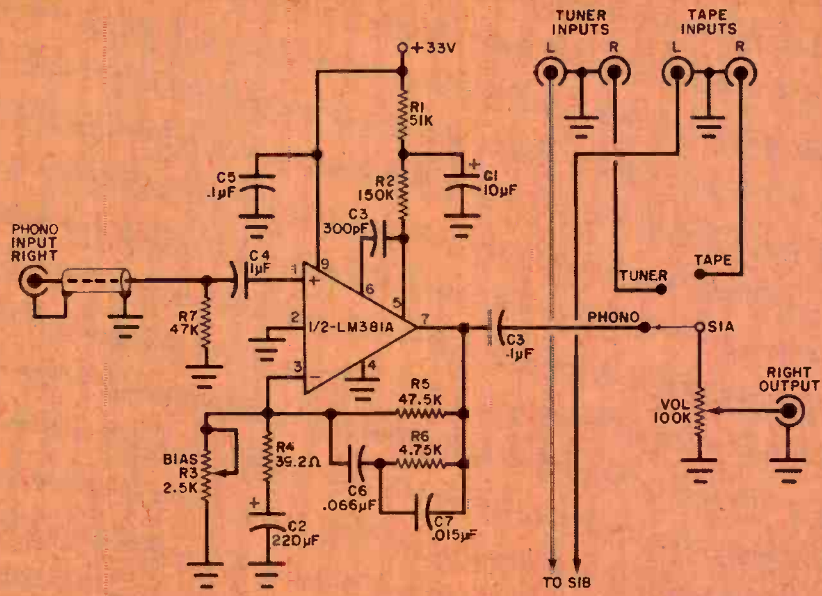
However, the variable-amplitude aspect of this system poses serious problems at both frequency extremes. Over the ten octaves between 20 and 20,000 Hz, the variation in groove amplitude is 1024 to 1. If 1000 Hz is taken as a reference point to establish the nominal degree of cutter amplitude modulation, then the amplitudes are so great at low frequencies that cutover will occur. At high frequencies, groove amplitude becomes so small that acceptable S/N ratios are unattainable. Indeed, displacement of the cutting stylus might not even take place.

Referring to Fig. 3B, two essentials of constant amplitude recording can be observed. In this case, groove amplitude is constant with frequency, which corrects the major disadvantage of constant velocity recording. But now groove velocity is directly proportional to frequency, and varies by a factor of 1024 to 1 over the frequencies of interest. Because magnetic pickups are constant-velocity and not constant-amplitude devices, their output levels will rise at the rate of 6 dB per octave, or double in amplitude when the frequency is doubled. To equalize such a system would require 60 dB of headroom in the preamplifier. That's not very practical!

The solution is to try and get the best of both systems by using a modified constant amplitude curve, where the midband region is allowed to operate in the constant-velocity mode. The resulting RIAA playback equalization curve is shown in Fig. 4, with the idealized version dotted and the actual realization drawn in a solid line. Three frequencies are noted as standard reference points, and are sometimes referred to as "time constants." This is a carryover from the practice of specifying corner or break frequencies by the time constants of the equivalent RC circuits that realized the response. The time constant $T$ is measured in seconds and is the product of $R$ in ohms and $C$ in farads ($T = RC$). The relationship between $T$ and corner frequency f (in hertz) is given by the equation $T = 1/(2\pi f)$, and results in time constants of 3180 µs for $f_1$, 318 µs for $f_2$, and 75 µs for $f_3$. Frequency $f_2$ is referred to as the *turnover* frequency because it marks the point at which the system changes from constant amplitude to constant velocity recording. Similarly, $f_3$ is the turnover frequency where the system reverts to constant amplitude recording.

**Ceramic and Crystal Pickups.** Before we consider the details of circuits providing the desired playback equalization for magnetic cartridges, a few words about ceramic and crystal transducers are in order. Unlike constant-velocity magnetic cartridges, ceramic and crystal pickups are constant-amplitude devices. Therefore they don't require equalization since their outputs are inherently flat. However, there will be some variation in output when these cartridges are used in an RIAA-equalized system. Referring to Fig. 4, we have noted that the region between $f_2$ and $f_3$ is the constant velocity portion of the curve. When a

*Fig. 7. This complete preamp features phono, tuner, and tape inputs, mode switching, low noise levels, and a volume control.*




constant-amplitude transducer operates there, its output will drop 12 dB between 500 and 2120 Hz. But this is not as serious a problem as you might think. These piezoelectric transducers tend to have poor frequency response anyway, and are used only in low-fi and mid-fi systems. Interestingly, a preamp is not necessary here. Output levels are so high (100 mV to 2 V) that the cartridge can drive a power amplifier directly through passive volume and tone controls without preamplification.

**Modern Designs.** Unlike ceramic and crystal pickups, magnetic cartridges have very low output levels and therefore require preamplification. Typical output levels for several popular cartridges at a velocity of 5 cm/sec are as follows:

| Manufacturer | Model | Output (mV) at 5 cm/sec |
|---|---|---|
| Empire Scientific | 999 | 5 |
| | 888 | 8 |
| Shure | V-15 | 3.5 |
| | M91 | 5 |
| Pickering | V-15 AT4 | 5 |

These outputs are directly proportional to velocity, so a cartridge producing 5 mV at 5 cm/sec will produce 1 mV at 1 cm/sec. It is specified as having a sensitivity of 1 mV/cm/sec. To transform cartridge sensitivity into useful preamp design information, we must know typical and maximum permissable velocities impressed on stereo records. The RIAA recording characteristic establishes a maximum recording velocity of 25 cm/sec in the 800-to-2500-Hz region. Typically, high-fidelity discs are recorded at a velocity of 3 to 5 cm/sec.

One low-noise IC circuit that will properly handle RIAA pre-emphasized program material is shown in Fig. 5. Corner frequencies $f_1$, $f_2$, and $f_3$ are set by combinations *C7R4*, *C7R10*, and *C8R10*, respectively. With the component values shown, it will drive a power amplifier with a 5-V rms input overload limit when it receives signal voltage from a cartridge with a 0.5-mV/cm/sec sensitivity. Since the maximum cartridge output level at 25 cm/sec is 12.5 mV, the required mid-band gain is 5V/12.5 mV or 400, and is determined by the values of *R6* and *R10*. Resistor *Rz* is inserted to stabilize the op amp, since the LM387 is not compensated for unity gain. An LM381 IC can be used in place of the LM387 by changing the appropriate pin designations.

We can make a very simple low-noise phono preamp by using the LM382 IC, which has an internal resistor matrix. The circuit is shown in Fig. 6, and has been optimized for use with a 12-to-14-volt dc supply. Its midband 0-dB reference gain is 46 dB (200) and can not easily be altered. For designs requiring gain or supply voltage changes, an LM381 or LM387 is a better choice.

An ultra-low-noise mini pre-amp based on the LM381A is shown in Fig. 7. Increased current density in the first stage of the LM381A is used to obtain optimum noise performance for magnetic cartridges. Included in this preamp are provisions for tuner and tape inputs, a mode selector switch, and ganged volume control. Tone controls are omitted but can be easily added if desired. The circuit's RIAA frequency response is within ± 0.6 dB of the standard. Its 0-dB reference gain is 41.6 dB (120), so a 1.5-V rms output signal will be generated when a nominal 12.5-mV rms input is applied. When a 33-volt supply is used, better than +25 dB of headroom (dynamic range) will be available for a typical 5-mV input signal at 1000 Hz. The input overload limit is 91 mV at midband frequencies. Signal-to-noise ratio is better than −85 dB, referenced to a 10-mV input level, and unweighted total output noise is less than 100 µV with the input shorted. Metal-film resistors and close tolerance capacitors should be used to minimize noise and maintain adherence to the RIAA playback characteristic.

**In Conclusion.** RIAA equalization is a method of impressing as much information on a vinyl disc as is practicable, given the inherent limitations of the recording process and the materials used. (The actual processes involved in making a disc have not been gone into in detail here. For such a description see "Stereo Scene" POPULAR ELECTRONICS, September 1975.) Fortunately, modern IC technology has made possible the design of phono preamps which can be inexpensively reproduced by a manufacturer or experimenter, and which provide excellent performance in terms of frequency response, noise levels, and distortion. ◈

# Recording For Stereo With 4-Channel Tape

*Mike setups and mixing hints for making better stereo recordings.*

BY DAVID L. LINKLETTER

RECORDING a live performance is a very satisfying accomplishment for an amateur tape enthusiast. It isn't as easy as it may seem, however, because setting down music in a pleasing stereo format requires the use of good recording techniques. These "tricks of the trade" have a decisive influence on the quality of the finished product. Here are some of the methods developed for live recording with a four-channel deck, followed by a mix-down to stereo to enhance sound quality.

**Miking.** Positioning the microphones is the first challenge. It's most important to set up microphones to avoid a "hole in the middle." (That happens when you play back in stereo and find program material left and right, but nothing in between.) Previously, recording engineers tried to overcome this by using a three-mike system. But now, with four-track machines, you can fill that hole without adding the directional blurring that results from using three microphones on two tracks. In practice, when you have four channels to work with, the best method is usually a combination of the three-microphone technique and the studio practice of miking some sound sources individually.

A typical setup for recording a band is shown in Fig. 1. Channels one and two are left and right, respectively. Drums are miked over the drummer's head and at the front of the bass drum. These two microphones are mixed onto channels one and two as "center" (individual miking of a sound source). The vocalist is recorded on channel three, and channel four is miked at a distance of 16 to 30 feet (4.9 to 9.1 m). These distances give a 15- to 30-millisecond delay, which is perhaps the ideal reverb time for maximum sonic clarity during reproduction. All microphones except the vocalist's have cardioid patterns, and all should be high-quality transducers which can handle high sound levels with a minimum of distortion.

Figure 2 shows miking techniques employed for a choir recital. Mikes one and two are mounted high, covering the left and right portions of the choir. The piano is miked left and right, with both mikes at least one foot away from the strings. Their outputs are mixed onto channels one and two as center and right. Solo performers are recorded onto channel three, and channel four is again the distant mike.

A playback configuration with tracks one and two as left and right, respectively, track three as center, and track four as rear will result in a very good simulation of the original performance. Notice how the three-microphone technique is adhered to, with the added benefit that the vocalist(s) are separated from the instruments and clearly centered no matter where your listening position is located. The delayed sound from channel four gives a fullness not otherwise possible, and the slight delay allows details in the performance that are normally masked a chance to be heard. In recording studios, electronic or electromechanical delay lines are used to create the same effect.

A total of six microphones is usually the ideal number, providing left, right, center, and back signals, with two microphones remaining for individual miking of instruments. Headphones that provide good acoustic isolation are imperative for the initial mixing of multiple-track recordings during the performance. The use of a high-quality omnidirectional mike for the lead singer is recommended. This type of microphone picks up sound from surrounding instruments, filling in the "hole in the middle." Secondly, a good omnidirectional mike is generally more resistant to wind noise and breath pops than is a cardioid (unidirectional) microphone.

The vocalist's recording mike should be fastened about two inches (5.1 cm) back from the PA mike (masking tape can be used). This will lessen the variation in signal levels caused by moving the microphone. At various times, singers can be as close as zero inches to about 4 inches (10.2 cm). If the recording mike is set back, the variation will be 2 to 6 inches (5.1 to 15.3 cm), which makes compensation easier. The inverse square law is at work here, so increasing the close distance will smooth out the sound pressure levels at the mike.

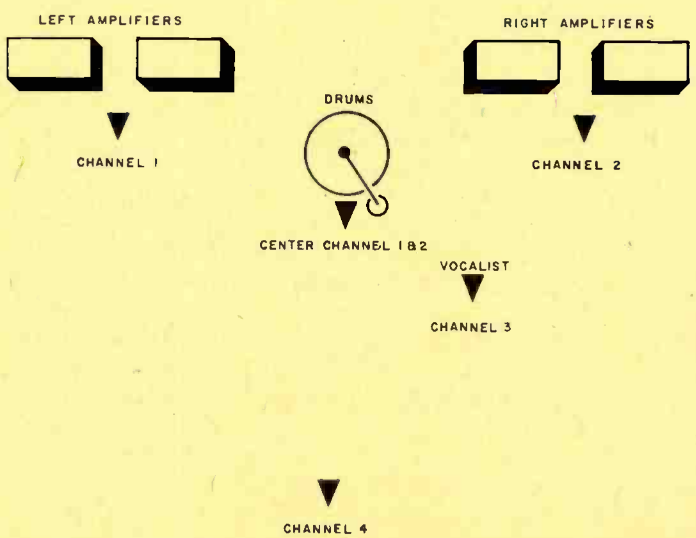



*Fig. 1. Typical setup for recording a band.*

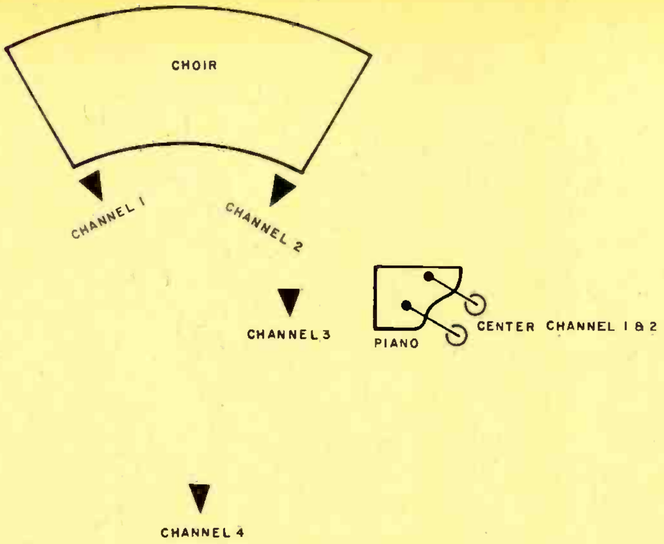



*Fig. 2. Miking techniques used for recording a choir include piano at right.*

**Before You Hit "RECORD."** Allow yourself an hour to set up before the performance begins. No matter how efficient you are, there are always ac power outlets to find, hum levels to reduce, etc. Be sure to get a level check from the band during its warmup. Record them at this time, and when all is quiet, listen to the playback. Is the balance between instruments correct? Are all the microphones getting onto the tape? The foregoing won't give you *perfect* settings because the acoustics will be somewhat different when the auditorium is filled with people. But you will get ball-park control adjustments that will require only minor changes later.

Level checks aren't always possible before choir recitals, but it's much easier to monitor the balance with headphones during the performance than is the case with a rock band. Be sure that the conductor knows you will be set up, and get approval for the location of your equipment *before* the night of the performance. (Classical musicians are sometimes "touchy" about electronics!)

Examine the recording area before the night or day of the performance if possible, and sketch a floor plan and layout of the instruments and vocalists you'll have to cover. From this information you can plan your miking setup. Clean and demagnetize the heads of your deck before you go to the performance. Bulk erase tape previously recorded, or use new tape for the recording session. This is especially important when using high-output/low-noise level tape—otherwise previous recordings on the tape might pop up in the background. Here are a few more items that are handy to have with you:

(1) A microphone snake—a consolidated set of mike extension cords to put some distance between you and the performers;

(2) Masking tape—tape all cords together to prevent interference with movement.

(3) A heavy-duty ac extension cord—Murphy's Law dictates that the nearest power outlet is at least 50 feet from where your equipment is positioned!

**The Mix.** When the tape is completed, odds are that friends of the performers will want copies for playback on their stereo decks. That's where the mix comes in—combining the four-track original and re-recording it into a two-channel format.

With proper care, the result can be clearer and more pleasing than a two-channel original. You can do some editing to reduce the dead time between songs, or rearrange the songs into a different sequence. The best equipment to use for the mix-down is a microphone mixer with line inputs. If you don't have one, you can make a passive mixer from six 33,000-ohm low-noise resistors, a utility box, and six line jacks (Fig. 3).

The problems that you'll face in mixing are compounded by the fact that final playback will be on someone else's equipment that might have limited frequency response, dynamic range, etc. It isn't uncommon for background instruments to simply disappear under the distortion products of the dominant instruments when a good recording is played on a low-fidelity stereo. Phil Spector and Don Kirschner have made their fortunes (in part) by producing records that sounded good when played over the finest system or the typical AM radio. Some of the basic techniques they helped develop are worth knowing, as follows.

First, volume range should be reduced. The difference between having four channels at medium-volume levels which swell to a peak is much greater than having two channels swell to a peak, and compensation for this difference must be made.

Second, mixing is best done by using two speaker systems. Choose one good pair for initial volume adjustments. The other pair should be a pair of inexpensive auto speakers. The need to keep volume levels fairly constant will become apparent when the second pair of speakers is used. Balancing the overall volume with that of the lead singer is very desirable. Reduce the band's level and boost the singer during vocals, then bring the band back up during bridges and instrumental passages. Not much change is necessary—even a 3-dB adjustment is often

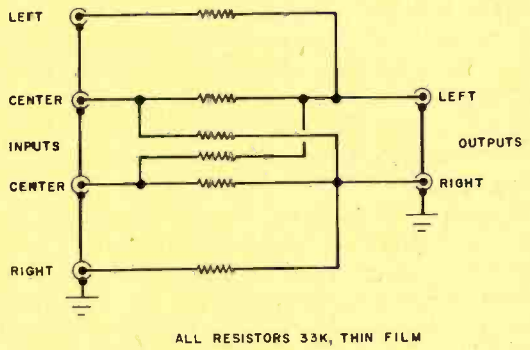


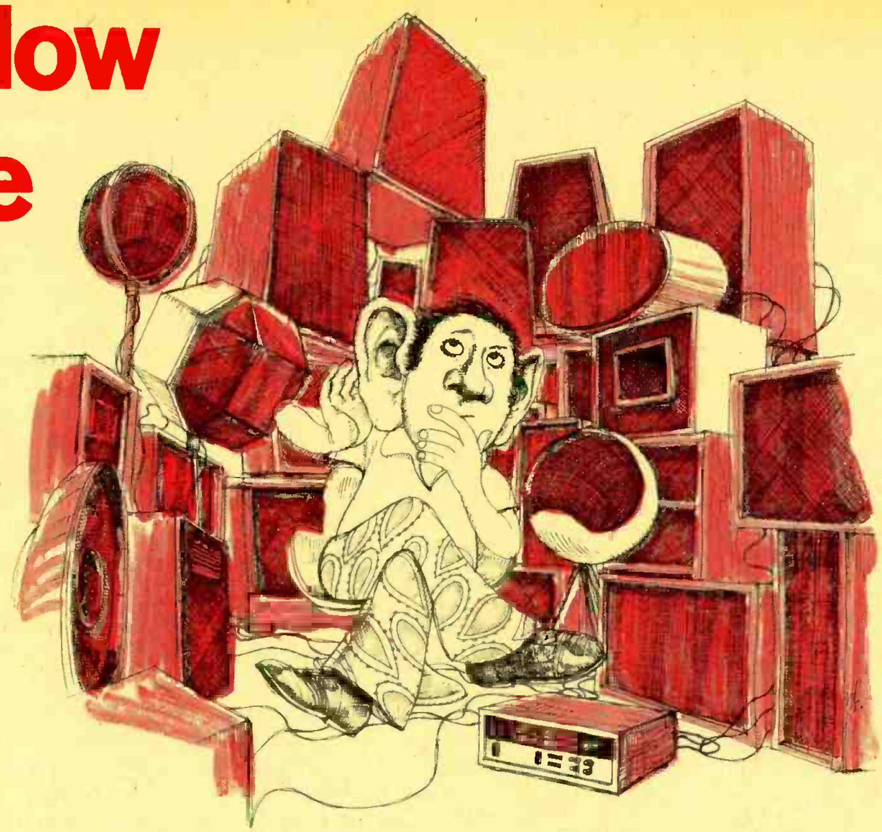

*Fig. 3. Passive mixer uses six 33,000-ohm resistors, utility box and six line jacks.*

adequate to keep sound within the optimum range. The fourth channel can be attenuated greatly during much of the mix and brought up only during instrumentals.

Third, use headphones that you know are balanced left to right to ensure that center information is really centered. Rely on your ears more than on the VU meters for this adjustment.

**In Conclusion.** Experience is really the best teacher of mixing methods. But it won't be long, if you follow these tips, before you will be able to provide mix-downs superior to two-channel originals. Of course, you will always be able to re-live the performance whenever you wish by using your four-track originals. ◈

# Tips On How to Choose Speaker Systems



*What to look for where performance is concerned.*

BY JOHATHAN R. SISK

YOUR CHOICE of speakers may affect the performance of your audio system more than any other component. Speaker systems should be chosen with the utmost care and forethought. However, this may be easier said than done. Most people have no real criteria for evaluating speakers and are usually persuaded to buy a particular product on the basis of enclosure type, number of drivers, size of the woofer, type of tweeter, etc. While these things do affect speaker system performance, they do not offer a concrete indication of performance. Manufacturing tolerances, design and engineering expertise, profit margin, and countless other things combine to determine the final performance and relative value of a given speaker system.

The objective in shopping for speaker systems is to find the products with the highest level of performance for a given price. The selection process may prove more confusing than enlightening on several counts. First, if you visit several dealers, you will quickly learn that there are an endless variety of claims and counter-claims. Second, unfamiliarity with specific performance criteria may limit your ability to evaluate what you hear in a dealer's showroom. Third, many dealers lack the knowledge and/or proper facilities to make valid comparisons between speaker systems. As a result, most people choose their speakers without the benefit of clinical testing or evaluation and usually settle for less than the best and may even buy an inferior product.

Buying speaker systems need not be a gamble — if you know beforehand what to look and listen for in the showroom. Just bear in mind that the function of any loudspeaker is to transform the electrical energy from an amplifier into sound waves and accurately recreate the recorded performance. Judging a speaker system's reproduction accuracy can be a very precise and scientific process if you thoroughly evaluate the following performance criteria one at a time.

**Tonal Balance.** Also sometimes known as octave-to-octave balance, tonal balance describes a speaker system's ability to reproduce tones from each of the 10 octaves of sound without emphasizing or diminishing the volume of any portion relative to another. A speaker system's tonal balance, more than any other factor, determines its characteristic sound.

Tonal balance is important for two reasons. First, it determines whether or not the relationship between the fundamental and harmonics (overtones) of a sound will be maintained during the reproduction. If this relationship is not maintained, the reproduced sound will differ in character from the recorded performance. Secondly, tonal balance determines to a large degree how long one can listen before experiencing listener fatigue.

To better understand the effects of a speaker system's tonal balance, one should examine the structure of a typical musical sound. Almost all sounds are a composite of a fundamental frequency and a series of harmonics at multiples of the fundamental. For example, the sound of a clarinet playing middle C is actually composed of a fundamental frequency of 262 Hz, second harmonic of 524 Hz, third harmonic of 768 Hz, fourth harmonic of 1048 Hz, and so on. These harmonics differ from the fundamental and from each other in relative amplitude.

The harmonic structure of an instrument's sound is what determines its distinctive quality or timbre. Obviously, if a speaker system has a large emphasis or de-emphasis in a portion of its range (poor tonal balance), this will change the value of all fundamentals and harmonics that fall within this range and thereby change the actual harmonic structure and the sound one hears.

Tonal balance is evaluated by carefully listening to a variety of recorded material to determine just how closely the timbre of the reproduction matches the original sound. This is accomplished in a side-by-side comparison, where each speaker system can be used as a reference point for another, eliminating possible confusion.

Since a speaker system with excellent tonal balance will sound good with a wide variety of music, it is wise to include samples from all categories, even if your own personal tastes and interests may not be that broad. This is necessary to avoid the possibility of being misled because a particular speaker system's deficiencies in tonal balance happen to be sympathetic with a particular record. Some recordings this author has found most suitable for judging tonal balance are listed under Tonal Balance in the box.

The main criterion for judging tonal balance in a comparison test is simply to determine which system sounds most like the real thing.

For the results of an evaluation to be most meaningful, it is imperative that all comparisons be made with each speaker system playing at the same loudness. If one system is even slightly louder than another, some of the finer details of tonal balance will be obscured. Almost always, the louder system, regardless of its basic quality, will sound better at the instant of comparison. This is a serious problem because most speaker systems play at different levels of loudness for a given amount of amplifier power. To avoid this problem, many of the better dealers have special loudness-compensation switches in their demonstration facilities so that the individual level of each speaker system can be precisely matched for a valid comparison. Without such a device, the volume control of the amplifier must be adjusted with each change of speaker systems.

**Frequency Range.** The low and high frequency limits of a speaker system describe its frequency range. The range of human hearing is generally from about 16 to 18,000 Hz, or roughly 10 octaves of sound. A speaker system should reproduce as much of this range as possible. While most speaker systems of recent design are able to exceed the high frequency limitations of human hearing, very few even approach the 16-Hz lower limit. In fact, the vast majority of good systems do not reproduce sounds below 40 Hz without deterioration of the sound quality. Therefore, when considering how wide a range of frequencies a system will reproduce, your primary concern should be how far into the deep bass range, below 50 Hz, the system will reproduce without severe distortion. Deep bass response is important for accurate reproduction of the pipe organ, bass drum, piano, bass violin, contra bassoon, electric bass guitar, and other instruments whose fundamental tones may lie in the range below 50 Hz.

Many people are misled by speaker systems whose mid-bass range (50 to 100 Hz) has been exaggerated to conceal a deficiency in deep bass. The quantity of bass in systems like this is high, the system often sounds "boomy" and lacks the impact and depth of the original instrument it is trying to reproduce.

Before attempting to test or compare deep bass response, you should find one or more recordings with very evident low-frequency tones. A few recordings this author recommends are listed under Frequency Range in the box.

In the deep-bass test, as in all other tests, it is imperative that all comparisons be made under conditions of equal loudness and placement. Also, since many speaker systems do not reproduce very deep bass tones, the amplifier's volume control setting must be previously determined with music of predominantly middle- and high-frequency content. Using this criteria, you should readily hear the differences in deep-bass response between speaker systems by switching from one to another when low tones are present and sustained in the music.

**High-Frequency Dispersion.** One of the unusual properties of sound reproduction is that, as a tone goes up in pitch (increases in frequency), the pattern of dispersion from the speaker tends to become narrower. At very high frequencies, the sound may be concentrated in a narrow path directly in front of the reproducing driver. This is undesirable because it produces inconsistencies in tonal balance throughout the listening room. Areas directly in front of the speaker system have an abundance of high frequencies, while other areas not within the dispersion pattern have a deficiency in high-frequency response.

With poor dispersion, one must listen from directly in front of the speaker system to hear properly balanced sound. This obviously limits speaker system placement. Conversely, the sound of a speaker system with good dispersion characteristics remains the same when you listen to it from almost any location in the room, and its sound should be less dependent on its physical position in the room.

Evaluating dispersion characteristics is accomplished by comparing the high-frequency balance one hears when standing directly in front (on-axis) of the speaker system to the balance one hears at various angles standing to the side (off-axis) of the system. The farther off-axis one can hear a good balance of high frequencies, the better the dispersion. With good dispersion, you should be able to hear no significant change in frequency balance when listening as much as 45° off-axis.

When performing a comparison, remember that the objective is to determine differences between on- and off-axis frequency response, not differences in tonal balance. Therefore, instead of the usual A-B test method, determine to what degree high-frequency dispersion is maintained for each speaker system on an individual basis and compare measurements. The speaker system that maintains its high-frequency output the farthest off-axis has the better dispersion.

It is recommended that all dispersion testing be done with the amplifier's controls set to mono and the balance control set so that only the right or the left channel is active. This will eliminate possible interference from the other speaker system, which could invalidate what you hear.

Dispersion-evaluation recordings should contain an abundance of high-frequency sounds (see listings under Dispersion in box). Also, many people evaluate dispersion by using the high-frequency interstation noise between FM stations.

**Transient Response.** A speaker system's ability to accurately reproduce sudden momentary increases in volume is termed transient response. The "explosive" sounds can be produced by most instruments, especially the percussion variety, when they are struck, strummed, or plucked. The human voice, too, produces transients when pronouncing the consonants b, p, and t.

Transients are musically important because they give impact and expression to a performance. Musicians use varying intensities of transients to create the moods they desire to convey to an audience. Cymbal crashes are just one example of this.

## TEST RECORDS

The following is a list of recordings for testing various features of speaker systems. To test a given performance feature, select a recording from the category to which it refers.

**Tonal Balance**

Cat Stevens: *Numbers*, A&M CS5749
Joni Mitchell: *Court and Spark*, Asy. 1001
Holst: *The Planets*, London CS6734
Bach: *Three Cantatas*, Advent D1016
Frank Sinatra: *Ol'Blue Eyes Is Back*, Reprise 2155
Quincy Jones: *Body Heat*, A&M 3617

**Frequency Range**

Saint-Saens: *Symphony No. 3 in C*, Columbia MS6469
Pink Floyd: *Dark Side of the Moon*, Harvest SMA11163
Richard Strauss: *Also Sprach Zarathustra*, London CS6609
Bob James: *Volume I*, CTI 6043

**Dispersion**

Rick Wakeman: *Journey to the Center of the Earth*, A&M 3621

**Transients**

Peter Frampton: *Frampton*, A&M 4512
Thelma Houston and The Pressure Cooker: *I've Got the Music In Me*, Sheffield Lab 2
Igor Kipnis: *The English Harpsichord*, Angel SB3816

**Spatial Characteristics**

The Carpenters: *Horizon*, A&M 4530
Bernard Hermann: *The Mysterious Film World of Bernard Hermann*, London SPC21137

To evaluate or compare transient response, you should select recordings that feature well-recorded piano, drum, bell, acoustic guitar, banjo, cymbal, etc., sounds. Listen for the impact (attack) and sharpness of the transients. Generally, a speaker system with good transient response will make the music sound detailed and "live." (For recordings with obvious transient characteristics, see listings under Transients in box.)

**Spatial Characteristics.** It is difficult to define spatial characteristics and imagery because there are no clear-cut, analytical methods of measuring them. Rather, they must be evaluated by the subjective impressions of the listener.

Generally, the terms spatial characteristics and imagery refer to a speaker system's ability to recreate the ambient, or reverberant, qualities of the recorded music and to achieve the acoustic position and perspective of the various instruments and voices. For example, a speaker system with exceptional imagery can reproduce a recording of a small ensemble and provide a definite position for each performer. Yet, it can also reproduce the sound of a symphony orchestra and give the vast open feeling of a concert hall. Good spatial characteristics and imagery add the elusive quality of "realism" to a good speaker system by producing a three-dimensional perception of depth.

To evaluate spatial characteristics and imagery, it is recommended that you first listen to a recording of a single vocalist with a small backup ensemble to test for the ability of the speaker system to assign definite placement to the voice and individual instruments. An excellent recording for this purpose is the first entry under Spatial Characteristics in the box. Then listen to an orchestral recording (see second entry) to test for the recreation of the ambient atmosphere of the concert hall. It helps significantly if you close your eyes during the test and try to visualize the placement of the different sounds from the speaker.

**Efficiency.** Speaker system efficiency is the ratio of the amplifier input in electrical watts to the speaker system's output in dB of sound-pressure level. Phrased differently, it is how many watts are needed to achieve a certain level of loudness from a given speaker system. Systems of very high efficiency require less amplifier power to produce the same level of loudness obtained from a low-efficiency system.

**Power Matching.** One of the most important aspects of choosing speaker systems is to match the proper amount of amplifier power to the speakers, according to the conditions under which they will be used. There are four basic factors to consider when power matching: the efficiency of the speaker systems, the cubic volume of the listening room, the type of furnishings in the room, and the level of loudness at which you normally listen to your music.

For every combination of speaker systems, listening room, and listener, there is a minimum level of amplifier power that will deliver the desired loudness level with good sound quality. Using less than this minimum power can cause the amplifier to be overdriven during the louder portions of the music, which causes distortion. This type of distortion is called "clipping" because the amplifier is unable to produce the full strength of the musical signal and literally clips off the top and bottom of the waveform during amplification.

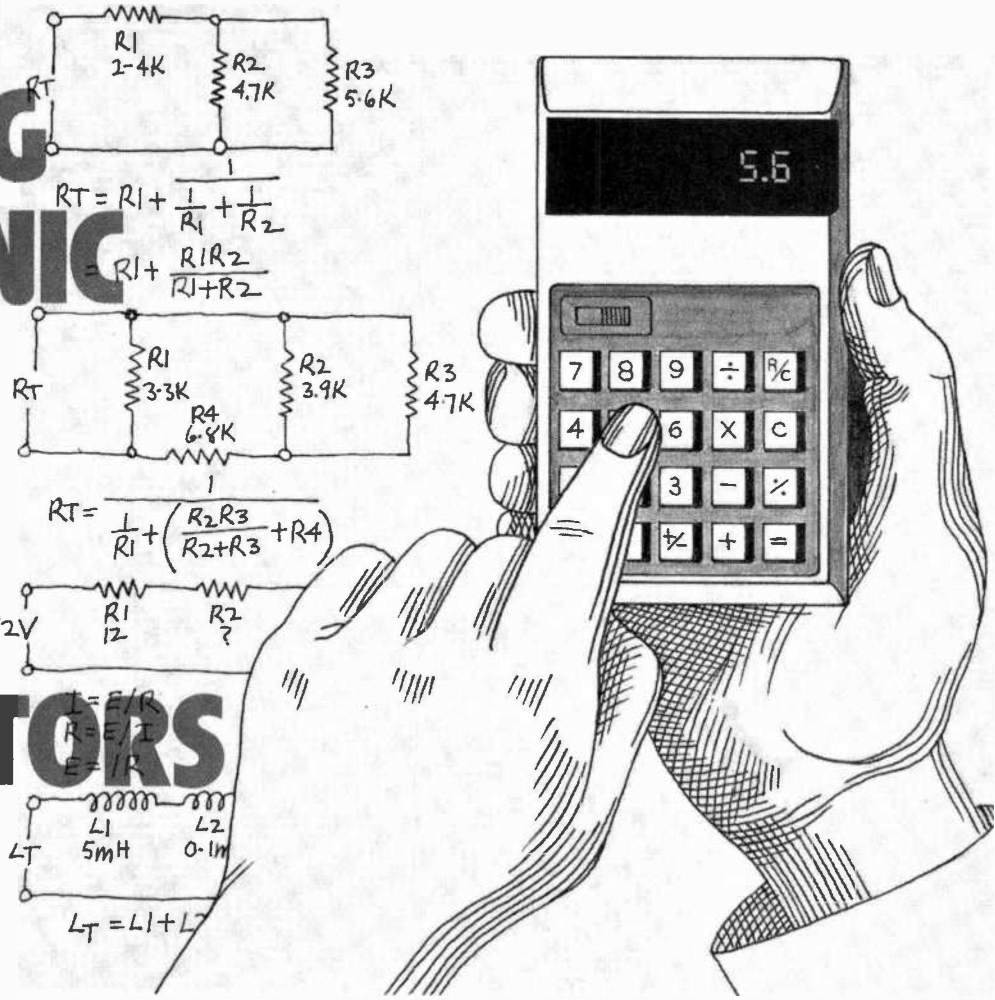
Many manufacturers recommend a minimum amount of amplifier power for their speaker systems. This figure is usually valid for the listener who does not require excessive volume and where the listening room is less than 1500 cubic feet (42.5 cu m) in volume. As the size of the room increases, the power of the amplifier must be increased by the same factor; double the volume, double the power to maintain the same level of loudness.

Soft, absorbent room surfaces, such as drapes, carpets, stuffed furniture, and open doors or entry ways, increase the need for power. If you desire extreme loudness, significantly more power will be required (a barely audible increase in loudness requires double the power). It is obvious, then, that if you like to listen at high volume levels in a large "soft" room, the manufacturer's minimum power recommendation will be inadequate.

The speaker system's minimum power requirement must not be confused with the "power-handling" specification. Many people have bought the wrong amplifier for their needs by matching the speaker system's power-handling specification to the amplifier's output power specification. If a manufacturer describes his product as a "30-watt speaker system," this means that 30 watts is the maximum amount of *continuous* power the system can safely handle. If the manufacturer does not specify the minimum power for the speaker system, seek the help of a knowledgeable and trustworthy dealer.

To properly match power, begin with the manufacturer's recommendation and then make allowances for room size and furnishings and for listening level. If possible, you should audition the exact combination of hi-fi components you are considering using in your listening room before making a final decision. ◈

# LEARNING ELECTRONIC THEORY WITH HAND CALCULATORS




BY EDWARD M. NOLL

## PART THREE: RC Coupling, Basic Amplifier Calculations, and RLC Relationships

WITH THIS installment, we close our three-part series on using the hand-held scientific calculator in electronics. We will be focusing on RC coupling, basic amplifier calculations, and RLC relationships.

**RC Coupling.** When resistor-capacitor (RC) coupling is used between the stages of an amplifier, the output voltage appears across the resistor, as shown in Fig. 1. The reactance of the capacitor ($X_C$), a function of frequency, determines what percentage of the input voltage to the RC network appears across the output.

When the reactance of the capacitor is low in comparison to the resistance, most of the output voltage appears across the resistor. You can prove this with a few simple calculations. For example, what is the input impedance for the RC network shown in Fig. 1 when $X_C$ is 1 ohm and R is 100 ohms. Using the equation $Z = \sqrt{X_C^2 + R^2}$:

1 x² + 100 x² = √x

Display: 100.0049998

Calculate the current when $V_{in}$ is 100 volts, using the Ohm's Law equation $I = V_{in}/Z$:

100 ÷ 100.0049998 =

Display: 9.999500044 −01

At this current, what is the output voltage across the resistor? Again, from Ohm's Law, we have $V_R = IR$:

.9999500044 × 100 =

Display: 99.99500044

Note that the output voltage is almost 100% of the input voltage.

Use the equation $P = I^2R$ to calculate the output power:

.999950004 x² × 100 =

Display: 99.99000105

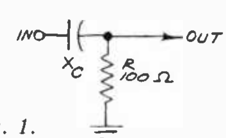



*Fig. 1.*

Now, repeat the same calculations when $X_C = R = 100$ ohms. You should obtain the following results:

Z = 141.4213562 (ohms)

I = 7.071067813 −01 (amperes)

$V_{out}$ = 70.71067813 (volts)

P = 50.00000002 (watts)

By how much have the voltage and power declined when $X_C$ is 100 ohms as opposed to when it was 1 ohm? For the voltage equation, use dB = 20 log ($V_2/V_1$):

20 × ( 70.71067813 ÷ 99.99500044 ) log = Display: −3.009865686

For the power equation, use dB = 10 log ($P_2/P_1$):

10 × ( 50.00000002 ÷ 99.99500044 ) log = Display: − 3.01008282

Note that in both cases, the level is down 3 dB. What this calculation proves is that at the frequency at which $X_C = R$, the voltage across R drops 70.7%, while the power dissipated by R drops 50%. This point is commonly referred to as the cutoff frequency, half-power point, or the 3-dB down point.

As an exercise in using the calculator, determine the parameters for the frequency at which R = $10X_C$. The results you obtain should be as follows:

Z = 100.4987562 (ohms)

I = 9.950371903 −01 (ampere)

$V_{out}$ = 99.50371903 (volts)

How much lower is the output voltage than the input voltage? By simple subtraction, we obtain

100 − 99.50371903 =

Display: 0.496281 (volt)

Our calculations indicate that the output voltage drops a very small amount at the frequency at which $X_C$ = 0.1R. From this, we can develop an equation for C that will let us calculate the required value of capacitance: R = 10/(2πfC), which gives us C = 10/(2πfR). The latter equation is often used to determine the value of the interstage coupling capacitor that results in a minimum voltage loss in transferring a signal from the input to the output of the RC network. Recall that a corresponding equation can also be developed for that frequency at which the response is permitted to drop to the 70.7% level (3-dB down point): R = $X_C$, in which case, R = 1/(2πfC) and C = 1/(2πfR).

Several examples demonstrate the usefulness of the equations:

What is the value of C required in an RC network to set the −3-dB point at 40 Hz when R is 240,000 ohms?

2 × π × 40 × 24 EE 4 = 1/x

Display: 1.65786399 −08

Hence, the value required is roughly 0.016 μF; a 0.02-μF capacitor can be used. There would be a 7.07-volt output if the input were 10 volts at 40 Hz. Increasing the frequency to 400 Hz would result in the reactance becoming $0.1X_C$ to make the output potential 9.95 volts, or a reduction of only 0.05 volt (10 − 9.95 = 0.05).

In the above circuit, what value of C would be required so that an input of 10 volts at 100 Hz would produce 9.95 volts at the output? In this case, you must make certain that $X_C$ is no greater than 0.1R. Using the equation C = 10/(2πfR):

10 ÷ ( 2 × π × 100 × 24 EE 4 ) = Display: 6.63145596 −08

Needless to say, a capacitor with a larger value would be required; this time, 0.068 μF would be appropriate.

In an RC circuit where C is 0.05 μF, what minimum R value would be required to have a −3-dB point at 120 Hz? From the formula R = 1/(2πfC):

2 × π × 120 × .05 EE +/− 6 = 1/x Display: 26525.82384

Which means that R should be roughly 26,500 ohms. Now, what would R's value have to be at 120 Hz if it was

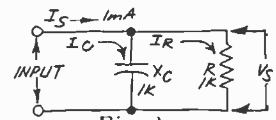



*Fig. 2.*

required that the output voltage be down by only a very small amount? In this case, $X_C$ would have to be no more than 0.1R. Hence, a ten-fold increase in the value of R, to 265,000 ohms, is indicated.

In the parallel RC network shown in Fig. 2, it is a current variation that develops a signal voltage across the network. Let us assume first that there is no capacitor. This means that a 2-mA input current will produce a 2-volt potential across R:

.002 × 1000 = Display: 2

Assume now that both R and C are in the circuit and that $X_C$ is 1000 ohms. What is the impedance of the network? Use the formula Z = $RX_C / \sqrt{R^2 + X_C^2}$:

1000 × 1000 ÷ ( 1000 x² + 1000 x² ) √x =

Display: 707.1067813

The voltage across the network is calculated from the formula V = IZ:

.002 × 707.1067813 =

Display: 1.414213563

To what level has the voltage declined, compared to the level obtained with no capacitor in the circuit? This voltage ratio is obtained simply by dividing V by 2:

1.414213563 ÷ 2 =

Display: 7.071067815 −01

What happens to the voltage when $X_C$ drops to 100 ohms? First, solve for Z:

1000 × 100 ÷ ( 1000 x² + 100 x² ) √x =

Display: 99.50371903

Note the decided drop in the impedance of the network. With this in mind, what is the output voltage?

.002 × 99.50371903 =

Display: 1.990074381 −01

In this case, where $X_C$ = 0.1R, the output voltage has dropped to approximately 0.2 volt, or one-tenth of the potential that existed when there was no capacitor present. This demonstrates the filtering action of a parallel RC network. The approximate decline here is 90%.

What value of C is required to maintain the above level of filtering down to 100 Hz? [Use the equation C = $(1/2\pi fX_C)$]:

2 × π × 100 × 100 = 1/1

Display: 1.59154943 −05

A 20-μF capacitor would do a good job here.

**Amplifier Calculations.** Amplifiers require a number of series and parallel RC networks for decoupling, interstage coupling, and filtering. The FET amplifier stage shown in Fig. 3 employs a series RC coupling network in the gate and a parallel RC bias/filtering network in the source circuits.

The input coupling network has component values designed to complement the input impedance characteristics of the FET and low frequency response of the stage. The input impedance to the FET is high and, therefore, input resistance to the stage is determined by the value of gate resistor $R_g$. Source resistor $R_s$ determines the gate-source bias, while source

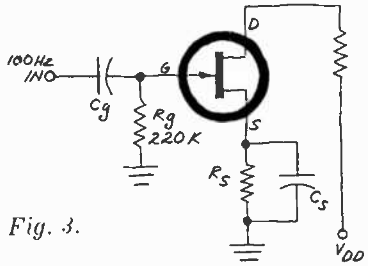



*Fig. 3.*

capacitor $C_s$ prevents feedback that could cause a loss of gain in the stage.

What value of $R_s$ is required if the operating point corresponds to a drain-source current of 15 mA and gate bias of −7.5 volts? From the formula $R_s = V_G/I_D$:

7.5 ÷ 0.15 = Display: 500

If the frequency response of the input network must have a cutoff of 100 Hz, what is the required value for $C_g$? The −3-dB point is that frequency at which $X_C$ is equal to R:

2 × π × 100 × 22 EE 4 = 1/x

Display: 7.234315592 −09

Hence, the required value for $C_g$ is approximately 0.007 μF. Since the actual value is not critical, a 0.01-μF capacitor will suffice here.

If the source filter is to operate efficiently at 100 Hz, the reactance of $C_s$ must be $0.1R_s$. Therefore, the reactance must be 50 ohms (500/10). The value of $C_s$ is obtained from the equation $C_s$ = 1/(2πfR):

2 × π × 100 × 50 = 1/x

Display: 3.183098861 −05

A 31.8-μF capacitor is required here.

**RLC Networks.** Electronic systems often contain circuits that use combinations of resistors, capacitors, and inductors in various resonant and nonresonant configurations. The simple series network shown in Fig. 4 is an example.

The voltages across the three elements in Fig. 4 are not in-phase, because the capacitive voltage lags the current by 90°, while the inductive

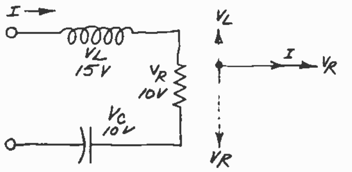



*Fig. 4.*

voltage leads the current by 90°, as illustrated in the vector diagram. Phase relationships depend on frequency and the relative magnitudes of R, L, and C. The equation for source voltage is $V_S = \sqrt{V_R^2 + (V_L - V_C)^2}$. For the component values given in Fig. 4, $V_s$ becomes:

10 $x^2$ + ( 15 − 10 ) $x^2$ =

$\sqrt{x}$ Display: 11.18033988

As in the case of the simple series RC network, the vector diagrams can be drawn in terms of reactance and resistance, as shown in Fig. 5. Capacitive reactance $X_C$ lags resistance R by 90°, while inductive reactance $X_L$ leads R by 90°. The equation for impedance is $Z = \sqrt{R^2 + (X_L - X_C)^2}$. The phase angle of the network is the angle between R and Z and in equation form is $\theta$ = arc cos R/Z.

Notice the influence of subtracting $X_C$ from $X_L$ in the vector diagram. This results in a certain equivalent reactance, or $X_{EQ}$. Inasmuch as this reactance leads the resistance, it is in effect an equivalent inductive reactance. If $X_C$ were greater than $X_L$, the network would have an equivalent capacitive reactance.

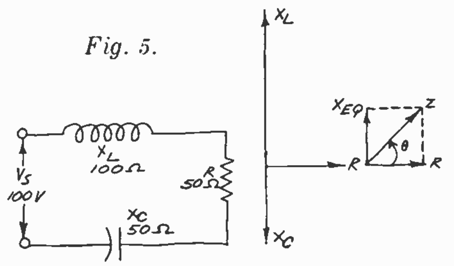
Calculate the impedance for the reactive values given in Fig. 5.

50 $x^2$ + ( 100 − 50) $x^2$ =

$\sqrt{x}$ Display: 70.71067811

This means that Z is approximately 70.7 ohms. Now, what is the phase angle?

*Fig. 5.*



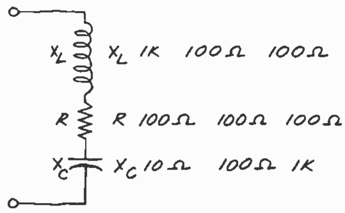




*Fig. 6.*

50 ÷ 70.71067811 = $\cos^{-1}$

Display: 45

Hence, the impedance angle is 45°, and Z is leading R by this amount.

Determine the source current, using the equation $I_S = V_S/Z$:

10 ÷ 70.71067811 =

Display: 1.414213562 −01

Once your know $I_S$, you can calculate $V_R$:

.141421356 × 50

Display: 7.07106781

Now, how much power is dissipated by the resistor? Using the equation $P = I_S^2R$:

.141421356 $x^2$ × 50 =

Display: 9.999999965 −01

This is the true power dissipated by the network, since no power is dissipated by the ideal reactance.

Next, determine the impedance and current for each of the three sets of component values given in Fig. 6. Note that the three sets of values illustrate the three possible conditions that can exist for the network — $X_L$ greater than $X_C$, $X_C$ greater than $X_L$, and $X_L$ equal to $X_C$. Solving for the impedances:

100 $x^2$ + ( 1000 − 10 ) $x^2$

= $\sqrt{x}$ Display: 995.0376877

100 $x^2$ + ( 100 − 100 ) $x^2$

= $\sqrt{x}$ Display: 100

100 $x^2$ + ( 1000 − 10 ) $x^2$

= $\sqrt{x}$ Display: 995.0376877

And solving for the currents:

100 ÷ 995.0376877 =

Display: 1.004987058 −01

100 ÷ 100 Display: 1

100 ÷ 995.0376877 =

Display: 1.004987058 −01

It should be noted that Z is high and I low when the reactive component is substantial. When $X_L = X_C$, impedance is low and current is high. This is the condition for a series-resonant setup, with a minimum Z and maximum I at resonance.

The resonance condition of equal reactances can be arranged to obtain the standard formula for resonance as follows: $2\pi fL = 1/(2\pi fC)$ and transposing, $f = 1/(2\pi\sqrt{LC})$. With this in mind, calculate the L and C values required to resonate the Fig. 6 circuit at 2 MHz when $X_L$ and $X_C$ are 100 ohms each. Since $X_L$, $X_C$, and f are known, L and C can be calculated from the formulas $L = X_L/(2\pi f)$ and $C = 1/(2\pi fX_C)$:

100 ÷ ( 2 × π × 2 EE 6 ) =

Display: 7.957747151 −06

and 2 × π × 2 EE 6 × 100 = 1/x

Display: 7.957747151 −10

The L and C values required are approximately 8 μH and 800 pF, respectively.

You can prove the validity of your calculations by plugging the answers obtained into the equation for the resonant frequency.

2 × π × ( 7.957747151 EE +/−

6 × 7.957747151 EE +/− 10 ) $\sqrt{x}$ =

1/x Display: 2000000 or 2 MHz

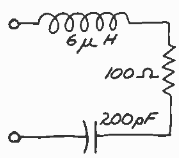
The example shown in Fig. 7 will give a better understanding of the operating conditions of the series-resonant circuit and how to use your scientific calculator to speed mathematical procedures. First, determine the circuit's resonant frequency:

2 × π × ( 6 EE +/− 6 × 200

EE +/− 12 ) $\sqrt{x}$ = 1/x

Display: 4594407.462

*Fig. 7.*




Now you can calculate $X_C$ and $X_L$:

2 × π × 4594407.462 × 200 EE

+/− 12 = 1/x

Display: 173.2050807

and 2 × π × 4594407.462 × 6 EE

+/− 6 = Display: 173.2050808

The reactances are almost identical at 173 ohms. Since at resonance $X_C = X_L$, the two reactances cancel out and effectively leave only the R value in the circuit. The current at resonance is determined by the formula $I = V_S/R$:

10 ÷ 100 = Display: 0.1 (ampere)

In the parallel RLC network shown in Fig. 8, the current divides and the source voltage is the same across each element and is of the same phase

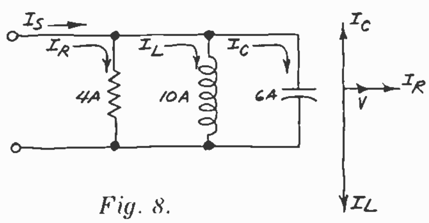



*Fig. 8.*

as the resistor current. As shown in the vectors, $I_C$ leads $I_R$ and $V_S$ by 90°, while $I_C$ and $I_L$ are 180° out of phase with each other. The equation for $I_S$ becomes $I_S = \sqrt{I_R^2 + (I_L - I_C)^2}$. Determine $I_S$ for the Fig. 8 network:

$4\ x^2 + (\ 10 - 6\ )\ x^2 = \sqrt{x}$

Display: 5.656854249

Because current is the quotient of voltage and the individual resistance, reactance, and impedance, the vector diagram can be redrawn as shown in Fig. 9A. Furthermore, the voltage is the same across each leg of the parallel arrangement, and the vector diagram can be simplified as in Fig. 9B. Hence, the impedance formula is $Z = 1/\sqrt{(1/R)^2 + (1/X_C - 1/X_L)^2}$. Now you can calculate Z for the Fig. 10 circuit:

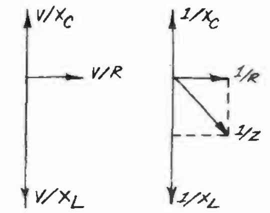



Fig. 9.

$100\ 1/x\ x^2 + (\ 10\ 1/x - 20$

$1/x\ )\ x^2 = \sqrt{x}\ 1/x$

Display: 19.61161351

Calculate $I_S$ when $V_S$ is 100 volts:

$100 \div 19.61161351 =$

Display: 5.099019514

Now, calculate Z if $X_C$ were to be increased to 20 ohms. Since in this event $X_C$ would be equal to $X_L$, the reactances cancel, leaving only R in the circuit. You can double check this on your calculator:

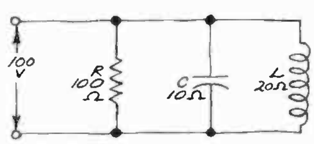



Fig. 10.

$100\ 1/x\ x^2 + (\ 20\ 1/x - 20$

$1/x\ )\ x^2 = \sqrt{x}\ 1/x$

Display: 100

The calculation proves that only the resistive element is effectively in the circuit when $X_C$ and $X_L$ are equal.

**Summing Up.** In this series of articles, we have shown how the hand-held scientific calculator lets you pursue electronics without the drudgery of inconvenient mathematical procedures. The calculator permits the solution of even lengthy problems in only a fraction of the time required by hand and with a great deal more accuracy.

As you become more familiar with the operation and capabilities of your calculator, you will in all likelihood want to dig much deeper into electronics theory. ◈

# LED BARGRAPH READOUTS

*Measure voltage, resistance, and frequency*

BY FORREST M. MIMS

IN THE ongoing revolution of digital electronics, the old-fashioned meter movement has almost been replaced by rows of plastic encapsulated LED digital display modules. Despite the accuracy and convenience of digital displays, however, the analog meter movement offers several important advantages over the more modern digital display.

Have you ever tried to observe trends on a digital voltmeter or frequency meter? Good luck, because the trend of a slowly changing voltage or frequency is tough to follow on a digital readout. For example, a meter needle will instantly indicate a fluctuating voltage by simply bouncing back and forth while a digital readout presents a series of seemingly unrelated readings.

The LED bargraph described here bridges the gap between the conventional meter and the digital display. Bargraph readouts consist of a linear row of LED's which light up in response to voltage, resistance, or frequency. Like meters, they present an analog readout and can therefore show trends. And like digital displays, they are solid state and have no moving parts. This means they are "inertialess" and have responses thousands or more times faster than conventional meters. It also means an LED bargraph readout has no undershoot or overshoot and, best of all, cannot be "slammed."

If LED bargraph readouts sound interesting, read on, as we show you how to build several different voltage, resistance, and frequency sensitive readouts.

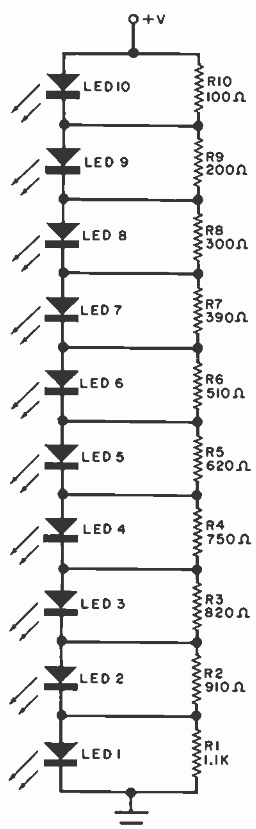



*Fig. 1. Resistor voltage-sensitive bargraph.*

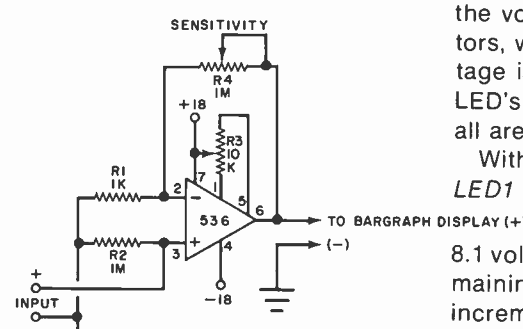



*Fig. 2. Bargraph readout with op amp input.*

**Resistor Voltage-Sensitive Bargraph.** You can make a simple but reliable LED bargraph readout from a string of resistors connected across a string of LED's as shown in Fig. 1. The resistors form a voltage divider. A single LED requires a certain forward voltage to produce light, and each LED in the circuit glows when the voltage across its resistor reaches this value. Since the voltage across the larger resistors increases faster than the voltage across the smaller resistors, when a gradually increased voltage is connected to the circuit, the LED's begin glowing sequentially until all are turned on.

With the values shown in Fig. 1, *LED1* will begin glowing with about 8.1 volts applied to the circuit. The remaining LED's will begin glowing at increments of about 1 volt until all 10 are illuminated. Different voltage indications can be obtained by changing the resistor values or by using green or yellow LED's.

The circuit draws about 20 milliamperes when all 10 LED's are on, and

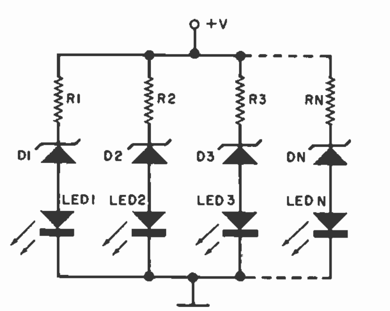



*Fig. 3. Zener diode voltage-sensitive bargraph.*

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you can effectively isolate the readout from a circuit under test with an op amp. Figure 2 shows a circuit with an op amp input. The op amp will increase the input impedance of the readout to a few hundred thousand ohms or more. Also, since the gain of the op amp is easily adjusted, you can measure small fractions of a volt with this modified circuit.

**Zener Diode Voltage-Sensitive Bargraph.** The unique voltage-sensing property of zener diodes makes them ideal for LED bargraph indicators. Figure 3 shows a typical circuit.

In operation, an increasing voltage applied to the circuit has no effect until the breakdown voltage of *D1* is reached. When *D1* breaks down, *LED1* receives forward current and glows, with *R1* limiting the current to a safe level.

Zener diodes *D2, D3 . . . DN* break down in succession as the voltage is increased. As with the voltage-divider readout, the zener diodes can be arranged for nonlinear response and other "custom" readout roles. Any number of LED-zener diode pairs can be used. You can also connect a zener diode bargraph readout to an op amp to provide a high input impedance and increased sensitivity.

**Transistorized Voltage-Sensitive Bargraph.** Transistors can be used to switch on a series string of LED's in succession as shown in Fig. 4. The circuit requires more components per resolution element than either of the previous two, but it works quite well.

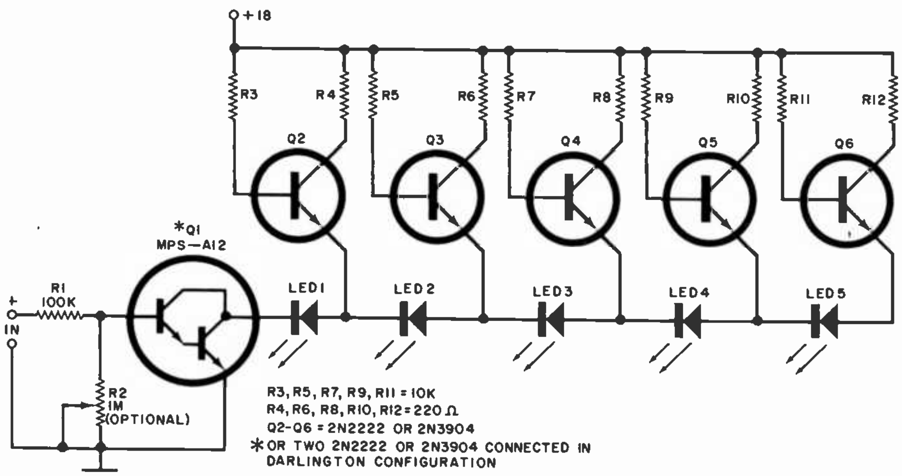



*Fig. 4. Transistors can be used to switch on a series string of LED's in succession as in this circuit.*

The circuit in Fig. 4 is connected to a Darlington input stage to isolate the circuit under test from the display. Potentiometer *R2* can be used to adjust the sensitivity of the bargraph from 0.1 to 0.5 volts (0.1-volt increments) to 1.0 to 10.0 volts (2.0-volt increments). Current through the LED's is limited by *R4, R6, R8, R10,* and *R12*.

Even higher sensitivity and better linearity can be obtained by substituting an op amp for the Darlington input stage. See Fig. 2 for details.

**Comparator Voltage & Resistance-Sensitive Bargraph.** You can make an exceptionally versatile bargraph readout from a batch of op amp comparators. The input of each comparator is connected to one stage of a voltage divider and the output to an LED. When an increasing voltage is applied to the voltage divider, the comparators turn on in sequence and cause their LED's to glow. The same effect occurs when an external resistance is connected across the divider.

Fig. 5 shows one possible configuration of this concept. Three LM339 quad comparators are used to provide the ten comparators for the circuit. The voltage divider consists of *R1-R11*, while *R12* limits current through the LED's to about 10 milliamperes.

Potentiometer *R1* is the source of this circuit's exceptional sensitivity. When it is set for a resistance of several megohms or more, for example, the LED's will turn on in increments of a millivolt or so. By substituting a ro-

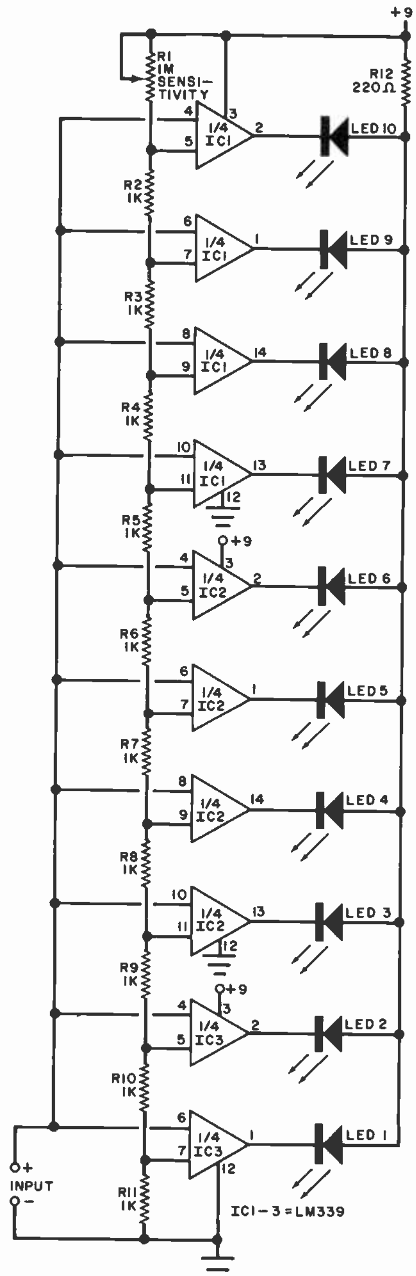



*Fig. 5. Bargraph using comparator voltage and resistance-sensitive circuit.*

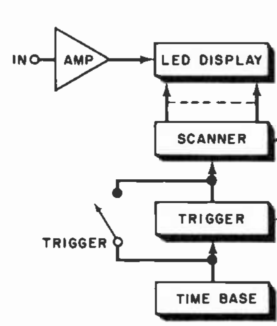



*Fig. 6. Block diagram for bargraph frequency meter.*

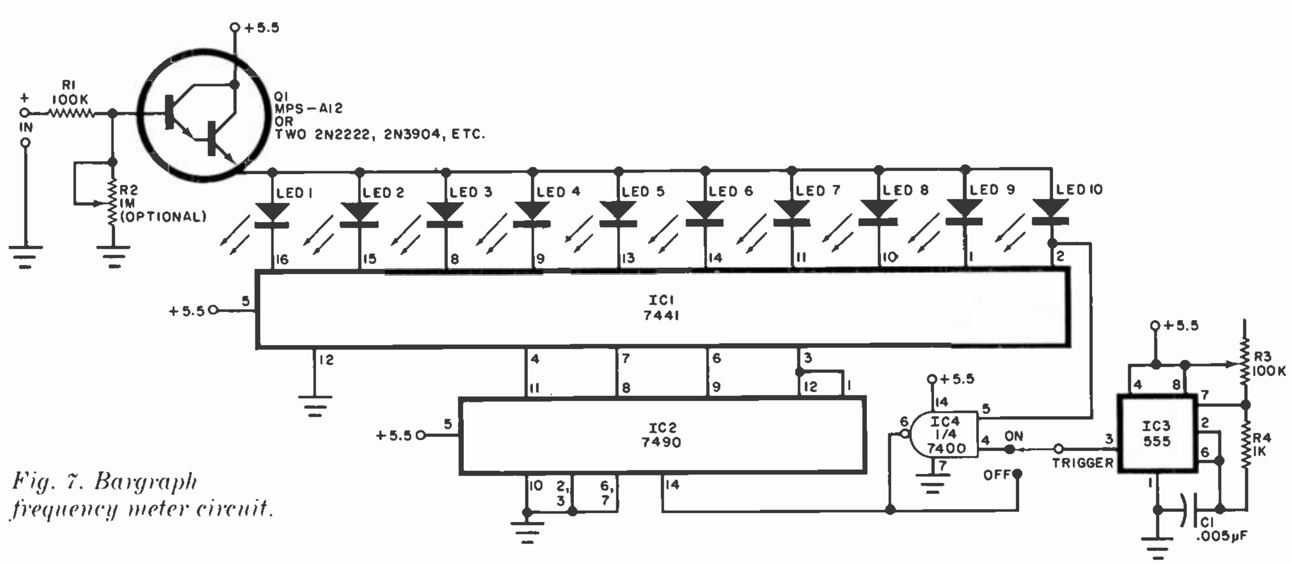


*Fig. 7. Bargraph frequency meter circuit.*

tary switch and several fixed precision resistors for *R1*, you can make a calibrated voltmeter which doubles as a resistance meter. In the resistance sensing mode, the circuit can be adjusted to indicate up to 10 megohms per LED.

This circuit can also be used as a timer or sensitive light meter. To operate it as a timer, connect a large-valued good-quality capacitor across the input leads. (Use at least 1 microfarad for best results.) As the capacitor charges, the LED's will glow in succession to indicate the charge on the capacitor. Intervals of a fraction of a second to more than a minute per LED can be obtained.

To use the circuit as a light meter, connect either a photovoltaic cell such as a silicon solar cell or a photoresistive cell to the input leads. The photovoltaic cell generates a voltage in response to light and the LED's glow in succession as the light level at the cell is increased. Photoresistors change their resistance in response to light, and the LED's react accordingly.

**Frequency-Sensitive LED Bargraph.** Believe it or not, you can make a frequency meter from a 555 timer, several TTL IC's, ten LED's, and a few miscellaneous parts. Figure 6 is a block diagram of the circuit; Fig. 7 is the schematic. Here's how it works:

The time base (555 timer) feeds clock pulses at an adjustable rate to a scanning circuit (7490 counter and 7441 decoder). An LED is connected to each of the decoder outputs.

Normally, all the LED's are off. However, a pulse applied to the input amplifier (a Darlington or FET stage) which is coincident with a clock pulse causes one or more LED's to be turned on. The number and arrangement of the LED's indicates the frequency of the incoming pulses *and* their width.

To view the individual pulses of the incoming signal on the display, the time base must be properly synchronized. This is accomplished by adjusting the time base's RC time constant. Calibration is accomplished in the same way.

Manual adjustment of the time base's time constant is adequate for pulses occurring at a rate of less than a few kilohertz, and faster frequencies require automatic synchronization. This is accomplished by a single NAND gate (7400 quad NAND gate) which is connected as an automatic trigger. The trigger operates much like the triggered sweep in an oscilloscope.

With the component values shown, the circuit will display frequencies ranging from about 20 microseconds per LED to 1 second per LED. You may have to increase C1 to 0.01 or 0.1 microfarad to obtain the full operating range.

Operation of the frequency meter can be a little tricky at first. You will need to calibrate the unit by using a known frequency source. For best results, a square or rectangular pulse shape should be employed.

Begin calibration by applying a known frequency and rotating R3 until the display resembles:

1 0 1 0 1 0 1 0 1 0

where "1" represents a glowing LED and "0" represents an LED which is off. If the input frequency is 1 kHz, each LED corresponds to 500 microseconds. Mark *R3's* shaft position accordingly, and continue calibrating for a range of input frequencies.

During calibration, you will notice that the LED's do not always glow in a uniform pattern. For example, the following pattern may appear:

1 0 1 0 1 0 1 0 1 1

This and similar effects are caused by slight changes in either the time base frequency, the input frequency, or noise.

After you have calibrated the circuit, you can use it to measure the frequency of a pulse train and the width of square pulses. For example, to measure the width of a square pulse, simply rotate *R3* until several LED's near the center of the display are glowing. The pattern might resemble this:

1 0 0 1 1 1 0 0 1 1

The 1 1 1 pattern near the center of the display is a single pulse (ignore the other LED's) and its width is found by adding the time increment represented by each LED. If R3 is set for 100 microseconds per LED, then the pulse is 300 microseconds wide.

Since the resolution of the 10 element readout is so limited, your measurements will not be very accurate. Nevertheless, you can get a good idea of both frequency and pulse width with the circuit. For best results, operate the frequency meter in subdued light since the LED's will not be very bright. This is especially true when measuring fast frequencies. ◈

# Product Test Reports

## ABOUT THIS MONTH'S HI-FI REPORTS

*Truly giant advances in performance and operating characteristics of audio equipment are rare. More common than "breakthroughs" are improvements on preceding models in a company's line, especially when the earlier models are at the state-of-the-art level. This is the case with the two hi-fi units examined this month.*

*Crown's magnificent Model 150 stereo preamp has been improved in performance as well as operating flexibility, including the ability to switch on power amplifiers drawing a total of 25 amperes! It's called the IC-150A, and, as the name suggests, it uses integrated circuits in all its active stages, including the power-supply regulator.*

*Similarly, Dual replaced its excellent automatic turntable, the 1229Q, with the new 1249, retaining the features and even the external appearance of its illustrious predecessor. Under the skin, however, the 1249 is a completely different unit, employing a lower-speed motor that drives the platter through a flexible belt.*

*Both models emphasize how, each year it seems, there are small increments of improvement that have a way of adding up to a giant step when viewed over a period of a few years.*

***—Julian D. Hirsch***

## CROWN MODEL IC-150A PREAMPLIFIER

*Has improved operating flexibility and performance.*


HIRSCH-HOUCK LABS REPORT

High-power audio amplifiers are making a lot of news recently, as the popularity of hi-fi "separates" increases. It takes two to tango, however, so we examine here a professional type of audiophile-priced preamplifier that could be a good match for a top-quality power amplifier. It's the new Crown Model IC-150A stereo preamplifier/control center.

Making full use of new integrated circuit design possibilities, the IC-150A utilizes five IC's that are equivalent to 89 bipolar transistors, 25 FET's, 3 zeners and 12 diodes. The result is a low-distortion, wide-dynamic-range, versatile control center. Proper equalization, and low-level and high-level gain are provided for use with a host of sources.

Housed in an attractive walnut cabinet, the preamp measures 5¼"H × 17"W × 8⅛"D (13.3 × 43.2 × 20.6 cm). It is $399.

**General Description.** The front panel of the preamp is divided horizontally into two sections. Across the upper section are grouped six rotary controls: input SELECTOR, VOLUME, BALANCE, PANORAMA, BASS, and TREBLE. The lower section of the panel contains five pushbutton switches labelled TAPE 1 and TAPE 2 MONITOR, LOW and HIGH FILTERS, and AC ON. Also on the lower part of the panel are three standard phone jacks, two of which provide inputs for the AUX 3 input. The third jack, labelled MONITOR, is for driving a third tape deck with signals from the preamp's output, where it can be modified by the tone controls.

The selectable inputs include PHONO 1, PHONO 2, AUX 1, AUX 2, AUX 3, TUNER, TAPE 1, and TAPE 2. The VOLUME control is a 31-position step switch that permits varying the volume in 2-dB steps over a 60-dB range, starting from full off at its lowest setting. Precision resistors in the volume-control circuit maintain channel balance within 0.2 dB.

The PANORAMA control provides a means of continuously varying channel separation and orientation, from normal stereo through mono to reverse stereo as the control is rotated clockwise. The tone controls for the two channels are concentric to permit independent adjustment. Pushbuttons near the controls can be used to bypass the tone circuits and connect the loudness-compensation circuit into the VOLUME control circuit.

Recessed into the rear of the preamp are the various inputs and outputs, including two parallel sets of outputs and a slide switch for reducing the output signal level by about 10 dB, for use with high-gain power amplifiers. Two screwdriver-adjustable controls near the PHONO jacks permit the user to vary the phono gain over a 20-dB range. There are also six ac outlets on the rear panel, five of which are switched by the preamplifier, able to supply up to 1200 watts of power to external components.

The preamp is rated to deliver at least 11 volts output to a high-impedance load, with less than 0.002% IM distortion, or less than 0.0005% THD, both at 1000 Hz. The rated output into 600 ohms is 2.5 volts.

**Laboratory Measurements.** To the extent that our test equipment was able to measure performance, the preamplifier met all of its published specifications with room to spare. Of course, no unmodified laboratory instruments are capable of measuring THD down to 0.0005%, but we satisfied ourselves that the preamp is as nearly distortionless as any piece of high-fidelity equipment we have ever used or tested.

The output clipped at 11.7 volts into 100,000-ohm loads and 4.8 volts into 600-ohm loads. The low-impedance load was used for our distortion and noise measurements, based on the maximum rated output of 2.5 volts. At 20 Hz, the THD was 0.018%, which is approximately the residual distortion of our signal generator. It decreased to less than 0.01% between 100 and 10,000 Hz and rose to 0.05% at 20,000 Hz. At most frequencies, the THD was below the minimum measurement limit of 0.003%.

The IM distortion was measured with a Crown IM analyzer, which can barely indicate its own 0.002% residual distortion. We obtained a 0.002% IM distortion at most output levels from 2.5 volts down to about 0.25 volt. At the rated output, the figure was 0.005%.

The preamp delivered a reference output of 1 volt at 1000 Hz with an input of 0.18 volt through its high-level inputs. The unweighted S/N ratio, relative to 1 volt, was 80 dB down. The phono gain is factory set at 60 dB for a 1-mV input to produce a 1-volt output. We measured a 76.5-dB S/N ratio through the phono inputs. The phono overload level occurred at 140 mV. The screwdriver-adjustable phono sensitivity controls permitted the gain to be varied from 0.27 to 3.1 mV, with corresponding overload levels occurring at 40 to 400 mV. The noise level was not significantly different at most usable settings.

The frequency response was basically flat within ±0.25 dB (which is also the rating of the General Radio frequency-response plotter we used during the test). The bass tone control varied the turnover frequency from about 50 to 300 Hz, making it possible to modify the low-frequency response over a considerable range without seriously affecting the midrange response. The treble control characteristic was hinged at a frequency in the range between 1000 and 1500 Hz. The low-frequency filter had a 6-dB/octave slope. Its response was down 3 dB at 90 Hz with the volume at maximum. (The filter's cutoff frequency decreases at lower volume settings.) The high-frequency filter cut off with a 12-dB/octave slope, and its response was down 3 dB at 6000 Hz. The loudness compensation was very mild (and, therefore, quite useful), producing a boost in response below 100 Hz, with no effect on the high frequencies.

The RIAA equalization was not affected by any significant amount by cartridge inductance. It was within ±0.5 dB from 70 to 20,000 Hz, rising slightly to +1.5 dB at 25 to 30 Hz. The square-wave risetime through the high-level inputs was 2 μs, and the slew rate was 6 volts/μs with a 600-ohm load.

**User Comment.** It would certainly be difficult to improve the noise, distortion, and frequency-response characteristics of this preamplifier. Furthermore, the preamp operates smoothly and silently, with no switching transients or other undesired side effects. (A plug-in reed relay shorts out the outputs for a few seconds when the preamp is first turned on and when it is turned off to prevent switching transients from reaching the system's speakers.)

The preamp is very flexible, seemingly able to handle any and all program sources and accessories that one would reasonably connect to it. It represents a clear improvement over the company's IC-150, which is also a fine unit. For example, the IC-150A surpasses its predecessor in that it has lower noise, lower distortion, tighter tracking between channels, an internal reed relay, an added input, switched ouput attenuation, and an additional switched ac outlet (to name a few).

The preamp isn't flawless, however. One has to be careful if a signal-processing accessory (equalizer, noise reducer, dynamic expander) is connected to one of the tape-monitoring circuits. If the preamp's monitor switch is in the tape source position, setting the SELECTOR switch to the corresponding TAPE input will cause a violent oscillation ("motorboating"). Of course, with separate preamp and power amp, one can install any accessory between the components, bypassing this problem.

Additionally, the handsomely designed front panel would benefit from a visible and contrasting index mark on control knobs. In dim light, it's difficult to determine many of the control settings, a problem that is by no means unique to the IC-150A, but nevertheless a minor annoyance.

In all other respects, one could hardly ask for a finer preamplifier. The Crown Model IC-150A is also reasonably priced for a component preamp/control center in today's market.

CIRCLE NO. 80 ON FREE INFORMATION CARD

## DUAL MODEL 1249 AUTOMATIC RECORD PLAYER

*Uses belt drive and combines best features of automatic and manual operation.*

HIRSCH-HOUCK LABS REPORT

Replacing the 1229Q at the top of Dual's automatic record player line is the Model 1249. It resembles its predecessor in many respects, but there are some important differences, both externally and beneath the motorboard. The 1249 is a two-speed (33⅓ and 45 rpm) belt-driven turntable, able to play records singly in a fully automatic or manual mode or to play a stack of six records in sequence when the short single-play spindle is replaced by the automatic center spindle.

For speed adjustment, there are

stroboscopic marks around the edge of the full-size (12") platter, illuminated from below through a window in the motorboard. A small knob, concentric with the speed-change lever is used to make the speed adjustments. The other operating control is a conventional Dual start-stop lever.

The cueing lever raises and lowers the tonearm with a smooth, damped motion in both directions, and a small knob near the arm base adjusts the height of the lift. A two-position knob in front of the cueing lever makes it possible to repeat a single record indefinitely, or to play it once and then shut off automatically.

The Dual 1249, measuring 14¾"W × 12¼"D (38 × 31 cm), is $279.95, less base and cover.

**General Description.** The tubular aluminum tonearm appears to be identical to that of the 1229Q and other Dual units. Its low-friction pivots are mounted on gimbals, for equal freedom of motion in both planes. The anti-skating dial, on the base next to the arm, is a drum with three separate scales, for conical, elliptical, and CD-4 styli.

A lever is used to raise the entire tonearm for multiple play so that the vertical stylus angle at the center of a 3-record stack will be approximately the same as when playing a single record with the arm lowered. In the 1249's belt-drive system, the 12-inch aluminum alloy platter rests on a smaller platter which is driven through a belt by an 8-pole synchronous motor turning at 900 rpm. The drive shaft provides vernier speed control.

The internal arm wiring of the Dual 1249 is low-capacitance, though the external signal cable is not. For CD-4 installations, it is only necessary to unplug the signal cable and replace it with a special CD-4 cable.

**Laboratory Measurements.** With an Ortofon VMS-20E cartridge installed, the tonearm of the Dual 1249 resonated at about 7 Hz. The measured vertical tracking force was identical to the settings of the dial on the tonearm, over the range of 1 to 3 grams. The tracking error was under 0.5 degrees per inch of radius over almost the entire record surface. With a 1-gram vertical tracking force, it was necessary to set the anti-skating dial to 1.5 grams for best correction.

Wow and flutter were virtually unmeasurable at 0.02 and 0.03%, which probably represents the residual of the test record. Rumble was −32 dB (unweighted), improving to −57.5 dB with RRLL audibility weighting. The speed vernier control range was about ±4% at 33⅓ rpm, but less than half as much at 45 rpm. Speed was absolutely constant when the line voltage was varied from 80 to 135 volts.

The automatic change cycle required 14.5 seconds, typical of record changers; and, in the single-play automatic mode, 17 seconds elapsed between the time the START lever was operated and the time the pickup reached the record.

The Dual arm-lift system is one of the best we have used, with no outward drift during the descent caused by anti-skating correction. The turntable mounting springs afforded good isolation from external vibration, comparable to what we have measured on other good automatic turntables.

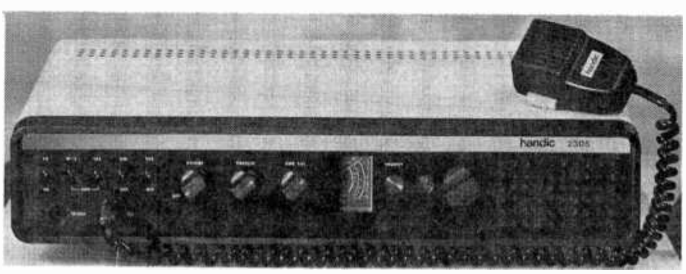
**User Comment.** The overall level of performance of Dual's top automatic players has been so high in recent years that, quite frankly, we had difficulty pin-pointing any specific superiorities of the 1249 over its predecessors. For all practical purposes, its wow, flutter, and rumble are nonexistent, since almost any record is inherently likely to have more of these unwanted characteristics than will be contributed by the 1249.

The operating features of the 1249 combine the best parts of automatic and manual players. (It can be operated manually by picking up the tonearm, which starts the motor, and cueing it to the desired portion of a record, using the cueing lever to lower it if desired.)



## HANDIC MODEL 2305 AM CB TRANSCEIVER

*Attractive styling, excellent audio quality and good modulation.*

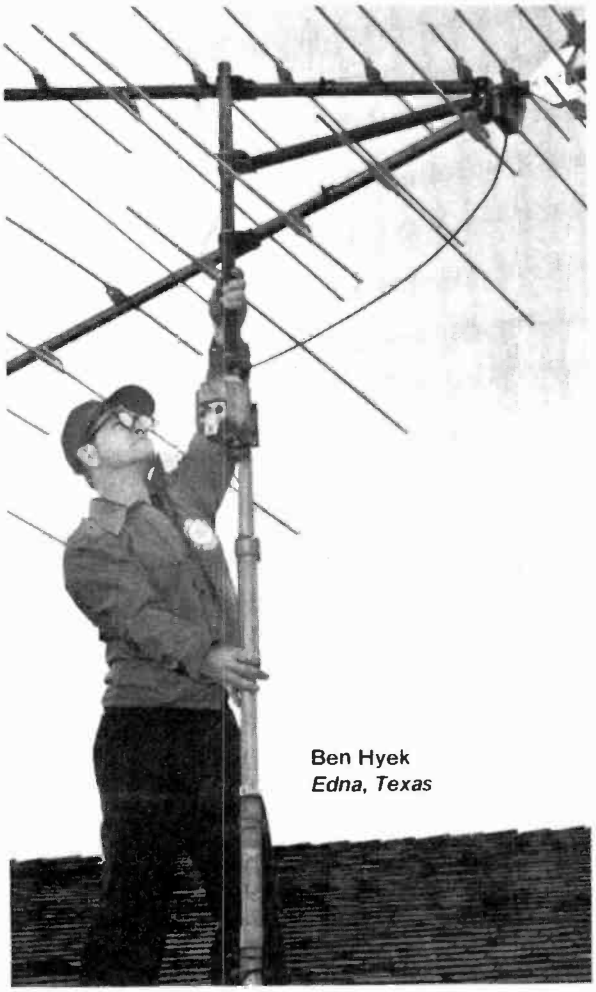


THE Handic Model 2305 AM CB base-station transceiver features a striking low-silhouette packaging design. This gives it a long, lean look and allows all controls, meter, and channel indicator to be arranged in a functional horizontal line. Another feature that makes this transceiver "different" from most others on the market is that it has a built-in priority receiver that operates separately from (and does not interfere with) the operation of the main transceiving functions. This SUB receiver can be set up to constantly or "on command" monitor any CB channel for which the correct crystal is installed.

The 23-channel transceiver can be operated from any 117- or 220-volt ac power source and uses electronic regulation in its power supply. Provisions are also made for charging up to 10 NiCd cells for use in walkie-talkies. In addition, a socket is provided for installation of a selective-call accessory, and there is a PHONE jack on the front panel for private listening. The remaining features are more or less standard for a CB base station: audio gain and squelch controls, S/RF/SWR meter, switchable anl, PA operation, external-speaker jacks, detachable dynamic microphone, front-facing speaker, amc, and operation at full legal power.

The transceiver measures 17"W × 8⅛"D × 8⅛"H (43 × 20.7 × 8 cm). It retails for $279.00.

**The Receiver.** A double-conversion design is used in the main receiver section, using the common crystal frequency synthesizing scheme to obtain a 10,595-to-10,635-kHz first i-f and a 455-kHz second i-f. The rest of the circuitry is quite conventional in de-



Ben Hyek
*Edna, Texas*

## Brothers Ben and Vic Hyek, Texas antenna installers agree:

# Chromstar™ gets the "Ayes" of Texas

Deep in the heart of Texas, the Hyek brothers, Ben and Vic, operate their separate TV service firms.*

Ben Hyek, of Ben's TV, Edna, Texas, says "I have yet to find a competitor's antenna as good as Winegard Chromstar."

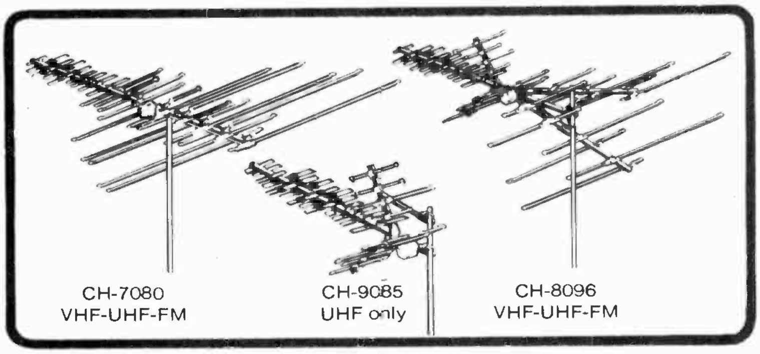
Only 30 miles from the Gulf, Ben sells the anodizing feature to his customers. "The combination of heavy duty construction and anodizing makes Chromstar the best long-life antenna on the market," he states. When he sells Chromstar, he tells the customer, "If it doesn't work, I'll take it down," and he hasn't taken one down yet.

Vic Hyek operates Vic's Radio & TV, Nada, Texas, and says: "I think Chromstar is by far the greatest antenna Winegard has ever offered. UHF performance is excellent, and VHF is better, too. Now I can pick up Channel 39 out of Houston, over 60 miles away, better than I have before. UHF performance in this area doesn't require a preamp."

Both Vic and Ben like the stronger construction of Chromstar, the ease of installation, the new color combination, and the compact packaging that allows easy handling and storage.

*Copies of letters from the Hyek brothers will be sent on request.

**Get Chromstar facts and free Spec Charts from your Winegard distributor.**





Vic Hyek, *Nada, Texas*

**WINEGARD**
COMPANY
3000 Kirkwood • Burlington, Iowa 52601

*TV ANTENNAS MORE PEOPLE LOOK UP TO*

CIRCLE NO. 72 ON FREE INFORMATION CARD

# Should your career in electronics go beyond TV repair?

## CREI prepares you at home for broader and more advanced opportunities in electronics—plus offers you special arrangements for engineering degrees

There is no doubt television repair can be an interesting and profitable career field. TV repair, however, is only one of the many career areas in the fast growing field of electronics.

As an indication of how career areas compare, the consumer area of electronics (of which TV is a part) makes up less than one-fourth of all electronic equipment manufactured today. Nearly twice as much equipment is manufactured for the communications and industrial fields. Still another area larger than consumer electronics is the government area. That is the uses of electronics in such areas as research and development, the space program, and others.

Just as television is only one part of the consumer field, these other fields of electronics are made up of many career areas. For example, there are computer electronics, microwave and satellite communications, cable television, even the broadcast systems that bring programs to home television sets.

As you may realize, career opportunities in these other areas of electronics are mostly for advanced technical personnel. To qualify for these higher level positions, you need college-level training in electronics. Of course, while it takes extra preparation to qualify for these career areas, the rewards are greater both in the interesting nature of the work and in higher pay. Furthermore, there is a growing demand for personnel in these areas.

Unlike most other home study schools, CREI programs are devoted exclusively to preparing you for careers in advanced electronics. All of CREI programs are college level. And CREI gives you both theory and practical experience in advanced electronics.

### Unique Design Lab

A unique feature of CREI training is its Electronic Design Laboratory Program, which trains you to actually design circuits. It also helps you understand the theories of advanced electronics and gives you extensive practical experience in such areas as tests and measurements, breadboarding, prototype construction, circuit operation and behavior, characteristics of electronic components and how to apply integrated circuits.

# Career Training at Home

Only CREI offers this unique Lab Program. It is a complete college lab and, we believe, better than you will find in most colleges. The "Lab" is one of the factors that makes CREI training interesting and effective. And the professional equipment in this program becomes yours to keep and use throughout your professional career after you complete the training.

## Engineering Degree

CREI offers you special arrangements for earning credit for engineering degrees at certain colleges and universities as part of your home study training program. An important advantage in these arrangements is that you can continue your full time job while "going to college" with CREI. This also means you can apply your CREI training in your work and get practical experience to qualify for career advancement.

## Wide Choice of Programs

CREI gives you a choice of specialization in 14 areas of electronics. You can select exactly the area of electronics best for your career field. You can specialize in such areas as computer electronics, communications engineering, microwave, CATV, television (broadcast) engineering and many other areas of modern electronics.

## FREE Book

In the brief space here, there isn't room to give you all of the facts about CREI college-level, home study programs in electronics. So we invite you to send for our free catalog (if you are qualified to take a CREI program). The catalog has over 80, fully illustrated pages describing your opportunities in advanced electronics and the details of CREI home study programs.

## Qualifications

You may be eligible to take a CREI college-level program in electronics if you are a high school graduate (or the true equivalent) and have previous training or experience in electronics. Program arrangements are available depending upon whether you have extensive or minimum experience in electronics.

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## GI Bill

*CREI programs are approved for training of veterans and servicemen under the G.I. Bill.*

sign. It consists of a diode-protected r-f stage, first and second mixers, two 455-kHz i-f stages, detector stage, agc stage, squelch system, and an audio section that terminates in a class-B output stage (that also serves as the transmitter modulator or provides the PA output).

The receiver's sensitivity measured 0.5 μV for 10 dB (S + N)/N. The maximum audio sine-wave output at the onset of clipping was 3.4 watts at 2.5% THD with a 1000-Hz test signal and an 8-ohm load. The overall audio frequency response was 400 to 2500 Hz at the 6-dB points. The agc system produced a relatively uniform audio output level, amounting to a change of only 8 dB with an 80-dB r-f input change at 1 to 10,000 μV. A 30-μV input signal was required to provide an S9 indication on the meter.

I-f selectivity is obtained with two cascaded 455-kHz ceramic filters that hold the ±10-kHz bandwidth to the area of 90 dB. However, due to r-f and mixer stage signal-handling characteristics, the adjacent-channel rejection, desensitization, and cross modulation were, in practice, on the order of 60 dB. Image and i-f signal rejection were 55 and 60 dB, respectively, while other unwanted-signal rejection was a minimum of 40 dB.

The automatic limiter, or anl, performed exceptionally well, particularly during weak-signal reception, where it is most important. The squelch threshold range was 0.1 to 1000 μV.

The priority SUB receiver employs single conversion to a 255-kHz i-f. This requires a special crystal for whatever channel is to be set up. Since we did not have such a crystal, we were unable to make any performance measurements in this section. Sensitivity is rated at 0.7 μV, and with a 255-kHz i-f, the image rejection cannot be expected to be as good as the main section's. Nevertheless, this is of little consequence for the application for which this section is intended. Separate squelch and anl are provided for the SUB receiver, too.

**The Transmitter.** The straightforward transmitter contains a synthesizer mixer, spurious-response filtering, and predriver, driver, and final (power) amplifier stages. The output of the last stage goes into a matching network for 50-ohm loads. The output carrier power measured 4 watts.

The automatic modulation control (amc) system provides a high degree of compression (35 to 40 dB above 50% modulation) for maintaining high modulation with differing voice levels. Under dynamic conditions, the splatter was nominally 50 dB down. With a 1000-Hz test tone at full compression and 100% modulation, the distortion was only 5%. The overall response was 350 to 4000 Hz.

Antenna switching is performed electronically with a diode switch. Other circuits are relay switched.

The frequency tolerance of the transmitter was within 0.0025%.

**User Comment.** The appearance of this transceiver is enhanced by a black control panel with an orange stripe across the top. Behind the bezel, the case is all white, presenting a pleasant contrast with the front panel.

Miniature toggle switches are used for the switchable functions, while the VOLUME, SQUELCH, and SWR CAL controls and the channel selector are rotary devices. The meter movement is oriented vertically and is easy to read.

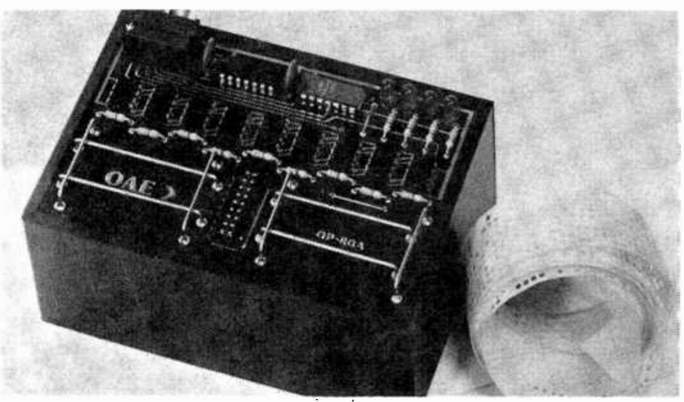
The priority SUB receiver is activated by a switch. When the switch is in the SUB position, the receiver is switched in and a light on the front panel flashes to indicate that the priority channel is on.

Attractive styling, excellent audio quality, and fine modulation characteristics make this transceiver a desirable piece of CB gear. The selective-call accessory socket and battery charging capability add unusual versatility.

CIRCLE NO. 82 ON FREE INFORMATION CARD

## OAE MODEL OP-80A TTY PAPER TAPE READER

*High-speed tape reader for less than $75.*




YOU CAN feed TTY paper tape programs into any computer with an 8-bit input port without having to spend $1000 or more for a Teletype® terminal. The OAE Model OP-80A high-speed paper tape reader lets you do it for just $74.50 if you build it from a kit or $95 if you buy it factory assembled and tested. The reader has no moving parts, unless you count the motion of the tape going through it. It also lets you feed tape programs into your computer at much faster speeds than a standard electro-mechanical tape reader will permit.

**General Description.** The tape reader can be assembled in a single evening. The design is so simple and complete, even a neophyte should have little difficulty in putting together the kit.

The tape reader's circuit design employs several 555 timer IC's, a precision optical sensor "head," and some "handshake" logic. All parts, including the heavy solid wire that serves as the tape guides, mount on the top surface of a single printed circuit board. The board itself becomes the top of a compact box. A 48" (1.2-m) multi-color flat ribbon cable interconnects the tape reader to the computer with which it is to be used.

The actual hookup to the computer is simple. If your computer has an 8-bit parallel input port, you can feed programs in parallel from tapes directly. On the other hand, if your computer is equipped with only a TTY serial input port pegged at a slow 110 baud, the tape reader's manual gives details on how to connect the reader to the computer's serial input UART so that you can load programs at high speed. No software modifications are required in either case.

Four LED's in the tape reader indicate status. One comes on when 5-volt power (obtained from the computer's power bus) is applied to the reader. A second LED comes on when the tape illumination through the sprocket hole sensor is sufficient for proper operation. The remaining two LED's are not dedicated; they can be used as signal indicators as desired. The illuminating source can be any standard 100-watt desk lamp.

The stiff wires used as tape guides on the reader maintain proper tape alignment as it passes over the optical read head. A large arrow on the top of the pc board indicates proper direction of tape motion. A smaller arrow identifies the sprocket sensor.

All internal and external connections are made to a conventional 14-pin dip socket mounted on one corner of the pc board. The color-coded ribbon cable is terminated at one end in a male connector that fits the DIP socket.

**User Report.** After assembling the kit, we wired it into the parallel port of our computer and connected the two required handshake leads. Then we loaded punched TTY tape in the guides, checked for the right indication of the sprocket LED, and pulled the tape through as fast as we could. It came as quite a shock to see how fast we could feed data into our computer and see it on our video monitor.

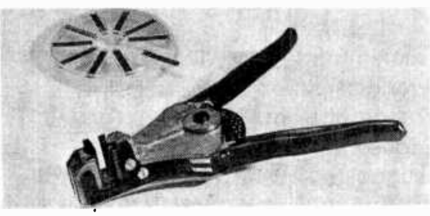
Once we confirmed the operation of the parallel port, we rewired the tape reader to the UART on our 110-baud serial TTY board and made all necessary changes. During our operational test, we were able to load 8K Basic into our computer as fast as we could pull the tape through the reader's guides. According to OAE, the tape reader is designed to let you run 12K Extended Basic through in about 30 seconds! We didn't have the equipment to verify this claim, but the results of our other tests gave us no reason to doubt it.

Needless to say, we are impressed with the performance of this paper tape reader. It is reasonably priced for the average computer user, and we predict that it will become one of the hottest computer accessory items on the market.



## ALPHA WIRE MODEL STRP-25 WIRE STRIPPERS

*Unique cutting material permits repeated, dependable stripping.*



STRIPPING insulation from wire and cable by hand has always been a chancy proposition at best. If you use diagonal cutters and don't apply enough pressure, you run the risk of tearing the insulation instead of neatly parting it. Apply too much pressure, and you nick the conductor or remove a few fine strands, weakening the structure at the connection point. Using automatic hand-type wire strippers is time consuming because you must carefully locate the wire in the proper notch in the steel jaws. But if you use Alpha Wire's new Model STRP-25 automatic strippers, you will not only produce perfect strips every time, you'll also strip wires faster than you can using any other tool we've examined on the market today.

The new strippers look and operate just like the standard steel-jawed automatic tool. What Alpha has done is redesigned the basic automatic tool to accept special Stilan® plastic cutting blades. The blades are harder than most materials used for wire and cable insulation—except Teflon and Kynar, which aren't commonly used by hobbists and experimenters—but softer than copper.

The Model STRP-25 strippers retail for $39.95 and come with three sets of plastic blades. A five-set replacement blade pack (No. BLD-5) can be obtained for $11.95.

**More Details.** The blades are similar in size and shape to the steel blades used in injector razors. They even install in the tool the same way, with the new blades ejecting the old.

The Stilan plastic material used for the blades is tough and resilient. As the opposing knife-edges of the blades come together during the stripping procedure, they neatly slice through the insulation and then deform around the conductor. The tool then cleanly and automatically parts the insulation from the wire. Inspection of the blades after a strip will reveal small notches where the plastic deformed around the wire. If you carefully position the wire in these grooves and make repeated strips, you'll find that the blades will continue to remove insulation several hundred times before you have to move on to a "fresh" area. Of course, in actual practice, you would use all areas of the blades randomly.

The wire strippers are designed to cope with a number of problems fast and accurately. For example, when stripping insulation from 4" (10.2-cm) or shorter lengths of hookup wire, the tool will not crush the insulation, kink the wire, or pull the wire clean out of the insulation. Also, it strips insulation from twisted-pair, speaker and line cord, and 300-ohm twin-lead cable with the same facility as single-conductor hookup wire. The tool will even strip insulation from wire bundles, multiple twisted pairs, and flat ribbon cable, whether or not the conductors are all of the same size.

**User Comment.** Over a period of weeks, we put the plastic-blade wire strippers through a strenuous series of tests. After performing some 10,000 strips using stranded and solid 22-gauge hookup wire with PVC insulation and several hundred strips on 300-ohm twin-lead with polyethylene insulation, we used the tool with the original blades to build two rather complex projects.

Periodic samplings of our strips were subjected to close inspection with a magnifying glass and high-intensity light. In all cases, the insulation was parted neatly at the strip points. More important, we detected no nicks in the wire, crushed conductors, or removal of fine wire strands.

Using a little bit of common sense, one can easily exceed 50,000 strips from a single pair of blades. You just start with the smallest size wire or cable with a pair of new blades and continue stripping away until the blades will no longer remove insulation. Then you use the same blades for the next larger size wire, working up to 12 gauge.

We highly recommend this new tool to anyone who is involved in electronics where speed and reliability are important.

# Solid State

By Lou Garner

## AN IC THAT IS ALSO DANDY

DISCUSSING a voltage-tuned FM broadcast-band front end in last February's column, I referred to it as a DANDY circuit, explaining that "DANDY" was my acronym for "Discretes Are Not Dead Yet." If we broaden the basic meaning a little, the LM389 might well qualify as a *DANDY IC*, for it combines the versatility of discrete transistors with the wiring density and compactness of an integrated circuit. Manufactured by the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051), the LM389 is supplied in a molded 18-pin DIP. As shown in Fig. 1, the device comprises three uncommitted npn transistors and a low-power integrated audio amplifier in a single package.

With its uncommitted transistors and overall electrical characteristics, the LM389 is one of the most versatile devices you're likely to encounter in some time and almost seems to have been "custom-designed" specifically for the experimenter/hobbyist. It can be used in hundreds of applications ranging from simple toys to sophisticated communications equipment. Its versatility, in fact, is limited only by the imagination and capabilities of the individual designer. Typically, the device might be used for such exciting and useful projects as AM or FM receivers, walkie-talkies, tape recorders, portable phonographs, games, power converters, musical instruments, and control systems. Depending on the equipment designer's skill, it may be the *only* active device needed for most of the projects in which it is used.

The LM389's three transistors are general-purpose npn types capable of operating from dc to 100 MHz. They are reasonably well matched and can function effectively at current levels from 1 µA to their maximum ratings of 25 mA. With a maximum $V_{CEO}$ of 12 volts and a maximum power dissipation of 150 mW, each transistor has a typical dc beta of 275. As long as their currents and voltages are kept within the absolute maximum ratings and the collectors are never at a negative potential with respect to the common substrate (pin 17), there is virtually no limit to the ways in which the transistors can be used. For example, they can be employed as conventional transistors, in a Darlington configuration for increased gain, as diodes, and even as zeners, utilizing their emitter-base break-down voltage of 7.1 volts at currents of from 1 µA to 5 mA. In addition, with a $V_{SAT}$ of only 150 mV when sinking 10 mA, they make excellent LED drivers.

The device's amplifier section comprises the equivalent of five npn and five pnp transistors together with two diodes and features a quasi-complementary power output stage capable of delivering up to 500 mW to a 16-ohm load with only 10% total harmonic distortion (THD). At the 125-mW level with an 8-ohm load, the THD drops to a typical value of 0.2%. The amplifier has a nominal bandwidth of 250 kHz, a power supply rejection ratio of 50 dB, and input impedances of, typically, 50,000 ohms. The input(s) are ground referenced while the output is biased automatically to one-half the supply voltage. The circuit's quiescent current (zero input signal) is typically a low 6 mA. Although the voltage gain is set internally at 20 (26 dB), external shunt components can be used to raise this to as much as 200 (46 dB).

Overall, the LM389 has a maximum supply voltage rating of 15 volts, a maximum power dissipation of 825 mW, and an operating temperature range of from 0°C to +70°C.

Referring to Fig. 1, the following tips are among the practical application hints suggested by the manufacturer in the 8-page technical brochure describing the LM389:

(1) The amplifier section's voltage gain is fixed at 20 by the 1350-ohm resistor between pins 4 and 12. Bypassing this resistor will raise the overall gain. With a 10-µF, 12-V capacitor here, the gain will increase to 200. Gain values between 20 and 200 may be obtained by connecting a fixed or variable resistor in series with the shunt capacitor. Gain control also can be achieved by capacitively coupling a resistor or FET between pin 12 and circuit ground (pin 17).

(2) The circuit's overall frequency response can be tailored to meet individual requirements. For example, bass boost can be added to compensate for a small loudspeaker's poor bass response by connecting a blocking capacitor (say, 10 µF) and series shunt resistor between pins 1 and 12, paralleling the internal 15,000-ohm resistor. A shunt resistor of 15,000 to 10,000-ohms here will provide an effective 6-dB bass boost. If pins 4 and 12 are bypassed for increased gain, shunt values as low as 2,000 ohms can be used without affecting overall stability.

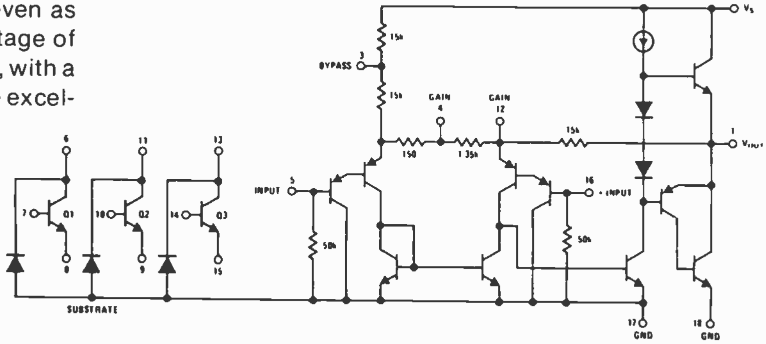



*Fig. 1. The equivalent circuit diagram for the LM389 shows its versatility.*

(3) Normally, both amplifier inputs (pins 5 and 16) are biased to ground via 50,000-ohm internal resistors. If capacitive coupling is used to either input or if direct coupling with a dc source resistance of more than 250,000 ohms is used, no modifications to the input circuits are needed. If direct coupling with a dc source resistance of between 10k and 250k is used, then the unused input terminal should be shunted to circuit ground with a resistor equal to the source resistance to minimize the effects of offset biasing. If the dc source resistance is less than 10k, the unused input terminal should be shorted directly to ground. In addition, when the LM389 is used at higher gain levels, it is necessary to bypass the unused input with a 0.1-µF capacitor to ground to prevent degradation of gain.

(4) If oscillation or circuit instability occurs due to specific load characteristics, these may be eliminated by connecting a 2.7-ohm and 0.05-µF series RC network from output pin 1 to circuit ground.

(5) Although the LM389 has excellent power supply rejection and does not require a well-regulated dc source, the supply should be decoupled to ground with a 0.1-µF bypass capacitor to eliminate possible instability.

(6) Separate ground returns to the dc power source from the small signal (pin 17) and power stages (pin 18) are recommended to minimize possible parasitic coupling.

(7) If desired, the amplifier may be muted (turned off) without affecting the input signal either by shorting pin 3 to the supply voltage or shorting pin 12 to ground.

Typical circuit applications for the LM389 are illustrated in Figures 2 through 4. Abstracted from the company's technical bulletin, these are but representative of the hundreds of ways in which the device may be used. All the circuits employ standard, readily available components, all utilize a single LM389 as their *only* active device, and all may be duplicated quite easily in the home workshop using conventional construction methods, such as perf board or pc techniques. Neither layout nor lead dress should be critical but, of course, good wiring practice should be observed, with all signal carrying leads kept short and direct, dc polarities maintained, and adequate separation provided between the input and output circuits. Unless otherwise noted, all resistors, except for potentiometers, can be either half-or quarter-watt types, at the builder's option. The smaller capacitors can be either low-voltage ceramic, paper or plastic film types, while the higher value units, identified by polarity markings, are low-voltage electrolytics. The loudspeakers are PM types with either 8- or 16-ohm voice coils. Finally, the dc power sources may be either series connected penlight or flashlight cells or well-filtered, line-operated power supplies, as preferred.

Designed for use with standard ceramic pick-ups, the phono amplifier circuit shown in Fig. 2 uses one of the uncommitted transistors as an emitter-follower preamp to achieve a high input impedance, while the other two are wired in a high-gain Darlington configuration. Parallel-tee and bridged-tee RC networks are used to provide treble and bass control, respectively. A 10k potentiometer, capacitively coupled to the Darlington's output load through a 1-µF capacitor, serves as the circuit's gain control. The LM389's amplifier section is capacitively coupled to the loudspeaker. The output (pin 1) to ground series RC network is optional.

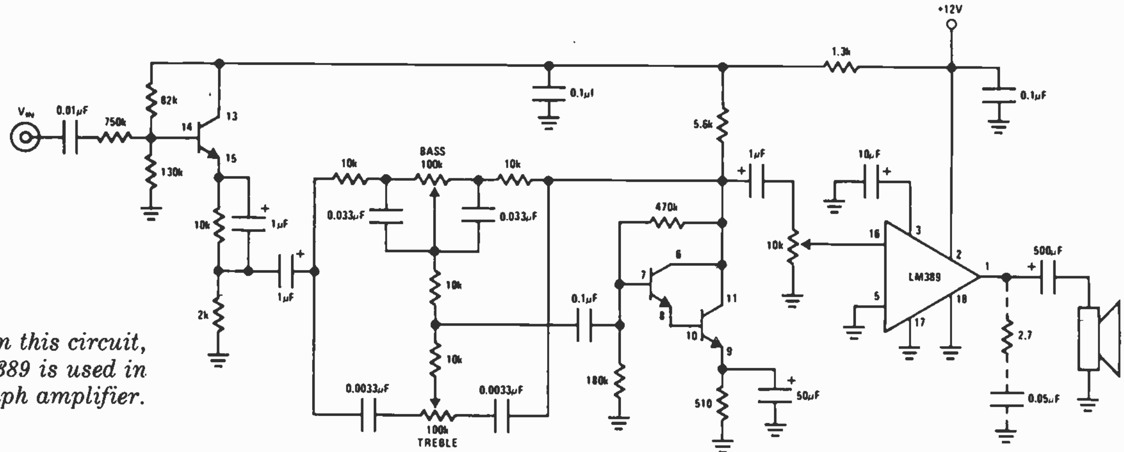



*Fig. 2. In this circuit, the LM389 is used in a phonograph amplifier.*

A portable tape recorder circuit is illustrated in Fig. 3. Here, two of the uncommitted transistors are cascaded as a voltage amplifier while the third serves as a variable resistor in the automatic level control (ALC) circuit used when the instrument is in its RECORD mode. A portion of the amplified signal is rectified by a general-purpose diode and applied back as dc bias to the control transistor's base through a two-stage L-type RC decoupling filter network. The transistor's collector-emitter circuit forms a voltage divider in conjunction with the 22k resistor in series with the instrument's microphone and acts to reduce or increase the input signal as necessary to maintain an optimum output voltage to the recording head. The recording/playback head's electrical characteristics are specified as 200-mH, 300 ohms, while the microphone is a conventional high-output electrodynamic type. A six-pole, two-position rotary or slide switch serves as the *Record/Playback* control and is shown in its RECORD position in the schematic diagram. The ALC feature is not used in the PLAYBACK mode; instead, a conventional gain control is switched into the circuit just ahead of the integrated amplifier section. The component values specified are for optimum performance with a 6-volt dc power source.

Chosen to demonstrate the LM389's great versatility, the circuits given in Fig. 4 include an electronic siren, Fig. 4(A), a voltage-controlled amplifier or tremolo circuit suitable for use in electronic musical instruments, Fig. 4(B), and a noise generator with potential applications in experimental test and research work, Fig. 4(C). All three designs feature loudspeaker outputs and utilize both the individual transistor and amplifier sections of the integrated circuit, with the noise generator, alone, requiring but two of the three available transistors. The siren uses two transistors as a low-frequency collector-coupled multivibrator to modulate the amplifier section through the third transistor, with the amplifier itself wired for operation as a higher frequency oscillator. The voltage-controlled amplifier circuit can be used as a tremolo when its gain control stage is driven by an external capacitively-coupled signal, as shown in the schematic diagram. The tremolo's maximum frequency is limited by the amplifier's interstage coupling network; with the component values specified, the maximum tremolo frequency should not exceed 160 Hz. Finally, the noise generator circuit is unique in that it uses the emitter-base junction of one of the transistors as a zener diode to form the basic noise source. The zener's output signal is amplified by a second transistor and applied to the amplifier section.

The circuits we've examined are but a sampling of the designs which can be developed using the LM389, and the average reader should have little or no difficulty devising additional applications for this extremely versatile device.

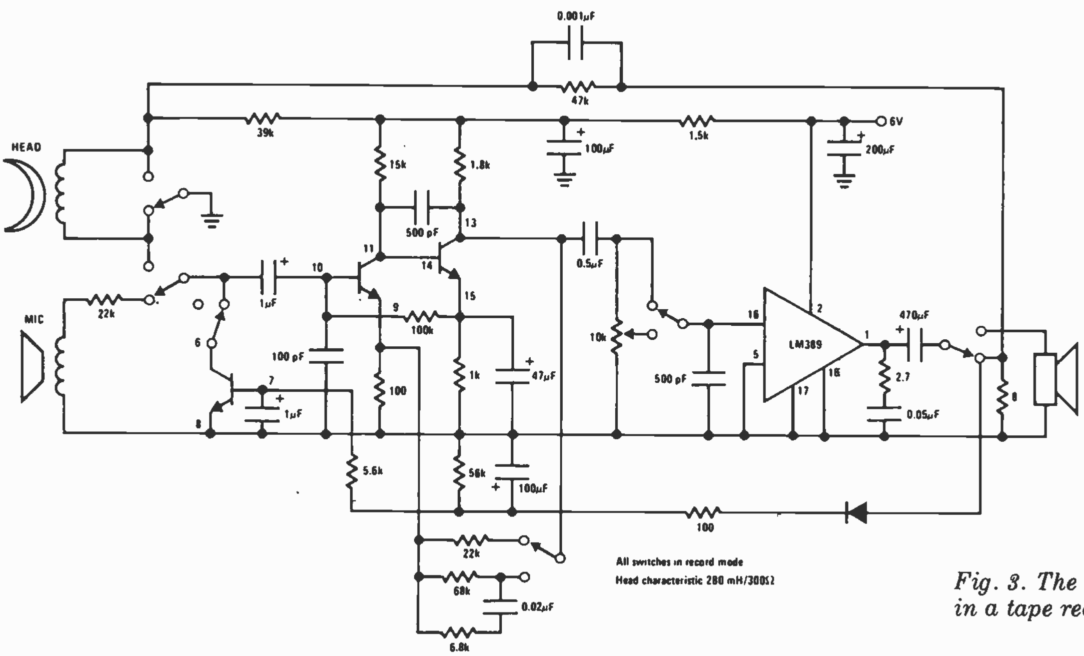



*Fig. 3. The LM389 used in a tape recorder circuit.*

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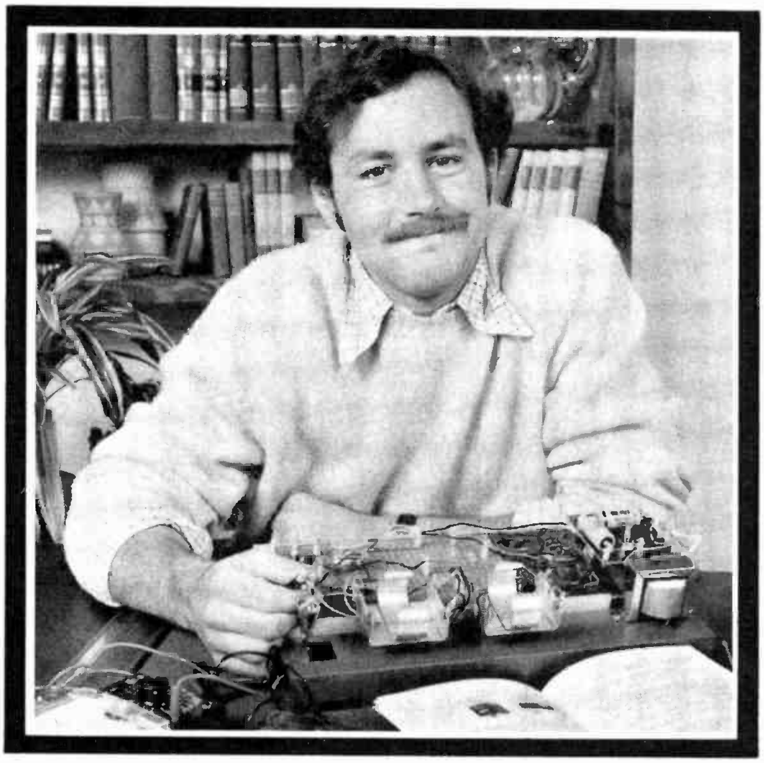

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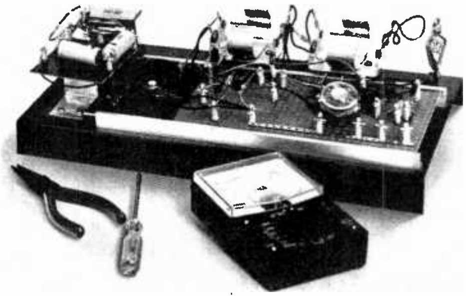

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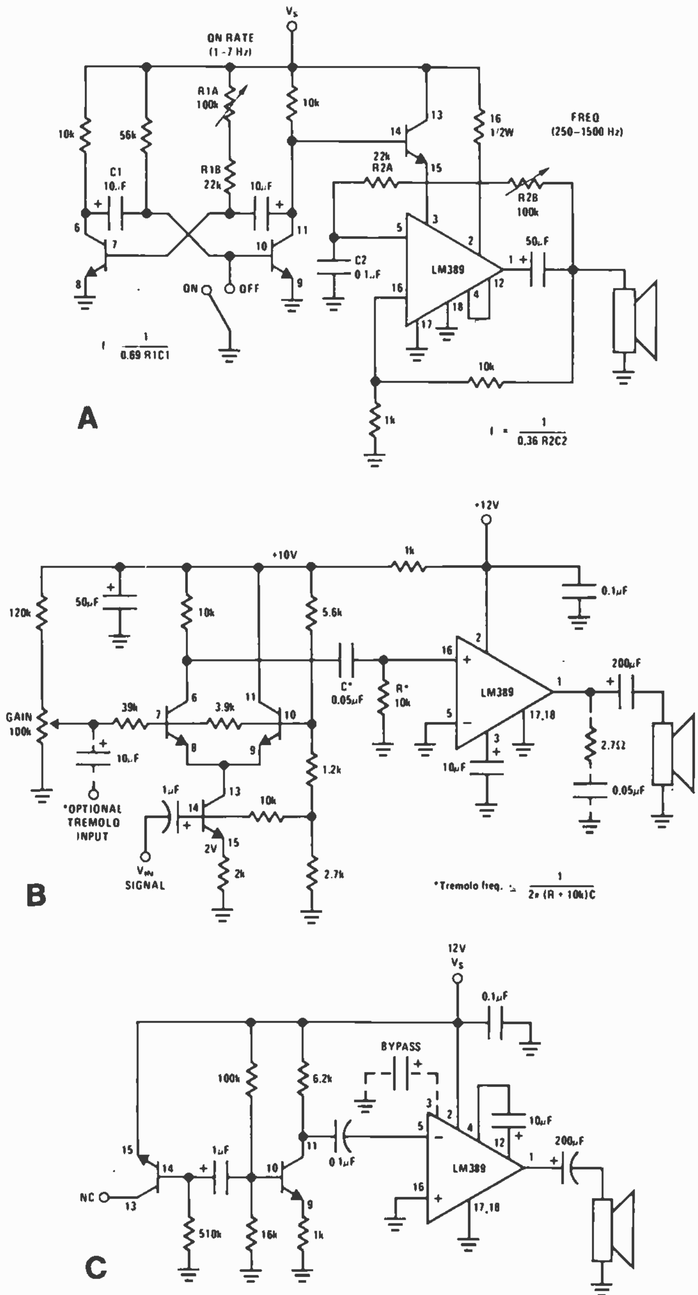



*Fig. 4. Additional applications for the LM389 include: (A) a siren circuit; (B) a voltage-controlled amplifier with tremolo; and (C) a noise generator circuit.*

The phonograph circuit (Fig. 2), for example, could be modified quite easily for use as an intercom. In addition, since the transistors have excellent high-frequency characteristics, the device is well suited for receiver and walkie-talkie projects. Add a suitable sensor, such as a photocell or thermistor, wire the amplifier section for operation as an oscillator (as in the siren circuit), and the LM389 can become the active part of a burglar or fire alarm system. The applications are there waiting—*all that's needed is your imagination!*

**Reader's Circuit.** Suitable for use in games, ESP experiments, and other applications, the random 4-digit number generator circuit illustrated in Fig. 5 was submitted by reader Michael S. Pyska (934 Seneca St., Lewiston, NY 14092). Requiring relatively few components, the design should be a good single evening's or weekend's project for the average hobbyist. The "heart" of Mike's design is a four-digit counter containing integral multiplexed 7-segment output drivers. In operation, a free-running pulse generator or "clock," *IC1*, drives the counter continuously. Since the instantaneous count in *IC2*'s register is changing rapidly, it is essentially a random number. Depressing and releasing the latch switch, *S2*, permits this number to be displayed on the readouts.

Standard components and devices are specified for the project. The clock, *IC1*, is a familiar type 555 timer while the counter/driver, *IC2*, is National Semiconductor's MM74C925. The four readouts are 7-segment common-cathode types, with the driver transistors, *Q1* through *Q4*, type 2N2222 general-purpose npn devices. All resistors are one-quarter or one-half watt types, with the series readout current limiters, *Rs*, 100 to 220 ohm units (the exact value is not critical). Power switch S1 is a spst toggle, slide, or rotary unit, while the latch switch, S2, is a spdt, spring return pushbutton or lever type. Finally, the power pack consists of three or four series-connected penlight or flashlight cells.

With neither parts arrangement nor wiring dress critical, the random number generator can be assembled using any standard construction technique from simple perfboard to a carefully designed PC card. If desired, it can be used as a two or three, rather than four, digit generator, and common-anode instead of common-cathode readouts can be used by adding a pair of hex inverters.

**Device/Product News.** Motorola Semiconductor Products, Inc. (P.O. Box 20294, Phoenix, AZ 85036) has introduced its popular *switchmode* power transistor in low-cost plastic packages. First in the new series are the MJE13002 and MJE13003 devices, rated at 1.5 amperes and 600/700 V blocking voltage. Switchmode transistors are designed especially for switching power supplies and other circuits requiring very fast turnoff time. They are characterized at 100°C operation with *limit* specifications for critical parameters—including a complete inductive-load switching performance matrix for collector currents ranging from 0.5 to 1.5 A., and reverse biased SOA for various turn-off voltages. The devices are housed in TO-126 packages.

A new line of inexpensive GE-MOV® varistors has been announced by GE's Semiconductor Products Department (Electronics Park, Bldg. 7-49, Syracuse, NY 13201). Ten models are available covering 14 to 250 V ac and 14 to 56 V dc. Typically, these devices are used for light-duty transient protection, such as relay-coil spike suppression.

Several products of potential interest to hobbyists and experimenters have been introduced by the Fairchild Camera and Instrument Corporation. Its Optoelectronics Division (4001 Miranda Ave., Palo Alto, CA 94304) is offering a complete digital clock module, a group of 8/10-inch high 3½- and 4-digit clock displays, and a family of 5-kV optical couplers, while its Linear Integrated Circuits Division (464 Ellis St., Mountain View, CA 94042) is manufacturing a new 5-watt, high-voltage audio amplifier IC in a molded 12-lead plastic package. The clock module, type FCS8100, contains a MOS circuit which features 10-second protection against power interruptions as well as a power failure indication, a display with a.m., p.m. and alarm set indicators and a colon in a solid-state assembly that measures only 3.5 × 1.75 inches and is 1-inch thick. The unit also incorporates power supply and output drive

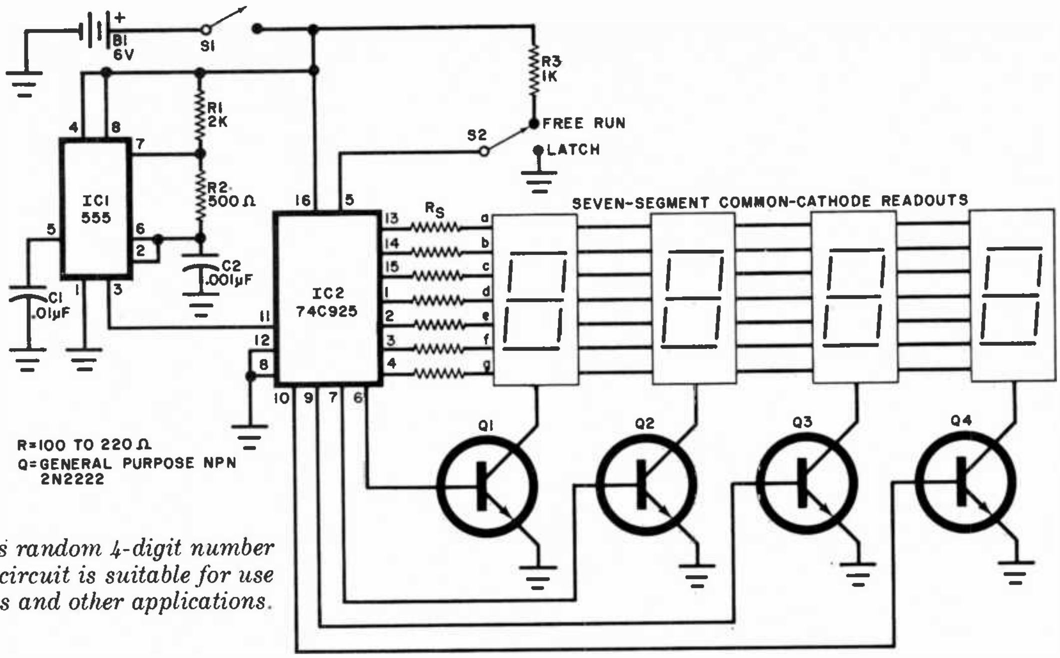



*Fig. 5. This random 4-digit number generator circuit is suitable for use in games, experiments and other applications.*

circuitry for alarm and clock radio operation; only the switches required by the application and a transformer with a 12.6-volt center-tapped secondary are needed to make the module a functioning clock. Similar 0.8-inch high clock displays also are available in either 3½- or 4-digit formats. The FCS8000 and FCS8001 are 3½-digit, common-cathode displays requiring only 8-mA drive current per segment and including AM/PM indicators, with the two versions offering optional spacing between digits. The FCS8024 and FCS8025 are 0.8-inch high 4-digit displays which permit 24-hour time readouts; the two versions offer optional spacing between digits, but do not include AM/PM indicators. All the displays utilize Fairchild's patented "light-pipe" construction for maximum brightness at low drive current levels. The new line of optical couplers is intended as direct replacements for most low voltage standard units and carries corresponding type numbers. ◈

# DESIGNING OPTIMUM -Q AND SMALL INDUCTORS

BY R. E. MARTIN

Optimum Q is achieved in an inductor when its length and diameter are equal. This table will serve as a guide when designing high-Q inductors for r-f circuits. It gives maximum turns and inductance for various wire sizes when close-wound in a single layer.

Higher Q's will be obtained if the turns are spaced at one wire diameter. This results in half the turns and one quarter of the inductances listed in the table. Should an intermediate inductance or number of turns be desired, the factor, K, at the bottom of each column can be used for calculation from the formula L=KT

| Wire AWG | | Diameter & Length (inches) 1/8 | 1/4 | 3/8 | 1/2 | 5/8 | 3/4 | 1 |
|---|---|---|---|---|---|---|---|---|
| 16 | T | | | 6 | 8 | 10 | 12 | 16 |
| | L* | | | .233 | .552 | 1.08 | 1.86 | 4.41 |
| 18 | T | | 5 | 8 | 10½ | 13 | 15½ | 21 |
| | L* | | .108 | .414 | .950 | 1.82 | 3.11 | 7.60 |
| 20 | T | 3 | 6½ | 10 | 13 | 16½ | 19½ | 26 |
| | L* | .0194 | .182 | .647 | 1.46 | 2.93 | 4.92 | 11.7 |
| 22 | T | 4 | 8 | 12 | 16½ | 20 | 24½ | 33 |
| | L* | .0345 | .276 | .931 | 2.35 | 4.31 | 7.76 | 18.8 |
| 24 | T | 5 | 10 | 15 | 20½ | 25 | 30½ | 41 |
| | L* | .0539 | .431 | 1.46 | 3.62 | 6.74 | 12.0 | 29.0 |
| 26 | T | 6½ | 13 | 19½ | 25½ | 32½ | 38½ | 51 |
| | L* | .091 | .728 | 2.46 | 5.61 | 11.4 | 19.2 | 44.8 |
| 28 | T | 8 | 16 | 24 | 32 | 40 | 48 | 64 |
| | L* | .138 | 1.10 | 3.72 | 8.83 | 17.2 | 29.8 | 70.6 |
| 30 | T | 10 | 20 | 30 | 40 | 50 | 60 | 80 |
| | L* | .215 | 1.72 | 5.82 | 13.8 | 27.0 | 46.5 | 110 |
| | K | .00215 | .00431 | .00647 | .00862 | .0108 | .0129 | .0172 |

*Inductance, L, is in microhenries.

When small inductors are needed, for r-f chokes or h-f filter networks, it's frequently convenient to wind them on composition (carbon) resistors. The table shows inductances for various wire sizes when close-wound on common resistor bodies. The resistor value should be above 4.7 kilohms for the low-value inductances and above 47 kilohms for the higher values., unless low Q is desired.

The number of turns listed leaves a little space at the end of the resister body to file small notches in order to guide the coil wire down to the resistor lead while not allowing the coil turns to fall off the ends. Do not use wire-wound resistors.

| Wire AWG | | Resister Size ¼W | ½W | 1W | 2W |
|---|---|---|---|---|---|
| 20 | T | 3 | 7 | 11 | 14 |
| | L* | .013 | .097 | .32 | .63 |
| 22 | T | 4 | 8 | 13 | 17 |
| | L* | .023 | .13 | .45 | .92 |
| 24 | T | 5 | 10 | 17 | 22 |
| | L* | .036 | .20 | .76 | 1.5 |
| 26 | T | 6 | 12 | 21 | 27 |
| | L* | .051 | .29 | 1.2 | 2.3 |
| 28 | T | 8 | 15 | 26 | 33 |
| | L* | .092 | .45 | 1.8 | 3.5 |
| 30 | T | 9 | 19 | 32 | 41 |
| | L* | .12 | .72 | 2.7 | 5.4 |
| 32 | T | 11 | 22 | 39 | 50 |
| | L* | .17 | .96 | 4.0 | 8.0 |
| 34 | T | 14 | 28 | 49 | 62 |
| | L* | .28 | 1.6 | 6.3 | 12 |
| 36 | T | 18 | 34 | 60 | 77 |
| | L* | .46 | 2.3 | 9.5 | 19 |

*Inductance, L, is in microhenries.

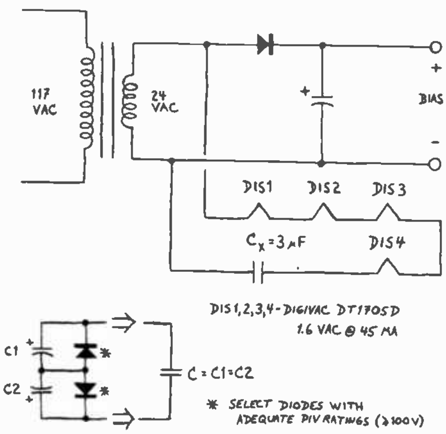
# Tips & Techniques

## EXTENDING TUBE LIFE

If you have a TV or radio receiver that uses a filament string, you can easily avoid tube failures due to current surges that occur when line power is first applied. The non-linear resistors (dubbed "lamp misers") that are sold to extend the life of incandescent lamps can be used for this purpose. These devices are inexpensive (about $1 each), have a cold resistance of about 150 ohms, a "hot" resistance of about 2 ohms, and a load capacity of about 300 watts. Drop one of the resistors into a wall outlet-to-bulb socket adapter, and then screw in a bulb socket-to-power outlet adapter. Plug the assembly into the wall, and the receiver into this device. The surge projector stabilizes to about a 2-volt drop in about 20 seconds. It runs hot (about 2 watts dissipation), but this heat is not critical.—*Bertram A. Thiel*

## FILAMENT POWER FOR FLUORESCENT READOUTS

You *can* supply power to the filaments of fluorescent readouts without using expensive transformers or dropping resistors that generate a lot of heat. Simply insert a




non-polarized capacitor in series with the filament string, and use the transformer in the bias supply as a voltage source. The capacitor will act as a voltage-dropping reactance without "consuming" any power. Experiment to find the value of $C_x$. Start with a small (about 0.5-μF) capacitance and gradually increase until the desired effect is obtained. When this idea was applied to a four-digit clock readout, as shown, only 3 μF was needed. You can buy nonpolarized electrolytics (designed for speaker crossovers), or make your own as shown.—*Gregory Whittier*

## PC STICK-ON DOTS

Here's a good source of stick-on dots for pc etching work. Stick a strip of vinyl electrical tape onto drafting acetate or any clean plastic thicker than the tape itself. Then use a leather punch (multiple die starwheel type) to punch out as many dots as required in the particular size you need. With practice, you can cut through only the tape, using the backing material again and again. You can even punch a hole within a disc to surround mounting holes on the corners of the pc board.—*Bob Best*

## ISOLATING COMPONENTS FROM PC BOARD

Before mounting a component on a pc board, slip a small piece of cardboard between it and the board. Then solder the leads, snip off excess, and gently pull the cardboard out from under the component. This will provide a degree of thermal insulation between component and board, and a more stable circuit.—*William Graham III*

## ZERO-INSERTION-PRESSURE DEVICE FOR IC'S

IC leads can easily be damaged when they are inserted into the usual breadboarding strips. A handy device called the ZIP-DIP (Zero Insertion Pressure) from Textool Products (1410 W. Pioneer Dr., Irving, Tx 75061) can eliminate such problems. The ZIP-DIP is inserted into the breadboard, and its lever brought to the upright position. The holes of the ZIP-DIP are opened and the IC is dropped in. Firm contact to the IC pins is made when the lever is moved to the closed (horizontal) position. The adaptor sells for about $4. It will accommodate 14-pin DIPs, 8-pin mini-DIPs, and metal-can types if the leads are bent into an in-line configuration.—*Sol D. Prensky*

## RUBBER FEET

Silastic* or RTV type silicone rubber can be used to make rubber feet for small enclosures. Drill holes in the corners of the bottom of the chassis or utility box and place self-tapping screws in each hole. (Hex-head screws work best.) Then, apply a blob of silicone rubber completely around each screw and touching the chassis. Allow the rubber to "cure" for about five minutes in an inverted position, and then turn upright onto a sheet of waxed paper for complete curing.—*Robert L. Gray*

## CUTTING PC BOAROS

Using a hacksaw to cut pc boards to proper sizes can be very difficult. Fortunately, there's a much easier way. Lay the board on a flat surface and draw a line where the cut is to be made. Then score the board on both sides with a common glass cutter and a straight edge. Place the scored line over a dowel and apply firm but even pressure on both sides of the score. The board will cleanly snap along the line. A glass cutter with a carbide tip is recommended over the less costly ones.—*W.J. Prudhomme*

# Operation Assist

*If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist,* POPULAR ELECTRONICS *1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)*

**Silvertone** Model 1946 3-band receiver covering .55-15.5 MHz. Serial 462653. Schematic and alignment information. A.F. Schweikhard, 3422 N. 24th Dr., Phoenix, AZ 85015.

**Jackson** Model 805 VTVM. Need a new function switch or substitute. Burt Douglas, 181 Lotus Pt. Road, Irving, NY 14081.

**Hallicrafters** S-40A receiver circa 1947. **Acton Labs** TCV-271 CB transceiver. Schematics and/or service manuals. David Newman, 418 Pleasant St., S. Weymouth, MA 02190.

**Symbolic Displays Inc.** Model 103 Digital IC tester. Need schematic and/or owner's manual. Benny R. Maestas, 17630 Lakewood Blvd. #10, Bellflower, CA 90706.

**IBM** Model 1571 diode tester known as IBM print 450918 S 32001. Uses Weston panel meter. Need operations manual and/or data on self-contained batteries, 10-pin male plug adapter cord, etc. Fred W. Gatzke, 184 Hewes St., Brooklyn, NY 11211.

**Zenith** Model 95244 cabinet "Long Distance Radio" serial R561561. Schematic diagram, operations manual, and any other information. Roz Paturick, 4201 Locust, Apt. 406, Kansas City, MO 64110.

**Granada** Model 8000 AM/FM/8-track stereo. Need drive motor for tape deck or a source of parts. Lyle W. Jenkins, Electronic Repair Service, Lakeside Acres, Rte. 2, Killen, AL 35645.

**Sonora** Model B31 AM radio covering 550 to 1500 kHz, circa 1929-35, with LL18 dynamic speaker. Schematic needed. Barry's Radio and TV, c/o George Barry, 89 Gilbert St., Quincy, MA 02169.

**Dumont** Model 3290 oscilloscope, serial 4X00. Schematic and parts list. C.H. Welch, Jr., 336 Orchid Rd., Birmingham, AL 35215.

**Thomas** Model VL-5 transistor organ. Need schematic and service information. N.M. Dietrich, Rt. 1, Box 393A, Texarkana, AR 75501.

**Central Electronics** Model 200-V broad-band exciter/SSB transmitter. Need a set of 160-meter band (1750 to 2500 kHz) broadband coupler coils. Jack Williamson, W5PJS, 127 Patton Ave., Shreveport, LA 71105.

**Hickok** Model 665 oscilloscope. Schematic, service and operation manuals. Joseph Planisky, 13690 Diagonal Road, Salem, OH 44460.

**Concertone** Model 800 stereo tape recorder. Schematic, service and operation manual needed. John L. Nowack, 1326 Maple St., Bellaire, OH 43906.

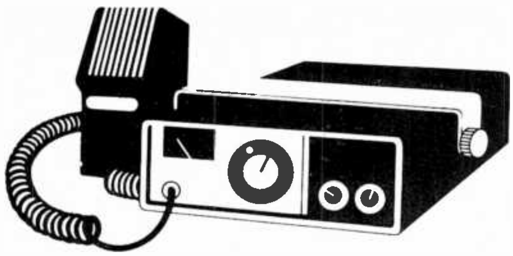
**Philco** Model 37-610 three-band receiver (1935). **Lear** VHF-LF aircraft transceiver. Model numbers on chassis: LR-6A-1 vhf receiver, LRA-6A LF receiver, RT-10E transmitter. Omnirange converter model 2214A. Schematics, oepration manual, and service info. needed. James Marple, 2801 Sequoia Ln., Arlington, TX 76010.

**E.H. Scott** Allwave Model 15 receiver, circa 1933. Chrome plated two chassis, electrodynamic speaker, 2-2A3 output tubes, 5Z3 rectifier. Require Dial escutcheon, tuning indicator, and schematic. T.W. Scott, Box 601, Greenwood, Nova Scotia, BOP 1NO, Canada.

**Hickok** Model 640 oscilloscope. Need power transformer or substitute info. Joe Grygar, 8816 Greyling Pl., San Diego, CA 92123.

**Hartman** Hurricane vhf/FM Marine transceiver, 5 channels. Serial 45866. Need schematic and/or service manual. Paul Smith, W1GHN, 65 West St., New London, CT 06320.

**Jackson** Model 655 Audio Oscillator. Service manual and/or schematic. John J. Schnupp, 6464 W. 11th Lane, Hialeah, FL 33012.



# CB Scene

By Ray Newhall, KWI6010

## FCC PROPOSES NEW CB RADIO CHANGES

WITH MORE than a half-million new license applications flooding the FCC mailbags each month at its new address (Gettysburg, PA 17326), you can be certain that the FCC is concerned with the future of the Citizens Band. A few months ago, I suggested that 6,000,000 to 7,500,000 CB rigs might be sold this year. Now it appears that even the most optimistic of CB marketeers may have short-changed public demands for CB. In mid-1976, a strange things seems to be happening . . . the people who bought mobile rigs earlier this year are returning to their dealers for base units to match.

Although it may not appear that way out in CB-land, the FCC is very anxious to expand the number of CB channels, as promised last March. It was just in the nick of time that FCC technicians determined that the addition of 50 or more channels on the Class D Band would raise unbelievable havoc on AM broadcast frequencies because of a phenomenon known as "intemodulation interference." It is created whenever two basic frequencies are mixed: two new frequencies are generated in addition to the two original frequencies. This phenomenon of "hetrodynes" is used as the basis of the common superhetrodyne receiver, in which the desired antenna frequency is mixed with the frequency of a local oscillator to create an intermediate frequency of 455 kHz. The three other frequencies are filtered out, and the IF frequency is isolated, amplified and demodulated.

Right now it appears that 45 channels may be the viable maximum that can be assigned in the 27-MHz Class D band without creating an intolerable level of harmonic interference. We expect the FCC to authorize this expansion in 1977, but do not anticipate that such expanded-channel units will be available for some time thereafter. For one thing, the FCC will not be certifying units for "Type Acceptance" for some time afterwards. But Uncle Charlie knows that 45 channels are not nearly enough to satisfy the future needs for personal two-way radio. One or more additional band must be assigned at higher frequencies where noise, skip and sunspot activity will not hamper communications. The FCC is now searching frantically for spectrum space which could be transferred from another allocation to The Citizens Radio Service.

The FCC is examining portions of the radio spectrum which might accommodate uhf CB. A portion near 460 MHz is under examination, as is another segment at 915 MHz. I think, however, that any allocation of CB channels above 300 MHz would be very unwise within the scope of current technology. Equipment to operate at these uhf frequencies would be too costly for the average citizen and would require special installation techniques which are not currently available to the consumer. We have already seen the demise of Class B CB because of its cost.

**Other New Proposals.** Along with new frequency authorizations, we can expect the FCC to require closer frequency tolerances and lower spurious emissions from future CB rigs. Already there are serious problems developing out of harmonic interference between legal CB transceivers and commercial TV, AM and FM receivers and solid-state stereo devices. Congress is considering legislation which would require these home entertainment electronic devices to be more immune to external inteference, but the permissible amount of harmonic radiation from the CB transceiver itself must also be reduced.

The FCC is now considering tighter restrictions and rule changes in all of the areas listed below.

- Harmonic radiation from the transceiver cabinet and antenna terminals suppressed to at least 70 dB.
- Frequency tolerances for single-sideband transmitters to be held to less than ±0.0001% (about 25 Hz @ 27 MHz). This would eliminate the need for clarifier controls. The present requirement for AM transmissions (about ± 1350 Hz) would probably not be changed.
- Manufacturers would be required to engrave or stamp a serial number into the chassis of each transceiver so that it can be identified if stolen.
- Manufacturers will be required to affix a warning label informing the buyer or user that the penalty for unlicensed use is $10,000 and/or one year imprisonment.
- FCC is proposing to reorganize all CB Radio classes under the name, "General Radio Service." Class C (remotely controlled devices) would be incorporated into Class D and called the "CB Radio Service." (The FCC is reportedly inundated by letters from Class C users objecting to this proposal, though users under 18 can still operate remote-control models under a CB'ers station license.) Class A woud be redesignated as the "UHF CB Service."
- The designation of Channel 11 as a "hailing-only" frequency has not worked out. It is proposed that it be restored to the status of all other CB channels, leaving only Channel 9 as a designated use frequency.
- After 1976, no more 100-mW Walkie-Talkies may be manufactured to operate on 11 meters. They have been moved to 49.82 - 49.90 MHz. Use of existing units will be permitted until 1983.

**Technological Improvements.** The recent manufacturer's CB show, "PC-76," revealed much technical development which will soon be evident on the display shelves of your local CB radio store.

Phase-locked loop (PLL) circuitry on an IC chip will come into greater use to determine and control r-f frequencies. This permits manufacturers to build highly versatile transceivers containing only two or three high-quality crystals instead of 14 or more as previously required. Digital displays will become more commonplace as channel indicators, and you may soon dial-in your channel selection on a ten-key pad.

These new circuitry techniques are already beginning to appear in the marketplace, and they will pave the way for extended channel allocations. But don't hold your breath waiting for rigs with extended channel capabilities. Even if 45 channels are authorized by FCC in 1977, it will be many months (or years) before they are available for use, as previously noted. And they will probably be considerably more expensive than present Class D rigs. If you buy a new rig this year, it will likely be well-worn before you can replace it with one with extended channel capability. The current channels will not become obsolete. In fact, it is possible that most of the extended channels may be reserved for SSB use, or use between units of the same station only.

**New Facts To Remember.** When you buy your new CB rig, file your license application (Form 505), along with your check for $4.00, with the FCC, Gettysburg, PA *17326*. This is a new address, the one on your Form 505 is obsolete.

You may use your rig immediately after you mail your *Form 505* if you complete a *Form 555-B* and hold it in your possession. You may copy the Form 555-B published in the July issue of PE, or you may obtain a copy by writing REST MARINE, Box 170, Old Greenwich, CT 06870. (Please enclose a self-addressed, *stamped* envelope.)

There is a new edition of Part 95 available for only $1.50 from the Superintendent of Documents, Government Printing Office, Washington, DC 20402, or the Public Documents Distribution Center, Pueblo, CO 81009. This is an extract of Volume IV, published in April, 1976, and contains only Part 95. It is not a subscription. (You must have a copy of Part 95 in your possession before you are properly licensed.)

*If you have any future subjects that you would like to see discussed in this column, please send your suggestions to me at* POPULAR ELECTRONICS, *One Park Avenue, New York, NY 10016.* ◈

# Inside Basic Electronics

By Sol D. Prensky

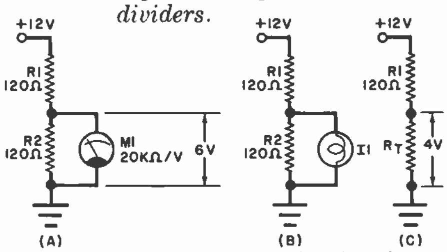
## USING RESISTANCES

IN OUR first column, we discussed the many various types of fixed and variable resistors that are available for use by the experimenter/hobbyist. Before leaving resistors altogether, we should consider some of the problems involved with using resistance itself. For instance, how do you design a resistive voltage divider—a very common configuration in electronic circuits.

Suppose we have a device that operates at 6 volts and our available source of supply is 12 volts. (The same principles would apply for any other combination of supply and demand.) A simple resistive voltage divider can be designed as shown in Fig. 1A. Resistors *R1* and *R2* are equal so the voltage across *R2*, as measured by the meter, is 6 volts.

When we proceed to connect a lamp across *R2* (Fig. 1B) we find that the lamp glows only dimly, if at all, and that the voltage across it is now sub-

*Fig. 1. Voltage dividers.*




stantially less than 6 V. What has happened, of course, is that the effective resistance of the lamp in parallel with *R2* has dropped so that the voltage across the combination is not sufficient to light the lamp. The lamp is rated at 6 volts and 50 mA, which means a resistance of 120 ohms. The combination of the lamp and *R2* thus gives a total resistance of 60 ohms and the voltage across the combination is 4 V (Fig. 1C).

We realize now that the 20,000 ohm/volt meter on its 10-V range, connected across *R2*, drew only a small amount of current and did not provide any appreciable load on the circuit. On the other hand, the current drawn by the lamp was sufficient to drag down the output voltage. As a general rule: *To avoid loading the circuit by more than 5%, the load should be at least 20 times greater than the parallel resistance.*

**Variable-Voltage Dividers.** It is often possible to adjust the voltage

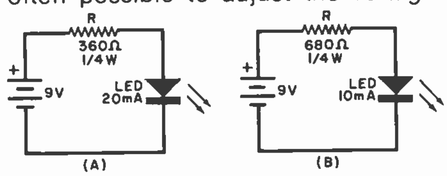



*Fig. 2. LED circuits.*

across a load by using a variable-voltage divider (a potentiometer as one leg of the divider), especially when in doubt about the definite current characteristics of the load. While such a technique generally seems easy, since it avoids the bother of some calculations, it can often prove to be more trouble than it is worth. This is especially true when miniature pots are used. It is very easy to exceed the wattage rating of a pot and ruin it permanently.

Suppose, for instance, that we want to use a ½- or ¾-watt pot in the example in Fig. 1. if the resistance of the pot (composition type) is 5000 ohms, the rated current turns out to be only 10 mA. Using a lower-resistance pot would provide a slightly higher current rating, but it would still be too low for a 50 mA load. So, it seems obvious that using a miniature ½-watt pot for a 50-mA load would exceed the pot's rating and possibly damage the pot. However, the miniature pot does have many uses in conjunction with op amps and IC's that draw less than 10 mA.

The common 2-watt composition potentiometer can usually be considered a good choice for loads up to 20 mA, with resistances up to 5000 ohms. Staying on the conservative side, the use of wirewound (or equivalent ceramic) types in the 4-to-5-watt ratings is even better. So keep this rule in mind: *For load currents larger than about 10 mA, be wary of using miniature pots in the range of ½ to ¾ watts (especially for resistance ranges greater than 5 kilohms).*

**Series Dropping—Resistor Method.** A much more direct way of reducing applied voltage is through the use of a simple series resistor. This avoids parallel-loading complications, but we must know how much voltage and current are required by the load. For instance, suppose we want to operate a low-voltage LED from a 9-volt battery. As shown in Fig. 2A, the LED is rated at 2 V and 20 mA, so we need a series resistor to drop the

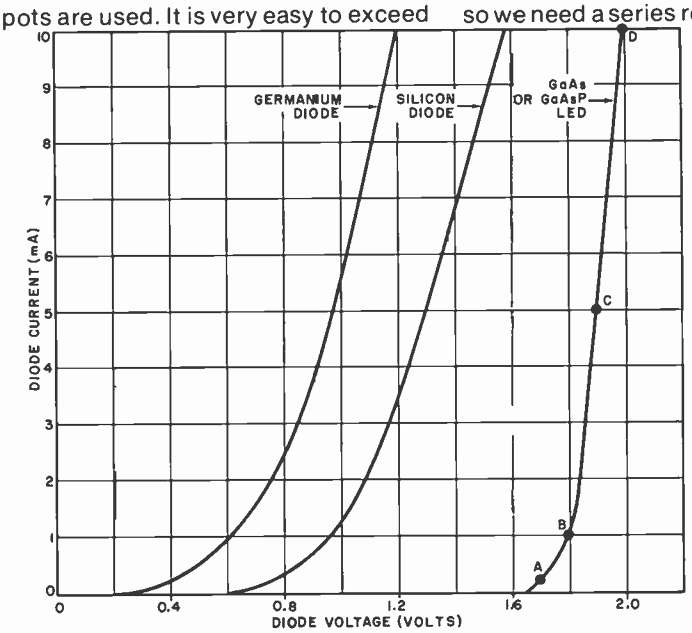



*Fig 3. Curves show dependence of resistance on applied voltage, as well as temperature for diodes.*

supply to 2 volts. So IR = 7, and R = 7/0.02 = 350 ohms. (Use 330 or 360 ohms.)

For a low-current LED (2 V and 10 mA as in Fig. 2B), the resistor would have to be about twice as big—say 680 ohms. The power requirement for the resistor is calculated from P = VI or (for Fig. 2A) P = 7 × 20 = 140 mW and (for Fig. 2B) P = 7 × 10 = 70 mW.

**Nonlinear Resistances.** Circuits involving incandescent lamps and LED's are not always as simple as they are described above, since these components, under certain circumstances, are nonlinear resistances. In actual practice, this need not present any big problem, as long as the lamp or LED is used at its rated operating value. (A lamp rated for 6 volts with 50 mA flowing through it can be considered a resistance of 120 ohms.) However, if the applied voltage is something less than the rated voltage, the so-called "cold" resistance of the lamp must be taken into account. This will be appreciably less than 120 ohms. A rule covering this action (since an incandescent lamp filament is tungsten) is: *The resistance of a metal increases with temperature or (similarly) when operated at a high current.*

On the other hand, the rule is reversed when it comes to a semiconductor such as the LED. Semiconductors have an unusual voltage-current characteristic as shown in Fig. 3.

Considering the LED specifically, note that the LED requires a much larger threshold voltage for forward conduction to occur. Then, with each small increase in voltage, there is a large increase in current, making the effective resistance smaller. As a result, we can refer to the effective resistance of the LED (or any other semiconductor diode) in terms of specific operating voltages and currents. The rule is: *Semiconductors show a substantially decreased effective resistance with increased temperature or (equivalently) at high voltages or currents.*

The following figures for the four points called out on Fig. 3 for the LED show how rapidly the effective resistance decreases for increasing voltage.

| | A | B | C | D |
|---|---|---|---|---|
| Voltage | 1.7 | 1.8 | 1.9 | 2.0 |
| Resistance (ohms) | 16k | 1.6k | 400 | 200 |

Many LED's have been ruined by too high a voltage. ◈

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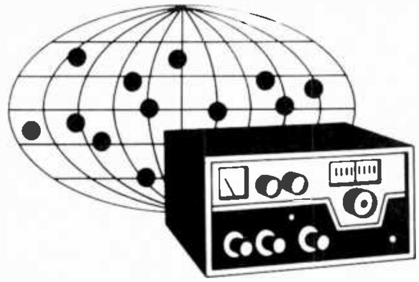

# DX Listening

Glenn Hauser

LISTENING to *Deutsche Welle* does not necessarily mean that you are receiving a broadcast direct from Germany. This broadcaster is one of eight major systems which use relay stations outside their home countries. Not only can you not assume that you are listening to a broadcast from the station's home country—you can't always accept what they themselves would lead you to believe. Each has its own peculiar policies and practices with respect to relays.

Programs reach relay sites by different routes. *Deutsche Welle* feeds its Rwanda relay by satellite, which assures freedom from fades and interference, but provides only low fidelity. Its Malta base receives signals from Germany by SSB feeds outside the broadcast bands. Radio Canada International picks up in-band broadcasts at Stittsville, Ontario, and microwaves them to Montreal and then Sackville, New Brunswick, for retransmission. *Deutsche Welle* on 6085 kHz via Sackville often has the interference on 6145 kHz.

*Deutsche Welle* has been building (with *BBC)* a new relay site in Antigua and Montserrat, which should now be on the air. Also under construction is a site in Sri Lanka, this one to be shared with *Radio Teheran*—which will put Iran in the 'big league' of countries with external relay sites. A few years ago, *DW* tested via the *Sierra Leone Broadcasting Service*, but this failed. *DW* also has an interest in *Radio Trans-Europe*, Sines, Portugal, which is used by a number of different broadcasters but has no programs of its own.

*Radio Free Europe* and *Radio Liberty*, now based in the same building in Germany, transmit from low-powered stations in Germany, and high-powered sites in Portugal and Spain, respectively. *Radio Liberty*, however, has been in serious danger of losing its rights to beam to the USSR from a Barcelona beach.

How do you know whether you're hearing these stations from Germany or Iberia? Only a current frequency schedule gives the exact answer. In general, however, higher frequencies come from Iberia rather than from Germany. In fact, most *RFE* programs on 11 MHz, and all on the 15, 17 and 21 MHz bands, are from Portugal.

**Multi-Site Broadcasters.** The *Voice of America* is the supreme multi-site broadcaster, with 72 transmitters in nine foreign countries (as of last year) and 41 at 6 U.S. sites. Last May, *VOA* resumed a policy DX listeners had criticised before—ceasing to show the site in use on QSL cards, and ceasing to announce specific sites (just the studio location of Washington, D.C.). *VOA*'s summer schedule still lists the sites, however. It's not uncommon for two or three different sites to be used on a single frequency within a 24-hour period. Several frequencies (5955, 9650, 11805 and 11830 kHz) show four sites per day, and one—15205 kHz—is listed for five sites each day (Delano, Dixon, Munich, Kavalla, Tangier).

Rather than expanding its network, *VOA* has trouble holding on to existing sites. Okinawa's lease ran out last May, and Thailand is eyeing the megawatt *VOA* station there for its own benefit as relations with the U.S. deteriorate.

Only two of the eight *VOA* transmitters in Liberia are on the air between 2300 and 0100 GMT, and none at all from 0100 to 0300. It's a pity politics prevents these from relaying hard-to-hear Asian, African and European stations back to the USA.

Many parts of the U.S. are too far from *VOA* transmitters for groundwave reception, yet too close for skywave. The central states hear all domestic *VOA* sites well by backradiation, but on the coasts transmissions from the opposite coast or overseas sites often come in better than backscatter from relatively close transmitters.

*AFRTS* uses *VOA* transmitters as backup for overseas military units depending primarily on cable or satellite feeds, 24 hours a day—despite the fact that few overseas *AFRTS* stations use much from *AFRTS*-Washington besides ball games and news. Consequently, *AFRTS* uses only one overseas relay—a Philippine transmitter beamed westward.

The *VOA* site near Bethany, Ohio, is used extensively by other organizations—for two main reasons. Bethany is at a disadvantage in reaching Europe, compared to Greenville, N.C. The latter has a much more southerly path, away from the auroral absorption zone, so the higher-priority *VOA* programs radiate from Greenville; also, *UN Radio, AFRTS,* and the *Voice of the OAS* are all interested in reaching Latin America, for which Bethany is as good as Greenville.

You may hear *VOA* out of band; if it's not a receiver image, it still may be a feeder, like 5745 kHz, with the carrier hardly reduced at all. However, *one* frequency-hour of *VOA* transmissions is officially broadcast out-of-band, via a long-established *BBC* channel—7325 kHz at 0600-0700 GMT.

*BBC* is another big multi-site station. Except along the East Coast, best reception in North America usually comes from *BBC* sites outside the UKOGBANI. *BBC* sites are referred to only in vague terms—"Atlantic Relay" for Ascension Island, "East Mediterranean Relay" for Cyprus; and "Far Eastern Station" for Malaysia.

Just as the *VOA* uses *BBC* facilities in England, and more recently in Ascension, the *BBC* uses *VOA* facilities in the USA. But despite *VOA*'s openhandedness about the deal, the *BBC* continues to avoid any official admission that it is depending on VOA for its Spanish broadcasts at 0215-0415 from Dixon-6010 and Delano-9680 kHz (*VOA* picks up the *BBC* signals at Greenville and feeds them by land line to the west coast); for Portuguese at 2200-2415 on 5995 kHz; and for the World Service at 0030-0330 from Greenville-9510 kHz, the last of which appears in *BBC* schedules as if it were from a site in England. *VOA* warms up that transmitter on 9500 to avoid interfering with an abutting *BBC* relay from Canada on 9510.

The relatively isolated Ascension site, however, uses tapes whenever possible, resulting in a much nicer audio sound, even though the signal may be weaker than from Sackville. Most mail to Ascension goes through Patrick AFB, Florida. There are times, such as 0100 GMT, when we can select *BBC* from any of four different countries: Canada on 6175, Britain on 5975, 7325 or 9410; USA on 9510, Ascension on 9580 kHz. A fifth is now being added, in cooperation with *Deutsche Welle*, on Antigua. This will involve some adjustments in *BBC* usage from other sites. Frequencies planned to be used from Antigua are 6010, 6065, 6085, 6175, 9545, 9590, 9605, 9735, 9765, 11765 and 11810 kHz. Not all are for BBC-English—some are Spanish, and some are for *DW*.

On the other side of the world, *BBC* is moving its Far Eastern Station from the southern tip of Malaysia to nearby Singapore, whence it once claimed to be operating before Singapore became independent. Christmas Island had been considered a possible replacement for Malaysia, but a Reuters report spotted by Gerry Dexter reveals why not: the phosphate island is being mined heavily.

The cable connecting Britain and Canada works both ways. *RCI* feeds some of its programs to Daventry, England. Indeed, there are no *RCI* broadcasts in Czech, Slovak, Hungarian and Polish from Canada itself; only from Britain. *Radio Trans-Europe*, Portugal, is also used for Russian and Ukrainian *RCI* programs. *RCI* once used the *DW* site on Malta, but was kicked off for political reasons. Most recently, Malta has started allowing Libya to broadcast from the station *DW* built. *RCI* probably wasn't too sorry to lose Malta; they had a lot of problems in feeding their signal there, direct and via Daventry.

However, *RCI* is the only station we know of to try beaming two *different* programs on the same frequency at the same time from the *same site*—Sackville on 9625 kHz. *RCI* European service mixed with the Northern Service two hours a day last summer, and for a few weeks this May, NS overlapped the South Pacific Service for half an hour. This kind of sharing just doesn't work!

Any *Radio Nederland* transmission you hear between 0030 and 0750 GMT is not from Holland, but from Bonaire, which is an excellent spot for reaching all of the Americas and Africa. Bonaire frequencies hardly ever change, which is another advantage for *RN*. The site has even been used for broadcasts back to Europe, as Holland is in the skip zone from much of Europe; but this is now an added benefit of *RN*'s other relay base, in Madagascar, which primarily serves Africa, Asia and Australia. *RN* prepares tapes weeks in advance so its relay stations can broadcast high-quality audio—except for news fed via SSB links on SW, often with incredible interference. The electronic-music version of *RN*'s interval signal, used only on PTP feeders such as 5925 kHz, must be heard to be believed. Some *RN* programs are broadcast from all three sites at the same time, with tapes as much as 30 seconds apart.

The USSR is so large it doesn't need—or at least doesn't have—overseas relay bases. However, though neither country admits it, Bulgaria helps the USSR reach North America. *Radio Moscow* on 9700 and 6070 kHz has long been known to be via Sofia, but this year it has come to light that another Bulgarian site, Plovdiv, also transmits Moscow programs, scheduled when summer began on 11750 and 9530; 11870 is another Sofian. These are the conclusions of monitor Roger Legge in McLean, VA. Most of the other *R. Moscow* North American Service sites are in Simferopol' or elsewhere in the Ukraine, which is most advantageous, next to Bulgaria.

Several Far East sites reach North America from the other direction. Petropavlovsk, on the Kamchatka Peninsula, is best situated, and was used as the summer began on 17720, 15210, 12050, 11970, 11720 and 9710 kHz, as observed by Bill Davis in Laguna Niguel, CA. Vladivostok is on 15100; Nikolayevsk on 12000 and 11870; Blagoveshchensk on 11690, and Khabarovsk on 9635. Do not believe the sites *Radio Moscow* claims on its QSL cards. Discrepancies have been determined by careful study of propagation and operation. Despite a growing Orbita comsat system in the USSR, many *Radio Moscow* frequencies exhibit the characteristics of relays off shortwave. *R. Moscow*, *R. Kiev*, *R. Vilnius* and *R. Yerevan* should be thought of as programs, rather than stations, as each uses transmitters outside its own republic.

Little is known about the sites within China, but there must be several of them. However, *Radio Peking* is relayed to the Americas and Africa from Albania (on 6135, 7120, 9500 and 9780 kHz), and extensively to Europe on

1457 kHz. But you won't hear any announcements like "This is the *Radio Peking* relay in Albania"!

**Smaller Stations.** *Radio Budapest* was relayed, briefly, a few years ago from East Germany. This had no particular advantage and was discontinued. This summer, C.M. Stanbury, reports a "relay sound" on *Radio Bucharest's* 5990 kHz outlet to North America, but we don't yet know where this one is relayed from.

Australia has no external relay sites, but several within the continent. The newest is at Carnarvon on the west coast. One of Carnarvon's three beams eventually crosses Boston, and it's not hard to hear elsewhere in North America though intended for Asia. Interestingly, it is the most distant international broadcasting site in the world from (roughly) the Eastern and Central time zones. (*R. Nederland* in Madagascar is farther from the Mountain and Pacific time zones.) Carnarvon is fed primarily by transcontinental microwave link, but with backup on SSB at 9210 and 9450 kHz from Lyndhurst, Victoria.

Several countries broadcast from two or more sites within their own country, but seldom specify which. Among them are England, France, Spain, Sweden, Switzerland, Saudi Arabia, Israel, East Germany, Hungary, Nepal and Malaysia.

New listeners are often confused by WYFR. Is it in Oakland, CA, or Scituate, MA? Most of the programming is recorded at the studios in Oakland, but newscasts in Spanish seem to be fed across the continent to Scituate, where all transmissions radiate. However, WYFR is planning a move to Florida.

Some stations are multi-site without being relays. *Trans World Radio* broadcasts from Monaco (actually France), Bonaire, Swaziland, Cyprus, Guam, and soon Sri Lanka. *IBRA Radio* owns no stations but buys time in Portugal and Malta, despite its studio location in Sweden.

## ENGLISH-LANGUAGE SHORTWAVE BROADCASTS FOR SEPT. & OCT. 1976

**by Richard E. Wood**

**TO EASTERN NORTH AMERICA**

| TIME–EDT | TIME–GMT | STATION | QUAL* | FREQUENCIES, MHz |
|---|---|---|---|---|
| 6:00-7:00 a.m. | 1000-1100 | **Montreal, Canada | G | 5.97, 9.57 |
| 6:30 a.m.-8:00 p.m. | 1030-2400 | **Montreal, Canada (Northern Service) | G | 9.625, 11.72 (includes French, etc.) |
| 7:00-7:25 a.m. | 1100-1125 | Tirana, Albania | F | 9.48, 11.985 |
| 7:00-9:00 a.m. | 1100-1300 | Melbourne, Australia | G | 9.58 |
| 7:00-9:30 a.m. | 1100-1330 | London, England | G | 15.07 |
| 7:00-10:00 a.m. | 1100-1400 | **VOA, Washington, U.S.A. | G | 9.655, 9.73 |
| 7:15-8:15 a.m. | 1115-1215 | Montreal, Canada | G | 5.97, 9.655 |
| 8:00-8:30 a.m. | 1200-1230 | Jerusalem, Israel | F | 11.655, 15.10, 15.485, 17.685 |
| 8:00-8:55 a.m. | 1200-1255 | Peking, China | F | 11.685 |
| 8:15 a.m.-12:30 p.m. | 1215-1630 | HCJB, Quito, Ecuador | G | 11.745, 15.115 |
| 9:00-11:00 a.m. | 1300-1500 | Trans-World Radio, Bonaire, N.A. | G | 15.255 (Sat., Sun.) |
| 9:15-9:45 a.m. | 1315-1345 | Berne, Switzerland | G | 15.14 |
| 9:15 a.m.-4:00 p.m. | 1315-2000 | **London, England | G | 9.41, 15.07 |
| 9:30-10:00 a.m. | 1330-1400 | Helsinki, Finland | F | 15.11 |
| 10:00-10:30 a.m. | 1400-1430 | Stockholm, Sweden | G | 15.305 |
| 11:00 a.m.-12:15 p.m. | 1500-1615 | London, England | G | 17.84 (via Ascension) |
| 12:00-1:00 p.m. | 1600-1700 | **Paris, France | G | 9.74, 11.705, 11.89, 11.93, 11.965, 15.21, 15.30, 15.32, 15.425, 17.72, 17.80, 17.82 |
| 1:00-2:15 p.m. | 1700-1815 | London, England | G | 9.58 (via Sackville) (Sun. to 1845) |
| 2:45-4:00 p.m. | 1845-2000 | **Abidjan, Ivory Coast | F | 11.92 (Mon.-Sat.) |
| 3:45-6:30 p.m. | 1945-2230 | **Delhi, India | F | 9.525, 9.912, 11.62 |
| 4:00-4:30 p.m. | 2000-2030 | **Tehran, Iran | F | 9.022 |
| | | Jerusalem, Israel | G | 7.395, 9.815, 11.645 |
| 4:00-5:00 p.m. | 2000-2100 | **Brasilia, Brazil | G | 11.78 |
| | | Accra, Ghana | F | 9.545, 11.85 |
| 4:00-5:15 p.m. | 2000-2115 | **London, England | G | 9.41, 11.75, 15.07, 15.26 |
| 4:00-5:20 p.m. | 2000-2120 | **Hilversum, Holland | F | 11.73 (via Talata) |
| 4:45-5:00 p.m. | 2045-2100 | **Valletta, Malta | G | 6.035 (Sat.) |
| 5:00-5:50 p.m. | 2100-2150 | **Johannesburg, South Africa | G | 4.875, 9.585, 11.90 |
| 5:00-6:00 p.m. | 2100-2200 | **Montreal, Canada | G | 9.625, 11.855, 15.325 |

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| 5:15-6:45 p.m. | 2115-2245 | London, England | G | 9.58 (via Ascension), 11.78, 15.26 (via Ascension) |
| 5:30-6:50 p.m. | 2130-2250 | Hilversum, Holland | G | 9.715, 11.73 (Sun.: Dutch) |
| 5:45-7:00 p.m. | 2145-2300 | **Cairo, Egypt | G | 9.805 |
| 6:00-6:15 p.m. | 2200-2215 | **Belgrade, Yugoslavia | F | 9.62 |
| 6:00-6:30 p.m. | 2200-2230 | **Montreal, Canada | G | 11.855, 15.325 |
| 6:00-8:00 p.m. | 2200-0000 | Montreal, Canada | G | 6.04, (Mon.-Fri.) |
| 6:00-9:20 p.m. | 2200-0120 | **Ankara, Turkey | F | 9.515, 11.88 |
| 6:30-7:00 p.m. | | Jerusalem, Israel | G | 7.395, 9.435, 9.815, 11.625 |
| | 2230-2300 | Vilnius, U.S.S.R. | G | 7.32, 7.355, 9.685, 9.735, 9.745 |
| 6:30-7:20 p.m. | 2230-2320 | Johannesburg, S. Africa | F | 4.875, 9.585, 11.90 |
| 6:45-8:30 p.m. | 2245-0030 | London, England | G | 5.975, 7.325, 9.58 (via Ascension), 11.78 |
| 6:55-7:15 p.m. | 2255-2315 | Brussels, Belgium | F | 9.73 |
| 7:00-7:30 p.m. | 2300-2330 | Stockholm, Sweden | F | 6.12, 9.605, 11.705 |
| | | Helsinki, Finland | P | 15.11 |
| 7:00-7:50 p.m. | 2300-2350 | **Buenos Aires, Argentina | G | 11.71 (Mon.-Fri.) |
| 7:00-8:30 p.m. | 2300-0030 | Moscow, U.S.S.R. | G | 5.905, 7.10, 7.11, 7.15, 7.205 7.355, 9.685 |
| 7:45-8:00 p.m. | 2345-0000 | **Voice of the Org. of American States, Washington, U.S.A. | G | 9.64, 11.74, 15.16 |
| 7:45-8:45 p.m. | 2345-0045 | Tokyo, Japan | F | 15.27, 15.30 |
| 8:00-8:25 p.m. | 0000-0025 | Tirana, Albania | G | 7.065, 9.78 |
| 8:00-8:30 p.m. | 0000-0030 | Oslo, Norway | G | 6.18, 9.645, (Sun.) |
| 8:00-8:55 p.m. | 0000-0055 | Peking, China | F | 11.945, 15.06, 15.52, 17.673 |
| | | Sofia, Bulgaria | F | 9.70 |
| 8:00-10:00 p.m. | 0000-0200 | **Luxembourg | F | 6.09 |
| | | **VOA, Washington, U.S.A. | G | 6.13, 9.65, 11.83 |
| 8:00 p.m.-1:05 a.m. | 0000-0505 | **Montreal, Canada (Northern Service) | F | 5.96, 9.625 (includes French, etc.) |
| 8:15-8:30 p.m. | 0015-0030 | Athens, Greece | F | 9.76 |
| 8:30-8:55 p.m. | 0030-0055 | Prague, Czechoslovakia | F | 6.055, 9.54 |
| 8:30-9:00 p.m. | 0030-0100 | Kiev, U.S.S.R. | G | 7.15, 7.205, 9.685, 9.72 |
| | | Stockholm, Swedin | F | 11.955 |
| 8:30-9:30 p.m. | 0030-0130 | **Trans-World Radio Bonaire, N.A. | G | 11.925 |
| 8:30-11:30 p.m. | 0030-0330 | London, England | G | 5.975, 7.325, 9.58 (via Ascension) |
| 8:40-9:00 p.m. | 0040-0100 | Brussels, Belgium | F | 9.73 |
| 8:40 p.m.-1:00 a.m. | 0040-0500 | HCJB, Quito, Ecuador | G | 6.095, 9.56,11.915 (includes some Eskimo) |
| 9:00-9:15 p.m. | 0100-0115 | Vatican City | G | 5.995, 6.105, 9.605 |
| 9:00-9:20 p.m. | 0100-0120 | Rome, Italy | G | 9.575, 11.81 |
| 9:00-9:45 p.m. | 0100-0145 | Berlin, Ger. Dem. Rep. | F | 9.73 |
| 9:00 p.m.-12 mdt. | 0100-0400 | Madrid, Spain | G | 6.065, 11.88 (Mon.-Sat.) |
| 9:00-9:55 p.m. | 0100-0155 | Peking, China | G | 7.12, 9.78 (via Tirana), 11.945, 11.965, 15.06, 15.52 |
| | | Prague, Czechoslovakia | G | 5.93, 7.345, 9.54, 9.74, 11.99 |
| 9:00-10:00 p.m. | 0100-0200 | Montreal, Canada | G | 6.085, 9.655 |
| 9:00-11:00 p.m. | 0100-0300 | Melbourne, Australia | F | 15.32, 17.795 |
| | | Moscow, U.S.S.R. | G | 5.905, 7.10, 7.11, 7.15, 7.205, 7.355, 9.685, 9.70 (via Sofia) |
| 9:00-11:30 p.m. | 0100-0330 | Havana, Cuba | G | 11.725, 11.93 |
| 9:30-9:50 p.m. | 0130-0150 | Cologne, Ger. Fed. Rep. | G | 6.01, 6.04, 6.075, 6.10 (via Malta), 9.565, 9.69, 9.745, 11.865 (via Malta) |
| 9:30-9:55 p.m. | 0130-0155 | Tirana, Albania | G | 6.20, 7.30 |
| | | Vienna, Austria | P | 6.155, 9.77 |
| 9:30-10:25 p.m. | 0130-0225 | Bucharest, Rumania | F | 5.99, 9.57, 9.68, 11.775, 11.94 |
| 9:45-10:15 p.m. | 0145-0215 | Berne, Switzerland | G | 5.965, 6.135, 9.725, 11.715 |
| 10:00-10:30 p.m. | 0200-0230 | Budapest, Hungary | G | 6.00, 6.115, 9.585, 9.833, 11.91, 15.22 (Ex. Sun.) |
| | | Lisbon, Portugal | G | 6.025, 11.935 |
| | | Oslo, Norway | F | 6.18, 9.645, (Sun.) |
| | | Warsaw, Poland | P | 6.095, 6.135, 7.27, 9.675, 11.815, 11.84, 15.12 |
| 10:00-10:55 p.m. | 0200-0255 | Peking, China | F | 11.965, 15.06 |
| 10:00-11:20 p.m. | 0200-0320 | Hilversum, Holland | G | 6.165 (via Bonaire) |
| 10:00-11:30 p.m. | 0200-0330 | Cairo, Egypt | G | 9.475 |
| 10:30-10:55 p.m. | 0230-0255 | Tirana, Albania | G | 6.20, 7.30 |
| 11:00-11:30 p.m. | 0300-0330 | Budapest, Hungary | G | 6.00, 6.115, 9.585, 9.833, 11.91, 15.22 |
| | | Kiev, U.S.S.R. | G | 7.15, 7.39, 9.61, 9.72 |
| 11:00-11:35 p.m. | 0300-0335 | Warsaw, Poland | P | 6.095, 6.135, 7.27, 9.675, 11.815, 11.84, 15.12 |
| 11:00-11:55 p.m. | 0300-0355 | Peking, China | G | 7.12, 9.78 (via Tirana) |
| 11:00-12 mdt. | 0300-0400 | Buenos Aires, Argentina | G | 9.69 (Mon.-Fri.) |

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| | | Prague, Czechoslovakia | G | 5.93, 7.345, 9.54, 9.74, 11.99 |
| | | Moscow, U.S.S.R. | G | 5.905, 7.10, 7.11, 7.355, 9.665, 9.685, 9.70 (via Sofia) |
| 11:00 p.m.-12:25 a.m. | 0300-0425 | **Johannesburg S. Africa | F | 3.23, 3.995, 4.875 |
| 11:30-11:55 p.m. | 0330-0355 | Tirana, Albania | G | 6.20, 7.30 |
| | | Vienna, Austria | P | 6.155, 9.77 |
| 11:30-12:30 a.m. | 0330-0430 | London, England | G | 5.975, 9.58 (via Ascension) |
| 11:30-12:50 a.m. | 0330-0450 | Havana, Cuba | G | 11.725, 11.76, 11.93 |
| 12 mdt.-12:15 a.m. | 0400-0415 | Budapest, Hungary | G | 6.00, 6.115, 9.585, 9.833, 11.91, (Tue./Fri.) |
| 12 mdt.-12:25 a.m. | 0400-0425 | Bucharest, Rumania | F | 5.99, 9.57, 9.68, 11.775, 11.94 |
| 12 mdt.-12:30 a.m. | 0400-0430 | Sofia, Bulgaria | G | 9.70 |
| 12 mdt.-1:00 a.m. | 0400-0500 | Moscow, U.S.S.R. | G | 5.905, 7.10, 7.15, 7.205, 7.355, 7.39, 9.685, 9.72 |
| 12 mdt.-2:00 a.m. | 0400-0600 | Montreal, Canada | G | 6.135, 9.655 |
| 12:30-1:00 a.m. | 0430-0500 | **London, England | G | 6.005, 9.58 (via Ascension) |
| 12:50-2:00 a.m. | 0450-0600 | Havana, Cuba | G | 11.725, 11.76 |
| 1:00-1:15 a.m. | 0500-0515 | Jerusalem, Israel | G | 5.90, 7.413, 9.009, 9.435 |
| 1:00-2:00 a.m. | 0500-0600 | **London, England | G | 6.005, 7.27, 9.60 (via Ascension) |
| 1:00-3:00 a.m. | 0500-0700 | HCJB, Quito, Ecuador | G | 6.095, 9.56 |

**TO WESTERN NORTH AMERICA**

| TIME-PDT | TIME-GMT | STATION | QUAL* | FREQUENCIES, MHz |
|---|---|---|---|---|
| 4:00-4:15 a.m. | 1100-1115 | Tokyo, Japan | G | 5.99 |
| 4:00-5:00 a.m. | 1100-1200 | London, England | F | 11.75 (via Tebrau) |
| 4:00-7:00 a.m. | 1100-1400 | **VOA, Washington, U.S.A. | G | 5.955, 9.73 |
| 5:00-5:15 a.m. | 1200-1215 | Tokyo, Japan | P | 5.99 |
| 5:00-6:15 a.m. | 1200-1315 | London, England | G | 5.99 (via Sackville)(opens 1300 Sun.), 11.75 (via Tebrau) |
| 5:15-9:30 a.m. | 1215-1630 | HCJB, Quito, Ecuador | G | 11.745, 15.115 |
| 6:00-6:15 a.m. | 1300-1315 | Tokyo, Japan | P | 5.99 |
| 6:00-8:00 a.m. | 1300-1500 | Trans-World Radio, Bonaire, N.A. | G | 15.255 (Sat., Sun.) |
| 6:30-8:00 a.m. | 1330-1500 | **Delhi, India | F | 11.81, 15.345 |
| 6:30-9:15 a.m. | 1330-1615 | **London, England | F | 9.74, 11.75, 15.31 (via Tebrau) |
| 7:00-7:30 a.m. | 1400-1430 | Tokyo, Japan | G | 9.505 |
| 7:00-8:20 a.m. | 1400-1520 | **Hilversum, Holland | G | 11.73 (via Talata) |
| 7:00-9:55 a.m. | 1400-1655 | Manila, Philippines | F | 9.58 (Closes 1555 Sun.) |
| 8:00-8:15 a.m. | 1500-1515 | Tokyo, Japan | G | 9.505 |
| 8:00-9:15 a.m. | 1500-1615 | London, England | G | 17.84 (via Ascension) |
| 9:00-9:15 a.m. | 1600-1615 | Tokyo, Japan | G | 9.505 |
| 9:00-9:30 a.m. | 1600-1630 | Oslo, Norway | F | 17.80 (Sun.) |
| 9:45-9:51 a.m. | 1645-1651 | Hilversum, Holland | G | 15.14, 15.19 (via Bonaire, Mon.-Fri.) |
| 10:00-10:15 a.m. | 1700-1715 | Tokyo, Japan | G | 9.505 |
| 10:00-11:30 a.m. | 1700-1830 | London, England | G | 9.58 (via Sackville closes 1845 Sun.) |
| 11:00-11:15 a.m. | 1800-1815 | Tokyo, Japan | G | 9.505 |
| 11:30 a.m.-1:00 p.m. | 1830-2000 | **London, England | F | 11.82 (via Ascension) |
| 12 noon-12:07 p.m. | 1900-1907 | **Papeete, Tahiti | F | 11.825, 15.17 (exc. Sun.) |
| 12 noon-12:15 p.m. | 1900-1915 | Tokyo, Japan | G | 15.105 |
| 1:00-1:15 p.m. | 2000-2015 | Tokyo, Japan | G | 15.105 |
| 1:00-2:20 p.m. | 2000-2120 | **Hilversum, Holland | G | 11.73 (via Talata) |
| 2:00-2:15 p.m. | 2100-2115 | Tokyo, Japan | G | 15.105 |
| 2:15-4:00 p.m. | 2115-2300 | London, England | G | 15.26 (via Ascension) |
| 3:00-3:15 p.m. | 2200-2215 | Tokyo, Japan | G | 15.105 |
| 3:00-5:00 p.m. | 2200-0000 | **VOA, Washington, U.S.A. | G | 17.82, 17.895, 21.61 |
| | | Montreal, Canada | G | 6.04 (Mon.-Fri.) |
| 3:30-4:00 p.m. | 2230-2300 | Jerusalem, Israel | F | 7.395, 9.815, 11.645 |
| 3:30-4:20 p.m. | 2230-2320 | Johannesburg, S. Africa | G | 4.875, 9.585, 11.90 |
| 4:00-4:30 p.m. | 2300-2330 | Tokyo, Japan | G | 15.105 |
| 4:00-5:30 p.m. | 2300-0030 | London, England | G | 6.175, 9.51 (via Sackville), 9.58, 15.26 (via Ascension) |
| | | Moscow, U.S.S.R. | G | 12.05, 15.18, 17.775 (via Soviet Far East) |
| 5:00-5:15 p.m. | 0000-0015 | Tokyo, Japan | G | 15.105 |
| 5:00-7:00 p.m. | 0000-0200 | **VOA, Washington, U.S.A. | G | 11.71, 15.205 |
| 5:30-6:30 p.m. | 0030-0130 | **Trans-World Radio, Bonaire, N.A. | G | 11.925 |
| 5:30-8:30 p.m. | 0030-0330 | London, England | G | 6.175 (via Sackville), 9.51 (via Greenville), 9.58 (via Ascension) |
| 5:40-10:00 p.m. | 0040-0500 | HCJB, Quito Ecuador | G | 6.095, 9.56, 11.915 (includes some Eskimo) |

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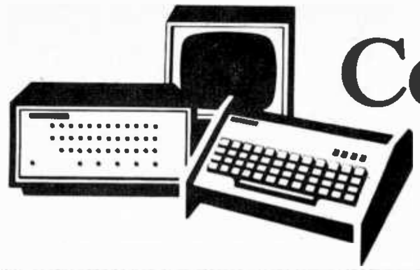
| 6:00-6:15 p.m. | 0100-0115 | Tokyo, Japan | G | 15.105 |
| 6:00-8:00 p.m. | 0100-0300 | Moscow, U.S.S.R. | G | 12.00, 12.05, 15.18, 17.775 (via Soviet Far East) |
| | | Melbourne, Australia | G | 15.32, 17.795 |
| 6:00-9:00 p.m. | 0100-0400 | Madrid, Spain | F | 6.065, 11.88 (Mon.-Sat.) |
| 6:30-7:30 p.m. | 0130-0230 | Tokyo, Japan | G | 15.195, 15.39, 17.725, 17.825 |
| 7:00-7:15 p.m. | 0200-0215 | Tokyo, Japan | G | 15.105 |
| 7:00-7:55 p.m. | 0200-0255 | Peking, China | G | 11.965, 12.055, 15.06 |
| 7:00-8:50 p.m. | 0200-0350 | Taipei, Taiwan | G | 11.86, 15.125, 17.72, 17.89 |
| 7:30-8:00 p.m. | 0230-0300 | Stockholm, Sweden | P | 9.695, 11.705 |
| 8:00-8:15 p.m. | 0300-0315 | Tokyo, Japan | G | 15.105 |
| 8:00-8:30 p.m. | 0300-0330 | Kiev, U.S.S.R. | G | 12.05, 15.18, 17.775 (via Soviet Far East) |
| 8:00-8:55 p.m. | 0300-0355 | Peking, China | G | 7.12, 9.78 (via Tirana), 12.055, 15.06 15.385, 17.735, 17.855 |
| 8:00-9:25 p.m. | 0300-0425 | **Johannesburg, S. Africa | F | 3.23, 3.995, 4.875 |
| 8:00-9:35 p.m. | 0300-0435 | **San José, Costa Rica | F | 6.175, 9.645 |
| 8:22-8:28 p.m. | 0322-0328 | Erevan, U.S.S.R. | G | 11.96, 15.13, 15.18, 15.455, (Sat./Tue./Wed./Fri., via Far East) |
| 8:30-9:00 p.m. | 0330-0400 | Moscow, U.S.S.R. | G | 6.02, 9.635, 11.72, 11.96, 12.05, 15.13, 15.18, 15.21, 15.245, (via Soviet Far East) |
| 8:30-9:15 p.m. | 0330-0415 | Berlin, Ger. Dem. Rep. | P | 9.73, 11.84, 11.89 |
| 8:30-9:30 p.m. | 0330-0430 | London, England | G | 6.175 (via Sackville), 9.58 (via Ascension) |
| 9:00-9:15 p.m. | 0400-0415 | Tokyo, Japan | G | 15.105 |
| 9:00-9:30 p.m. | 0400-0430 | Sofia, Bulgaria | P | 9.70 |
| | | Budapest, Hungary | P | 6.00, 6.115, 9.585, 9.833, 11.91 (Tue., Fri.) |
| | | Oslo, Norway | F | 9.645, 11.87 (Sun.) |
| 9:00-10:00 p.m. | 0400-0500 | Moscow, U.S.S.R. | G | 6.02, 9.635, 11.69, 11.96, 12.05, 15.10, 15.13, 15.18, 15.21, 15.245 (via Far East) |
| 9:00-11:00 p.m. | 0400-0600 | Montreal, Canada | G | 6.135, 9.655 |
| 9:15-10:30 p.m. | 0415-0530 | Bangkok, Thailand | P | 9.655, 11.905 |
| 9:30-10:00 p.m. | 0430-0500 | Lisbon, Portugal | P | 6.025, 11.935 |
| | | Berne, Switzerland | F | 9.725, 11.715 |
| | | Vienna, Austria | P | 6.015 |
| | | **London, England | G | 6.005, 9.58 (via Ascension) |
| 9:30-10:15 p.m. | 0430-0515 | **Cologne, Ger. Fed. Rep. | F | 7.225 (via Kigali) |
| 10:00-10:15 p.m. | 0500-0515 | Jerusalem, Israel | F | 9.815 |
| | | Tokyo, Japan | G | 15.105 |
| 10:00-10:30 p.m. | 0500-0530 | Seoul, Rep. of Korea | F | 9.64, 15.335 |
| 10:00-11:20 p.m. | 0500-0620 | Hilversum, Holland | G | 6.165, 9.715 (via Bonaire) |
| 10:00 p.m.-12 mdt. | 0500-0700 | HCJB, Quito, Ecuador | G | 6.095, 9.56 |
| | | **London, England | G | 6.005, 7.27, 9.60 (via Ascension) |
| 10:00 p.m.-12:30 a.m. | 0500-0730 | Moscow, U.S.S.R. | G | 6.02, 9.635, 9.71, 11.69, 11.96, 12.05, 15.10, 15.13, 15.18, 15.21 (via Soviet Far East) |
| 10:30-10:50 p.m. | 0530-0550 | Cologne, Ger. Fed. Rep. | G | 6.10 (via Malta), 6.185, 9.545 |
| 11:00-11:15 p.m. | 0600-0615 | Tokyo, Japan | G | 9.505 |
| 11:00-11:30 p.m. | 0600-0630 | Oslo, Norway | P | 9.645, 11.87 (Sun.) |
| 11:00-12 mdt. | 0600-0700 | Buenos Aires, Argentina | G | 9.69 (Mon.-Fri.) |
| 11:30 p.m.-1:30 a.m. | 0630-0830 | Havana, Cuba | G | 9.525 |
| 11:30 p.m.-1:55 a.m. | 0630-0855 | **Kuala Lumpur, Malaysia | G | 11.90, 15.275 |
| 12 mdt.-12:15 a.m. | 0700-0715 | Tokyo, Japan | G | 9.505 |
| 12 mdt.-12:30 a.m. | 0700-0730 | **London, England | G | 6.005, 9.60 (via Ascension) |
| 12:30-1:15 a.m. | 0730-0815 | **London, England | G | 9.60, 11.86, 15.40 (via Ascension) |
| 1:00-1:15 a.m. | 0800-0815 | Tokyo, Japan | G | 9.505 |
| 2:00-2:15 a.m. | 0900-0915 | Tokyo, Japan | G | 9.505 |
| 2:00-2:30 a.m. | 0900-0930 | Seoul, Rep. of Korea | F | 9.64, 15.335 |
| 3:00-3:15 a.m. | 1000-1015 | Tokyo, Japan | G | 5.99 |
| 3:00-3:50 a.m. | 1000-1050 | Pyongyang, D.P.R. Korea | G | 9.42, 9.535 |
| 3:00-4:00 a.m. | 1000-1100 | **Montreal, Canada | G | 5.97, 9.625 |

*Reception quality, East Coast (West Coast) location: G-good, F-fair, P-poor
**Not intended for North America, but receivable satisfactorily

Frequencies are accurate as of press time, but subject to change. Many stations broadcasting in English but not beamed to North America are often audible here depending upon conditions, locations, time, etc. Sometimes, they are more audible than those nominally beamed here. To help readers and as a sampling of what can be heard, we have added a selection of interesting stations heard here in English. The fine programs from Paris and Brasilia are particularly recommended.



# Computer Bits

By Hal Chamberlain

## COMPUTER MUSIC

BEGINNING with this month, "Computer Bits" is a monthly feature of POPULAR ELECTRONICS. As a consequence, we are able to offer a two-part discussion of computer music—this month and in October.

Playing music with your computer can be a refreshing diversion, an impressive demonstration, or a mild obsession, depending on your inclination. We will discuss computer music performance first, with computer music composition to follow.

**Some History.** Elementary, monophonic music is just a series of tones with different frequencies and durations. Over the years, several methods have been devised by which a computer could either generate the tones directly or control tone-generating devices.

Perhaps the strangest method of output is one employed by an IBM-1401 computer program that played the line printer! Computer printers work much like a typewriter in that a metal type face strikes the paper under computer control. A pulse of sound is emitted when the paper is struck. In a 1401, the printer was interfaced in such a way that a program could control precisely when a print hammer fired. Proper relative timing among hammer strikes in the row of 120 hammers could actually produce a tone. Different frequency tones could be produced by changing the hammer timing. A rendition of "Anchors Aweigh" was heard by the author; and, while sounding rather raspy, it was in tune!

Another unexpected way to get a computer to produce tones involves the use of a common AM broadcast-band radio. Modern computer logic circuits generate pulses having risetimes of about 10 nanoseconds. These fast risetimes imply the existance of high-frequency harmonics that may fall into the radio's tuning range. Furthermore, the harmonic frequencies are separated from each other by the pulse repetition rate. An AM receiver interprets the harmonics within its passband as a carrier with upper and lower sidebands corresponding to audio modulation at the pulse repetition rate. Different instructions cause pulses to appear at different places within the computer. It is therefore possible to set up program loops that execute at controlled rates and thus produce tones of different frequencies. An interesting problem with this method is that there is no way to get the radio to "shut up" for a rest or a break between two identical notes.

A more predictable way to get audio output is to connect a speaker to an output port bit. A tone may be programmed by alternately setting the bit on and off with an accurately timed loop. This has an advantage since the speaker may be silenced when desired. One commercial computer (the LINC) even had a speaker complete with volume control connected to one bit of the accumulator as standard equipment! Some hobbyist systems have a speaker installed in their surplus keyboards. It is normally clicked to signal that a character has been accepted or beeped if an error is detected. Of course, it is also available as a simple "music peripheral."

Although the above methods make interesting demonstrations and do not require any specialized hardware, they are far from being suitable for serious music performance. Early in the development of electronic music, it became apparent that any audio signal waveform could be represented as a very rapid series of discrete voltage values. With a digital-to-analog converter connected to the computer,

*Fig. 1. Example of a tone generation subroutine for the 8080.*

```
                         *    ENTER WITH THE FREQUENCY PARAMETER IN C
                         *    ENTER WITH THE DURATION PARAMETER IN D & E              CLOCK
                         *    USES SPEAKER CONNECTED TO ANY BIT OF OUTPUT PORT        CYCLES

000:100 076 000     TONE      MVI  A,0          OUTPUT ZERO TO SPEAKER                  (7)
000:102 232 XXX               OUT  (port address)                                       (10)
000:104 101                   MOV  B,C          MOVE FREQ. PARAMETER TO                 (5)
000:105 005         DELAY1    DCR  B            B AND USE AS A DELAY COUNT              (5)
000:106 302 105 000           JNZ  DELAY1       DELAY 15 X FREQ. PARAMETER CLOCK CYCLES (10)
000:111 033                   DCX  D            DECREMENT DURATION PARAMETER            (5)
000:112 172                   MOV  A,D          TEST IF DECREMENTED TO ZERO             (5)
000:113 263                   ORA  E                                                    (4)
000:114 312 136 000           JZ   RETURN       GO RETURN IF SO, CONTINUE IF NOT        (10)
000:117 076 377               MVI  A,377Q       OUTPUT ONE TO SPEAKER                   (7)
000:121 323 XXX               OUT  (port address)                                       (10)
000:123 101                   MOV  B,C          DELAY AS ABOVE                          (5)
000:124 005         DELAY2    DCR  B                                                    (5)
000:125 302 124 000           JNZ  DELAY2                                               (10)
000:130 033                   DCX  D            DECREMENT AND TEST DURATION AS ABOVE    (5)
000:131 172                   MOV  A,D                                                  (5)
000:132 263                   ORA  E                                                    (4)
000:133 302 100 000           JNZ  TONE         LOOP BACK FOR ANOTHER SQUARE WAVE CYCLE (10)
000:136 311         RETURN    RET               RETURN TO MAIN PROGRAM
```

a series of numbers could be converted into the series of voltages and thus an audio signal. Waveforms could then be computed directly and literally any possible sound or tone produced. Some very impressive and musically important results have been obtained in this manner. Although this method has perfect generality, the number of computations needed for even a simple piece is staggering. Typically, hours of computer time are required for minutes or even seconds of musical output.

The newest method of musical output is to interface a computer to a sound synthesizer. Units such as a Moog or ARP or some of the circuits described by Don Lancaster in this magazine can be used. The amplitude, frequency, and spectrum of tones produced by the synthesizer are set with control voltages. Contrary to actual sound waveforms, control voltages typically change slowly. This greatly reduces the computational load on the computer. With only $50 to $100 worth of components, a multiplexed digital-to-analog converter with a dozen or more control voltage outputs can be built. Ordinary patch cords may then be used to connect the control voltages to the synthesizer.

**Timed Loop Techniques.** Let's look at the timed-loop technique of producing single tones with a computer. The two most important elements of music are pitch and rhythm. Curiously, these are the only elements that can be easily controlled in a timed-loop music program. Pitch is determined by the frequency of a tone in cycles per second (Hertz) and rhythm by the relative durations of individual tones in seconds. The computer used must have a definite clock cycle time, and most hobby computers on the market use a crystal clock which gives a very stable and accurate cycle rate. A few of the "trainer" kits may use an RC clock which is not nearly as good, but can still be used to illustrate the principles.

The basic component of a timed-loop music program is the tone-generation subroutine. The tone frequency and duration are passed to the subroutine as two arguments. The main body of the subroutine consists of two "nested" loops. The frequency argument determines how many times the inner loop is executed. The duration argument determines how many times the outer loop is executed. Note that the frequency argument is actually proportional to the period of the wave and the duration is actually the number of cycles of the wave to be played before returning for the next note.

A tone generation subroutine for an 8080 microprocessor is shown in Fig. 1. This routine generates an absolutely symmetrical square wave and uses two inner loops of identical length to accomplish it. To determine what the frequency argument value should be, it is necessary to count up the clock cycles used by the inner wait loop and by the "overhead" instructions outside of the loop. The overhead is found to be 46 cycles and the wait loop is 15 cycles times the value of the frequency parameter. Assuming that the 8080 runs at full speed (0.5 microsecond clock cycle) with no memory waits, the time for a half squarewave cycle is 23+7.5N microseconds, where N is the frequency parameter. A full cycle time is twice as long. The frequency is, of course, the reciprocal of the full cycle period. Using the routine shown, N must be between 1 and 255; if zero is given, it is interpreted as 256. Thus, the lowest possible frequency is 500,000/(23+7.5×256) Hz. or 257.33 Hz. The table in Fig. 2 may be used to determine the proper value of N for any note.

*Fig. 2. Table of musical notes.*

| Note | Frequency Hertz | Period Microseconds |
|---|---|---|
| C (middle) | 261.62 | 3822.3 |
| C# | 277.18 | 3607.8 |
| D | 293.66 | 3405.3 |
| D# | 311.13 | 3214.2 |
| E | 329.63 | 3033.8 |
| F | 349.23 | 2863.5 |
| F# | 369.99 | 2702.8 |
| G | 391.99 | 2551.1 |
| G# | 415.30 | 2407.9 |
| A | 440.00 | 2272.8 |
| A# | 466.16 | 2145.2 |
| B | 493.88 | 2024.8 |
| C | 523.25 | 1911.2 |
| C# | 554.37 | 1803.9 |
| D | 587.33 | 1702.7 |
| D# | 622.25 | 1607.1 |
| E | 659.26 | 1516.9 |
| F | 698.46 | 1431.8 |
| F# | 739.99 | 1351.4 |
| G | 783.99 | 1275.6 |
| G# | 830.61 | 1204.0 |
| A | 880.00 | 1136.4 |
| A# | 932.33 | 1072.6 |
| B | 987.77 | 1012.4 |
| C | 1046.5 | 955.58 |

The duration parameter is actually a count of half cycles to be played before returning. As a result, the argument value is a function of both the duration in seconds and the note played. Thus M=2TF, where M is the argument value, T is the time in seconds, F is the frequency in Hertz, and the factor of 2 accounts for both halves of the square wave. Note that the routine of Fig. 1 uses a double precision duration argument to provide for long notes.

*Fig. 3. Basic specification for music language NOTRAN.*

1. **TEMPO statement**
   Example: TEMPO ¼=500
   TEMPO is keyword identifier.
   ¼ refers to a "quarter note."
   500 is duration of quarter note in milliseconds.
2. **Note statement**
   Example: 1C#4,⅛
   1 refers to voice 1 (optional).
   C is note name, # following is sharp, @ is flat.
   4 is octave number, C4 is middle C.
   ⅛ specifies an eighth note.
3. **Rest statement**
   Example: R,½
   R signifies rest
   ½ means rest duration equivalent of half note.
4. **For monophonic music,** one statement per line

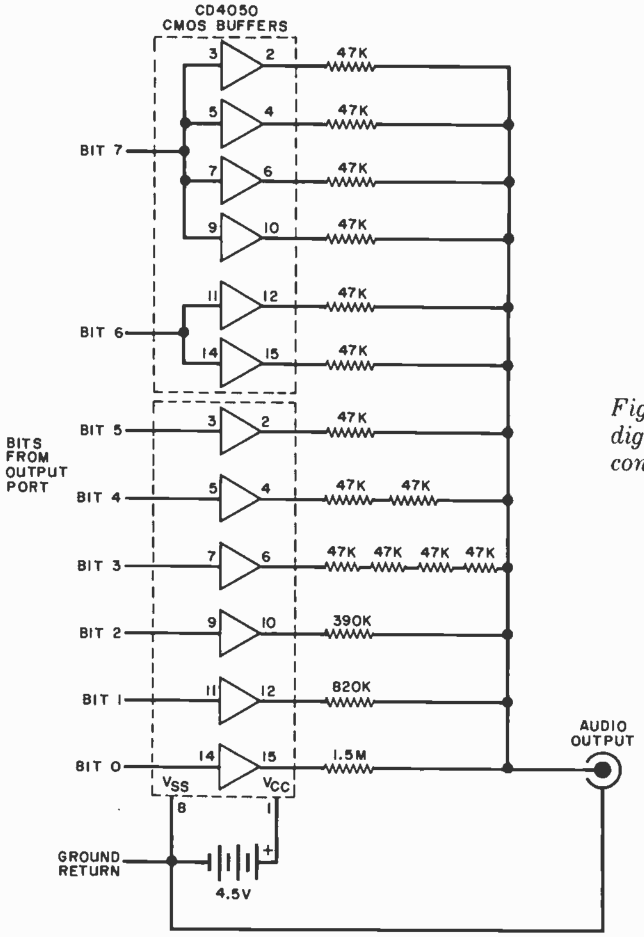



*Fig. 4. Simple 8-bit digital-to-analog converter.*

Using the subroutine in a music program is simply a matter of calling it with the right frequency and duration arguments for each note to be played. Care must be taken to insert some silence between notes of the same frequency or else they will run together. A simple-minded program might fetch these from a hand-prepared list stored in memory. A more challenging approach is to write a program that accepts statements written in a simple "music language" and computes the tone-generation arguments (Fig. 3). Then your musically inclined wife, for example, may perpare scores for the computer herself.

**Improving Basic Timed Loop Techniques.** For better sounding music, a number of refinements can be made to the basic technique. It is possible to get some limited change of tone color by changing the duty cycle of the wave. This may be accomplished by inserting some "no operation" instructions in one of the wait loops. Unfortunately, the frequency arguments will have to be recomputed. Good duty cycle values to try are ⅓ and ¼, since harmonics divisable by 3 and 4, respectively, will be missing from the spectra.

Another interesting experiment is to improve the frequency accuracy of the routine. As written, the half-cycle time is in increments of 7.5 microseconds. This results in significant frequency errors, particularly for high notes. By inserting additional selected overhead instructions, it is possible to be as accurate as 0.5 microsecond. This might be accomplished by writing 15 copies of the routine with extra instructions added in increments of one clock cycle. Obtaining the right note would then be a combination of calling the proper routine with the proper frequency argument.

The computer-generated tones can be made more natural sounding if an amplitude envelope is added to the notes. All this amounts to is changing the volume in a controlled manner over the duration of the note. Additionally, there would then be some control over the dynamics (changes in loudness during a piece) of the music. At this point, some specialized hardware must be added.

The circuit in Fig. 4 may be added to an output port. This is actually a very simple 8-bit digital-to-analog converter. Best results are obtained if the 47k resistors are 5% carbon film types from the same batch. Several mail-order firms now offer this type of resistor. A battery is used to power the circuit so that system noise will be isolated. Any type of audio amplifier can be connected to the circuit's output.

The dc output voltage of this circuit is 0.0176N volts, where N is the binary number last sent to the output port. Note, in the tone generation subroutine, that 0 and 255 (decimal) were alternately sent to the output port for a square wave. If this circuit was connected to the output port, the output voltage would alternately switch between 0 volts and +4.5 volts. If instead, 0 and 128 were alternately sent out, then the wave would switch between 0 volts and about 2.26 volts. This is only about one-half of the previous amplitude so the tone would not be as loud. Thus, amplitude control may be exercised by simply changing the values sent to the output port by the tone-generation subroutine.

Unfortunately, programming amplitude envelopes during a tone without upsetting the precise loop timing is a bit tricky. As the level of sophistication increases, a point is reached where the effort needed to preserve the loop timing is excessive. At this point specialized hardware is needed to relieve the computer of the actual tone generation task.

**Experiments with Other Sounds.** Other sounds can also be easily generated by a computer. For example, a high-speed stream of random bits will provide a good source of white noise. An 8080 program to generate white noise is given in Fig. 5. Random bits are generated by simulating a 16-stage shift register with appropriate feedback. White noise might be used in a rhythm program to approximate the sound of a snare drum.

The program in Fig. 6 produces some really "way-out" sounds. One should first try it and listen to each of the 16 possible output bits. Then study the program and see if you can figure out what it is actually doing. Finally, try to explain the weird results near the end of each repetition.

Many other interesting experiments can be performed with the simple digital-to-analog converter described earlier. Some of these will be described next time. ◈

```
                         *       CONNECT SPEAKER TO ANY BIT OF OUTPUT PORT

000:000 021 000 000  WHITEN  LXI  D,0               SET D & E TO ZERO
000:003 041 001 000          LXI  H,1               RET SHIFT REG.  IN H & L NON-ZERO
000:006 174          LOOP    MOV  A,H               OUTPUT UPPER 8 BITS OF SHIFT REGISTER
000:007 323 XXX              OUT  (port address)    AS A SET OF RANDOM BITS
000:011 017                  RRC                    FORM EXCLUSIVE-OR OF SHIFT REGISTER
000:012 254                  XRA  H                 BITS 15,14,12, AND 3 IN BIT 0 OF A
000:013 017                  RRC
000:014 017                  RRC
000:015 254                  XRA  H
000:016 017                  RRC
000:017 255                  XRA  L
000:020 017                  RRC
000:021 017                  RRC
000:022 017                  RRC
000:023 346 001              ANI  1                 ISOLATE BIT 0 OF A
000:025 051                  DAD  H                 SHIFT SHIFT REGISTER LEFT 1
000:026 137                  MOV  E,A               AND BRING BIT 0 OF A INTO
000:027 031                  DAD  D                 VACATED SHIFT REGISTER BIT 0
000:030 303 006 000          JMP  LOOP              LOOP
```

*Fig. 5. White noise generation routine for 8080*

*Fig. 6. Weird sound generation routine for the 8080.*

```
                 *       CONNECT SPEAKER TO ANY BIT OF OUTPUT PORT
                 *       A DIFFERENT SOUND WILL BE HEARD AT EACH BIT

000:000 021 001 000  WEIRD  LXI  D,1               INITIALIZE
000:003 041 000 000         LXI  H,0
000:006 175         LOOP    MOV  A,L               CHANGE TO:  MOV A,H FOR 8 MORE SOUNDS
000:007 323 XXX             OUT  (port address)    OUTPUT TO SPEAKER
000:011 031                 DAD  D
000:012 322 006 000         JNC  LOOP
000:015 023                 INX  D
000:016 172                 MOV  A,D
000:017 263                 ORA  E
000:020 302 006 000         JNZ  LOOP
000:023 023                 INX  D
000:024 303 006 000         JMP  LOOP
```

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*Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46206. 192 pages. $5.95 soft cover.*

# Experimenter's Corner

By Forrest M. Mims

## THE LM380 POWER AMPLIFIER

FOR YEARS I've used one of the popular commercial modular amplifiers when it was necessary to beef up a weak audio signal and drive a miniature speaker. These amplifiers are available in a range of power output levels (100 mW to several watts or more) and are supplied completely preassembled on a compact pc board.

Though many of these modular amplifiers are reasonably priced and easy to use, I've recently switched over to the versatile LM380 power amplifier IC for many routine amplifier applications. This deceptively simple chip comes in both eight- and fourteen-pin versions with only six active pins. The remaining pins are all connected to ground and can be used to heat sink the chip when it is operated at high power levels.

Unlike most modular amplifiers which use discrete components, the LM380 has a very low output impedance and can be directly connected to an 8-ohm speaker. And, best of all, you can buy LM380's from several of the firms who advertise in the back pages of this magazine for less than $1.50 each.

The twelve-transistor circuit of the LM380 incorporates several important and useful features. For example, a pnp input stage permits direct coupling of the input signal. The overall gain of the circuit is set to 50 (34 dB) by internal feedback resistors, but you can get more gain with a simple positive feedback circuit.

One of the really bothersome problems of semiconductor power amplifiers is overheating of the output stage. The LM380 solves this problem with an automatic thermal shutdown circuit which turns the amplifier off when excessive output current overheats the chip. Several times this feature has saved me from having to buy a new chip.

At room temperature, the chip dissipates up to about 1.25 watts without a heat sink. For higher power operation, the heat sink pins (3,4,5,10,11, and 12 on the fourteen-pin version) should be soldered to a common copper foil pad on a pc board. Six square inches of two-ounce foil will permit operation up to 3.7 watts (room temperature).

The pin diagrams for both the standard fourteen-pin and the miniature eight-pin versions of the LM380 are shown in Fig. 1. Since the eight-pin

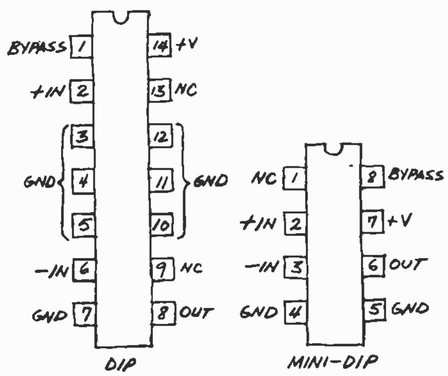


*Fig. 1. Pin configurations for standard and miniature LM380.*

mini-DIP version has less internal heatsinking, it is limited to about a half watt without an external heatsink.

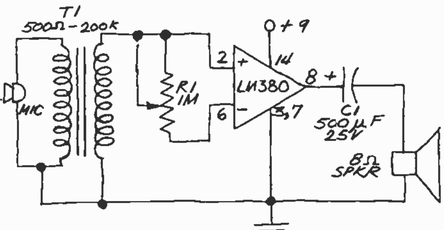


*Fig. 2. Simple audio amplifier circuit using an LM380.*

Fig. 2 shows one of the simplest circuits you can build with an LM380, a straightforward amplifier for an inexpensive, low-impedance microphone like those commonly used with miniature cassette tape recorders. The circuit uses an input transformer to match the impedance of the microphone to that of the amplifier, and the resulting gain is adequate for a super-simple one-way intercom. You'll know the circuit is working properly if you place the microphone a few inches away from the speaker because of the resulting feedback sounds.

The simple circuit in Fig. 2 draws only about 4 mA from a 9-volt supply during standby operation, but loud sounds at the microphone can create drains of 70 mA or more. A drain of 100 mA at 9 volts is a power consumption of 0.9 watt, well within the maximum operating range of the fourteen-pin version of the LM380 without an external heat sink. Potentiometer *R1* serves as a volume control.

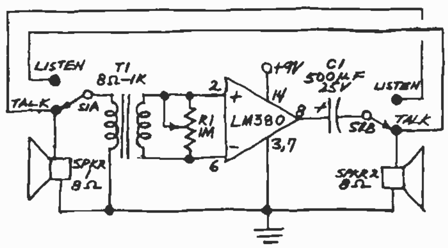


*Fig. 3. Circuit for elementary two-way intercom system.*

You can build a complete two-way push-to-talk intercom with a single LM380 and only six external components with the circuit in Fig. 3. The circuit uses a pair of ordinary 8-ohm speakers which double as microphones. In the TALK mode, *SPKR1* serves as the microphone and *SPKR2* as the speaker. The roles of the two speakers are reversed in the LISTEN mode.

This circuit also draws only 4 mA during standby (at 9 volts) so it can be

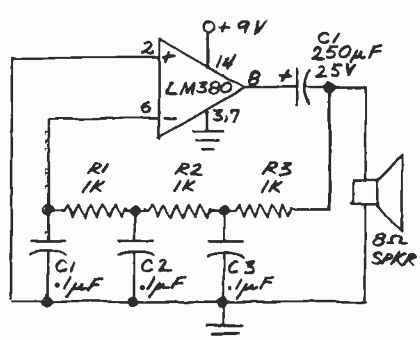


*Fig. 4. LM380 phase-shift oscillator produces shrill tone.*

left on for long periods of time at little expense. Since the LM380 has a wide voltage range(8-22 volts), the power supply requirements are quite flexible. I have used a 12-volt lantern battery with excellent results.

**Phase-Shift Oscillator.** National Semiconductor's LM380 spec sheet shows how to use the chip as a simple phase-shift oscillator. The circuit, which is shown in Fig. 4, uses a simple RC network to produce an exceptionally shrill tone from a miniature speaker. With the parts values shown in Fig. 4, the circuit oscillates at a frequency of 3.6 kHz and drives a miniature 2½" speaker with plenty of ear-piercing volume for a burglar alarm or other attention-getting or warning device. The output waveform is a square wave with a width of 150µs, sloping rise and fall times, and a peak-to-peak amplitude of 4.2 volts (when powered by 9 volts).

Current drain of the oscillator is a high 90 mA at 9 volts, but total power dissipation at this voltage is only 0.81 watt, well below the 1.25 watts the fourteen-pin version will absord (at room temperature) before shutting down. Therefore you don't have to heat sink the chip for safe operation of this circuit.

If the internally set 50× gain of the LM380 isn't enough for your application, the circuit in Fig. 5 uses positive feedback (via *R2*) to provide a gain of 200. National Semiconductor recommends 15.2K (1%) for *R1* and 2.7 ohms for *R3*, but I obtained excellent results with a 10%, 15K resistor for *R1* and three 1-ohm resistors in series for *R3*. The circuit makes a very sensitive one-way intercom or you can omit *T1* and connect an appropriate input device directly to pin 6 and ground.

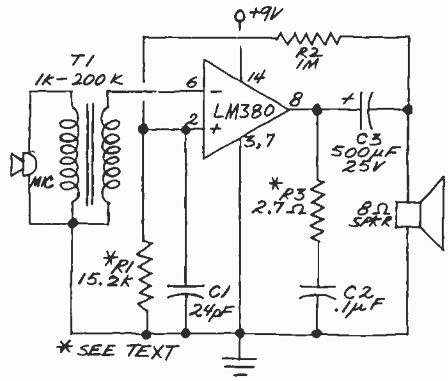


*Fig. 5. An audio amplifier circuit with gain of 200.*

Incidentally, when operating any of the circuits described here you may encounter a couple of undesirable problems. One is a 5-10-MHz oscillation whose presence can easily be determined (if you don't have access to a scope) by simply placing an AM radio near the circuit. If the radio hisses or if station interference occurs, connect the *C2-R3* network shown in Fig. 5 to the circuit to suppress the oscillation. Oscillation may also occur if the power supply leads are too long. Connect a 0.1-µF capacitor between pins 14 and 7 to eliminate this problem.

Finally, a particularly troublesome problem is erratic circuit operation. The circuit seems to work fine for a while and then quits. After the power supply voltage is removed for a few seconds, the circuit operates in a normal manner.

You can be thankful for this "problem" since the IC is being overloaded and the thermal shutdown circuit is saving you from having to buy a new IC! Solve this problem by reducing the level of the input signal, decreasing the power supply voltage, or both.◈

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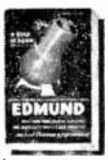


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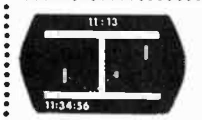


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| CD4001 | 24 | CD4040 | 2.45 | 74C20N | .65 |
| CD4002 | .24 | CD4042 | 1 20 | 74C30N | .65 |
| CD4006 | 2 50 | CD4044 | .95 | 74C42N | 1.95 |
| CD4007 | 24 | CD4046 | 2.50 | 74C73N | 1.35 |
| CD4009 | .60 | CD4047 | 2 00 | 74C74 | 1.10 |
| CD4010 | 50 | CD4049 | 60 | 74C90N | 2.50 |
| CD4011 | .24 | CD4050 | 56 | 74C95N | 1.90 |
| CD4012 | 24 | CD4051 | 1.50 | 74C107N | 1 25 |
| CD4013 | .30 | CD4053 | 1.40 | 74C151 | 2.50 |
| CD4015 | 1.10 | CD4060 | 1.40 | 74C154 | 2.50 |
| CD4016 | 56 | CD4066 | 85 | 74C157 | 2.10 |
| CD4017 | 1.10 | CD4069 | 44 | 74C160 | 2.95 |
| CD4018 | 1.20 | CD4071 | .44 | 74C161 | 2.95 |
| CD4019 | 60 | CD4072 | .44 | 74C163 | 2.95 |
| CD4020 | 1.45 | CD4081 | 44 | 74C164 | 2.95 |
| CD4022 | 1.10 | CD4511 | 2.00 | 74C173 | 2.60 |
| CD4023 | 24 | CD4512 | 1 30 | 74C193 | 2.60 |
| CD4024 | 1 50 | CD4515 | 5.00 | 74C195 | 2 60 |
| CD4025 | 24 | CD4516 | 1.75 | | |
| CD4027 | .69 | CD4518 | 1 10 | | |
| CD4028 | 1.10 | 74C00N | 35 | | |
| CD4029 | 1.20 | 74C02N | .45 | | |
| CD4030 | 65 | 74C04N | 65 | | |

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# Olson electronics
## Parts and Accessories

master charge — THE INTERBANK CARD
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| | | REG. | SALE |
|---|---|---|---|
| 5-Pc. SCR Kit | TR-298 | 1.79 | 1.00 |
| 500 Mw Zeners (5 Asstd) | DI-052 | .99 | .50 |
| Unijunction Transistors (Pkg.3) | TR-441 | 1.29 | .50 |
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| 9 Digit Sperry Display | XM-399 | 1.00 | .60 |
| 20 Key Calculator Keyboard | XM-339 | 2.49 | 1.40 |
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| 60 CFM Exhaust Fan | MO-390 | 5.00 | 2.50 |
| Metal TV Cart | XM-375 | 2.49 | .99 |
| 2 Volt Wet-Cell Battery | BA-329 | 6.95 | 3.00 |
| CB Rules Book with License | BK-292 | 1.00 | .30 |
| Set of 4 Easy-Roll Casters | XM-111 | .69 | .49 |
| "Mini" Nixie Tube | XM-107 | 1.69 | 1.00 |
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| Solder Lugs (Pkg. 13 Asstd) | XM-004 | 1.49 | .80 |
| Digital Clock Kit | XM-511 | 19.00 | 11.00 |
| 3½ Digit L-C Display | XM-371 | 10.00 | 4.50 |
| LM 309K 5V Regulator | TR-511 | 1.60 | 1.10 |
| CB Carrying Case | CB-557 | 13.95 | 9.00 |
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| 8" 2-Way Wood Speaker System | SS-080 | 20.00 | 12.00 |
| Hi-Fi Stereo Headphones | PH-331 | 7.00 | 3.50 |
| FM-Converter For Auto Radio | AU-333 | 22.00 | 15.00 |
| CB Hump Mount | CB-558 | 4.95 | 3.00 |
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| CB Converter for Auto Radio | CB-417 | 17.00 | 11.00 |
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| 1.2 Volt Ni-Cad Battery | BA-328 | 6.00 | 3.00 |
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| 117 VAC Black Light Bulb | XM-291 | 1.00 | .50 |
| Window Lock-Alarm | XM-112 | .88 | .70 |
| 117 VAC Heavy-Duty Solenoid | SW-839 | 1.79 | 1.00 |
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| 100 Ceramic Capacitors | CC-210 | 1.29 | 1.00 |
| 1/30 RPM Timing Motor 117 VAC | MO-359 | .89 | .50 |
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| 709 IC DP Amp. | RE-131 | 1.49 | .90 |
| Cadmium Photocells (Pkg. 2) | TR-514 | 1.00 | .50 |
| Miniature 12 VDC Solenoid | SW-836 | 1.19 | .70 |
| Magnetic Reed Switch (Pkg. 5) | SW-807 | 1.00 | .70 |
| Low Voltage Elect. Capacitor (50 Asstd) | CD-407 | 5.00 | 2.70 |
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THESE FREQUENCIES ONLY

| Part # | Frequency | Case/Style | Price |
|---|---|---|---|
| CY1A | 1.000 MHz | HC33/U | $4.95 |
| CY2A | 2.000 MHz | HC33/U | $4.95 |
| CY3A | 4.000 MHz | HC18/U | $4.95 |
| CY7A | 5.000 MHz | HC18/U | $4.95 |
| CY12A | 10.000 MHz | HC18/U | $4.95 |
| CY14A | 14 31818 MHz | HC18U | $4.95 |
| CY19A | 18.000 MHz | HC18/U | $4.95 |
| CY22A | 20.000 MHz | HC18/U | $4.95 |
| CY30B | 32.000 MHz | HC18/U | $4.95 |

## CLOCK CHIPS — CALCULATOR CHIPS

| | | |
|---|---|---|
| MM5309 | 6 Digit, BCD Outputs, Reset PIN. | $5.95 |
| MM5311 | 6 Digit, BCD Outputs, 12 or 24 Hour | 4.95 |
| MM5312 | 4 Digit, BCD Outputs, 1 PPS Output | 4.95 |
| MM5313 | 6 Digit, BCD Outputs, 1PPS Output | 4.95 |
| MM5314 | 6 Digit, 12 or 24 Hour, 50 or 60 Hz | 4.95 |
| MM5316 | 4 Digit, Alarm, 1PPS Output | 6.95 |
| MM5318 | Video Clock Chip, For Use With MM5841 | 9 95 |
| CT7001 | 6 Digit, Calander, Alarm, 12 or 24 Hour | 6.95 |

### CALCULATOR CHIPS

| | | |
|---|---|---|
| MM5725 | 6 Digit, Four Function, Less Decimal | $2 95 |
| MM5738 | 8 Digit, 5 Function, +, =, ×, ÷, % | 2 95 |
| MM5739 | 8 Digit, 4 Function, Floating Decimal | 2.95 |
| CT5001 | 12 Digit, 4 Function | 3.95 |
| CT5005 | 12 Digit, 4 Function with Memory | 5.95 |
| CT5030 | 12 Digit, 4 Function and % | 7 95 |

### MISC. MOS

| | | |
|---|---|---|
| MM5320 | TV Camera Sync. Generator | $19.95 |
| MM5330 | 4½ Digit DVM Chip | 9.95 |
| MM5369 | 60 Hz Timebase Circuit From 3.58 MHz | 5.00 |
| MM5841 | Video Generator For MM5318 | 18.00 |
| MC1408-L7 | 7 Bit Digital to Analog Converter | 9.95 |
| MK5007 | 4 Decade Counter with Latches | 10.95 |
| LD110/LD111 | 3½ Digit DVM Chip Set | 25.00 |
| 95H90 | 100 MHz ÷ 10 Counter For Prescalers | 13.95 |

## THE NEW RCA CA3140
## MOST USEFUL OP AMP SINCE THE 741
## CA3140 vs. 741 at a glance

| | CA3140T,S | CA741CT,S |
|---|---|---|
| Input Resistance $R_I$ (MΩ) | 1,500,000 | 2 |
| Input Current $I_I$ (pA) | 10 | 80,000 |
| Slew Rate, SR (closed loop) (V/μs) | 9 | 0.5 |
| Gain-Bandwidth Product, $f_T$ (MHz) | 4.5 | 1.0 |

**$1.25**

## VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin, onto component leads or terminals installed on pre-punched "P" Pattern Vectorbord®. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire. **$9.50**

### REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

| | | |
|---|---|---|
| W36-3-A-Pkg. 3 | 250 ft. 36 AWG GREEN | $2.40 |
| W36-3-B-Pkg. 3 | 250 ft. 36 AWG RED | $2.40 |
| W36-3-C-Pkg. 3 | 250 ft. 36 AWG CLEAR | $2.40 |
| W36-3-D-Pkg. 3 | 250 ft. 36 AWG BLUE | $2.40 |

## 1/16 VECTOR BOARD

0.1" Hole Spacing, P-Pattern

| | Part No | L | W | Price 1-19 | 20-49 |
|---|---|---|---|---|---|
| PHENOLIC | 64P44 062XXXP | 4.50 | 6 50 | 1 72 | 1 54 |
| | 169P44 02XXXP | 4.50 | 17 00 | 3 69 | 3 32 |
| EPOXY GLASS | 64P44 062 | 4 50 | 6.50 | 2 07 | 1 86 |
| | 84P44 062 | 4 50 | 8.50 | 2 56 | 2 31 |
| | 169P44 062 | 4 50 | 17 00 | 5 04 | 4 53 |
| | 169P84 062 | 8 50 | 17 00 | 9 23 | 8 26 |
| EPOXY GLASS COPPER CLAD | 169P44 062C1 | 4 50 | 17.00 | 6.80 | 6 12 |

## VECTOR TERMINALS

| Series | Part No. Finish Gold | Tinned | Post Size | 25 pcs Gold | 25 pcs Tin | 50 pcs Gold | 50 pcs Tin |
|---|---|---|---|---|---|---|---|
| T44 | T44-1 | T44 | 025 sq | 1 50 lot | 1 00 lot | 2 75 lot | 1 75 lot |
| T46 | T46-1 | T46 | 028 sq | 1 75 lot | 1 25 lot | 3 00 lot | 2 25 lot |
| T49 | T49A | T49 | 025 sq | 1.75 lot | 1 25 lot | 3 10 lot | 2 25 lot |

T42-1 PKG 100 Terminals $3.50 C $13 00M

## DIP SWITCH

These switches feature seven SPST slide switches in a molded dip. They are ideally suited for microprocessor applications **$1.95**

## SCR AND FW BRIDGE RECTIFIERS

| | | | |
|---|---|---|---|
| C36D | 15A @ 400V | SCR | $1.95 |
| C38M | 35A @ 200V | SCR | 1.95 |
| 2N2328 | 1.6A @ 200V | SCR | .50 |
| MDA 980-1 | 25A @ 50V | FW BRIDGE REC | 1.95 |
| MDA 980-3 | 25A@ 200V | FW BRIDGE REC | 1.95 |

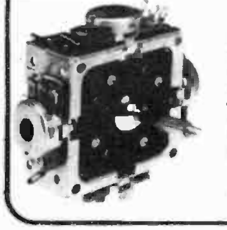
## 64 KEY KEYBOARD

This keyboard features 64 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications.

**$19.95**

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

## JOYSTICK



These joysticks feature four 100K potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

**$9.95 ea.**

# MICROPROCESSOR COMPONENTS

## 8080 SUPPORT DEVICES

**8080A $37.95**

| | | |
|---|---|---|
| 8212 | 8 BIT INPUT/OUTPUT PORT FOR 8080 | $ 5.95 |
| 8224 | CLOCK GENERATOR AND DRIVER FOR 8080 | 12.95 |
| 8228 | SYSTEM CONTROLLER AND BUS DRIVER FOR 8080 | 12.95 |

**8080 $24.95**

### CPU'S

| | | |
|---|---|---|
| 8008 | 8 BIT CPU | $19.95 |
| 8080 | Super 8008 | 24.95 |
| 8080A | Super 8008 | 37.95 |

### SR'S

| | | |
|---|---|---|
| 2504 | 1024 Dynamic | $ 9.00 |
| 2518 | Hex 32 BIT | 7.00 |
| 2519 | Hex 40 BIT | 4.00 |
| 2524 | 512 Dynamic | 2.95 |
| 2525 | 1024 Dynamic | 6.00 |
| 2527 | Dual 256 BIT | 3.95 |
| 2529 | Dual 512 BIT | 4.00 |
| 2532 | Quad 80 BIT | 3.95 |
| 2533 | 1024 Static | 7.95 |
| 3341 | Fifo | 6 95 |
| 74LS670 | 16 x 4 Reg. | 3 95 |

### UART'S

| | | |
|---|---|---|
| AY-5-1013 | 30K Baud | $ 6 95 |

### ROM'S

| | | |
|---|---|---|
| 2513 | Char Gen | $11 00 |
| 2516 | Char Gen. | 13.00 |
| 74S387 | 1024-Bit Programmable | 1.95 |

### RAM'S

| | | | |
|---|---|---|---|
| 1101 | 256 x 1 | Static | $ 2.25 |
| 1103 | 102 x 1 | Dynamic | 2.95 |
| 2101 | 256 x 1 | Static | 6.95 |
| 2102 | 1024 x 1 | Static | 1.95 |
| 2107 | 4096 x 1 | Dynamic | 19.95 |
| 2111 | 256 x 4 | Static | 7.95 |
| 7010 | 1024 x 1 | MNOS | 29.95 |
| 7489 | 16 x 4 | Static | 2 49 |
| 8101 | 256 x 4 | Static | 7.95 |
| 8111 | 256 x 4 | Static | 7.95 |
| 8599 | 16 x 4 | Static | 3.49 |
| 91L02 | 1024 x 1 | Static | 2.49 |
| 74200 | 256 x 1 | Static | 6.95 |
| 93410 | 256 x 1 | Static | 1.75 |

### PROMS

| | | | |
|---|---|---|---|
| 1702A | 2048 | Famos | $15.95 |
| 5203 | 2048 | Famos | 14.95 |
| 82S23 | 32 x 8 | Open C | 5 00 |
| 82S123 | 32 x 8 | Tristate | 5.00 |
| 74S287 | 1024 | Static | 7.95 |
| 3601 | 256 x 4 | Fast | 5.00 |

## 2K RAM SPECIAL

MM5262 Fully decoded 2Kx1 dynamic RAM. All inputs except clocks are TTL compatible. Provides a 635 ns minimum access time, and requires, a +5, +8 5, and −15V power supply. Low power provides non volatile memory using battery back up.

**$0.99 ea. (0.05 cents per bit)**

## *Special Requested Items*

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|---|---|---|---|---|---|---|---|---|
| RC4194 | Dual Track V Reg | $ 5 95 | N8T97 | $ 2.00 | MK5007 | $10.95 | MC4044 | $ 4 50 |
| RC4195 | ±15V Track Reg | 3.25 | 4024P | 2.25 | 8263 | 5.95 | LM3909 | 1.25 |
| F9368 | Decoder | 3 95 | DM8130 | 3.25 | 8267 | 2.75 | MM5320 | 19 95 |
| LD110/111 | DVM Chip Set | 25.00 | CD4520 | $2.50 | 8288 | 1.15 | 4072AE | .45 |
| CA3130 | Super CMOS Op Amp | 1.39 | MC14016 | .56 | 8826 | 3.00 | 7422 | 1.50 |
| MC1408L7 | D/A | 9.95 | 2525 | 6 00 | 8880 | .80 | 7497 | 4.00 |
| F3341 | FIFO | 5.95 | 2527 | 3.95 | 4511AE | 2.50 | 74186 | 5.00 |
| MM5841 | Character Gen. | 18 00 | CD4518 | 2.50 | XR4136 | 2.00 | 74279 | .90 |
| AY5-9100 | Push Button Dialer | 17 50 | MM5309 | 5.95 | 4566AE | 3.00 | 82S90 | 4.00 |
| | | | | | | | MCT-2E | 2.95 |

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**$75 Proto Board 203**

Breadboard Prototyping with 5 Volt 1 AMP Regulated Power Supply Included!

A total ready to use power breadboard prototest device with a built-in regulated short proof power supply. Just plug in and start building! 2 extra floating 5-way binding posts for external signals. Self contained with power switch indicator lamp and power fuse. 24-14 pin DIP capacity. Attractive two tone quality case. All metal construction. 9¾ L x 6½ W x 2¾ H. 5 lbs. Order today!

For the economy-minded experimenter . . .

NEW

## Proto Board 100

**19.95**

Here is a low cost, big 10 IC capacity breadboard kit with all the quality of QT Sockets and the best of the Proto-Board series ... complete down to the last nut, bolt and screw. Includes 2 QT-35S Sockets, 1 QT-35B Bus Strip, 2 5-way binding posts, 4 rubber feet, screws, nuts, bolts and easy assembly instructions.

Proto Board 104 Huge 3,060 solderless tie points, (4) 5-way binding posts, 32 14 pin DIP capacity, 9½ long x 8 wide **79.95**

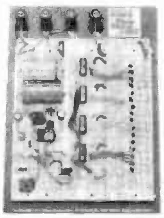
COMPLETE KIT

THE MINI-BREADBOARD BUDGET KIT

Proto Board 101 Compact, inexpensive 10 14 pin DIP capacity 5.8 long x 4.5 wide **29.95**

Proto Board 102 Compact 12 14 pin DIP capacity, 7 x 4½ **39.95**

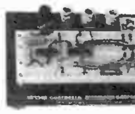
Proto Board 103 2,250 solderless tie points, (4) 5-way binding posts, 24 14 pin DIP capacity, 9 x 6 **59.95**



DESIGN MATE 1

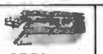
CIRCUIT DESIGNER

You asked for it. HERE IT IS! CSC's basic circuit designer to help you build and test ANY electronic circuit. Solid #22 AWG wire interconnects any discreet component without solder. Resistors, Transistors, Linear Digital ICs in TO-5 DIP packages (from 8-40 pins). And more. Components fit directly into Sockets and Bus strips instantly and easily. Plus DESIGN MATE ONE (DM-1) variable regulated power supply gives 5-15VDC up to 600ma (9 watts). Now that's design flexibility for you! You can even monitor the DM-1's internal power supply or external circuits thanks to the built-in 15V voltmeter. If you're into electronics, DM-1 is a must for your laboratory. It comes to you completely wired, tested and ready to use for only $49.95



PROTO BOARD 6

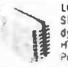
The PB 6 lets the user test and build circuits without soldering or patch cords. All interconnections between components are made with common #22 AWG hook up wire. This quality breadboarding kit includes 630 component tie points at less than 2.5 cents each. It measures 6" long by 4" wide. Designed specially to Breadboard Microprocessor Circuits. $15.95



Now trace signals or troubleshoot fast. Inject signals or wire unused circuits into existing boards. Scope probes, test leads lock onto Hydragrip inset. Plastic construction — no springs or pivots. Thousands of operations. Narrow Head for high density PC boards.

| | | |
|---|---|---|
| PC-14 | 14 pin Proto Clip | $3 50 ea |
| PC-16 | 16 pin Proto Clip | $3 00 |
| PC-24 | 24 pin Proto Clip | $8 00 |

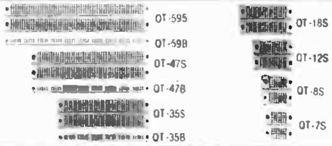
**SPECIAL!**



LOGIC MONITOR

Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs.

Pocket size $84.95.





QT Proto Strips

| QT type | # holes | price |
|---|---|---|
| QT-59S | 590 | 12 50 |
| QT-59B | bus strip | 2 50 |
| QT-47S | 470 | 10 00 |
| QT-47B | bus strip | 2 25 |
| QT-35S | 350 | 8 50 |
| QT-35B | bus strip | 2 00 |
| QT-18S | 180 | 4.75 |
| QT-12S | 120 | 3.75 |
| QT-8S | 80 | 3.25 |
| QT-7S | 70 | 3 00 |

## DIGITAL CLOCK KIT — 3½ INCH DIGITS

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½", and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

4 DIGIT KIT $49.95 — 4 DIGIT ASSEMBLED $59.95

6 DIGIT KIT $69.95 — 6 DIGIT ASSEMBLED $79.95

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## 5 FUNCTION ELECTRONIC CALCULATOR RADOFIN MODEL 8P

**$8.95**

FEATURES:

- 8 Digit Display
- 5 Functions consists of addition, subtraction, multiplication, division, percentage; with constant on all functions, with full floating decimal point.
- Power source is 1 piece 9V DC Battery 00GP, jack for AC adapter
- Black superfine grained finish plastic cabinet

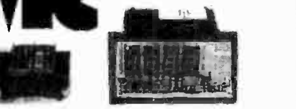
## 5 FUNCTION ELECTRONIC CALCULATOR WITH WALLET-NOTEBOOK AND POCKET CHECKBOOK RADOFIN MODEL 1710

**$19.95**

FEATURES:

- 8 Digit Display
- 5 Functions consists of addition, subtraction, multiplication, division, percentage; with constant on all functions, with full floating decimal point
- Power source is 6 AAA cells 9 V DC
- Wallet is 2 tone texon; cabinet is black plastic

## 3½ DIGIT DVM KIT

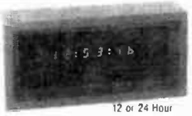


This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an Injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

**A. 0-2V DVM with Case $49.95**

**B. 5V Power Supply $14.95**

## JE700 CLOCK



12 or 24 Hour

115 VAC

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip.

**$17.95**

Liquid Crystal Temperature Display

Six Digit Light Emitting Diode Display

DL 33 Display

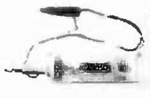
This clock makes an attractive addition to any desk. It has an extruded, black anodized aluminum case. It displays hours, minutes, and seconds with .11 inch displays, and comes complete with a liquid crystal thermometer. It operates off 115 VAC at 50 or 60 Hz. **$24.95**

This large digit clock (.6" hours & minutes, .3" seconds) features the MM5314 clock chip. It operates from 117 VAC, and will operate in either a 12 or 24 hour mode. The clock is complete with a walnut grain case, and has fast set, slow set, and hold time set features.

**KIT - ALL COMPONENTS & CASE $34.95**

**WIRED & ASSEMBLED $39.95**

## JE803 PROBE



The Logic Probe is a unit which is for the most part indispensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (H) - 1 (LOW) - 0 (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

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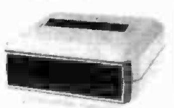

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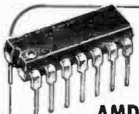

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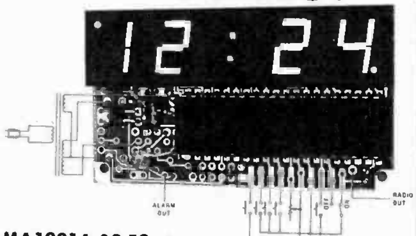

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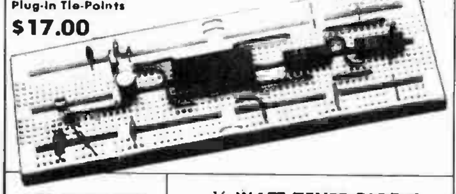

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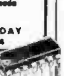

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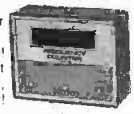

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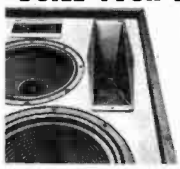

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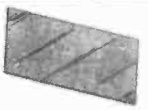

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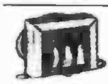

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|---|---|
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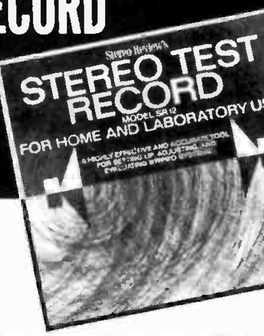


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| 7420 | 14 | 74163 | 75 |
| 7427 | 25 | 74165 | 80 |
| 7438 | 25 | 74173 | 1.25 |
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| 7445 | 45 | 74175 | 75 |
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| 7451 | 14 | 74181 | 1.50 |
| 7473 | 22 | 74191 | 1.00 |
| 7474 | 23 | 74192 | 70 |
| 7493 | 50 | 74193 | 70 |
| 7495 | 49 | 74198 | 1.00 |
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| 74150 | 60 | | |

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| 74S85 | 2.00 | 74S181 | 3.50 |
| 74S139 | 1.50 | 74S197 | 1.50 |
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| 74H01 | 20 | 74H52 | 20 |
| 74H04 | 20 | 74H74 | 40 |
| 74H10 | 20 | 74H103 | .50 |
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| 4002 | 16 | 4028 | 60 |
| 4006 | 90 | 4030 | 35 |
| 4007 | 16 | 4040 | 95 |
| 4008 | 70 | 4042 | 60 |
| 4011 | 16 | 4043 | 75 |
| 4012 | 16 | 4044 | 70 |
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| 4015 | 80 | 4050 | 38 |
| 4016 | 35 | 4066 | .65 |
| 4019 | 70 | 4068 | .35 |
| 4020 | 90 | 4069 | 16 |
| 4021 | 95 | 4071 | .16 |
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| 2SC517 | 4.75 | 2SC776 | 3.00 | 2SC1018 | 1.50 | 2SC1728 | 2.15 | SK3047 | 3.75 |
| 2SC614 | 3.80 | 2SC777 | 4.75 | 2SC1173 | 1.25 | 2SC1760 | 2.15 | SJ2095 | 3.50 |
| 2SC615 | 3.90 | 2SC778 | 3.25 | 2SC1226A | 1.25 | 2SC1816 | 5.50 | SK3048 | 3.25 |
| 2SC616 | 4.15 | 2SC797 | 2.50 | 2SC1237 | 4.50 | 2SC1908 | .70 | SK3054 | 1.25 |
| 2SC617 | 4.25 | 2SC798 | 3.10 | 2SC1239 | 3.50 | 2SC1957 | 1.50 | | |
| 2SC699 | 4.75 | 2SC781 | 3.00 | 2SC1243 | 1.50 | 2SF8 | 3.00 | 2SK19 | 1.75 |
| 2SC710 | .70 | 2SC789 | 1.00 | 2SC1306 | 4.75 | HEP-S3001 | 3.25 | 2SK30 | 1.00 |
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| 2SA490 | .70 | 2SB367 | 1.60 | 2SC515 | .80 | 2SC945 | .65 | 2SD65 | .75 |
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| 2SA699 | 1.30 | 2SB476 | 1.25 | 2SC643 | 3.75 | 2SC1166 | .70 | 2SD300 | 2.50 |
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| 2SB22 | .65 | | | 2SC712 | .70 | 2SC1243 | 1.50 | 2SD352 | .80 |
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| 2SB77 | .70 | 2SC261 | .65 | 2SC733 | .70 | 2SC1347 | .80 | 2SD-390 | .75 |
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| 1N914 | .10 | 2N962 | .40 | 2N2221 | .25 | 2N2914 | 1.20 | 2N3771 | 1.75 | 2N4402 | .20 |
| | | 2N967 | .50 | 2N2221A | .30 | 2N2916A | 3.65 | 2N3732 | 1.90 | 2N4403 | .20 |
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| 2N178 | .90 | 2N1142 | 2.25 | 2N2222A | .30 | 2N3053 | .30 | 2N3819 | .32 | 2N4410 | .25 |
| 2N327A | 1.15 | 2N1302 | .25 | 2N2270 | .40 | 2N3054 | .70 | 2N3823 | .70 | 2N4416 | .75 |
| 2N334 | 1.20 | 2N1305 | .30 | 2N2322 | 1.00 | 2N3055 | .75 | 2N3856 | .20 | 2N4441 | .85 |
| 2N336 | .90 | 2N1377 | .75 | 2N2323 | 1.00 | 2N3227 | 1.00 | 2N3866 | .85 | 2N4442 | .90 |
| 2N338A | 1.05 | 2N1420 | .20 | 2N2324 | 1.35 | 2N3247 | 3.40 | 2N3903 | .20 | 2N4443 | 1.20 |
| 2N398B | .90 | 2N1483 | .95 | 2N2325 | 2.00 | 2N3250 | .50 | 2N3904 | .20 | 2N4852 | .55 |
| 2N404 | .30 | 2N1540 | .90 | 2N2326 | 2.85 | 2N3375 | 6.50 | 2N3905 | .20 | 2N5061 | .30 |
| 2N443 | 1.75 | 2N1543 | 2.70 | 2N2327 | 3.80 | 2N3393 | .20 | 2N3906 | .25 | 2N5064 | .50 |
| 2N456 | 1.10 | 2N1544 | .80 | 2N2328 | 4.20 | 2N3394 | .17 | 2N3925 | 3.75 | 2N5130 | .20 |
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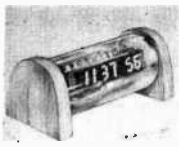

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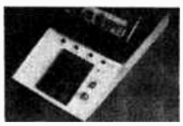

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| 74200 | 256 bit RAM tri-state 16 pin | 5.45 |

### CALCULATOR CHIPS

| | |
|---|---|
| CT5002 | 1.95 |
| CT5005 | 2.49 |
| MM5725 | 1.98 |
| MM5736 | 2.95 |
| MM5738 | 3.95 |
| MM5739 | 3.95 |

### CLOCK CHIPS

| | |
|---|---|
| MM5311 | 4.45 |
| MM5312 | 3.95 |
| MM5314 | 4.45 |
| MM5316 | 4.95 |
| 5375AA | 4.95 |
| CT7001 | 5.95 |

### DISPLAYS

| | |
|---|---|
| MAN1 | $1.95 |
| MAN2 | 3.95 |
| MAN3A | .19 |
| MAN5 | 2.25 |
| MAN6 | 2.49 |
| MAN7 | 1.49 |
| MAN8 | 2.25 |
| MAN66 | 2.25 |
| DL10A | 2.19 |
| FND500 | 1.89 |
| NS71L | 1.39 |

### DISCRETE LED'S

| | |
|---|---|
| ME4 | $ .29 |
| MV50 | .12 |
| NSL100 | .12 |
| NSL101 | .12 |
| NSL102 | .15 |
| MV5020 | |
| RED | .15 |
| GREEN | .15 |
| AMBER | .15 |
| CLEAR | .15 |

### MULTIPLE DISPLAYS

| | | |
|---|---|---|
| NSN33 | 3 digit .12" red LED | 1.79 |
| HP5082-7405 | 5 digit .11 red LED | 3.49 |
| HP5082-7414 | 4 digit .11 red LED | 3.25 |
| SP-425-09 | 9 digit .25 gas disch. | 1.79 |

### OPTO ISOLATORS

| | | |
|---|---|---|
| MCD2 | Opto isolator diode | 1.09 |
| MCT2 | Opto isolator transistor | .70 |

### SPECIAL DEVICES

| | | |
|---|---|---|
| 372 | AF-IF Strip Detector DIP | 2.93 |
| 546 | AM Radio Receiver Subsystem DIP | .75 |
| 1310 | FM Stereo Demodulator DIP | 2.90 |
| 1496 | Balanced Modulator-Demodulator | .99 |
| 1800 | Stereo multiplexer DIP | 2.48 |
| ULN2208 | FM Gain Block 34db (typ) mDIP | 1.18 |
| ULN2209 | FM Gain Block 48db (typ) mDIP | 1.35 |
| 2513 | Character Generator 64x8x5 DIP-24 | 10.20 |
| 3046 | Transistor Array OIP-14 | .73 |

### TTL

| | | | | | |
|---|---|---|---|---|---|
| 7400 | .13 | 7451 | .17 | 74153 | .89 |
| 7401 | .16 | 7453 | .17 | 74154 | 1.20 |
| 7402 | .15 | 7454 | .17 | 74155 | .97 |
| 7403 | .15 | 7460 | | 74156 | .97 |
| 7404 | .16 | 7464 | .35 | 74157 | .99 |
| 7405 | .19 | 7465 | .35 | 74158 | 1.79 |
| 7406 | .20 | 7470 | .30 | 74160 | 1.23 |
| 7407 | .28 | 7472 | .30 | 74161 | .97 |
| 7408 | .18 | 7473 | .35 | 74162 | 1.39 |
| 7409 | .19 | 7474 | .28 | 74163 | 1.09 |
| 7410 | .16 | 7475 | .49 | 74164 | .99 |
| 7411 | .25 | 7476 | .30 | 74165 | .99 |
| 7413 | .43 | 7483 | .68 | 74166 | 1.25 |
| 7414 | .65 | 7485 | .88 | 74170 | 2.10 |
| 7416 | .35 | 7486 | .40 | 74173 | 1.49 |
| 7417 | .35 | 7489 | 2.25 | 74174 | 1.23 |
| 7420 | .16 | 7490 | .43 | 74175 | .97 |
| 7422 | .30 | 7491 | .75 | 74176 | .89 |
| 7423 | .29 | 7492 | .48 | 74171 | .84 |
| 7425 | .27 | 7493 | .48 | 74180 | .90 |
| 7426 | .26 | 7494 | .78 | 74181 | 2.45 |
| 7427 | .29 | 7495 | .79 | 74182 | .79 |
| 7430 | .20 | 7496 | .79 | 74184 | 1.90 |
| 7432 | .23 | 74100 | .98 | 74185 | 2.20 |
| 7437 | .25 | 74105 | .44 | 74187 | 5.75 |
| 7438 | .25 | 74107 | .37 | 74190 | 1.15 |
| 7440 | .15 | 74121 | .38 | 74191 | 1.25 |
| 7441 | .89 | 74122 | .38 | 74192 | .95 |
| 7442 | .59 | 74123 | .65 | 74193 | .85 |
| 7443 | .73 | 74125 | .54 | 74194 | 1.25 |
| 7444 | .73 | 74126 | .58 | 74195 | .74 |
| 7445 | .73 | 74132 | .89 | 74916 | 1.25 |
| 7446 | .81 | 74141 | 1.04 | 74197 | .73 |
| 7447 | .79 | 74145 | 1.04 | 74198 | 1.73 |
| 7448 | .79 | 74150 | .97 | 74199 | 1.69 |
| 7450 | .17 | 74151 | .79 | 74200 | 5.45 |

**LOW POWER**

| | | | | | |
|---|---|---|---|---|---|
| 74L00 | .29 | 74L51 | .29 | 74L90 | 1.40 |
| 74L02 | .29 | 74L55 | .29 | 74L91 | 1.20 |
| 74L03 | .23 | 74L71 | .29 | 74L93 | 1.50 |
| 74L04 | .29 | 74L72 | .45 | 74L95 | 1.50 |
| 74L06 | .29 | 74L73 | .56 | 74L98 | 2.25 |
| 74L10 | .29 | 74L74 | .56 | 74L164 | 2.25 |
| 74L20 | .29 | 74L78 | .75 | 74L165 | 2.30 |
| 74L30 | .29 | 74L85 | 1.09 | | |
| 74L42 | 1.39 | 74L86 | .65 | | |

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| | | | | | |
|---|---|---|---|---|---|
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| 74LS02 | .36 | 74LS40 | .45 | 74LS107 | .59 |
| 74LS04 | .36 | 74LS42 | 1.40 | 74LS164 | 2.20 |
| 74LS08 | .38 | 74LS74 | .59 | 74LS193 | 2.20 |
| 74LS10 | .36 | 74LS90 | 1.30 | 74LS197 | 2.20 |
| 74LS20 | .36 | 74LS93 | 1.30 | | |

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| | | | | | |
|---|---|---|---|---|---|
| 74H00 | .25 | 74H22 | .25 | 74H61 | .25 |
| 74H01 | .25 | 74H30 | .25 | 74H62 | .25 |
| 74H04 | .25 | 74H40 | .25 | 74H74 | .39 |
| 74H08 | .25 | 74H50 | .25 | 74H101 | .58 |
| 74H10 | .25 | 74H52 | .25 | 74H102 | .58 |
| 74H11 | .25 | 74H53 | .25 | 74H103 | .60 |
| 74H20 | .25 | 74H55 | .25 | 74H106 | .72 |
| 74H21 | .25 | 74H60 | .25 | 74H108 | .72 |

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| | | | | | |
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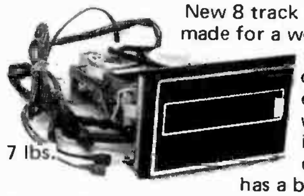


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| SN7404N | .19 |
| SN7410N | 17 |
| SN7414N | 63 |
| SN7416N | 34 |
| SN7417N | 39 |
| SN7420N | 17 |
| SN7430N | 20 |
| SN7438N | 25 |
| SN7439N | 25 |
| SN7440N | 17 |
| SN7447N | 60 |
| SN7450N | .17 |
| SN7473N | 36 |
| SN7474N | .32 |
| SN7475N | .49 |
| SN7476N | .32 |
| SN7483N | 70 |
| SN7486N | 39 |
| SN7489N | 2 00 |
| SN7490N | .45 |
| SN7492N | .45 |
| SN7493N | .49 |
| SN7496N | .75 |
| SN74100N | 90 |
| SN74107N | 39 |
| SN74121N | 39 |
| SN74123N | .59 |
| SN74126N | 55 |
| SN74145N | 89 |
| SN74150N | .95 |
| SN74151N | 75 |
| SN74154N | 1 10 |
| SN74155N | 95 |
| SN74157N | 95 |
| SN74161N | .95 |
| SN74166N | 1 35 |
| SN74170N | 1 95 |
| SN74174N | 1 19 |
| SN74175N | 90 |
| SN74191N | 1.25 |
| SN74193N | .85 |
| SN74298N | 1 65 |
| SN75494 | 3 00 |
| **74LS00 TTL** | |
| SN74LS00N | 34 |
| SN74LS02N | 34 |
| SN74LS04N | 39 |
| SN74LS08N | 39 |
| SN74LS10N | 39 |
| SN74LS20N | .34 |
| SN74LS28N | 41 |
| SN74LS30N | 34 |
| SN74LS38N | 39 |
| SN74LS74N | 59 |
| SN74LS75N | 75 |
| SN74LS90N | 1 10 |
| SN74LS93N | 1 10 |
| SN74LS95N | 1 89 |
| SN74LS107N | .52 |
| SN74LS132N | 1 50 |
| SN74LS151N | 1 28 |
| SN74LS157N | 1.40 |
| SN74LS163N | 2 05 |
| SN74LS194N | 2 00 |
| SN74LS258N | 2 20 |

| LINEAR | |
|---|---|
| CA3082 | 1.90 |
| CA3089 | 2.75 |
| LM301AN | .35 |
| LM301AH | 35 |
| LM307N | 35 |
| LM308N | 89 |
| LM309K | 95 |
| LM311H | 90 |
| LM318 | 1.35 |
| LM324N | 1.10 |
| LM339N | 1.55 |
| LM340K-5 | 1.60 |
| LM343H | 4 25 |
| LM358N | 2.40 |
| LM380N | 1.00 |
| LM710N | .65 |
| LM723N | 44 |
| LM733N | 89 |
| LM741CH | 35 |
| LM741N | 25 |
| LM1303N | 82 |
| LM1812 | 7 50 |
| LM3900N | 55 |
| LM3909 | 1 10 |
| MC1458V | .59 |
| NE540L | 5 00 |
| NE550N | 65 |
| NE555V | .43 |
| NE556A | 1 00 |
| NE565A | 1.00 |
| NE566V | 1 85 |
| NE567V | 1 25 |
| SN75451CN | 39 |
| SN75452CN | 39 |

| CMOS | |
|---|---|
| CD34001 | .42 |
| CD4001 | 25 |
| CD4002 | 25 |
| CD4011 | .25 |
| CD4012 | .25 |
| CD4013 | .40 |
| CD4016 | 50 |
| CD4017 | 1 25 |
| CD4020 | 1.35 |
| CD4024 | 1 20 |
| CD4027 | 62 |
| CD4030 | 55 |
| CD4049 | 62 |
| CD4050 | 62 |
| CD4071 | 40 |
| CD4072 | 40 |
| CD4082 | .45 |
| CD4511 | 2 20 |
| CD40192 | 3 00 |
| 74C00 | 28 |
| 74C04 | 33 |
| 74C74 | 75 |
| 74C160 | 2 00 |
| 74C192 | 2 40 |
| 74C221 | 2 75 |
| **INTERFACE** | |
| N8T25V | 2 20 |
| N8T26V | 2.00 |
| N8T28B | 2 75 |
| N8T97B | 2.75 |
| N8T98 | 2.75 |
| **MOS/MEMORY RAM** | |
| 2102 | 1 80 |
| 2102-1 | 2 20 |
| 2107B | 8 00 |
| 2112-2 | 7 90 |
| 2513B | 10 00 |
| MM5262 | 90 |
| MM5058 | 2 20 |
| **PROM** | |
| 1702A | 13 00 |
| N82S23 | 3 25 |
| N82S123 | 4 00 |
| N82S126 | 4 85 |

| DISPLAY LEDS | | | |
|---|---|---|---|
| MAN1 | CA | 270 | 2 90 |
| MAN3 | CC | 125 | 39 |
| DL704 | CC | 300 | 1 25 |
| DL707 | CA | 300 | 1.50 |
| DL727 | CA | 500 | 2 55 |
| DL747 | CA | .600 | 2.25 |
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| FND503 | CC | 500 | 1 35 |
| FND510 | CA | .500 | 1 35 |
| FND800 | CC | .800 | 2.75 |
| FND807 | CA | .800 | 2.75 |
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| MV5022 | | | 69 |
| MV5082 | | | 89 |
| 5082-7414 | | | 1.40 |

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| 32 MHz | 3 90 |
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| SN7410 | .22 | .23 | SN74150 | 1.12 | 1.13 |
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| SN7414 | 2.75 | 2.76 | SN74154 | 1.53 | 1.54 |
| SN7417 | .62 | .63 | SN74157 | 1.09 | 1.10 |
| SN7420 | .22 | .23 | SN74158 | 1.55 | 1.56 |
| SN7421 | .55 | .56 | SN74160 | 1.59 | 1.60 |
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| SN7425 | .37 | .38 | SN74164 | 1.79 | 1.80 |
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| 9E2853 | 5262 | 3.95 | 3.96 |
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| 9E2155-B | MM5202 | 9.95 | 9.96 |
| 9E2854 | 1702-A | 12.50 | 12.51 |

Phone : Wakefield, Mass. (617) 245-3829
Terms: Add postage Rated: net 30
MINIMUM ORDER — $6.

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CIRCLE NO. 53 ON FREE INFORMATION CARD

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- IMPROVES ENGINE PERFORMANCE
- INCREASES GAS MILEAGE
- CUTS MAINTENANCE COSTS

**90 DAY GUARANTEE on Material/Workmanship**
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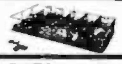
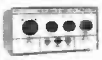
XM-S Micro Hook (1.75" long) Permits hookups to delicate wires where weight and leverage may damage component. Available in 10 Retma colors: red, black, blue, green, gray, orange, yellow, white violet or brown. . . . . . . . . . . . . . . . . . . . . . . . 10 for $7.95

## PLESSEY SAMPLER

300 METALIZED CAPACITORS
18 DIFFERENT STD. VALUES **$26.00**



## L-15 PULSE/SWEEP FUNCTION GENERATOR KIT



FEATURES: 1 HZ to 100 KHz in 5 ranges, at constant amplitude • Sine and triangle adjustable to 20vp-p into 600 ohms • Sine distortion is .5% typical • Voltage controlled sweep of sine and triangle waves • TTL square wave has a fully adjustable pulse and drives 600 ohms • Frequencies of lower than 1 Hz and greater than 100 kHz are obtainable • short proof • Small, only 3"H x 6¼"W x 4"D. State-of-the-art design! .... $55.00

## 7400N TTL

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7400 | .18 | 7432 | .32 | 7480 | .80 | 74136 | 1.80 | 74177 | 1.20 |
| 7401 | .20 | 7433 | .44 | 7482 | 1.50 | 74141 | 1.70 | 74178 | 1.40 |
| 7402 | .18 | 7437 | .36 | 7483 | .82 | 74145 | 1.20 | 74179 | 1.80 |
| 7403 | .20 | 7438 | .35 | 7485 | 1.20 | 74147 | 2.00 | 74180 | 1.20 |
| 7404 | .21 | 7439 | .36 | 7486 | .44 | 74148 | 1.80 | 74181 | 3.10 |
| 7405 | .23 | 7440 | .20 | 7489 | 2.20 | 74150 | 1.70 | 74182 | 1.00 |
| 7406 | .30 | 7441 | .90 | 7493 | .62 | 74151 | 1.20 | 74184 | 2.80 |
| 7407 | .36 | 7442 | .66 | 7494 | .88 | 74152 | 1.20 | 74185 | 2.90 |
| 7408 | .28 | 7443 | .78 | 7495 | .90 | 74153 | 1.20 | 74188 | 5.00 |
| 7409 | .28 | 7444 | 1.05 | 7496 | .80 | 74154 | 1.20 | 74190 | 1.40 |
| 7410 | .22 | 7445 | 1.05 | 7497 | 5.00 | 74155 | 1.10 | 74191 | 1.30 |
| 7411 | .26 | 7446 | 1.05 | 74100 | 1.20 | 74156 | 1.20 | 74192 | 1.20 |
| 7412 | .36 | 7447 | .98 | 74105 | .90 | 74157 | 1.20 | 74193 | 1.20 |
| 7413 | .54 | 7448 | .98 | 74107 | .40 | 74158 | 1.40 | 74194 | 1.20 |
| 7414 | .98 | 7450 | .15 | 74109 | .45 | 74160 | 1.30 | 74195 | 1.00 |
| 7416 | .42 | 7451 | .16 | 74110 | .80 | 74161 | 1.40 | 74196 | 1.40 |
| 7417 | .42 | 7453 | .18 | 74111 | 1.00 | 74162 | 1.90 | 74197 | 1.40 |
| 7420 | .15 | 7454 | .18 | 74116 | 2.00 | 74163 | 1.50 | 74198 | 1.40 |
| 7421 | .38 | 7459 | .25 | 74118 | 2.00 | 74164 | 1.50 | 74199 | 1.40 |
| 7422 | .60 | 7460 | .19 | 74121 | .60 | 74165 | 1.60 | 74200 | 7.00 |
| 7423 | .35 | 7470 | .40 | 74122 | .48 | 74166 | 1.60 | 74221 | 1.40 |
| 7425 | .40 | 7472 | .40 | 74123 | .95 | 74170 | 2.00 | 74279 | 1.20 |
| 7426 | .30 | 7473 | .42 | 74125 | .55 | 74173 | 1.70 | 74298 | 1.80 |
| 7427 | .36 | 7474 | .42 | 74126 | .60 | 74174 | 1.20 | | |
| 7428 | .50 | 7475 | .70 | 74128 | .60 | 74175 | 1.20 | | |
| 7430 | .26 | 7476 | .44 | 74132 | 1.50 | 74176 | 1.20 | | |

### HIGH SPEED TTL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 74H00N | .33 | 74H08N | .40 | 74H73N | .80 | 74H106N | .95 |
| 74H04N | .33 | 74H10N | .33 | 74H74N | .80 | | |

### 74LS00

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 74LS00N | .36 | 74LS32N | .45 | 74LS112N | .58 | 74LS174N | 2.20 |
| 74LS02N | .36 | 74LS51N | .39 | 74LS114N | .92 | 74LS175N | 2.40 |
| 74LS04N | .44 | 74LS54N | .58 | 74LS138N | 1.89 | 74LS181N | 3.69 |
| 74LS05N | .45 | 74LS73N | .58 | 74LS139N | 2.00 | 74LS190N | 2.85 |
| 74LS08N | .38 | 74LS74N | .56 | 74LS151N | 1.68 | 74LS191N | 2.85 |
| 74LS10N | .36 | 74LS76N | .65 | 74LS153N | 1.80 | 74LS193N | 2.50 |
| 74LS20N | .44 | 74LS107N | .59 | 74LS160N | 3.00 | 74LS260AJ | .44 |
| 74LS30N | .39 | 74LS109N | .92 | 74LS161N | 3.00 | | |

### SCHOTTKY TTL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 74S00 | .44 | 74S11 | .65 | 74S64 | .80 | 74S114 | 1.20 |
| 74S02 | .60 | 74S20 | .65 | 74S74 | .90 | 74S133 | .80 |
| 74S04 | .55 | 74S30 | .80 | 74S76 | 1.15 | 74S138 | 2.20 |
| 74S08 | .80 | 74S32 | .80 | 74S112 | 1.00 | 74S151 | 2.20 |
| 74S10 | .55 | 74S40 | .65 | 74S113 | 1.50 | 74S160 | 3.90 |
| | | | | | | 74S257 | 2.40 |

### LINEAR IC's

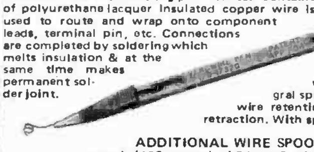
H=TO-5 N=DIP M=MINI-DIP D=CER DIP K=TO-3

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LM105H | 12.00 | LM308AH | 8.00 | LM336K | 2.60 | LM710CN | .90 |
| LM105F | 18.00 | LM308AM | 7.00 | LM337K | 2.60 | LM715CH | 3.90 |
| LM108H | 9.00 | LM308M | .90 | LM339N | 2.20 | LM723CH | .60 |
| LM301AH | .55 | LM309H | 1.90 | LM320-5K | 2.90 | LM723CN | .90 |
| LM301AM | .90 | LM309K | 1.90 | LM320-5T | 2.50 | LM725CH | 4.00 |
| LM301AN | .95 | LM310H | 1.90 | LM320-12K | 2.90 | LM725CD | 5.00 |
| LM302N | 1.80 | LM310D | 3.50 | LM320-12T | 2.50 | LM733CH | 1.40 |
| LM304H | 1.40 | LM311H | 2.50 | LM340-5K | 2.60 | LM733CD | 3.50 |
| LM305H | 1.20 | LM311D | 4.00 | LM340-6K | 2.60 | LM733CN | 2.00 |
| LM305AH | 1.40 | LM311M | 1.90 | LM340-8K | 2.60 | LM741CH | .50 |
| LM305N | 1.40 | LM312H | 1.90 | LM340-12K | 2.60 | LM741CM | .45 |
| LM306H | 4.00 | LM316H | 3.00 | LM340-15K | 2.60 | LM741CN | .82 |
| LM307H | .65 | LM318H | 2.50 | LM340-18K | 2.60 | LM747CH | 1.20 |
| LM307M | 1.00 | LM318M | 2.90 | LM340-24K | 2.60 | LM747CN | 1.20 |
| LM307N | 1.00 | LM319N | 3.50 | LM555CM | .70 | LM748CM | .95 |
| LM308H | 1.50 | LM324N | 2.40 | LM556CN | 1.30 | LM3054CN | 1.50 |
| LM308D | 2.80 | LM331N | 1.25 | LM567CM | 1.70 | SG4501N | 2.40 |

### CMOS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4000AE | .15 | 4023AE | .24 | 4051AE | 1.49 | 4093AE | 1.65 |
| 4001AE | .24 | 4024AE | .80 | 4052AE | 1.40 | 4095BE | 1.95 |
| 4002AE | .24 | 4025AE | .24 | 4053AE | 1.40 | 4098AE | 1.30 |
| 4006AE | 1.30 | 4026AE | 1.50 | 4055AE | 1.95 | 4099AE | 2.90 |
| 4007AE | .24 | 4027AE | .55 | 4056AE | 1.99 | 4502AE | 1.50 |
| 4008AE | 1.15 | 4028AE | .95 | 4060AE | 1.70 | 4507BE | .60 |
| 4009AE | .50 | 4029AE | 1.20 | 4063AE | 2.50 | 4508BE | 2.20 |
| 4010AE | .50 | 4030AE | .48 | 4066AE | .90 | 4510AE | 1.40 |
| 4011AE | .24 | 4033AE | 2.00 | 4068AE | .44 | 4511BE | 2.00 |
| 4012AE | .24 | 4035AE | 1.20 | 4069AE | .44 | 4512BE | 1.30 |
| 4013AE | .30 | 4040AE | 1.20 | 4070BE | .60 | 4514AE | 5.00 |
| 4014AE | 1.05 | 4041AE | 1.25 | 4071AE | .45 | 4515AE | 5.00 |
| 4015AE | 1.15 | 4042AE | 1.00 | 4072AE | .34 | 4516AE | 1.75 |
| 4016AE | .55 | 4043AE | .95 | 4073AE | .40 | 4518AE | 1.28 |
| 4017AE | 1.05 | 4044AE | .95 | 4075AE | .40 | 4520AE | 1.28 |
| 4018AE | 1.24 | 4046AE | 3.10 | 4076AE | 1.24 | 4528AE | 2.20 |
| 4019AE | .54 | 4047AE | 2.00 | 4077AE | .40 | 4585AE | 2.05 |
| 4020AE | 1.45 | 4048AE | 1.43 | 4078AE | .40 | 4901AE | .32 |
| 4021AE | 1.30 | 4049AE | .58 | 4081BE | .40 | 4911AE | .32 |
| 4022AE | 1.05 | 4050AE | .58 | 4082AE | .39 | | |

## NEW FROM verowire® WIRING SYSTEM



WIRING PEN — The wiring pen with self-contained spool of polyurethane lacquer insulated copper wire is used to route and wrap onto component leads, terminal pin, etc. Connections are completed by soldering which melts insulation & at the same time makes permanent solder joint. Wiring pen with unique integral spring wire clamp for wire retention advancement & retraction. With spool. . $7.99 each.

ADDITIONAL WIRE SPOOLS — Package of 2 spools (120 meters) of 34 AWG wire. . . . . . . $2.68

## DISPLAYS — (COMMON ANODE)

| LARGE 1" | | | XCITON .3" | | |
|---|---|---|---|---|---|
| EP1000 | RED | 5.50 | XAN72 | RED | 2.00 |
| 3 pcs | EP1000 | 15.00 | XAN52 | GREEN | 2.00 |
| 5 pcs | EP1000 | 22.50 | XAN82 | YELLOW | 2.00 |
| | | | LITRONIX .6" | | |
| Data sheet EP1000 | | .25 | DL747 | RED | 2.50 |

## LEDs

| .125" dia. | | .160" dia. | | .200" dia. | |
|---|---|---|---|---|---|
| 209 RED | $.25 | 216 RED | $.25 | 220 RED | $.25 |
| 209 YELLOW | .35 | 216 YELLOW | .30 | 220 YELLOW | .30 |
| 209 GREEN | .35 | 216 GREEN | .30 | 220 GREEN | .30 |

| LOW PROFILE .200" dia. | | .200" dia. | | | |
|---|---|---|---|---|---|
| 226 RED | $.25 | 5053 RED | $.35 | MV50 RED | $.30 |
| 226 YELLOW | .30 | 5053 YELLOW | .40 | | |
| 226 GREEN | .30 | 5053 GREEN | .40 | | |
| 226 ORANGE | .30 | 5053 ORANGE | .40 | | |

## TRANSISTORS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2N321 | .50 | 2N834 | .35 | 2N2218A | .26 | 2N2906 | .19 | 2N3553 | 1.80 |
| 2N324 | .55 | 2N918 | .40 | 2N2219 | .28 | 2N2906A | .20 | 2N3563 | .16 |
| 2N404A | .50 | 2N930 | .28 | 2N2219A | .36 | 2N2907 | .26 | 2N3565 | .18 |
| 2N456 | 1.30 | 2N1132 | .30 | 2N2221 | .23 | 2N2907A | .26 | 2N3568 | .28 |
| 2N508A | .40 | 2N1302 | .50 | 2N2221A | .25 | 2N2926 | .14 | 2N3569 | .19 |
| 2N555 | .60 | 2N1304 | .60 | 2N2222 | .24 | 2N3053 | .36 | 2N3638 | .18 |
| 2N652A | .50 | 2N1305 | .60 | 2N2222A | .26 | 2N3054 | .90 | 2N3638A | .20 |
| 2N681 | 2.80 | 2N1307 | .65 | 2N2369 | .28 | 2N3055 | .94 | 2N3903 | .20 |
| 2N683 | 2.90 | 2N1544 | 1.40 | 2N2369A | .29 | 2N3375 | 5.50 | 2N3904 | .22 |
| 2N697 | .25 | 2N1613 | .38 | 2N2484 | .30 | 2N3392 | .20 | 2N3905 | .20 |
| 2N705 | .28 | 2N1711 | .40 | 2N2605 | .48 | 2N3393 | .20 | 2N3906 | .22 |
| 2N711 | .34 | 2N1893 | .36 | 2N2713 | .13 | 2N3394 | .22 | 2N4303 | .30 |
| 2N711B | .60 | 2N1990 | .75 | 2N2904 | .36 | 2N3395 | .24 | 2N4416 | .89 |
| 2N718 | .36 | 2N2060 | 2.05 | 2N2904A | .38 | 2N3416 | .30 | | |
| 2N718A | .38 | 2N2160 | 1.50 | 2N2905 | .36 | 2N3440 | .98 | | |
| 2N744 | .35 | 2N2218 | .24 | 2N2905A | .38 | 2N3442 | 2.15 | | |

## MATSUO DIPPED TANTALUM CAPACITORS

| MF | V | $ | MF | V | $ |
|---|---|---|---|---|---|
| .1 | 35 | .33 | 6.8 | 16 | .40 |
| .15 | 35 | .33 | 6.8 | 35 | .45 |
| .22 | 35 | .33 | 10.0 | 16 | .42 |
| .33 | 35 | .33 | 10.0 | 25 | .45 |
| .47 | 35 | .33 | 10.0 | 35 | .90 |
| .68 | 35 | .33 | 15.0 | 20 | .45 |
| 1.0 | 35 | .33 | 15.0 | 35 | 1.32 |
| 1.5 | 35 | .40 | 22.0 | 16 | .45 |
| 2.2 | 20 | .33 | 33.0 | 20 | 1.32 |
| 2.2 | 35 | .40 | 47.0 | 20 | 1.53 |
| 3.3 | 35 | .42 | 68.0 | 16 | 1.62 |
| 4.7 | 35 | .45 | | | |

## PLESSEY POLYESTER

| MKT 160 | | | MINI BOX | | |
|---|---|---|---|---|---|
| MF | V | $ | MF | V | $ |
| .001 | 1000 | .14 | .039 | 250 | .15 |
| .0012 | 1000 | .14 | .047 | 250 | .15 |
| .0015 | 1000 | .14 | .056 | 250 | .15 |
| .0018 | 1000 | .14 | .068 | 250 | .15 |
| .0022 | 1000 | .14 | .082 | 250 | .17 |
| .0027 | 1000 | .14 | .1 | 100 | .17 |
| .0033 | 1000 | .14 | .12 | 100 | .18 |
| .0039 | 630 | .14 | .15 | 100 | .20 |
| .0047 | 630 | .14 | .18 | 100 | .21 |
| .0056 | 630 | .14 | .22 | 100 | .23 |
| .0068 | 630 | .14 | .27 | 100 | .26 |
| .0082 | 630 | .14 | .33 | 100 | .30 |
| .01 | 630 | .14 | .39 | 100 | .33 |
| .012 | 630 | .14 | .47 | 100 | .36 |
| .015 | 400 | .15 | .56 | 100 | .44 |
| .018 | 400 | .15 | .68 | 100 | .47 |
| .022 | 400 | .15 | .82 | 100 | .54 |
| .027 | 400 | .15 | 1.0 | 100 | .60 |
| .033 | 250 | .15 | | | |

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Designed specifically for electronic organs and other musical instrument designs. Detailed applications book, only . . . . . . . . . . $1.95
M252BIAA — 16 PIN DIP — $15.00. 15 programmable rhythms which cannot be superimposed. M253BIAA — 24 PIN DIP — $19.50. 12 programmable rhythms which can be superimposed. 16-page data sheet for both devices — only $.90.

## INDUSTRIAL QUALITY COMPONENTS

What is more important?
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FIRST QUALITY ONLY

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500 mW — 5%

| | V | Price |
|---|---|---|
| 1N5223B | 2.7 | .22 |
| 1N5224B | 2.8 | .22 |
| 1N5225B | 3.0 | .22 |
| 1N5226B | 3.3 | .22 |
| 1N5227B | 3.6 | .22 |
| 1N5228B | 3.9 | .22 |
| 1N5229B | 4.3 | .22 |
| 1N5230B | 4.7 | .22 |
| 1N5231B | 5.1 | .22 |
| 1N5232B | 5.6 | .22 |
| 1N5233B | 6.0 | .22 |
| 1N5234B | 6.2 | .22 |
| 1N5235B | 6.8 | .22 |
| 1N5236B | 7.5 | .22 |
| 1N5237B | 8.2 | .22 |
| 1N5238B | 8.7 | .22 |
| 1N5239B | 9.1 | .22 |
| 1N5240B | 10 | .22 |
| 1N5241B | 11 | .22 |
| 1N5242B | 12 | .22 |
| 1N5243B | 13 | .22 |
| 1N5244B | 14 | .22 |
| 1N5245B | 15 | .22 |
| 1N5246B | 16 | .22 |
| 1N5247B | 17 | .22 |
| 1N5248B | 18 | .22 |
| 1N5249B | 19 | .22 |
| 1N5250B | 20 | .22 |
| 1N5251B | 22 | .22 |
| 1N5252B | 24 | .22 |
| 1N5253B | 25 | .22 |
| 1N5254B | 27 | .22 |
| 1N5255B | 28 | .22 |
| 1N5256B | 30 | .22 |
| 1N5257B | 33 | .22 |
| 1N5258B | 36 | .22 |
| 1N5259B | 39 | .22 |
| 1N5260B | 43 | .22 |
| 1N5261B | 47 | .22 |
| 1N5262B | 51 | .22 |
| 1N5263B | 56 | .22 |
| 1N5264B | 60 | .22 |
| 1N5265B | 62 | .22 |
| 1N5266B | 68 | .22 |
| 1N5267B | 75 | .22 |

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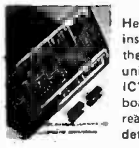
ONLY $289.00

## WAVEFORM GENERATOR KIT

EXAR XR205K . . . . . $25.00



Here's a highly versatile lab instrument at a fraction of the cost of conventional unit. Kit includes 2 XR205 IC's, data & applications, PC board (etched and drilled, ready for assembly) and detailed instructions.

## CARBON FILM RESISTORS . . ¼ WATT 5%

139 STANDARD VALUES—$1.69 per 100
10 ohm to 10 megohms — only in multiples of 100 per value

## SPDT MINIATURE TOGGLE SWITCH

105D . . . . 115V. . . . 5A Rating. . . . $.95

## CONTINENTAL SPECIALTIES

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*Build & test circuits as fast as you think!*

| | | |
|---|---|---|
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Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs. Pocket size. $74.95

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Automatically and accurately displays static and dynamic states of digital ICs. Selectable threshold control . . . $124.95

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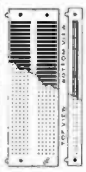
Compact, circuit-powered multifunction logic probe. Multi-family compatability. DTL/TTL/HTL/CMOS. Traces logic levels and pulses through digital circuitry. $44.95

### PROTO-CLIP

For power-on/hands off signal tracing. Bring IC leads up from PC board surface for fast trouble-shooting.

| | | |
|---|---|---|
| PC14 | 14-pin | $4.50 |
| PC16 | 16-pin | 4.75 |
| PC24 | 24-pin | 8.50 |

### SOCKETS & BUS STRIPS



Plug-in, wire, test, modify or expand without patch cords or solder. Snap together to form breadboard needed.

| PN/Description | L. | Hole-to-Hole | Term's | Price |
|---|---|---|---|---|
| QT59S Socket | 6.5" | 6.2" | 118 | $12.50 |
| QT59B Bus | 6.5" | 6.2" | 20 | 2.50 |
| QT47S Socket | 5.3" | 5.0" | 94 | 10.00 |
| QT47B Bus | 5.3" | 5.0" | 16 | 2.25 |
| QT35S Socket | 4.1" | 3.8" | 70 | 8.50 |
| QT35B Bus | 4.1" | 3.8" | 12 | 2.00 |
| QT18S Socket | 2.4" | 2.1" | 36 | 4.75 |
| QT12S Socket | 1.8" | 1.5" | 24 | 3.75 |
| QT8S Socket | 1.4" | 1.1" | 16 | 3.25 |
| QT7S Socket | 1.3" | 1.0" | 14 | 3.00 |

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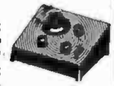
*With built-in regulated short-proof power supplies*

| | | |
|---|---|---|
| PB203 | 5V, 1 amp regulated power supply | $ 75.00 |
| PB203A | 5V, 1 amp and ±15V, ½ amp regulated power supply | 120.00 |

### DESIGN MATES



**DESIGN MATE 1. . . . . . CIRCUIT DESIGNER**
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| | | | |
|---|---|---|---|
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|---|---|---|---|
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| 14 | .25 | .22 | .20 |
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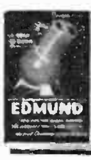


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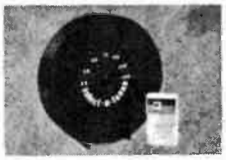

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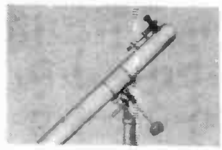

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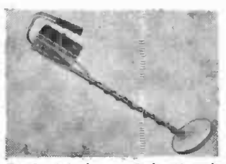

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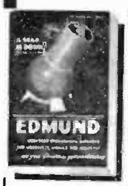


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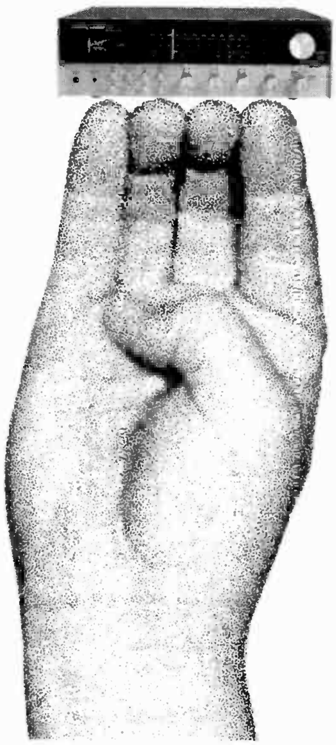
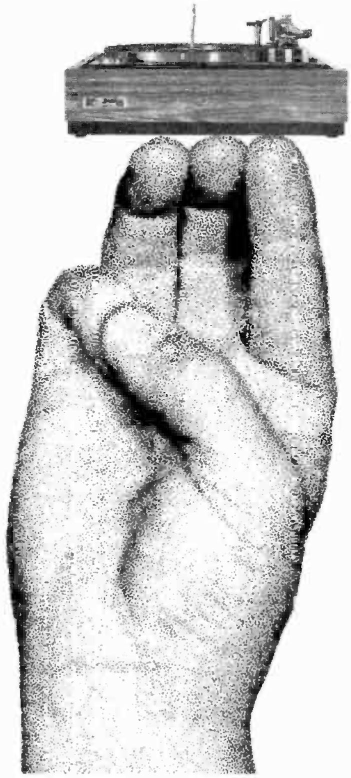
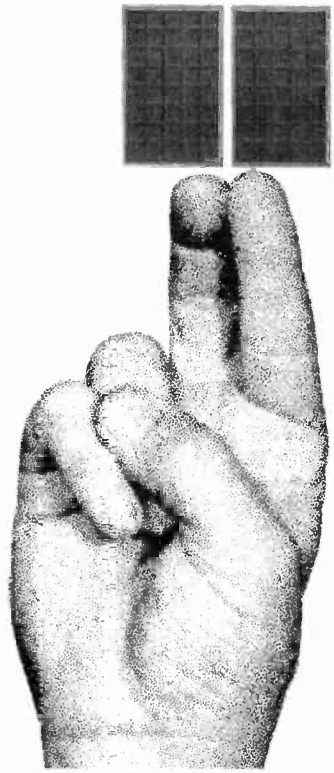


Your Turntable?



Your speakers?



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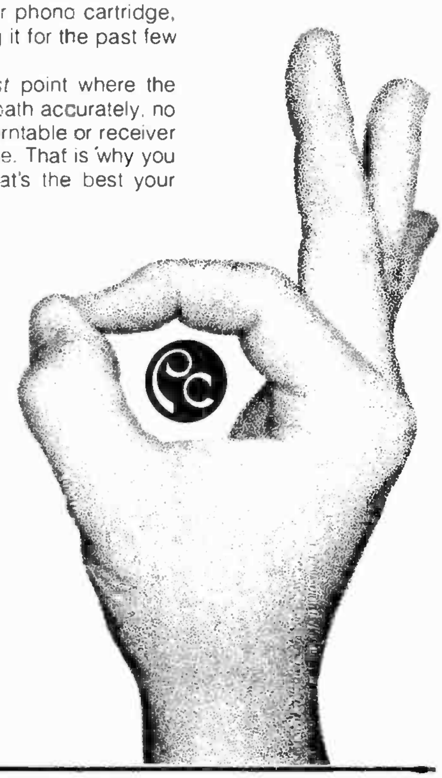

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