

BUYER'S GUIDE TO ANTENNA ROTATORS

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

AUGUST 1976 / \$1

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Stereo Receiver**

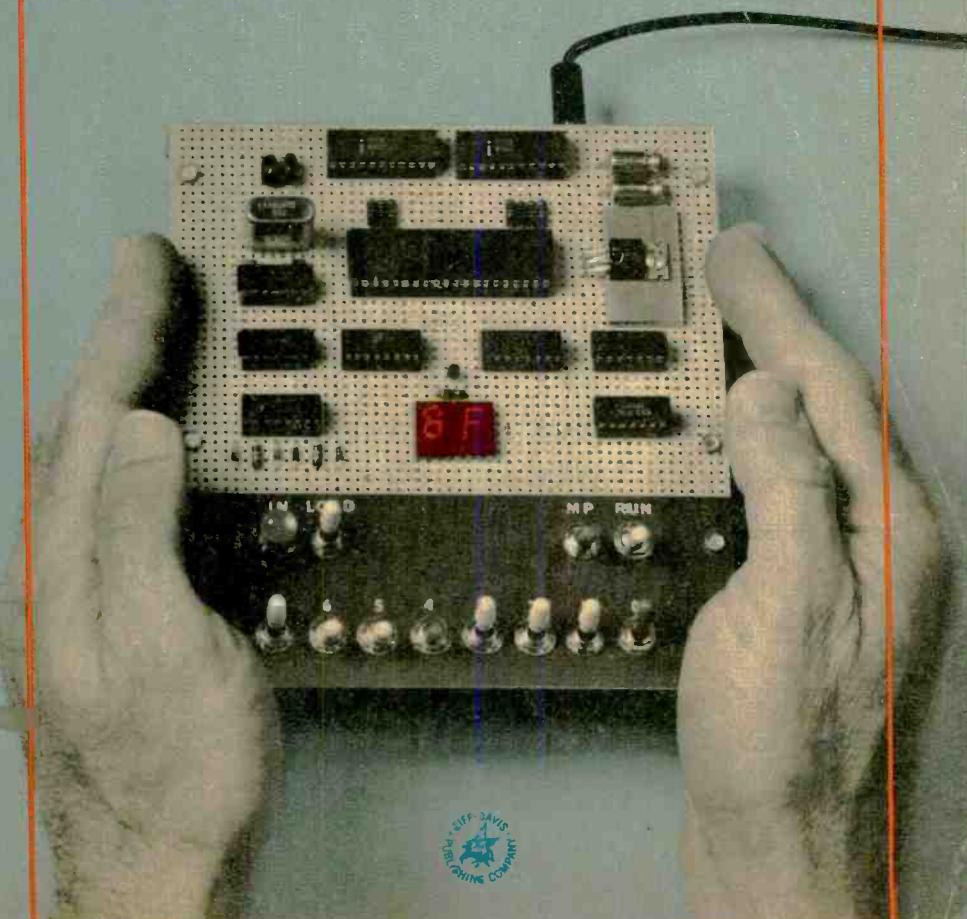
**B&O Beogram 1900
Manual Turntable**

**Realistic Phase-Lock
AM/SSB CB Transceiver**

**ANOTHER 
BREAKTHROUGH!**

THE COSMAC 'ELF'

**A MICROCOMPUTER TRAINER
THAT'S POWERFUL,
EXPANDABLE AND
COSTS AS LITTLE AS \$80.**



Experience is the best teacher. You might settle for any CB first time around. Understandably. A lot of people think they're all pretty much alike. But you'll soon discover that, like everything else, there are exceptions.

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Listen to Cobra. You'll hear a big difference. Because the Cobra 29 gives you features which assure crystal clear reception. Like switchable noise limiting and blanking, to cut out practically all pulse and ignition interference. Add squelch control and RF gain and you've got exceptional—adjustable—receiver clarity. Even in the heaviest CB traffic. You also get Delta Tuning which makes up for the other guy, because even off-frequency transmitters are pulled in. Perfectly.

Talk to Cobra. And you know you're punching through. One glance at the

29's over-sized illuminated meter tells you just how much power you're punching out and pulling in. For voice modulation the DynaMike delivers at 100%. Same way with power: The 29 transmits at maximum power levels.

Sooner or later you'll get a Cobra. And you'll get engineering and craftsmanship second to none. Performance that will make your first CB seem obsolete. Reliability and durability that have set standards for the industry. Above all, you'll get power. The power to punch through loud and clear like nothing else. Because when it comes to CB radio, nothing punches through loud and clear like a Cobra.



Punches through loud and clear.

Cobra Communications, Products of Dynascan Corp.
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CIRCLE NO. 14 ON FREE INFORMATION CARD

IF YOUR FIRST CB ISN'T A COBRA YOUR SECOND ONE WILL BE.



The small wonder



of the micro-world

Measuring just 11" wide x 11" deep x 5" high, and weighing a mere 7 pounds, the Altair™ 680b is a complete, general-purpose computer.

The secret to this revolutionary, small computer is its CPU board. This double-sided board fits along the bottom of the Altair case and plugs directly into the front panel board. It contains the new 6800 microprocessor, 1,024 bytes of RAM memory, a 256 byte PROM monitor, provisions for 768 bytes of additional PROM or ROM, and a single Interface port with a Motorola ACIA serial interface adapter which can be configured either RS-232 or TTY. A five level Baudot interface option is also available.

The Altair 680b can be programmed from front panel switches, or it can be interfaced to a video display terminal, or teletypewriter. Three additional circuit boards can be plugged inside the Altair 680b for further memory and interface expansion. The first of these boards is a 16K static RAM memory board.

Software already developed includes Altair 680 BASIC with all the features of the 8K BASIC previously developed for the Altair 8800. These include Boolean operators, the ability to read or write a byte from any I/O port or memory location, multiple statements per line, and the ability to interrupt program execution and then continue after the examination of variable values. This software takes only 6.8K bytes of memory space and a copy is included free with the purchase of the Altair 680 16K memory board.

Other software includes a resident two pass assembler. The Altair 680b is also compatible with Motorola 6800 software.

The Altair 680b is ideal for hobbyists who want a powerful computer system at an economic price. Altair 680b owners qualify

for membership in the Altair Users Group, and like other Altair owners, they receive a complimentary subscription to **Computer Notes** and complete factory support.

PRICES:

Altair 680b kit with complete, easy-to-understand assembly manual, operator's manual, and programming manual.....	\$466
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Expander Card 680MB (required to expand 680).....	\$ 24
Altair 680BSM 16K static RAM board kit with 680 BASIC.....	\$685
Altair 680 BASIC when purchased separately.....	\$200
Baudot option.....	\$ 42

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AUGUST 1976 VOLUME 10, NUMBER 2

Popular Electronics®

WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE

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Editorial

PLANTING ELECTRONICS HOBBY SEEDS

A hobby is generally described as a pursuit of an interest outside one's regular occupation. In electronics, however, many hobbyists are on a busman's holiday. For example, a recent study revealed that over 44% of PE readers view electronics as both a career and a hobby, while an additional 13% note that they pursue the hobby because they're either employed in electronics or in an area where electronics knowledge is valuable.

Other interesting PE-reader demographics include: 14.4% have taken post-graduate work, which is included in 65.7% that are attending, have attended or have graduated from college. At the other end of the spectrum, 8.2% are under 18 years old and a total of 16.8% are students. Play these figures against almost 400,000 paid circulation and you'll appreciate the depth and diversity of our readership.

Most hobbyists try to get as much as they can out of their avocations. But electronics hobbyists are among the few that have the chance to give, which can be equally rewarding. For our readers attuned to education, and fortunate to have a hobby that can be shared, there is an excellent opportunity to personally plant the seeds for what might become a lifelong, fulfilling hobby for many people.

For example, a growing number of electronics enthusiasts take the time to teach youngsters about electronics—from how to get a Novice license to wiring a kit. Where can the newcomers be reached? Try churches, synagogues, local Parent-Teacher-Student Associations (PTSA's), Boy Scouts, fraternal organizations, and the neighborhood children for starters. One of our editors, for instance, has a string of neighborhood boys and girls who visit him (and his home computer) regularly. Interestingly, his is the only undamaged property in the area when Halloween ends.

Other electronics hobbyists visit veterans' hospitals to introduce them to electronics so that the patients can fill their otherwise boring days with meaningful efforts. And the hobbyists follow up with other visits to provide continuing guidance.

Some experienced electronics buffs work with local schools to refine science, math and vocational curricula, to develop programs for gifted children, etc. They've discovered that ivory-tower curricula specialists rarely know "where it's at," unfortunately, and too often develop "busy work" for advanced students, the equivalent of a fancy way to shoe a horse or some other useless pursuit.

In contrast, some of our readers have set up microcomputer training programs to introduce youngsters to computer science, binary, hexadecimal and octal arithmetic, all at little cost. Moreover, it has been proved that it's as easy to learn about computers as it is to learn multiplication. It's a lot more fun, too. Others have arranged for student trips to their homes to see how a radio amateur operates his rig, how a home microcomputer can perform astounding feats in print and video, and how to make professional-type tape recordings.

So the next time you're wondering about which sub-par TV program to watch, why not give some thought to the art of giving. You've got the knowledge, the experience, and a stimulating hobby in your corner.

Art Salsberg

SBE OPTI/SCAN.

The scanner that's only a light beam away from 16,000 frequencies.

OPTI/SCAN is, without question, the world's most advanced scanning receiver. It is the only crystal-less scanner that optically scans any station in the nation by the use of programmed cards with permanent memory. Simply program and insert the card, OPTI/SCAN does the rest. You can change cards even while driving without taking your eyes off the road. Built-in AC/DC operation.

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Letters

IN REBUTTAL

In rebuttal to A.D. Acton's comment in the April 1976 Letters Column, I for one appreciate having a source from which to buy parts and kits listed at the ends of parts

lists for POPULAR ELECTRONICS construction articles. I live in an area of the country where obtaining many parts is almost impossible. Without a parts or kit supplier, I would have to forego building many of the PE construction projects that appeal to me.

—Glenn A. Goss, Elon College, N.C.

SWL SPACE INVADERS

I am very disturbed with the "DX Listening" column. As I'm sure you are aware, the 40-meter Amateur Radio band covers the frequency range of 7.0 to 7.3 MHz. Most countries acknowledge these frequencies as belonging to hams and do not broadcast on them. Several communist countries, however, insist on transmitting on several

frequencies in the 40-meter band, causing considerable interference to the hams, who have legal ownership of this band.

I feel that your printing of frequencies of these illegal broadcasts aids and abets the invasion of the 40-meter band. I hope, therefore, that in the future you will delete any listing of international broadcasts on amateur frequencies.—Onis Cogburn, K5VKQ, College Station, TX.

The 7.0-to-7.1-MHz segment of the 40-meter band is allocated to Amateur Radio on a world-wide basis (to 7.3 MHz in Region II). In Regions I (Eurasia & Africa) and III (China, India, Iran, and Australasia), the 7.1-to-7.3-MHz portion is allocated to Broadcasting by the ITU. Many noncommunist countries use the "41-meter" band.

WHERE'S MY CB LICENSE?

After five months, I still haven't received my license. I am frantic because I can't use my CB rig without a license for fear of being caught. As a result, I'm on the verge of selling my rig.

—Roger L. Triplett, Louisburg, WV.

As mentioned in last month's CB Scene, there's a new temporary permit that can put you on the air legally without delay. The form to be filled out was also printed last month. However, the address to which Form 505 is to be sent (Item 2, p 98) is simply: Federal Communications Commission, Gettysburg, PA 17326.

Out of Tune

FREE

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Get all the newest and latest information on the new McIntosh Solid State equipment in the McIntosh catalog. In addition you will receive an FM station directory that covers all of North America.



MX 113

FM/FM STEREO - AM TUNER AND PREAMPLIFIER

**SEND
TODAY!**

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In "Now You Can Build a Scientific Programmable Calculator" (May 1976), there is an error in the program for solving $x - 3 =$ on page 38. Steps 12, 13, and 14 (GO TO, 2, and 0) will cause the machine to subtract 11 from x instead of 1. It will also cause the program to "not count" the number of times it goes through a loop, and the ultimate answer to any x with this program will be 0. The proper instructions should be GO TO, 1, and 8, respectively.

In "Space War Game" (April 1976), type numbers were inadvertently omitted in the Parts List for IC7 through IC10. Integrated circuits IC7 and IC8 are 4023's, IC9 and IC10 4001's.

In "Tips and Techniques," June, 1976, the circuit for Alan Kong's tip is incorrect. To add a tail to a seven-segment "9", the bottom resistor should be connected to the "g" segment output, not the "d" segment output. The other input is correctly shown connected to the "a" segment output, and the collector of the top transistor is properly connected to the "d" segment driver. The circuit for adding a top tail to a seven-segment "6" is correct.

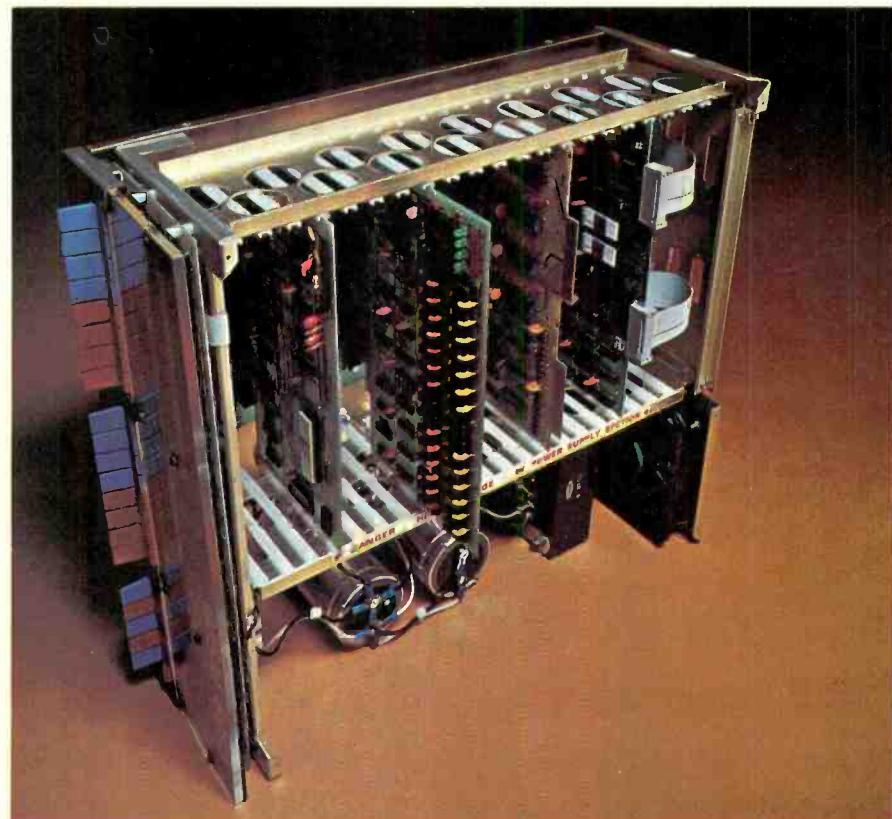
If you thought a rugged, professional yet affordable computer didn't exist,

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. And prices that are competitive with Altair's hobbyist kit. 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 Altair kit only provides 16 slots maximum in four separate sections, each section



requiring 200 solder connections.

The IMSAI 8080 power supply produces a true 28 amp current, enough to power a full system. The Altair produces only 8 amps.

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. 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,

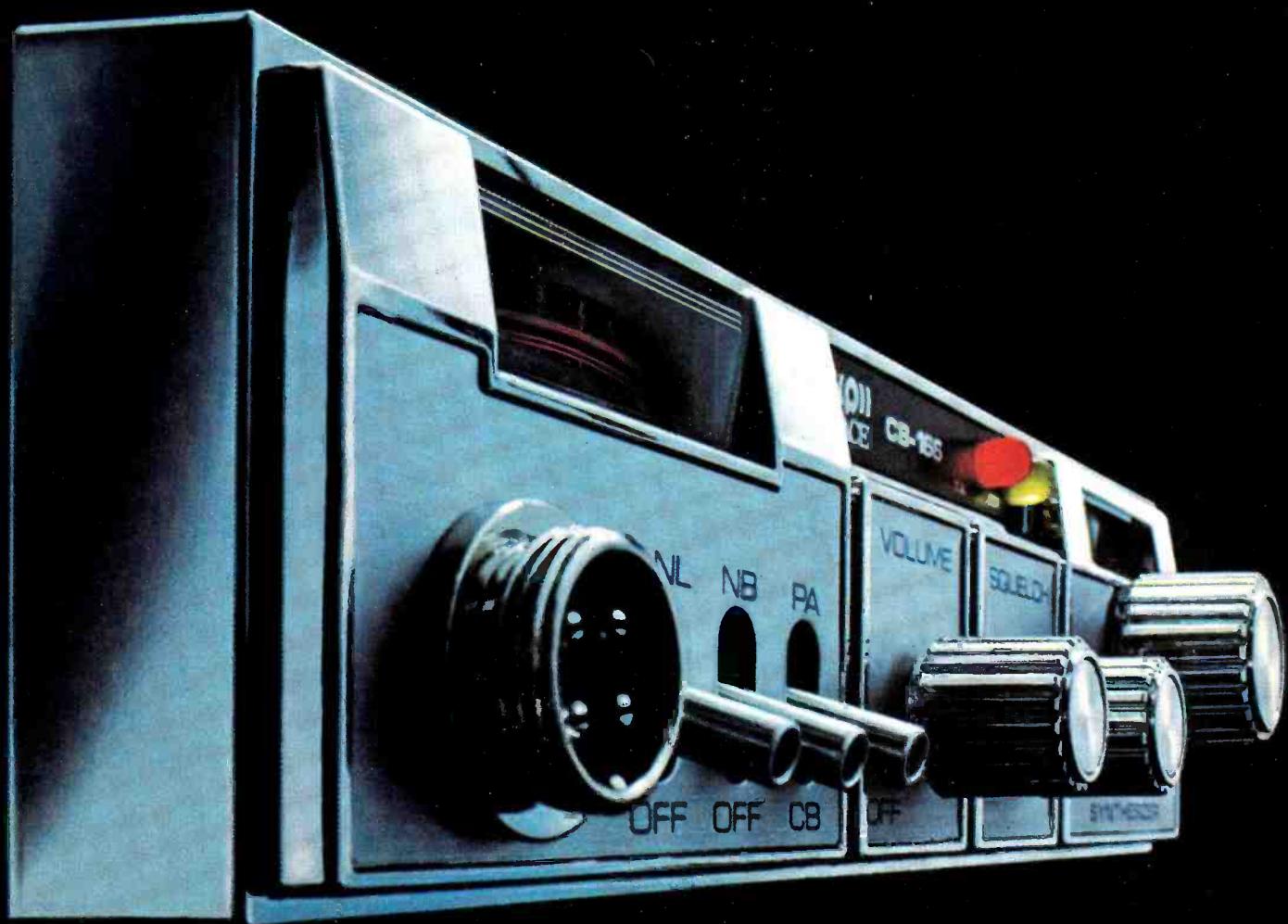
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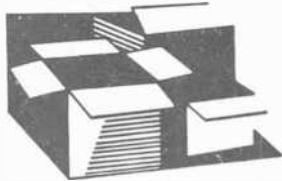
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New Products

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

SWR/FIELD-STRENGTH METER

Siltronics' Model SWR-3DX SWR power and field strength meter permits direct reading of SWR from 1:1 to 3:1 with an accuracy of 5%. The unit has two r-f power scales, reading from 0 to 20 watts and 0 to 200 watts with 10% accuracy. Includes antenna for field-strength measurements. Frequency range is 3.5 to 55 MHz. \$27.95.

CIRCLE NO. 84 ON FREE INFORMATION CARD

THORNTON DUAL-TRACE OSCILLOSCOPE

Thornton's Model 4D-10 portable solid-state oscilloscope features a 10-MHz bandwidth and dual-trace capability. Built in is a trace finder circuit that speeds searching for a lost trace. A single control is used for trigger level and polarity. Sensitivity is independently adjustable for the



two input channels over a range of from 10 mV/cm to 50 V/cm in 12 calibrated ranges. A wide selection of sweep speeds (1 μ s/cm to 100 ms/cm in 16 ranges) is backed up by a $\times 5$ magnifier. Display size is 8 \times 6 cm. Display modes include A-only alternate and chopped. Input impedance is 1 megohm, which can be increased to 10 megohms with an optional probe. \$445.

CIRCLE NO. 85 ON FREE INFORMATION CARD

EMPIRE MANUAL RECORD PLAYER

Empire's new Model 698 manual record playing system features a newly designed tonearm, while retaining the belt-drive and anti-acoustic feedback system used in an earlier unit. The low-mass tonearm has a rear counterweight that is decoupled through a special rubber compound sus-



pension and a new removable cartridge shell. Touch-sensitive controls actuate the cueing system through a damped solenoid that is said to accurately raise and lower the stylus in the same groove every time. A photocell is used to electronically trigger the tonearm to lift at the end of record play. The units' antiskating device applies a diminishing force as the tonarm moves closer to the center of the record.

CIRCLE NO. 86 ON FREE INFORMATION CARD

NEW-TRONICS BASE STATION CB ANTENNA

In line with changes in FCC Rules permitting greater antenna heights, New-Tronics Corp. has announced availability of the Hustler Model 27-TD "Super Swamper" base station CB antenna. The antenna's design is based on the 0.64-wavelength principle used in commercial broadcasting to obtain optimum low-angle signal radiation. In CB, the 0.64-wavelength, 22 (6.7-m) radiating element of the Super Swamper is said to substantially improve performance to extend AM and SSB two-way omnidirectional radio communications over greater distances. Additionally, the antenna has extremely low SWR. \$52.95.

CIRCLE NO. 87 ON FREE INFORMATION CARD

MICRO GENERAL CHESS COMPUTER

Micro General Corp. has announced the introduction of the "Micro-80" chess computer that keeps exact time and move count for the most popular variations of time-controlled chess after being programmed. The computer keeps track of the type of game being played, as well as time and moves. The crystal-controlled timer always displays the time remaining to each player down to the second as well as the number of moves yet to be played. It also automatically adds unused thinking time to each player's "time bank" when applicable. A beeper in the lock provides warnings and end-of-game signals. The clock features STOP, CONTINUE, and RESET functions, a low battery power level indicator, and display blanking for power conservation. \$245.

CIRCLE NO. 88 ON FREE INFORMATION CARD

ADVENT BOOKSHELF SPEAKER SYSTEM

The Advent/3 is a two-way acoustic-suspension speaker system housed in a walnut-grained, vinyl-clad cabinet that measures 16" \times 10" \times 6 1/2" (49.6 \times 25.4 \times 16.5 cm). The 8-ohm system requires a minimum of 10 watts of driving power. Its frequency range is essentially the same as that of the original Advent loudspeaker, with the exception of the lowest half-octave of bass. Price is \$50.

CIRCLE NO. 89 ON FREE INFORMATION CARD

ZODIAC CB SERVICE MONITOR

The Swiss-made Model U-2 is a CB service instrument from Zodiac Communications Corp. It uses a frequency synthesizer for testing by CB equipment manufacturers and field service technicians. The portable instrument is powered by its own 12-volt battery. On the bench, it can be powered by an external 12-volt dc source. The instrument features a r-f signal generator, wattmeter, SWR meter, and field-strength meter. It generates 210 frequencies at 5-kHz intervals within the 26.49-to-30.11-MHz range, including all existing and proposed CB channel frequencies. It can also be used to measure sensitivity at the carrier frequency, passband in kilohertz, and adjacent-channel selectivity. Power output up to 5 watts, modulation up to 100%, and SWR up to 3:1 can also be measured.

CIRCLE NO. 90 ON FREE INFORMATION CARD

NAKAMICHI CASSETTE DECK

Nakamichi's Model 600 cassette "console" features a record-playback head. It's said to provide a frequency response of 40 to 18,000 Hz \pm 3 dB. (The signal-to-noise ratio is rated at better than 68 dB.) "Intermodulation Suppressor" circuitry makes possible a distortion of 0.5% at 0 dB and increases dynamic range to permit recording at levels up to +7 dB at reference 3% distortion. Special peak-reading meters have a



47-dB range. A pulse-controlled dc servo motor is used. Also included are: built-in Dolby noise reduction, 400-Hz calibration tone, MPX filter for FM recording, memory rewind and equalization switches.

CIRCLE NO. 92 ON FREE INFORMATION CARD

PIONEER AM/Stereo FM RECEIVER

Pioneer's Model SX-1250 AM/stereo FM

THE SILENCER

Your ears are burning with amplified noise. Even though your system is delivering sound accurately, it's also doing an efficient job of pumping out noise . . . accurately. Ideally, music should be recreated against a dead silent background. The Phase Linear 1000 accomplishes just that with two unique systems: The Auto Correlator Noise Reduction and the Dynamic Range Recovery Systems.

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Even the finest stereo systems are limited in performance by the quality and nature of the recording. With the Phase Linear 1000, these limitations are overcome. Added to any receiver or preamplifier, it gives you the most significant improvement in sound reproduction for the money . . . more than any other single piece of equipment you could add to your system. Ask your dealer for an audition. The silence is deafening.



Phase Linear 1000

Phase Linear Corporation,
20121 48th Avenue W.
Lynnwood, Washington 98036

CIRCLE NO. 47 ON FREE INFORMATION CARD

receiver is rated at 160 watts/channel (rms) into 8 ohms from 20 to 20,000 Hz at 0.1% or less THD. It has twin stepped tone controls for bass and treble adjustments, step-type volume control calibrated in decibels, two tape monitor circuits, pushbutton function selection with illuminated readout, separate access to preamplifier and power amplifier, five-gang tuning capacitor and dual MOSFET's in the FM front end, phase-locked loop IC for stereo FM decoding, and 25- μ s deemphasis switch for Dolby-encoded FM broadcasts. Among the more important specifications are: 1.5 μ V IHF usable sensitivity in mono (2.9 μ V in stereo); 80 dB mono, 74 dB stereo S/N; 11.5 (mono) and 36 dBf (stereo) for 50-dB quieting sensitivity; typically 0.3% maximum FM distortion; 83 dB alternate-channel selectivity; 35 dB stereo (FM) separation, 30 to 15,000 Hz; 110 dB image and spurious rejection; 120 dB i-f rejection.

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TRIPPLETT HIGH-ACCURACY MULTIMETER

The Model 60-NA from Triplett Corp. is a portable precision VOM that features a large easy-to-read 4½" (11.4-cm) anti-parallax mirrored scale. It has a dc accuracy of ±1.5% full-scale (±3% on ac), plus a multiplier switch that permits more read-

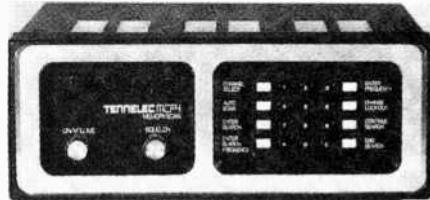


ings to be taken at the upper portion of the scale for greater accuracy. Fifty separate ranges provide measurement capacity of up to 1000 volts ac and dc, 1000 mA dc current, up to $\times 100K$ ohms, and from -20 to +52 dB. Ac current up to 300 amperes can be measured when the VOM is used with the optional Model 10-C adaptor. Three fuses are used in the meter to provide burn-out-proof protection and for user safety. \$130.

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SCANNER USES MICROPROCESSOR

The Tennelec Model MCP-1 is said to be the first scanning receiver to use a computer-like microprocessor that lets the user tune in as many as 16,000 low- and high-vhf and uhf band frequencies. Sixteen different frequencies can be stored in memory through a calculator-like keyboard. The microcomputer system operates without channel crystals. Super-



selective dual filters reduce station overlap for maximum radio reception. The receiver's search mode can be set to go through 256 channels in 5-kHz increments at 10 channels/second. Channels can be quickly entered into memory or changed by pressing the appropriate keys. The scanner has a six-digit, 7-segment LED frequency display.

CIRCLE NO. 95 ON FREE INFORMATION CARD

ESS STEREO POWER AMPLIFIERS

The Model 500A is one of a new Eclipse series of stereo power amplifiers introduced by ESS, Inc. It is rated at 250 watts minimum continuous power per channel, both channels driven into an 8-ohm load with no more than 0.25% THD. Frequency response is said to be 20 to 20,000 Hz ± 0.25 dB. Other specifications include: hum and noise, -102 dB; sensitivity, 0.75 volt; input impedance, 25,000 ohms. It has two 4½" VU meters with three sensitivity ranges, pushbutton twin stereo speaker system selection, and two viscous damped level controls. Measures 19" W × 13" D × 7½" H (48 × 33 × 19 cm) and weighs 49 lb (22 kg). \$826.00. Address: ESS, Inc., 9613 Oates Dr., Sacramento, CA 95827.

CRAIG MOBILE AM CB TRANSCEIVER

Economy is the key feature of the Model 4101 mobile AM CB transceiver from Craig Corp. The transceiver has a crystal-synthesizer network that provides full 23-channel coverage. Built-in are automatic noise limiter (anl), voice compression, and adjustable-squelch circuits. A LED modulation indicator monitors transmissions, while an ON AIR legend lights up when in



the transmit mode. A crystal filter system guards against adjacent-channel interference, and automatic protection is provided for transistor overload. Included are an external-speaker jack and detachable microphone. The reversible mounting bracket allows mobile installation from top or bottom. \$129.95.

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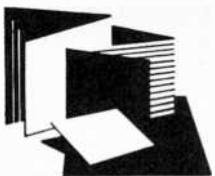
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New Literature

HUSTLER CB & MONITOR ANTENNAS

New-Tronics' 20-page, illustrated catalog of Hustler CB and monitor antennas includes telescopic and dual antenna mod-

els, as well as mounting hardware, gutter clips, coax leads, matchers and phasing harnesses. Monitor antenna systems described include the Monitor Match Model 5M5, which accomplishes the functions of four separate antennas, and the Discone Model DCX, a wide-band antenna with complete coverage from 40 to 700 MHz. Address: Sales Department, New-Tronics Corporation, 15800 Commerce Park Drive, Brookpark, OH 44142.

SILTRONIX CB PAMPHLET

A new, pocket-sized pamphlet from Siltronix lists the popular trucker CB channels used on the major highways of

the continental United States. Listed by state, the booklet designates the most common trucker channels, giving specific exceptions and secondary channels. Also included is a table of commercial radio stations that make announcements warning drivers of weather conditions, detours, and other obstacles along major routes. Address: Siltronix, 269 Airport Rd., Ocean-side, CA 92054.

DISCRETE SEMICONDUCTOR GUIDE

A new 112-page guide from Intersil describes the company's complete line of field effect, dual field effect and dual bipolar transistors. Products are grouped by typical application with complete specifications and a comparison table of key parameters for each device. Applications are illustrated with detailed schematics, and there's a section on chips and wafers. A comprehensive cross reference and a complete listing of parts in alphanumeric order are also included. Address: Intersil, Inc., 10900 North Tantau Ave., Cupertino, CA 95014.

EDMUND CATALOG #762

Edmund Scientific announces its latest catalog #762. The 172-page, illustrated catalog describes over 4500 unusual and hard-to-find items in science, optics, and electronics, including a variety of telescopes, binoculars, microscopes, photographic attachments, tools, games, and puzzles. Solar-Chron, one of the many items featured, is a solar electronic digital wrist watch with nine solar cells that use the sun or incandescent light to obtain reserve power. Another item described is the pocket-sized Executive GSR Meter, a biofeedback monitoring device to help you learn about tension-reduction techniques. Address: Edmund Scientific Co., 380 Edscorp Bldg., Barrington, NJ 08007.

BOMAN ASTROSONIX LITERATURE

Boman Industries offers literature on its line of car sound systems and citizens band products. A 16-page, four-color brochure describes its Astrosonix line of in-dash and under-dash AM, AM/FM and AM/FM/MPX car radios, cassette and 8-track cartridge car stereos, speakers, booster amplifiers and accessories. Also offered is a six-page flier describing Boman's citizens band transceivers, some featuring AM/FM-MPX radio. Address: Boman Industries, 9300 Hall Rd., Downey, CA 90241.

VOLTAGE-SUPPRESSION MANUAL

A new 108-page "Transient Voltage Suppression Manual" from General Electric has 80 pages of text on transient cause, detection and protection. Also included are a selection guide and product specification sheets for selecting GE-MOV varistors. Available for \$2.50 (plus local tax) from GE Semiconductor, Electronics Park, Bldg. 7-49, Syracuse, NY 13201.

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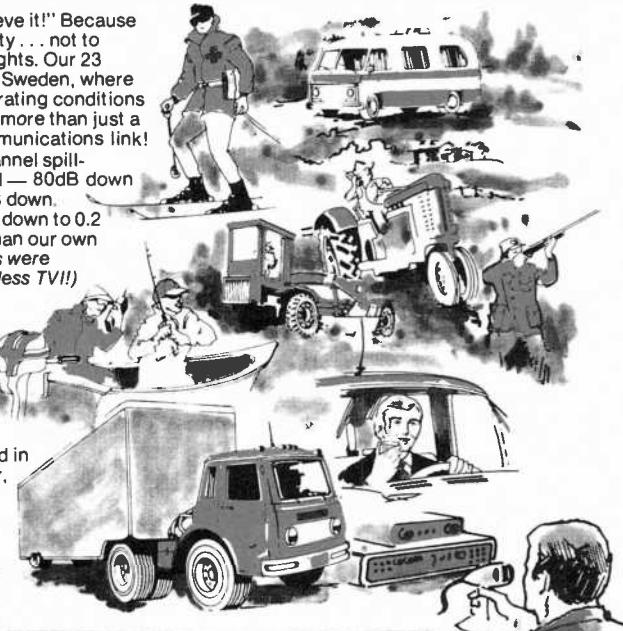
SWEDEN'S SOLID CB IS HERE

"You've got to hear it to believe it!" Because Handic is committed to quality...not to gimmicks, frills or flashing lights. Our 23 channel rigs are designed in Sweden, where the climate is tough and operating conditions tougher...and where CB is more than just a convenience, it's a vital communications link!

With Handic, adjacent channel spillover problems are minimized—80dB down @ 10KHz, not the usual 45dB down.

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And Handic is required to maintain ± .003% crystal frequency tolerance in Sweden—exceeding our own FCC specs significantly. From "mic" to antenna, this is the kind of sophisticated circuitry found in every Handic rig. Remember, Handic CB's have their own special orange color...symbolic of CB excellence.



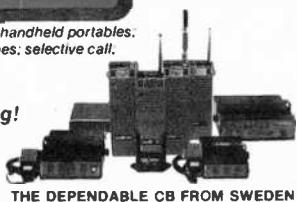
Handic CB radios include: mobile/base transceivers; handheld portables; scanners with FM radio option; antennas; microphones; selective call; and a full line of accessories.



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THE DEPENDABLE CB FROM SWEDEN

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Pocket CB

New integrated circuit technology and a major electronic breakthrough brings you the world's smallest citizens band transceiver.

SMALL ENOUGH FOR YOUR POCKET

Scientists have produced a personal communications system so small that it can easily fit in your pocket. It's called the PocketCom and it replaces larger units that cost considerably more.

MANY PERSONAL USES

An executive can now talk anywhere with anybody in his office, his factory or job site. The housewife can find her children at a busy shopping center. The motorist can signal for help in an emergency. The salesman, the construction foreman, the traveler, the sportsman, the hobbyist—everybody can use the PocketCom—as a pager, an intercom, a telephone or even a security device.

LONG RANGE COMMUNICATIONS

The PocketCom's range is limited only by its 100 milliwatt power and the number of metal objects between units or from a few blocks in the city to several miles on a lake. Its receiver is so sensitive, that signals several miles away can be picked up from stronger citizens band base or mobile stations.

VERY SIMPLE OPERATION

To use the PocketCom simply turn it on, extend the antenna, press a button to transmit, and release it to listen. And no FCC license is required to operate it. The PocketCom has two Channels—channel 14 and an optional second channel. To use the second channel, plug in one of the 22 other citizens band crystals and slide the channel selector to the second position. Crystals for the second channel cost \$7.95 and can only be ordered after receipt of your unit.



The PocketCom components are equivalent to 112 transistors whereas most comparable units contain only twelve.

A MAJOR BREAKTHROUGH

The PocketCom's small size results from a breakthrough in the solid state device that made the pocket calculator a reality. Mega scientists took 112 transistors, integrated them on a micro silicon wafer and produced the world's first transceiver linear integrated circuit. This major breakthrough not only reduced the size of radio components but improved their dependability and performance. A large and expensive walkie talkie costing several hundred dollars might have only 12 transistors compared to 112 in the Mega PocketCom.

BEEP-TONE PAGING SYSTEM

You can page another PocketCom user, within close range, by simply pressing the PocketCom's call button which produces a beep tone on the other unit if it has been left in the standby mode. In the standby mode the unit is silent and can be kept on for weeks without draining the batteries.

AUGUST 1976

SUPERIOR FEATURES

Just check the advanced PocketCom features now possible through this new circuit breakthrough: 1) Incoming signals are amplified several million times compared to only 100,000 times on comparable conventional systems. 2) Even with a 60 decibel difference in signal strength, the unit's automatic gain control will bring up each incoming signal to a maximum uniform level. 3) A high squelch sensitivity (0.7 microvolts) permits noiseless operation without squelching weak signals. 4) Harmonic distortion is so low that it far exceeds EIA (Electronic Industries Association) standards whereas most comparable systems don't even meet EIA specification. 5) The receiver has better than one microvolt sensitivity.



EXTRA LONG BATTERY LIFE

The PocketCom has a light-emitting diode low-battery indicator that tells you when your 'N' cell batteries require replacement. The integrated circuit requires such low power that the two batteries, with average use, will last weeks without running down.



The PocketCom can be used as a pager, an intercom, a telephone or even a security device.

MULTIPLEX INTERCOM

Many businesses can use the PocketCom as a multiplex intercom. Each employee carries a unit tuned to a different channel. A stronger citizens band base station with 23 channels is used to page each PocketCom. The results: an inexpensive and flexible multiplex intercom system for large construction sites, factories, offices, or farms.

NATIONAL SERVICE

The PocketCom is manufactured exclusively for JS&A by Mega Corporation. JS&A is America's largest supplier of space-age products and Mega Corporation is a leading manufacturer of innovative personal communication systems—further assurance that your modest investment is well protected. The



The PocketCom measures approximately $\frac{3}{4}'' \times 1\frac{1}{2}'' \times 5\frac{1}{2}''$ and easily fits into your shirt pocket. The unit can be used as a personal communications link for business or pleasure.

PocketCom should give you years of trouble-free service, however, should service ever be required, simply slip your 5 ounce PocketCom into its handy mailer and send it to Mega's prompt national service-by-mail center. It is just that easy.

GIVE IT A REAL WORKOUT

Remember the first time you saw a pocket calculator? It probably seemed unbelievable. The PocketCom may also seem unbelievable so we give you the opportunity to personally examine one without obligation. Order only two units on a trial basis. Then really test them. Test the range, the sensitivity, the convenience. Test them under your everyday conditions and compare the PocketCom with larger units that sell for several hundred dollars.

After you are absolutely convinced that the PocketCom is indeed that advanced product breakthrough, order your additional units, crystals or accessories on a priority basis as one of our established customers. If, however, the PocketCom does not suit your particular requirements perfectly, then return your units within ten days after receipt for a prompt and courteous refund. You cannot lose. Here is your opportunity to test an advanced space-age product at absolutely no risk.

A COMPLETE PACKAGE

Each PocketCom comes complete with mercury batteries, high performance Channel 14 crystals for one channel, complete instructions, and a 90 day parts and labor warranty. To order by mail, simply mail your check for \$39.95 per unit (or \$79.90 for two) plus \$2.50 per order for postage, insurance and handling to the address shown below. (Illinois residents add 5% sales tax). But don't delay.

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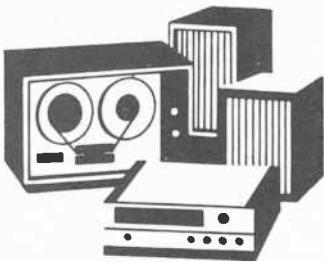
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Stereo Scene

By Ralph Hodges

THE GREAT TUBE/TRANSISTOR CONTROVERSY

THE STORY, as it was told to me by a close and reliable source, goes like this. A few years ago a highly esteemed manufacturer of solid-state high-fidelity equipment was contacted by a talented group of audio amateurs who challenged him to equal the performance of their equipment — to their satisfaction — using any solid-state techniques he cared to apply. Their equipment used vacuum tubes exclusively in its signal-handling circuits and had been designed by ear as much as by instrument to satisfy the requirements of the supremely critical listener.

The manufacturer accepted the challenge and presented himself at the appointed time, with a spectrum analyzer, among other test gear, a supply of resistors and capacitors, and his stock, consumer-available electronics. He was given about a weekend to complete the test.

First, he analyzed the frequency response of the tube amplifier in one-third octave bands and matched the response of his own gear to that reference. Then he altered the noise spectrum of his amplifier to conform to that of the tube amplifier, adding hiss to his own designs as required. Finally, he injected just a touch of hum into his

electronics — a subaudible amount at normal listening levels, but enough to provide the subliminal sense of low-frequency potency that the tube equipment's hum level suggested. Reportedly, his manipulations were so successful that not one of his challengers could consistently distinguish his solid-state amplifier from their own specially designed tube equipment, nor could they say definitely which sounded better in the long run.

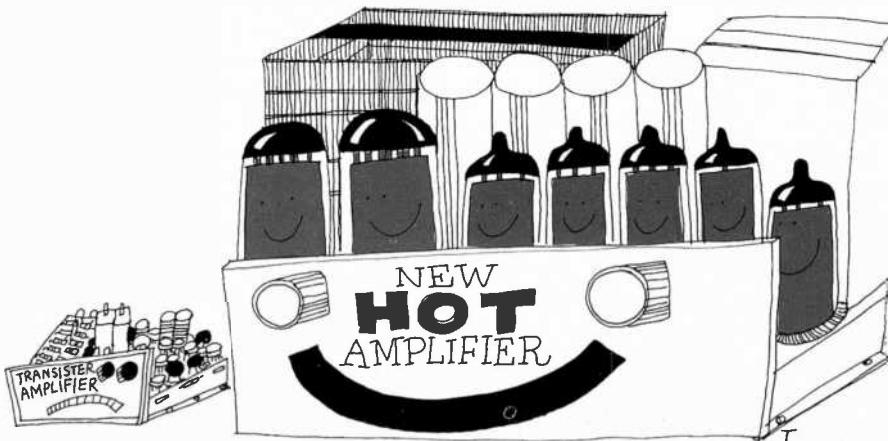
A Mountain Or a Molehill? If nothing else, this anecdote demonstrates just how serious the tubes versus transistors controversy has become in the audio industry. Manufacturers of highly advanced transistorized gear are beginning to pay some attention to the experienced audiophile's views on the virtues of vacuum-tube equipment, perhaps because these preferences are steadily becoming more widespread. Vacuum-tube amplifiers and pre-amplifiers are briskly being sold by Audio Research, Lux (which has even developed new output and driver tubes for its designs), and Dynaco (which has had so much success with its Mark III power amplifier that it is now introducing a new tube amplifier,

the 120-watt Mark VI). These three just account for the bulk of the market, but numerous smaller manufacturers are also making their contribution.

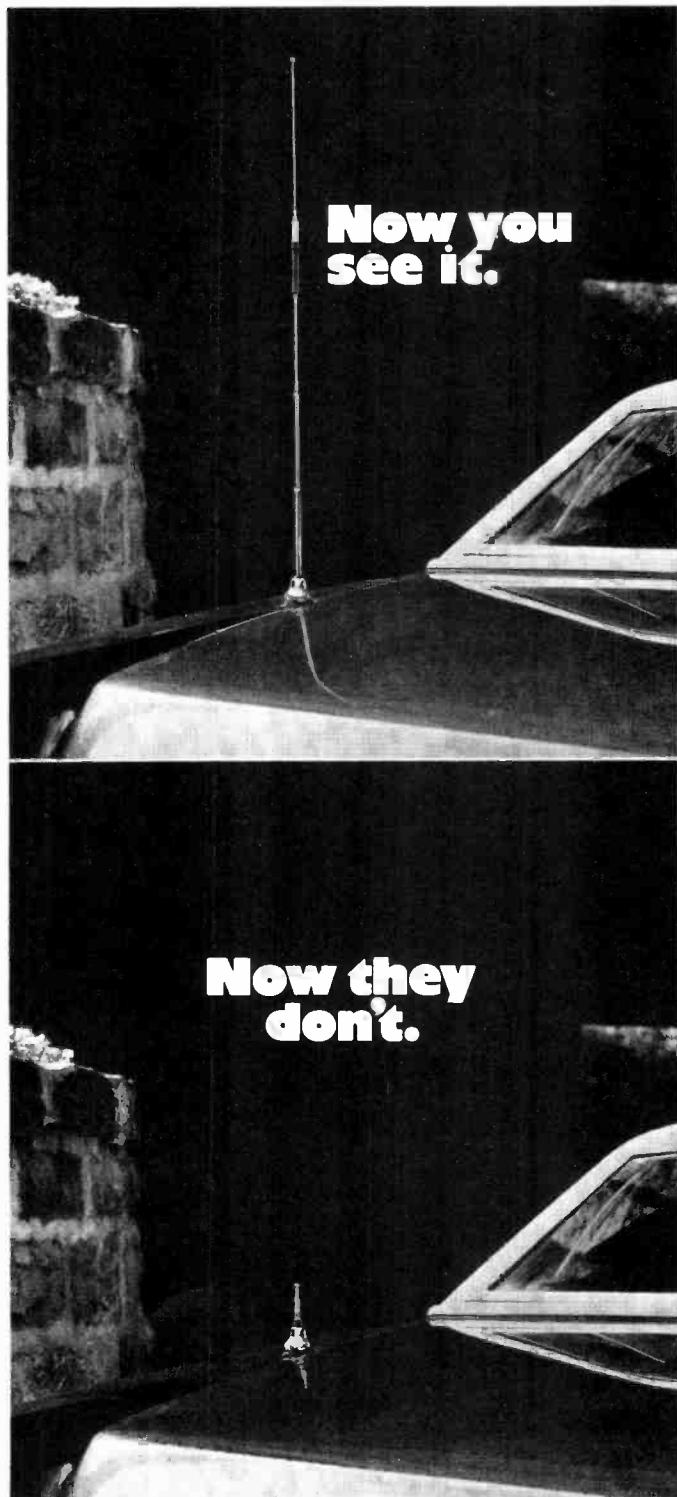
In the midst of all this activity, the manufacturers most involved are not overwhelmingly convinced that the tube itself is more desirable than the transistor. Dynaco's chief engineer, Wade Burns, says that the introduction of the Mark VI, "... does not contradict our feeling that in state-of-the-art audio equipment, tubes offer no distinct technical advantage over the use of modern semiconductors." And Wendell Diller, sales manager and spokesman for Audio Research, a company that deals exclusively in tube equipment, is surprisingly moderate in his views: "Tubes *per se* do not make an amplifier superior. A tube can be operated in a nonlinear fashion just as a transistor can be operated in a relatively linear fashion. We are not trying to start a tube fad. However, under the best conditions the tube is more linear than the bipolar transistor." If the major manufacturers of tube amplifiers are willing to concede that transistor designs can be decent or even equivalent reproducers, why is there such a polarization among amplifier users?

Defining the Difference. Analyzing the difference between tube and transistor amplifiers is not as easy as it first appears. Far from being nonlinear, a good solid-state amplifier is so linear that it can often embarrass the sine-wave signal generator used to test it. Modern tube designs can do just as well. The difference between the best of both types of amplifiers cannot amount to much more than 0.1% distortion of any sort (using standard measuring techniques). At any listening level you could stand, 0.1% distortion is lower in level than the sound of your heartbeat. You'd never hear it.

Denied any definitive help from their test gear, amplifier designers have lately fallen back on theoretical approaches and listening tests to cope with the responses from tube-oriented consumers. Bob Bird, chief engineer at ESS, neatly summarizes the listening-test criteria as centering on (1) sonic clarity, (2) bass definition, and (3) clipping characteristics. Bass definition is an area in which almost everyone, including tube proponents, feels that much vacuum-tube equipment falls short. Lawrence Niles of



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And our Disappearing CB Electric Antenna gives you this big, exclusive advantage: it's made by Tenna. We're the world leader in electric car antennas. Because we've built over 5 million disappearing electric car radio antennas for GM, Ford, Chrysler and Rolls Royce.

So buy the TennaPower Disappearing CB Electric Antenna at a dealer near you who sells CB or car stereo. You can ask him about installation or you may want to do it yourself.

Then beat the Citizens Bandits with the CB antenna thieves can't see. We think you can see why.

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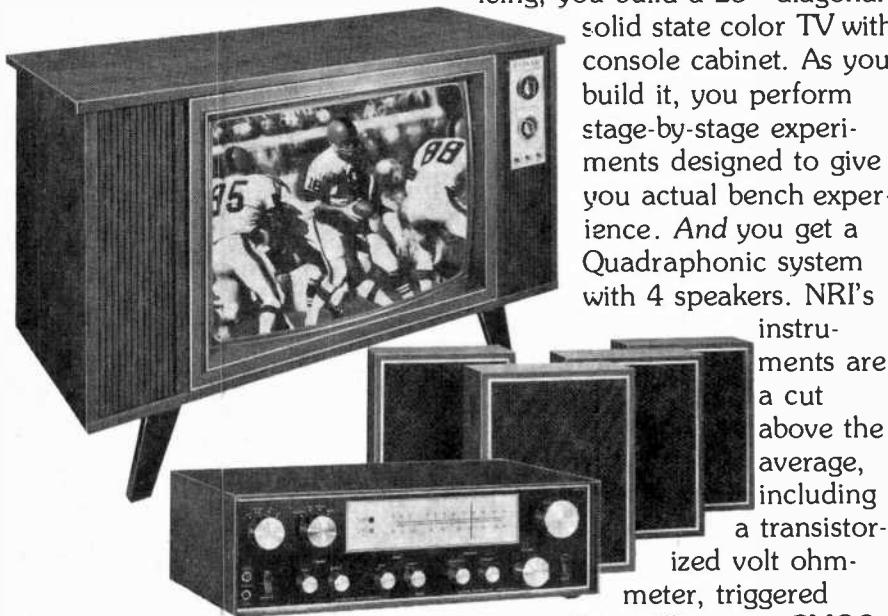
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Epicure has advanced some possible explanations. The output section of any amplifier is essentially an "impedance-translating stage between the last voltage-gain stage and the speaker output terminals." Practically every vacuum-tube amplifier ever designed has used an output transformer to do this impedance translation, and, "... a transformer ... exhibits considerable phase shift at both low and high frequencies. The low-frequency phase shift is a likely explanation for the loss of low-frequency definition characteristic of some tube designs."

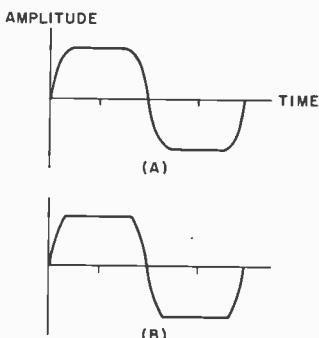


Fig. 1. Clipped waveforms in tube (A) and transistor (B) equipment.

A corollary to this is that the amplifier's output impedance tends to rise at low frequencies, which, in turn, reduces the damping factor at a point where it should be high, particularly with a vented-box (speaker system) design operating below resonance. This and problems like transformer hysteresis and core saturation, are the sources of a tube amplifier's major performance limitations in terms of bandwidth, distortion, and power handling." (Note, however, that a class-A vacuum tube amplifier can function *without* an output transformer. A suitably designed, high-power, wideband cathode follower could drive the speaker directly. This would avoid transformer-related problems. But, to my knowledge, no commercial amplifier has such an output circuit.)

"Sonic clarity" is a subjective concept that no one knows how to handle without performing listening tests. But clipping characteristics, although not so easy to generalize on as you might expect, are readily measurable, and some investigators of the tube-versus-transistor controversy have been having a field day with them.

How Does It Clip? As is well known an amplifier clips on signal peaks when the output signal voltage

reaches the upper and/or lower limits of the power supply voltage. However, just before this occurs, the active output devices (tubes or transistors) are being operated in the nonlinear regions of their input/output characteristic curves. It is in such nonlinear operations that the difference between tubes and transistors becomes apparent. As illustrated in Fig. 1, the rounded corners of tube clipping are quite different from the squared-off plateaus of a transistorized amplifier. This means that a heavy dose of spurious high-order harmonics is generated by a transistor amplifier when it clips, the almost universal consensus being that these harmonics just don't sound good.

In May 1973, Russell Hamm published a paper in the *Journal of the Audio Engineering Society* that is probably the most complete guide to the observable consequences of clipping available. Hamm, a recording engineer, investigated the differences between tube and solid-state recording equipment as heard by technicians and musicians. He got such re-

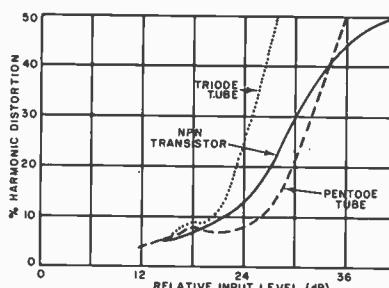


Fig. 2. Single-stage amplifier comparison of total harmonic distortion (THD).

sponses as, "With tubes there is a space between the instruments, even when they play loud . . . Transistors make a lot of buzzing" and "Transistors give a 'shattered glass' sound that restricts the dynamics." He stated further that whenever he or his associates heard "an unusually loud and clear popular-music studio recording," they investigated and found in almost every case that the recording console involved used vacuum tubes in its critical circuits.

Hamm delved pretty deeply into the physics and psychoacoustics of the situation and discovered, among other things, that the vacuum tube's clipping characteristics are not so "gentle" in terms of total harmonic distortion as is generally believed (Fig.

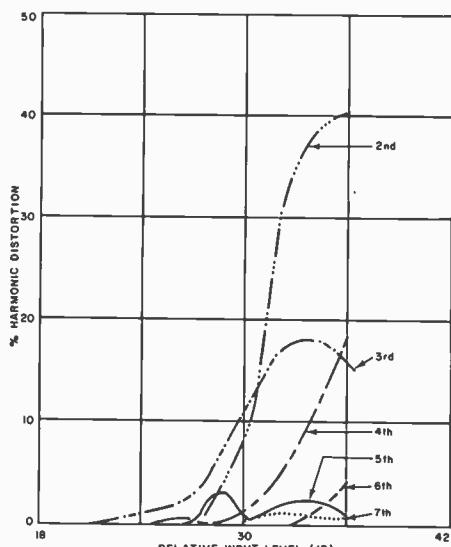


Fig. 3. Distortion components for two-stage triode amplifier (top) and for a multistage capacitor-coupled transistor amplifier (bottom).

2). But at the same time, he found reason to attribute the preference for tube sound to the spectral distribution of distortion products (Fig. 3). In a fascinating discussion based on the techniques for musical instrument design, Hamm suggested that the triode's generation of second-order harmonic distortion during overload made the sound fuller, which would account for the more satisfying dynamic range that listeners heard when tube electronics was used. He also identified harmonics above the seventh as the cause for the sharply defined "edge" we hear on tones from instruments like violins and trumpets. This "edge" is purportedly a loudness cue to the human ear. When we hear it unsupported by a strong second harmonic (presumably the result of transistor clipping), the sound is overly loud, annoying, and "glassy." When

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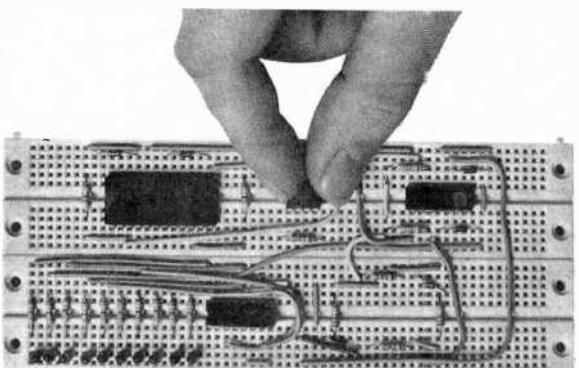
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the distortion products include a prominent second harmonic (as in the output of a clipping triode amplifier), the sound is naturally loud, rich, and full-bodied.

Hamm's descriptions of transistor behavior read like a tube enthusiast's critique of transistor amplifiers. But who, besides recording studios, operates his equipment in a state of almost constant overload? Also, most audio enthusiasts don't object to amplifier overload when they recognize it as such. They do object to poor sound on relatively quiet musical passages when the amplifier can't be close to exceeding its specified power output. And, apparently, they are hearing effects from transistor amplifiers that sound remarkably like Hamm's clipping symptoms—but without any obvious possibility of clipping in the amplifier.

TIM Again. Although the concept of transient intermodulation distortion (TIM) is being taken very seriously in Europe and elsewhere, it gets almost no attention here in the U.S. Perhaps that's because it's not widely understood that TIM (like any type of distortion) can arise from numerous causes, and therefore it's tricky to isolate. Also, the mechanism of TIM is so obvious that you'd not expect an amplifier designer to overlook it. Also, it's possible that TIM has been misnamed; maybe it should be called "feedback inertia," because it invariably arises when there are high-speed events within the amplifier that are too short in duration for the feedback to affect properly.

Most transistor amplifiers use large amounts of negative feedback. They use it for various reasons, such as to extend frequency bandwidth and maintain stability and to convert 0.5% distortion figure to 0.005%, which looks very good in the test labs. But the test labs employ a steady-state sinusoid signal to evaluate amplifiers, and they allow the amplifiers to cope with the signal for a finite period of time before measurements are made. It's just possible that the amplifier under test could go crazy at the first moment the test signal is applied to it, and then settle down to a comfortable accommodation a few milliseconds later. But music almost never stands still, and TIM devotees claim that an amplifier that can't keep up with the music signal is not suitable for audio

reproduction of the highest quality.

If the amplifier under test goes crazy in these critical first few milliseconds, it has TIM. What does this mean? First of all, it means that a small fraction of the input signal gets through without being "corrected" by negative feedback. Maybe that will result in 0.5% distortion rather than 0.05%, for that instant. This is trivial. What is not trivial is that the feedback-receiving stage of the amplifier is designed to work with a lot of negative feedback, and for a moment it's not getting it! Overload is a likely result — not overload of the output stage, which might coast effortlessly through the whole process, but overload of a preliminary driver stage. If you consider the possibilities of such a situation — poor overload recovery in the stage affected or in other parts of the amplifier, current limiting in subsequent stages, etc. — you'll begin to realize why some people describe all amplifiers as having special characteristics of their own. They may not always do so for the right reasons, but they do have justifiable cause. The audible symptoms seem to point to overload,

just as Russell Hamm describes it. The measurable symptoms point to driver or pre-driver stages as being responsible.

Why are tube designs comparatively free of this effect? I suggest it's because tube amplifiers don't employ a lot of negative feedback. And if you use a minimal amount of feedback, you'll get a minimum of TIM.

The Overall Outlook. Lots of people have theories why tubes sound different from transistors. Many others have theories why they don't. I believe that amplifiers, tube or transistor, can sound different from one another, for reasons essentially unrelated to the inherent characteristics of the active devices they employ. In support of my argument, I'll quote Tom Jelsing of Bang & Olufsen:

"When complete knowledge of the waveform at all stages in an amplifier is essential, it is not adequate to analyze the total transfer function from input to output in an amplifier with feedback. The transfer function must be analyzed at all points in the circuit, or at least at all possibly critical

points. Some of these (analyses) are more straightforward than others, but the analysis must be made if the designer is to be certain that the signal amplitudes do not exceed the dynamic range available at every point."

I'll also quote Tomlinson Holman of Advent:

"In 1976, tube technology must be considered to be very mature; transistor technology should be considered to be approaching adolescence. A comparison of the average tube unit with the average transistor unit would certainly demonstrate a lopsided balance in favor of the tube unit, simply because only a few high-quality tube units remain on the market at this time."

"I see no *inherent* advantage with any of the possible technologies: bipolar transistors, field-effect transistors, tubes, or integrated circuits. Tubes have frailties and can definitely age. Transistors can be nonlinear if tube-based designs are translated to solid state. Yet very fine transistor designs have evolved by treating transistors as what they are." Amen! ◊

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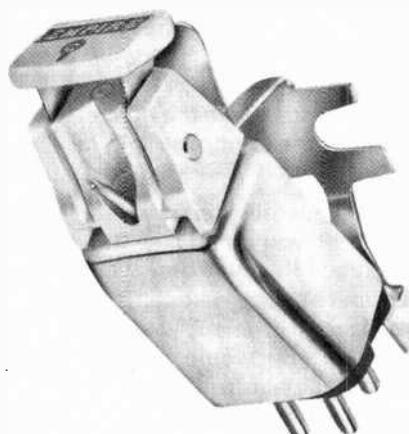
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EMPIRE

Hobby Scene

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.

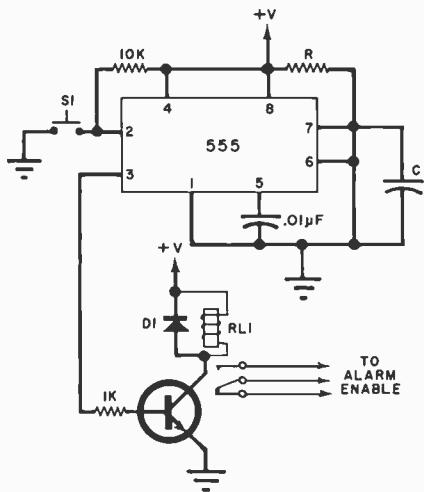
By John McVeigh

ALARM EXIT DELAY

Q. I want to add an exit delay (about 30 seconds) to my 6-volt alarm system. Any ideas?

—Scott Goldman, Great Neck, NY

A. We've received a number of similar requests, some of which sought a circuit to turn off an alarm siren, say, five minutes after it was enabled. The circuit shown can perform either function. As an exit delay, push S1 to activate. Then T seconds later ($T = 1.1RC$),



relay K1 will be deenergized. Use the relay contacts to activate the alarm sensor circuit (however this is done in your alarm system). To turn off a siren, K1's contacts can simply interrupt the siren power supply. To activate this circuit, pin 2 of the 555 must be momentarily brought to ground — through an inverted one-shot, or similar means. Use a momentary pushbutton for S1, a general-purpose diode for D1, and a low-voltage (6-18 V, depending on supply) dc relay for K1. Be sure to select a switching transistor (Q1) which can handle the relay coil's current.

REFRIGERATORS AND TURNTABLES

Q. Whenever my refrigerator turns on, I hear a loud pop through my speakers. But this only happens when I'm using my turntable. The problem isn't due to noise on the ac line, because it still happens with the turntable power cord unplugged.

—Tom Russell, Providence, RI

A. The noise could be due to one of two things. First, a physical vibration could cause a transient movement of the stylus. (You didn't mention whether or not you removed the tone arm from the disc when you removed the cord). Shock-mounting the turntable with foam rubber should take care of that. The more probable cause is the strong magnetic field generated by the compressor motor at the instant it turns on. It could induce a transient signal on the cable to the preamp, and thus be amplified and fed to the speakers. Alternatively, the field could induce a signal on a lead in the phono preamp itself. Such problems have no easy cure. But you'd best start by slipping the phono signal leads into a length of tubular copper braid, which should be grounded to the amplifier chassis. In turn, the chassis should be connected to a good earth ground. If the problem persists, you might have to shield the entire phono preamp circuit with fine screening bolted to the chassis. Finally, rotating the amplifier so that the lead picking up the signal is parallel to the field's line of force will weaken any residual induced signal.

24V to 12V

Q. I have a 24-volt, 1 ampere dc power supply. I would like to step down the output to 12V dc so I can power my auto tape player and CB mobile transceiver in the house. What do I need to accomplish this task?

—P.C., New Jersey

A. Three simple options come to mind. First, you could insert a 12-volt zener diode in series between the 24-volt output and the +12-volt lead of the tape player. However, at one ampere maximum, you would need a zener with a dissipation of 12 watts. That could be done by paralleling two matched 12-volt, ten-watt zeners. But high power zeners can be expensive. Alternatively, a 12-volt, low power zener, limiting resistor, and pass transistor could be used. A cheaper solution would be to use a 12-volt IC regulator. The Radio Shack No. 276-1771 is a suitable regulator in a TO-3

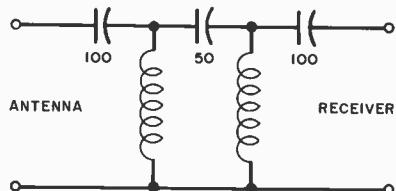
can. The INPUT pin should be connected to +24 volts (it is rated at +30 V max.), the OUTPUT pin to the +12-V lead of the player, and the case to an adequate heat sink and both chassis grounds. The regulator costs only \$1.59 as listed in the 1976 Radio Shack catalog. However, due to limitations of your power supply, only 1 A max. at 12 volts can be obtained. Many tape players and transceivers draw about 1.5 A. Getting more current output would mean modifying the power supply's transformer and built-in regulator.

HIGH-PASS FILTER

Q. Do you have a simple circuit for a high-pass TV filter for use with 75-ohm coaxial lines?

—Murray Becker, Brooklyn, NY

A. Here's a filter that can be used with coax-fed TV and FM receivers. Capacitors are silver mica types, rated in picofarads. The inductors are three



turns of No. 14 wire, $\frac{3}{4}$ " (19.05-mm) diameter, spaced eight turns to the inch. It will attenuate all signals below 40 MHz, but will pass TV and FM signals. For best results, the filter should be constructed in a shielded enclosure, but shielding will not always be necessary.

MOBILE STEREO AMPLIFIER

Q. I want to build the "Mobile Stereo Amplifier" in the February issue, but I can't find the NE540 or SE540 driver chips. Do you know of any sources?

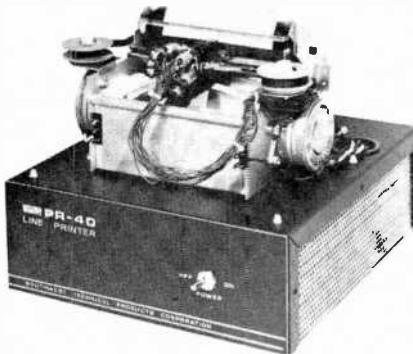
—Michael McMahan, Urbana, Ohio

A. Surprisingly, I've received a large number of similar requests. I really didn't expect that to happen, because the 540 is offered by many surplus dealers in the back of PE. Some of them even sell a 540 and the complementary output transistors as one package. At any rate, referring to the June issue, you will find the following dealers offering the 540 driver IC: Solid State Sales (P. 108); James Electronics (P. 111); Quest Electronics (P. 117); and Digi Key (P. 118). In some recent issues of PE, I've counted as many as ten dealers offering the NE 540 or SE540!

NEED HARDCOPY?

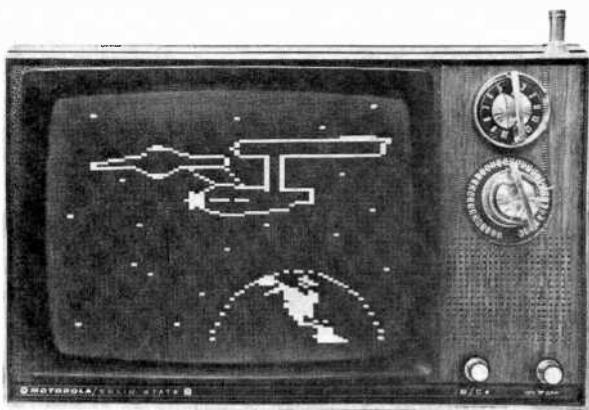
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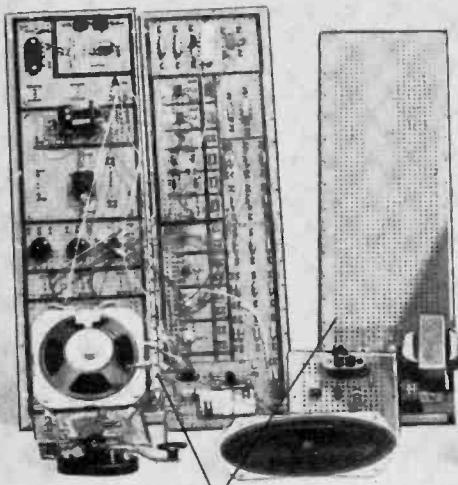
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news HIGHLIGHTS

TV Rivals Phones & Cars

It has taken only 30 years for television to rival both the telephone and motor vehicle in worldwide popularity, according to RCA. Based on latest available statistics, it is estimated that there are 364 million TV receivers worldwide, compared with 360-million phones and 300-million cars and trucks. The U.S. leads in all categories, with approximately 120-million TV receivers, 144-million phones, and 130-million motor vehicles. The U.S.S.R. comes in second with 50-million TV receivers, 15.8-million telephones, and 7-million vehicles, while Japan is third with 25.5-million, 41.9-million and 25-million respectively. The size of the worldwide TV market is impressive, considering that the industry growth began only in 1946, whereas the telephone is 100 years old and the car is almost 80 years old.

RCA Tube Business To GTE

RCA Corp. has sold machinery, parts, raw materials, work in process, and technical data related to the manufacture of Nuvistors and certain other receiving tubes produced at its plant in Harrison, N.J. to GTE Sylvania, Inc. On January 15, 1976, RCA announced its decision to cease manufacturing operations at its Harrison plant by July 30 and that efforts were being made to sell the manufacturing tools and equipment. With all receiving tube manufacturing ending in April, RCA stated its intention to close the Edison, N.J. warehouse and distribution center by the end of June 1976.

LED Watch Circuit Extends Battery Life

Gruen Industries, Inc., has announced a new electronic circuit that increases battery life by 65% in LED digital watches. The circuit was developed through Gruen's efforts to produce thinner, more fashionable solid-state watches for women without sacrificing the battery life. Batteries rated at 6600 cycles operated on an average of 25 cycles per day yield a life of 264 days in conventional LED watches. With Gruen's new circuit, the battery is said to last an average of 11,000 cycles, or 440 days. The new circuit will be used only in the company's Telstar lady's watches, but men's modules are slated for early development.

MDS Threatens Cable TV

Although it has been around for more than half a decade, Multipoint Distribution Service (MDS) has during the past year or so become a widespread concern in the cable TV world. Since mid-1975 when multiple system operators entered into agreements with the largest MDS owner to provide pay-TV service to communities via MDS technology, cable-TV operators have seen it as a growing threat to them. The cable-TV people feel that

MDS will "skim the cream off the urban market" by providing pay services to multi-dwelling housing units at costs far below those of wiring for cable. Others view MDS as a communication "link" with the potential for expanding the scope and flexibility of a cable system by providing a new means of delivering programming to cable headends.

Walkie-Talkies Move From 27 MHz

Acting on Docket 20119, the Federal Communications Commission has shifted the 100-mW walkie-talkie that can be operated without a license from the 27-MHz Citizens Band to 49.82 to 49.90 MHz. Manufacture of the 100-mW (27-MHz) CB transceivers is permitted to continue for a year, and their use will be permitted until 1983.

Calculators For The Blind

The American Foundation for the Blind has introduced two calculators—one braille and the other an audible unit—for blind and visually handicapped persons. The braille calculator was adapted by AFB's engineering division from a standard portable calculator. It is a five-function unit with floating decimal point, mounted in a box and equipped with a single braille cell. The cell, which uses four dots of the basic six-dot braille notation, is activated by depressing the "read" button at the front of the instrument. The digits and decimal point displayed on the visual readout are presented in sequence in the form of small pins which pop up to form a braille digit. The audible version has a 24-word vocabulary which announces every entry and result. It has six basic functions, accumulating memory, automatic constant, change-of-sign key, floating decimal point, and 8-digit display. The speech key can be pressed repeatedly to announce what is on display without initiating further calculations. The speaker is loud enough for small classrooms and there is an earphone for private listening. AFB's catalog, "Ideas for Better Living," describes these units along with several hundred other devices designed for the blind. Write to Aids and Appliances Division, AFB, 15 W. 16th St., New York, NY 10011, for a free copy.

Magnetic Recording Tape to Smithsonian

A piece of the world's first magnetic recording tape has been presented to the Smithsonian Institution by BASF Wyandotte Corporation. The company developed magnetic tape in Germany in 1932 and began commercial production in July 1934 at BASF's plant in Ludwigshafen, Germany. The 1934 tape was made of cellulose acetate, coated with carbonyl iron powder. It could be played on one side only and was further limited by a playing speed of one meter per second. Even so, this was an improvement over the steel wire which had been used until then since the magnetic tape was lighter than steel and could be cut and spliced.

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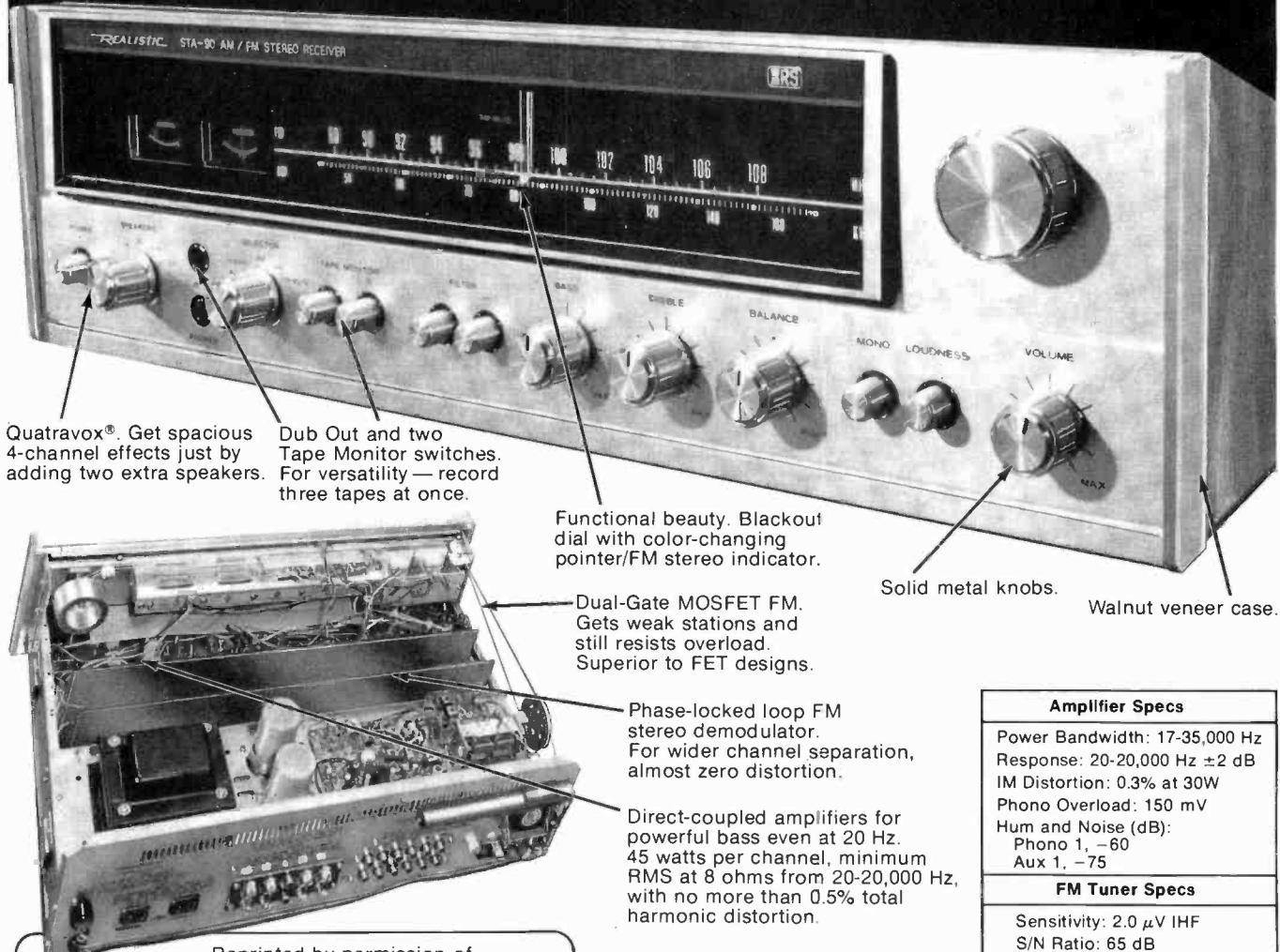
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HERE are basically two ways in which you can get involved with microcomputers on the nonprofessional level. You can buy one of several reasonably priced hobby computer kits, add a TV or typewriter terminal, and learn to use high-level language. On the other hand, you can build your own inexpensive system from scratch. This permits you to experiment with simple applications that do not require an expensive terminal or a large memory. You can communicate with the computer in a relatively simple language.

The "Elf" microcomputer project gives you the latter category of computer system—for about \$80. It is an excellent hardware and software trainer that uses machine language and can be easily expanded to do just about anything a full-blown microcomputer can. Packaging, however, is up to you.

The basic Elf has toggle-switch input, hex LED display, 256 bytes of RAM, four input lines and a latched output line. It can be used to play games, sequence lights, control motors, generate test pulses, count or time events, monitor intruder-alert devices, etc. You can do all these things while learning how to program in order to produce a "real" output to determine whether or not the program you designed works. If you prefer not to control or time things, a simple LED can be used to indicate whether or not your program works.

Our focus here is on the construction of the low-cost computer and some simple examples of programming.

Design Details. The heart of the Elf microcomputer is the new RCA CDP1802 COSMAC microprocessor chip that sells for less than \$30. The chip can use any combination of standard RAM and ROM devices and can address up to 65,536 (65 k) bytes of memory. It has flexible programmed I/O and program-interrupt modes, an on-chip DMA (direct memory access), four I/O flag inputs directly tested by branch instructions, and a 16 × 16 matrix of registers for use as multiple program counters, data pointers, or data registers.

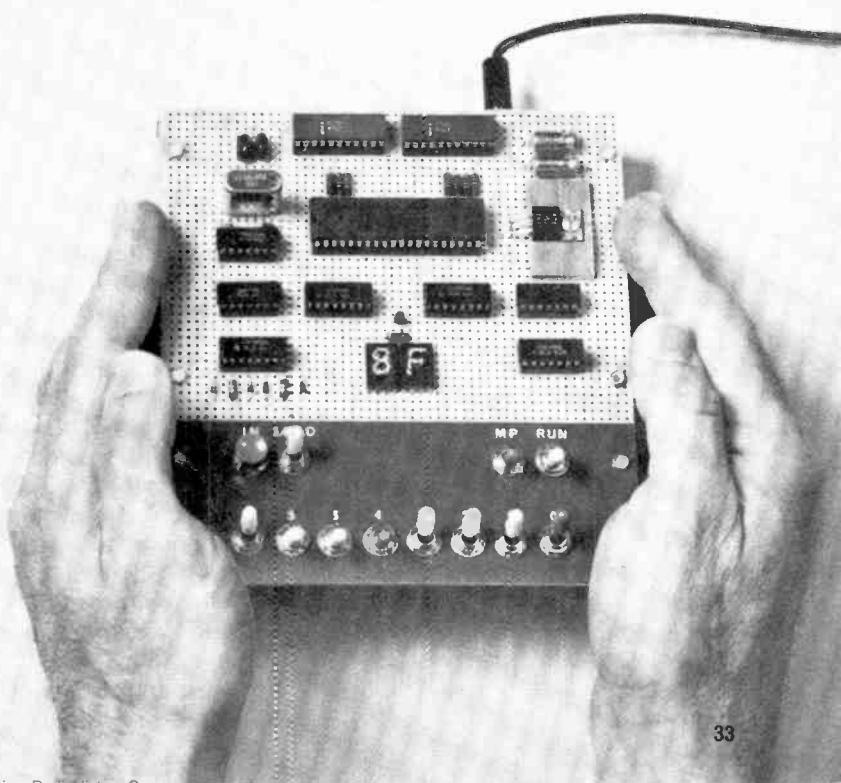
Other features of the 1802 chip include voltage operation between 3 and 12 volts dc at very low current drain, TTL compatibility, built-in clock, and simplified interfacing. There is also a built-in program load-

BUILD THE COSMAC "ELF" A LOW-COST EXPERIMENTER'S MICROCOMPUTER PART 1



*Simple-to-build computer trainer
can be expanded
for advanced applications.*

BY JOSEPH WEISBECKER



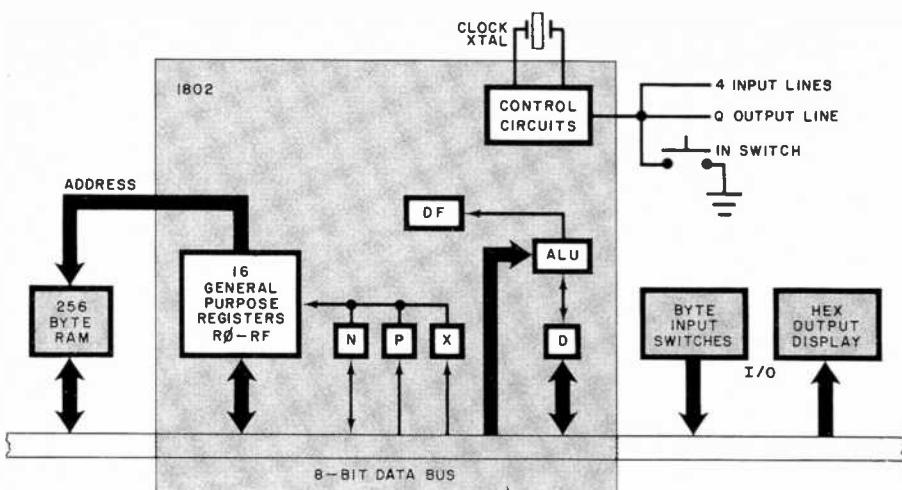


Fig. 1. Block diagram of basic computer. Up to 65K bytes of memory, 91 instructions, and varied I/O ports can be added as the system grows.

ing capability that allows you to load a sequence of bytes without having to toggle in a new address for each byte. No ROM is required for the minimum trainer system described here. The multiple program counters permit some interesting programming "tricks," and the many single byte instructions keep programs short.

A block diagram of the Elf system is shown in Fig. 1. The pinout for the 1802 microprocessor chip is shown in Fig. 2.

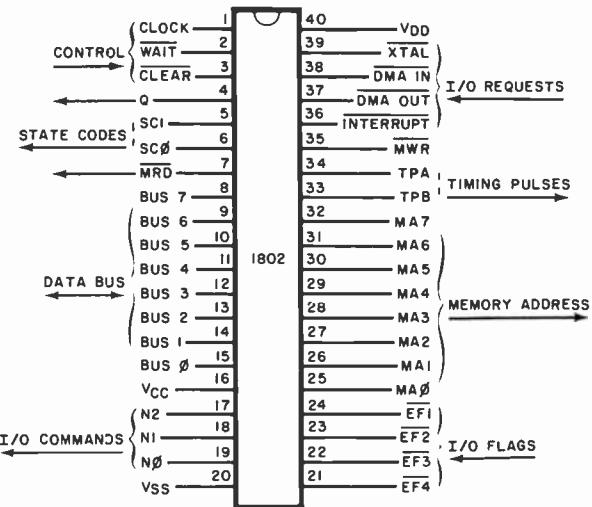
Basic Operation. The key to understanding the computer is the method used for addressing the memory. At first, the procedure may appear to be complicated, but you will soon see that it is not difficult.

The 1802 chip contains 16 general-purpose registers, each holding 16 bits (two bytes) of memory addresses or data. The registers are labelled R0 through RF to conform to the hexadecimal numbering system, as shown in Fig. 3. (In the diagrams, and in computer technology in general, a Danish zero—a zero with a slash through it—is used to distinguish zero from a capital letter O.) Hence, if we refer to the low-order, or least-significant, byte of R1, we can call it R1.0, while the high order byte of RF would be called RF.1.

There is also an 8-bit D register that is used to move bytes around. In the instruction set shown in part in the Instruction Subset Table, note that the 8N (8 with a digit) code will copy a low-order general register byte into register D. Writing this instruction as 81 in a program will cause R1.0 to be copied into D when the instruction is executed. We can then use instruction

BF (BN in the table, with B and a digit) to copy the D byte into RF.1. It takes two bytes, 81 BF, to transfer a byte from R1.0 to RF.1 via temporary holding register D. The byte in D can also be used in arithmetic operations per-

Fig. 2. Pin out for the CDP1802 COSMAC microprocessor.



formed by the ALU (arithmetic logic unit) circuits.

There are three other important registers that are labelled N, P, and X. Each can hold a 4-bit digit that is used to select one of the 16 general-purpose registers. For example, if you wanted to talk about the general-purpose register selected by the hex digit in X, you would call it RX. If you wanted just the low-order byte of RX, call it RX.0. RN would refer to the general-purpose register designated by the 4-bit digit currently contained in N; if the digit is 4, RN = R4.

The general-purpose registers can contain 16-bit memory addresses. Suppose register R3 contains data

0012. M3 would mean the memory location specified by the contents of R3, and M(0012) means memory location 0012 directly. MX means the memory location addressed by the contents of the general register selected by the current digit in X. If X = 3, MX = M3; if R3 = 0012, MX = M3 = M(0012).

Since the basic computer has only 256 bytes of memory, we use just the low-order bytes of the general registers to address the memory. In expanded-memory systems, you can use the high-order bytes of the general-purpose registers to select individual 256-byte pages of random-access memory (RAM).

The memory contains both instructions and data bytes. Instruction bytes tell the computer what to do with the data bytes. One-byte instructions have two hex digits, where high-order bits 7, 6, 5, and 4 tell the computer what type of operation to perform. Low-order bits, 3, 2, 1, and 0 are usually placed in the N register when a new instruction is fetched from memory.

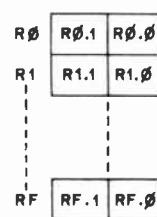


Fig. 3. The 16 registers in the 1802 are labelled RØ through RF (hex).

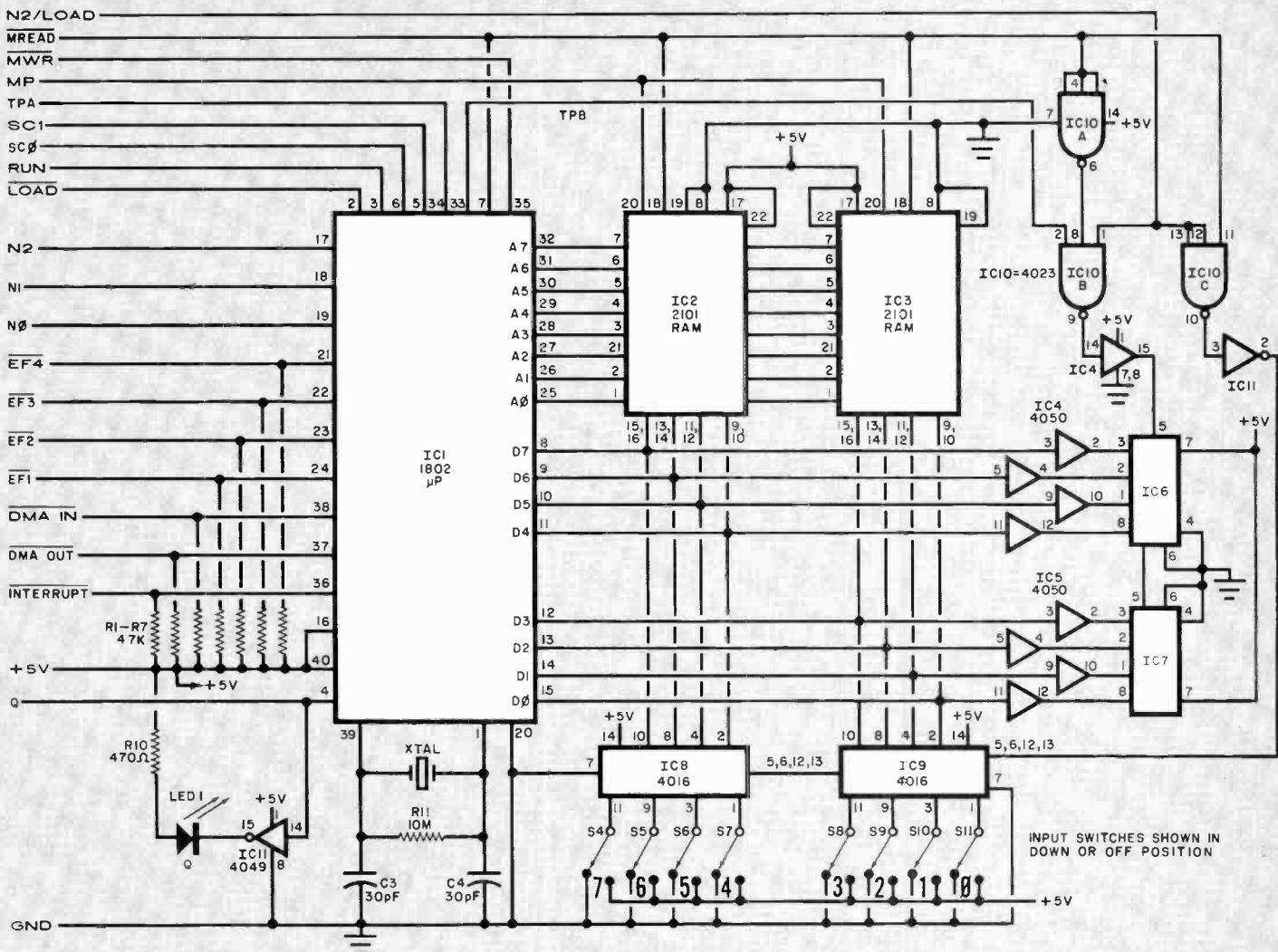


Fig. 4. Complete circuit for the Elf computer. Identified connections on the left go to the "front panel" with the eight data switches. The remaining can be left "floating" at 1802, or tied to terminal strip.

PARTS LIST

C1, C2—10- μ F, 16-volt electrolytic capacitor
 C3, C4—30-pF disc capacitor
 D1 through D6—IN914 switching diode
 IC1—CDP1802 COSMAC microprocessor chip (RCA)
 IC2, IC3—2101 (256 \times 4) static RAM IC
 IC4, IC5—4050 noninverting hex buffer IC
 IC6, IC7—Hex LED display (H-P No. 5082-7340)
 IC8, IC9—4016 quad bilateral switch IC
 IC10—4023 triple 3-input NAND gate IC
 IC11—4049 inverting hex buffer IC

IC12—4013 dual D flip-flop IC
 IC13—LM309K 5-volt regulator IC
 LED1—Red light-emitting diode
 R1 through R9—47,000-ohm, 1/4-watt resistor
 R10—470-ohm, 1/4-watt resistor
 R11—10-megohm, 1/4-watt resistor
 S1 through S11—Spdt toggle switch
 S12—Pushbutton switch with one set each normally open and normally closed contacts
 XTAL—1-to-2-MHz crystal (see text)
 Misc.—5½" \times 4" (14 \times 10.1 cm) perforated board with 0.1" (2.54 cm) hole spacing;

5½" \times 2" (14 \times 5.1cm) piece of thin aluminum; ¾" \times ¾" (19.1 \times 9.5 cm) pine for chassis rails; 14-pin IC sockets (4); 16-pin IC sockets (3); 22-pin IC sockets (2); 40-pin IC socket; connector for power supply; 9-volt, 350-mA dc power source; 1¼" \times ¾" \times ½" (31.8 \times 19.1 \times 3.2 mm) piece of aluminum; dry-transfer lettering kit; machine and wood hardware; hookup wire; solder; etc.
 Note: the CDP1802 COSMAC microprocessor chip is available from any RCA parts distributor as is the COSMAC user manual.

automatically incremented so that it points to the next instruction to be fetched. Branch instructions can be used to change the address in the program counter to permit jumping (branching) to a different part of the program when desired. The digit in the 4-bit P register specifies which 16-bit general-purpose register is being used as the program counter.

Timing Sequence. Since many of

the 1802 microprocessor's instructions are only one-byte long and require two machine cycles, the first cycle is always an instruction fetch, or memory read. The fetched instruction is executed during the next machine cycle, which could be a memory-read, memory-write, or register-transfer type of cycle.

Program execution always consists of a sequence of fetch-execute cycles, and the two SC0 and SC1 lines (see

Fig. 4 and Fig. 5) indicate what type of cycle is being performed according to the following criteria:

SC1 SC0 Type of Machine Cycle

0	0	instruction fetch
0	1	instruction execute
1	0	DMA in/out
1	1	interrupt

Direct memory access (DMA) and interrupt are special types of cycles, which we will discuss later.

Circuit timing is shown in Fig. 6.

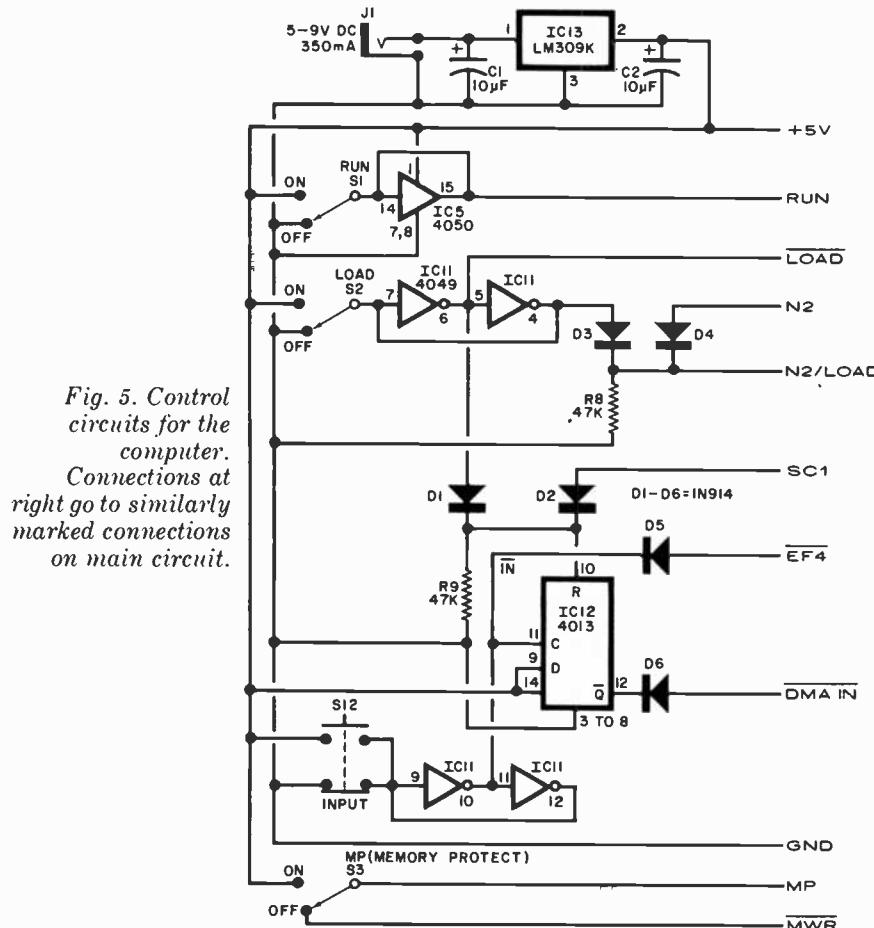


Fig. 5. Control circuits for the computer. Connections at right go to similarly marked connections on main circuit.

Note that each machine cycle requires eight clock pulses.

The microprocessor has an internal single-phase clock circuit. Connecting a crystal between pins 1 and 39 of the 1802 chip causes the clock to run continuously. If desired, XTAL, C3, C4, and R11 can be omitted and an external clock with a 5-volt swing can be substituted between pin 1 and ground.

During each machine cycle, timing pulses TPA and TPB are available at pins 33 and 34 of the 1802. TPA occurs at the beginning of each machine cycle and can be used to clock the high-order byte of a 16-bit memory address into a memory page-selection register. Note that the 1802 sends out memory addresses as two 8-bit bytes. The high-order byte appears on address lines A0 through A7 first. Then the low-order byte is held on the A0 through A7 lines for the remainder of the machine cycle. This low-order address byte can, by itself, specify one of 256 locations in the minimum 256-byte memory.

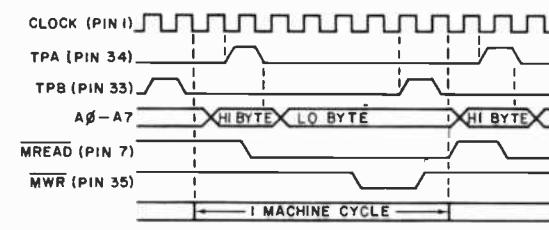
TPB occurs toward the end of the machine cycle and is used to clock a byte from the RAM into an output device (such as the hex display used here). An input byte, to be stored in the

RAM, is gated to the bus for the duration of the input (memory-write) machine cycle so that no time pulse is needed for input bytes.

The MREAD line is low during any memory-read machine cycle. When low, it opens the pin-18 RAM data output gates of IC2 and IC3, permitting the byte stored in the RAM location addressed by A0 through A7 to appear on the data bus. The RAM's access time is such that the output byte appears on the bus prior to TPB. The bus byte from the RAM can then be clocked into an internal register of the 1802 or clocked to an external register (such as the hex display) with TPB, depending on the type of instruction being executed.

When the 1802 is performing an instruction cycle that requires a byte to be stored in the RAM, the MREAD line is held high to disable the RAM output

Fig. 6. Microprocessor timing. One machine cycle requires eight clock pulses. TPA and TPB control various functions, both on and off the computer.



bus gates. The microprocessor then causes the byte stored in the RAM to be gated onto the bus during the memory-write cycle. This byte can come from an internal register of the 1802 or from an input device (such as switches), depending on the type of instruction being executed. The 1802 then generates a low memory-write pulse (MWR) that causes the bus byte to be stored in the RAM location addressed by the A0 through A7 lines.

Circuit Operation. Using Fig. 4, Fig. 5, and the Instruction Subset Table, we can now discuss the logic of the Elf microcomputer. The RAM address is sent out on lines A0 through A7. Eight tri-state bidirectional bus lines are used to transfer the data bytes back and forth between the 1802's registers and the IC2-IC3 RAM. A RAM byte can be transferred to hex displays IC6 and IC7 via the data bus, using /C4 and /C5 to supply the current drive for the displays. Displays IC6 and IC7 contain latches to store the display byte.

The basic clock frequency of the processor is determined by XTAL, which should not go above 2 MHz in this circuit. The MREAD and MWR lines control the read and write cycles of the RAM, while TPA and TPB provide the timing pulses. TPA can be used for memory expansion address latching, TPB to clock bytes into output circuits. SC0 and SC1 indicate the type of cycle being performed by the 1802.

The N0, N1, and N2 lines are used to select input or output devices. In the Elf, selection can be made among four input and four output devices. The table details the values of the N0, N1, and N2 lines during the machine cycle in which an input or output instruction is executed. Instructions 69, 6A, 6B, 61, 62, and 63 are spares that can be used to add I/O devices or ports to the computer. When 6C is executed, the N2 line goes to a logic-1 state and the bus byte is written into the RAM. Since this is a write cycle, MREAD will be high. With both N2 and MREAD high, the output of gate IC10C will be low, putting the input toggle switch byte on

ONE BYTE INSTRUCTIONS		TWO BYTE INSTRUCTIONS	
1N RN+1		30MM GO TO MM	
2N RN-1		31MM GO TO MM IF Q=1	
8N RN.0→D		39MM GO TO MM IF Q=0	
9N RN.1→D		32MM GO TO MM IF D=00	
AN D→RN.0		3AMM GO TO MM IF D=00	
BN D→RN.1		33MM GO TO MM IF DF=1	
4N MN→D, RN+1		38MM GO TO MM IF DF=0	
5N D→MN		34MM GO TO MM IF EF1=1	
DN N→P		3CM GO TO MM IF EF1=0	
EN N→X		35MM GO TO MM IF EF2=1	
7A 0→Q (LIGHT OFF)		3DMM GO TO MM IF EF2=0	
7B 1→Q (LIGHT ON)		36MM GO TO MM IF EF3=1	
FO MX→D		3EMM GO TO MM IF EF3=0	
F1 MX or D→D		37MM GO TO MM IF EF4=1	IN
F2 MX and D→D		3FMM GO TO MM IF EF4=0	SWITCH
F3 MX xor D→D		F8KK KK→D	
F6 SHIFT D RIGHT, BIT 0→DF		F9KK KK or D→D	
76 ROTATE D RIGHT, DF→B7, B0→DF		FAKK KK and D→D	
FE SHIFT D LEFT, BIT 7→DF		FBKK KK xor D→D	
7E ROTATE D LEFT, DF→B0, B7→DF		FDKK KK-D→D, CARRY→DF	
F5 MX-D→D, CARRY→DF		FFKK D-KK→D, CARRY→DF	
F7 D-MX→D, CARRY→DF		FCKK KK-D→D, CARRY→DF	
F4 MX+D→D, CARRY→DF		7CKK KK+D→D, CARRY→DF	
ONE BYTE INPUT INSTRUCTIONS		N2N1NO	1-BYTE OUTPUT INSTRUCTIONS
69 BUS→MX,D		0 0 1	61 MX→BUS, RX+1
6A BUS→MX,D		0 1 0	62 MX→BUS, RX+1
6B BUS→MX,D		0 1 1	63 MX→BUS, RX+1
6C INPUT SWITCH BYTE→MX,D		1 0 0	64 MX→HEX DISPLAY, RX+1

Instruction Subset Table shows required sequence of steps.

the bus so that it can be stored at the memory location addressed by RX. This input byte will also be placed in the 1802's D register.

When a 64 instruction is executed, N2 is high and MREAD is low, making the output of IC10C high and preventing the input switch byte from getting onto the bus. Instead, gate IC10B generates an output clock pulse with TPB that clocks the RAM output byte into the hex display.

The four external flag input lines—EF1, EF2, EF3, and EF4—can be pulled low by external switches. These four lines can be tested by instructions 34, 3C, 35, 3D, 36, 3E, 37 and 3F. Note in Fig. 5 that the INPUT pushbutton switch, debounced by portions of IC11, is connected to the EF4 line. This means that EF4 = 1 when S12 is depressed and EF4 = 0 when S12 is in its normal position.

Latched output line Q can be set high by a 7B instruction or reset to low by a 7A instruction. The Q LED comes on when Q is high. The DMA IN, DMA OUT, and INTERRUPT lines can be pulled low to cause these operations to occur.

The LOAD and RUN lines control the operation of the microprocessor according to the following conditions:

LOAD	RUN	Mode
gnd	gnd	load
+5V	gnd	reset
gnd	+5V	—
+5V	+5V	run

RUN and LOAD switches S1 and S2 in Fig. 5 control the operation of the computer. With both switches set to

OFF, LOAD is +5V and RUN is at ground potential. This resets the 1802. Neither TPA nor TPB are generated in the reset state and R0 = 0000, P = 0, X = 0 and Q = 0 after the 1802 is reset. When the LOAD switch is set to ON, LOAD goes low and RUN stays low, forcing the system into the load mode. Now you can load a sequence of bytes into the RAM, starting at address 0000, by setting the bytes into the input toggle switches, one at a time, and operating the INPUT switch.

In the load mode, the 1802 does not execute instructions but waits for a low to appear on the DMA IN line. When this happens, the 1802 performs one memory write cycle during which the switch input byte is stored in memory. R0 is used to address memory during the DMA IN cycle. After the input byte is stored at the address specified by R0, this register is in-

INTRODUCTION TO PROGRAMMING.

Once you have built your Elf, you must learn how to load a sequence of bytes into memory and then go back and display the sequence. Let us write a simple program that can be loaded into the memory and run.

Suppose you want to program the computer to turn on the Q LED whenever the INPUT switch is set to on. First, you must draw a flow chart that shows the required sequence of steps (Fig. 7). Locate the correct instructions in the Instruction Subset Table. A 7A instruction will perform Step 1. Load this instruction into M(0000). Note that when the INPUT switch is not depressed, EF4 = 0. A two-byte 3F 00 instruction will jump (branch) back to the 7A instruction at M(0000) as long as the INPUT switch is not operated (EF4 = 0). This condition is known as a "loop," and the program will stay in this loop while it is waiting for the INPUT switch to be depressed. Load 3F 00 into memory locations M(0001) and M(0002) to perform the second step in the flow chart. All GO TO MM instructions shown in the Table put MM into the lower-order byte of the program counter if a GO TO condition exists. Otherwise, the next instruction in sequence is fetched by the 1802.

Loading a one-byte 7B instruction into M(0003) takes care of Step 3, while a 30 01 instruction will jump back to the 3F 00 instruction at M(0001). Load the 30 01 instruction into M(0004) and M(0005) to complete the program.

You load this 6-byte program by placing the LOAD switch on the ON position, with

RUN and MP set to OFF, setting up the toggle switches for the hex number 7A, and depressing the INPUT switch. Release the INPUT switch, insert 3F and operate the INPUT switch again. Then load 00 and so on until the last byte, 01, has been stored at M(0005). If you "blow" the program, set MP to ON and LOAD to OFF. Then set LOAD to ON and operate the INPUT switch until you get to the byte immediately preceding the wrong entry. Set MP to OFF, set up the correct byte, and operate INPUT. Flip MP back to ON to protect what you have stored in memory.

To start the program running, set LOAD to the down position to reset the 1802 and set the RUN switch to ON. Nothing should happen until you depress the INPUT switch, at which time the Q LED should come on. Releasing the INPUT switch should cause the LED to extinguish. If you like, you can now observe the timing signals of the 1802 on an oscilloscope while the program is running.

Another simple program involves counting the number of times the INPUT switch is operated and then turning on the Q LED at the end of the count. The flow chart for this program is shown in Fig. 8. When you load and run this program, nothing will happen until you operate the INPUT switch five times, at which point the LED will come on and remain on. Note in Step 1 that you can change the number of times the INPUT switch is operated. Step 6 just loops on itself to terminate the program after the INPUT switch has been operated the specified number of times.

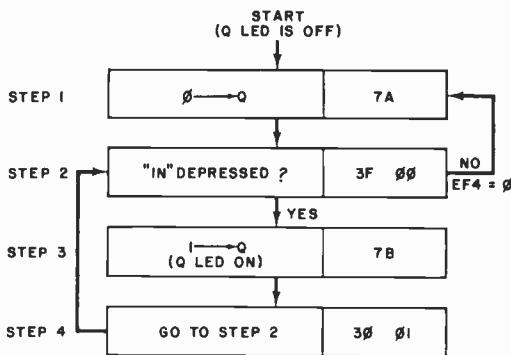


Fig. 7. Program turns on Q-LED when INPUT switch is operated.

cremented by one so that input bytes will be sequentially loaded into RAM locations. Line SC1 goes high during the DMA IN cycle so that the control circuits know when the input byte has been stored in the RAM.

Depressing and releasing INPUT switch S12 sets flip-flop IC12 (Fig. 5). The Q output of this stage goes low, causing the required low on the DMA IN line. The 1802 responds to this request with a memory-write cycle during which SC1 is high. During this cycle, MREAD is high and, since LOAD switch S2 is also ON, the N2/LOAD signal causes gate IC10C to go high, gating the switch input byte to the data bus and storing it in memory. When SC1 goes high, it also resets IC12, which causes DMA IN to return to its high state. The computer then waits for the next switch input byte and LOAD switch operation.

Following each DMA IN cycle, the 1802 holds the A0 through A7 lines at the address of the byte just stored in the RAM. MREAD is also held low while waiting for the next input byte. This means that the previously loaded byte is being gated to the bus (from the

RAM) while waiting for a new byte. This bus byte is continuously clocked into the hex display, since the LOAD switch is holding IC10B open.

A sequence of program bytes can be loaded into the RAM starting at M0 = M(0000) by setting the LOAD switch to the ON position, with the RUN switch set to OFF. Set the eight input switches, S4 through S11, to the desired byte code (in hexadecimal) and depress the INPUT switch to store the byte in the RAM. The value of this byte will be displayed with the hex displays IC6 and IC7. Repeat this procedure for each byte to be loaded. Setting the LOAD switch to OFF puts the 1802 back in the reset state where R0 = 0000, P = 0, X = 0, and Q = 0. If you wish to see what is stored in memory, set MP (memory-protect) switch S3 and the LOAD switch to ON. Now, each time you operate the INPUT switch, successive bytes in the RAM, starting with M(0000), will be displayed.

To change a byte, proceed to the byte just before the one to be changed. Flip the MP switch to OFF, set the input toggle switches to the hex value of the new byte, and depress the INPUT switch once. This new byte will be displayed and stored in the RAM at the location following the byte at which you stopped. Place the MP switch in the ON position. You can now continue to operate the INPUT switch to sequence through the RAM without modifying the bytes in memory.

To start the executive cycle of a program, set both the LOAD and RUN switches to OFF (to reset the 1802). Then set the RUN switch to ON. The program counter is always specified by the hex digit in register P, which can be set to zero by reset so that the program counter will always initially be R0. Set R0 to 0000 by resetting so that instruction fetching, or program execution, will always begin at M(0000). Instructions will continue to be fetched from the RAM and executed until the RUN switch is set to OFF, resetting the computer. Make sure that the MP switch is OFF when running programs so that computer operation is not inhibited.

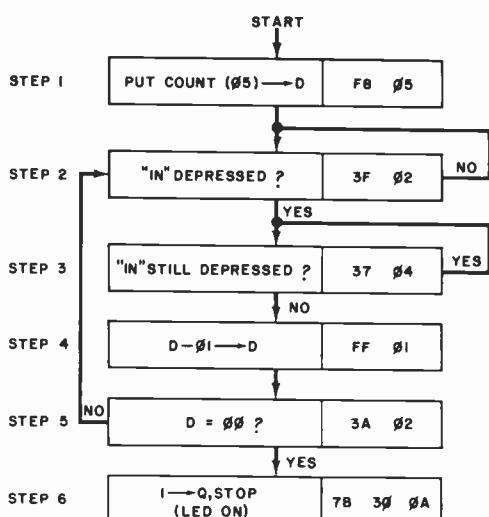


Fig. 8. Program counts number of times INPUT switch is operated.

and is supported on a base made up of lengths of $\frac{3}{4}'' \times \frac{3}{8}''$ (19.1 × 9.5) pine. A sheet of thin aluminum provides the support for the eight toggle-type data switches. The LM309 voltage regulator IC (IC13) is mounted on a $1\frac{1}{4}'' \times \frac{3}{4}'' \times \frac{1}{8}''$ (31.6 × 19.1 × 3.2-mm) piece of aluminum to serve as a heat sink.

Do not mount the IC's (except the display devices) in their sockets until after all wiring is complete. Socket, switch, and component layout should be roughly the same as shown in the photo. Be sure to locate the crystal close to pins 1 and 39 of the microprocessor's socket. Then wire the circuit in accordance with the schematics in Figs. 4 and 5.

Any crystal with a frequency of between 1 and 2 MHz can be used in the Elf, or you can substitute a simple 555 or CMOS oscillator with a 5-volt signal swing between pin 1 of the 1802 and circuit ground, in which case, you will have to omit XTAL, C3, C4, and R11. There is no lower limit to the clock frequency, but most of the sample programs discussed in this series of articles are based on a clock frequency between 1 and 1.8 MHz.

Displays IC6 and IC7 are relatively expensive hex devices. They are the only TTL devices in the computer and, as a result, draw most of the power required by the circuit. If you wish to economize, you can substitute ordinary LED's for the displays. (Next month, we will discuss how to make the substitution.)

An inexpensive 9-volt, 350-mA dc battery eliminator, like those used as battery charger/eliminators for calculators, can be used to power the Elf.

When the computer is completely assembled, use a dry-transfer lettering kit to label all switches and positions, IC socket locations, and pins 1 of all sockets. Then, exercising the usual safety procedures for handling MOS devices, install the integrated circuits in their respective sockets.

Coming Up. In future articles, we will provide more programs as well as methods of adding other types of inputs and relay-control output circuits. We will also detail how to save programs in battery-powered COSMOS RAM's and describe a simple operating system that lets you read/write any memory location and inspect general register contents for program debugging purposes. Memory expansion, hex keyboard input, and an inexpensive video graphics display are other subjects we will cover in detail.

BUYER'S GUIDE TO ANTENNA ROTATORS

How they work and what's available.

BY KRIS CARROLE

TV AND FM signals usually come into a given reception area from all directions and at various strengths. Modern TV and TV/FM antennas are highly directional to provide maximum gain. It is obvious, therefore, that to obtain the best possible reception, an antenna must be accurately aimed in the direction from which a desired signal is coming. When two or more stations are located in different directions, the only practical way of aiming an antenna is with an antenna rotator system. Too, the weaker the signals, the more accurate must be the aiming ability of the rotator system.

Basically, an antenna rotator system consists of two parts. The drive unit does all the heavy work. It mounts atop a mast, just below the antenna, where it is subjected to the elements. The other part of the system, the control box, is usually located near the TV or FM receiver where it is safe from the elements and is easily accessible to the user.

All antenna rotator systems are a great convenience, but some provide more than others. A basic system simply provides a means of rotating an antenna, while a top-of-the-line automatic rotator system can make aiming an antenna easier than tuning a TV channel or FM station. There are rotators designed to bear relatively lightweight loads and others that can accommodate loads of up to 1000 lb (455 kg).

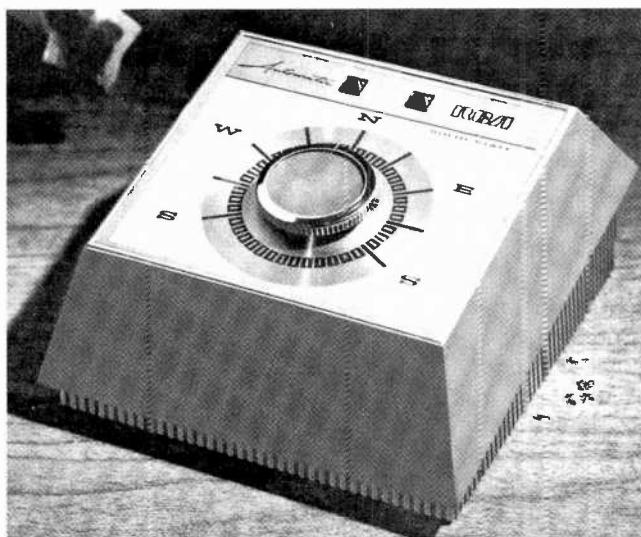
Types of Rotators. There are basically three types or categories of antenna rotator systems in common use. In order of increasing price range, they include manual, semiautomatic, and fully automatic models (see Table).

The manual rotator is a simple system. The controller contains two pushbutton switches (one for turn-left and another for turn-right commands). The antenna rotates while one of the buttons is held in the depressed position. It stops when the button is released. The pushbutton switches are designed so that when one is depressed, the other is locked out to prevent conflicting drive commands from burning out the drive motor. The only

visual indication of system operation is a light that comes on when the rotator comes to the mechanical stop at either end of rotation travel.

The major disadvantage of the manual rotator system is that each time you change a channel or station, you must experiment with the controls until you obtain the best possible reception. Except for knowing when the antenna is at one of the rotator's mechanical stop positions, there is no way of telling in which direction the antenna is pointing, short of going outside and looking at the antenna itself. There is no way of marking the controller for future reference to obtain a duplicate setting.

The big advantage of the manual



RCA's Model 10W707 fully automatic controller.

rotator system, of course, is its cost. If you don't mind experimenting with the controls and wish to save money, the manual rotator system might be just the thing for you.

The semiautomatic rotator system offers a bit more operating convenience at additional cost. It provides a visual indication of the antenna's position. The indicator is usually a compass-like dial with a pointer that indicates antenna direction. The pointer is driven by a small motor synchronized with the antenna drive. (Alliance uses a meter movement with a scale calibrated in N, E, S, W, and N to indicate antenna direction.)

The controls in the semiautomatic rotator system are the same pushbutton switches used in the simple manual systems. However, the fact that there is a visual direction indicator gives the advantage that channel and station directions can be marked on the dial for future reference.



*Example of an in-line antenna rotator design.
(Cornell-Dubilier Ham-II)*

For most manufacturers, the only step up from a basic manual rotator system is to a fully automatic system. The fully automatic system has no pushbutton switches for the turn commands. Instead, the compass indicator becomes the antenna position selector. As you turn the selector knob to any position on the compass scale, the antenna rotates and automatically stops at the selected heading. Again, you can mark the dial for each channel or station that can be received in your area.

While all fully automatic systems offer a high order of operator convenience, Cornell-Dubilier's Model AR-33 deserves special mention. In addition to the standard compass-dial control, this system's controller has five pushbutton switches that allow the user to "key in" heading commands. Operation of any of the but-

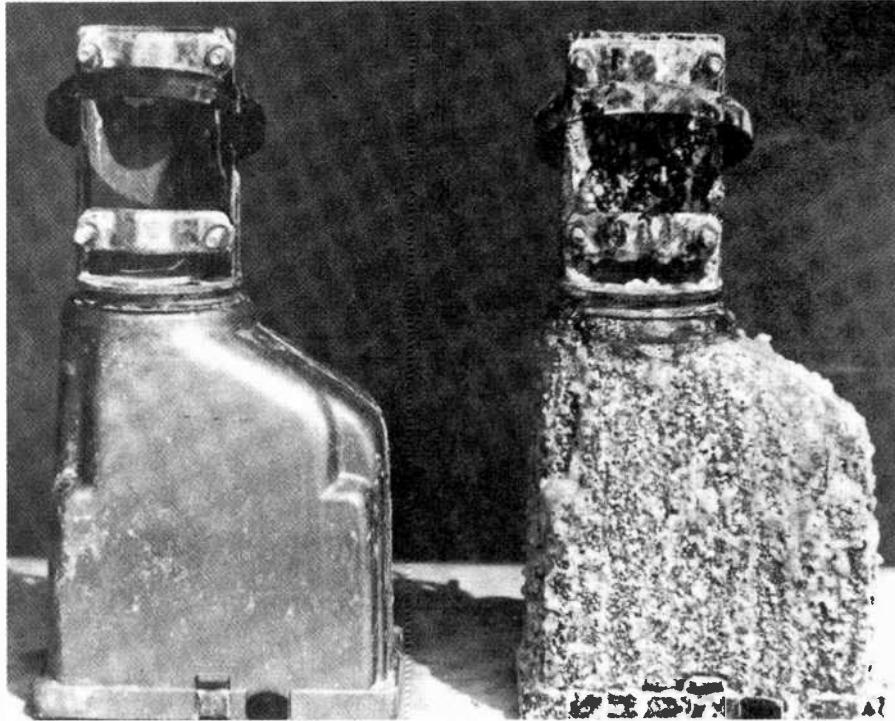


Photo shows effects of salt air (right) on rotator housing as opposed to rotator in normal atmospheric conditions (left).

tons relieves the user of having to turn the compass dial to select the direction for a given station. He just pushes the button, and the antenna automatically rotates to the heading which he had previously set in.

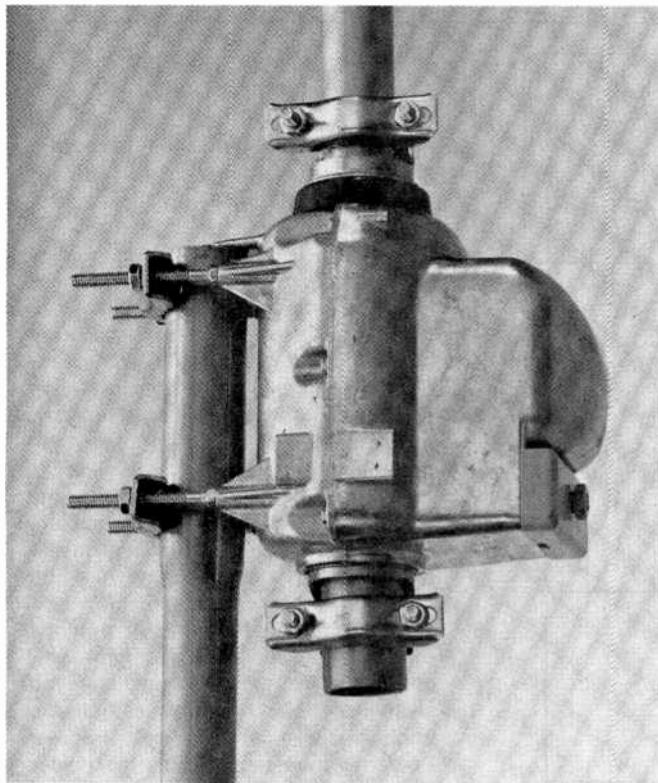
More About Automatics. You pay top dollar for a good automatic antenna rotator system, but with it you get more than just operational convenience. Materials and design considerations are top quality, and the accuracy of the system is greater. The latter is especially important if you happen to live in a deep-fringe reception area.

The less expensive automatic antenna rotator systems employ a small dc motor in the controller to turn the position indicator in unison with the drive motor at the antenna end. A cam-actuated switch in both the controller and antenna drive keeps the system in synchronization. However, because of electrical and mechanical tolerances, each control "step" requires from 3° to 6° of rotation. Since the system is electromechanically synchronized, it is possible for the motors to eventually move out of sequence.

The more expensive systems are totally electronic. The direction control



*Blonder-Tongue
SA-1000 manual
rotator controller.*



Radio Shack 15-1220 drive system is an example of the offset design.

in the controller forms half of a bridge circuit. The other half of the bridge is a disc potentiometer that is turned when the drive motor rotates the antenna; this pot is located in the drive unit. Turning the direction control unbalances the bridge, which then signals the drive unit to rotate the antenna until the bridge balances. When the bridge is balanced, antenna rotation ceases.

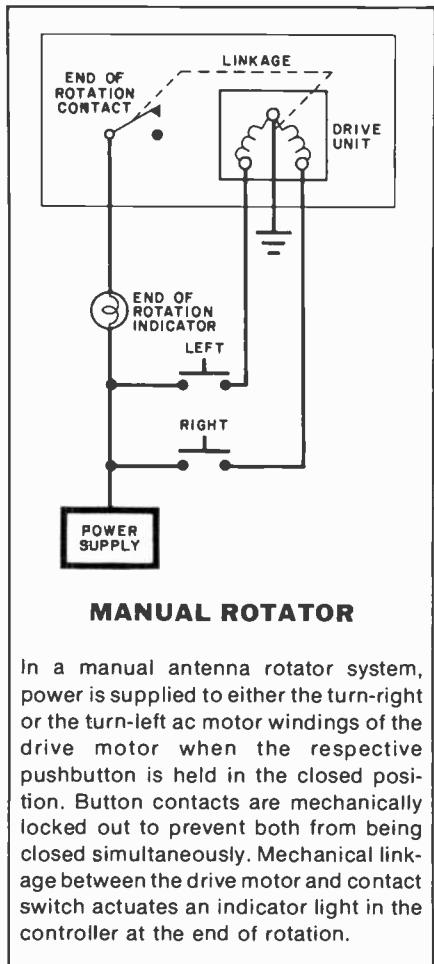
The elimination of mechanical elements in the all-electronic system brings the tolerance down to about 2° steps, providing as many as 60 more set points on the controller dial. Another extra of the all-electronic system is completely silent operation, except for the click of a relay at the end of rotation. Even the relay click is eliminated in Blonder-Tongue's Ultramatic

system, which uses SCR's for the switching.

Drive Units. No matter which model you choose, from simple manual to top-of-the-line fully automatic, the drive unit in the rotator system is the weakest link. It does all the heavy work and is generally subjected to a wide range of weather conditions. The drive unit must be able to bear up under the mechanical stresses placed upon it by weight and loading factors, heat, cold, water, ice, and corrosive elements (usually salt) in the air. To beat the elements, manufacturers have de-

vised quite reliable housing and sealing designs for their drive systems.

Inside the drive unit, a worm or spur (planetary) gearing system is used for the final power train between the motor and turning head to which the antenna is mounted. The spur gear has the greater efficiency, averaging about 80% to 90% as opposed to the 50% or so of the worm drive. This per-



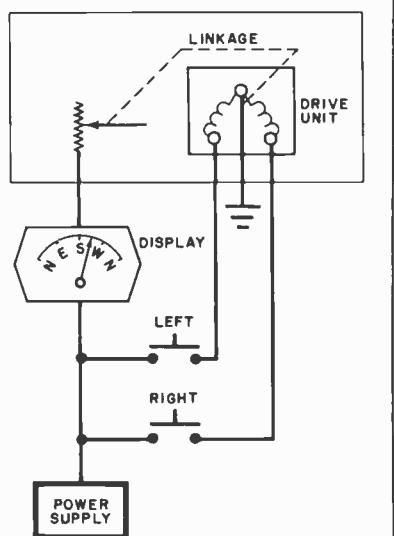
In a manual antenna rotator system, power is supplied to either the turn-right or the turn-left ac motor windings of the drive motor when the respective pushbutton is held in the closed position. Button contacts are mechanically locked out to prevent both from being closed simultaneously. Mechanical linkage between the drive motor and contact switch actuates an indicator light in the controller at the end of rotation.

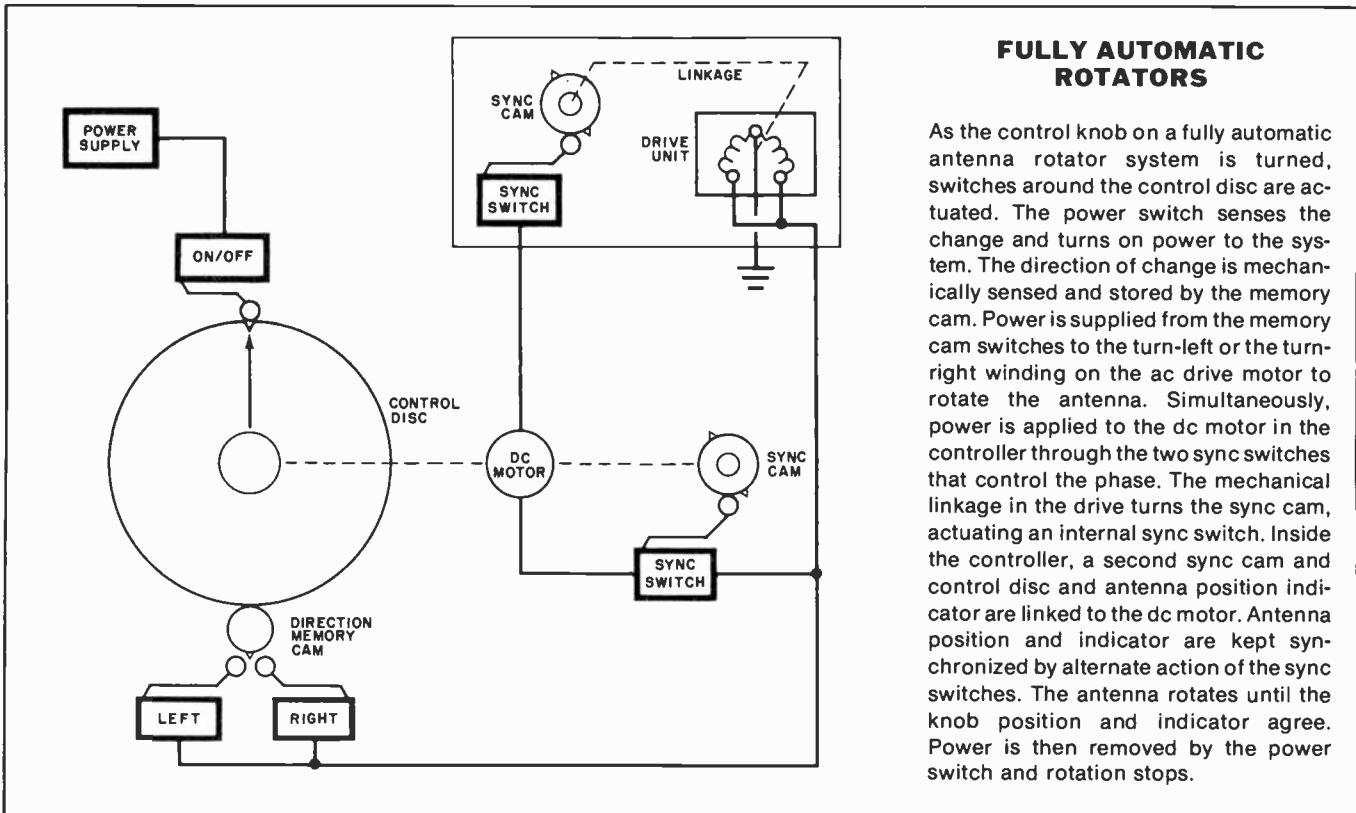


Alliance's T-45 controller uses meter indicator.

SEMAUTOMATIC ROTATOR

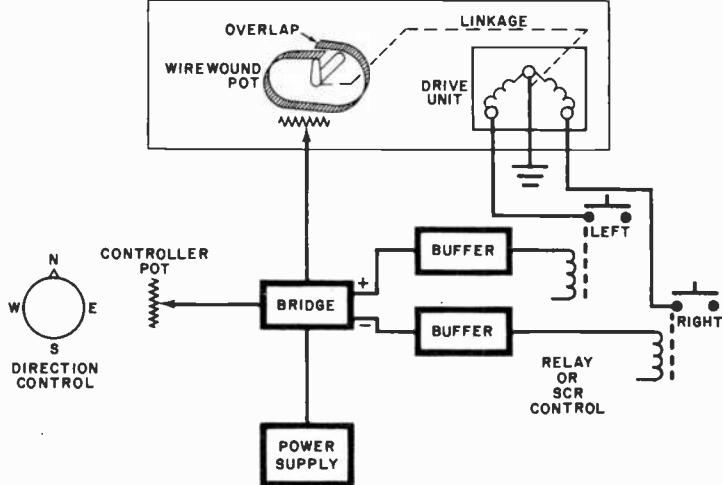
Operation of the metered semiautomatic antenna rotator is identical to that of the manual rotator. Mechanical linkage from the drive system, however, turns a potentiometer in the drive housing as the antenna rotates. The amount of current through the meter is proportional to the direction in which the antenna is pointing. Semiautomatic systems that use a revolving disc as an indicator are basically identical to fully automatic systems, except that the automatic-stop mechanism is not included.





FULLY AUTOMATIC ROTATORS

As the control knob on a fully automatic antenna rotator system is turned, switches around the control disc are actuated. The power switch senses the change and turns on power to the system. The direction of change is mechanically sensed and stored by the memory cam. Power is supplied from the memory cam switches to the turn-left or the turn-right winding on the ac drive motor to rotate the antenna. Simultaneously, power is applied to the dc motor in the controller through the two sync switches that control the phase. The mechanical linkage in the drive turns the sync cam, actuating an internal sync switch. Inside the controller, a second sync cam and control disc and antenna position indicator are linked to the dc motor. Antenna position and indicator are kept synchronized by alternate action of the sync switches. The antenna rotates until the knob position and indicator agree. Power is then removed by the power switch and rotation stops.



ELECTRONIC-CONTROL AUTOMATIC ROTATOR

The direction control knob in an all-electronic controller makes up half of a bridge circuit. Once the control is turned, the bridge is offset from null, in a positive or a negative direction, depending on the direction in which the antenna is to be moved. The offset voltage is buffered and used to actuate a relay or SCR. Turn-left or turn-right power is sent to the respective winding of the drive motor, and the antenna begins to rotate. The mechanical linkage from the drive motor repositions the wiper of a

wirewound potentiometer. (The ends of the pot overlap to provide full-rotation sensing.) The resistance of the drive-mounted pot is used as the other half of the bridge. When the resistance of the drive pot is the same as the controller pot, the bridge is balanced and the output is null. The relay then cuts out (or SCR turns off), removing power from the drive motor. A power indicator comes on while the antenna is rotating and shuts off when power is removed from the drive motor.

mits a higher starting torque for moving a heavy antenna and breaking through ice.

Although somewhat less efficient on start-up, the worm drive is better than the spur for stopping antenna rotation. The gear itself acts as a positive brake and is less prone to windmilling. However, unlike the spur, which uses the weight of the armature as a clutch, the worm drive can be stripped and permanently damaged if windmilling does occur.

In-line and offset drive arrangements are design considerations that depend primarily on the gearing system used in the drive unit's housing. It's simpler, for example, to package a worm drive in an offset arrangement than to try to use an in-line arrangement.

An offset system can usually be made more compact and lighter in weight than an in-line design. The result is less resistance to wind, since the top and bottom masts overlap to minimize the mounting area. However, the offset design lowers the center of gravity, placing more stress on the bottom mast. As a result, it is often necessary to lower the drive unit so that the additional strain is placed on the chimney or wall mounting brackets.

In-line arrangements evenly distribute antenna weight and wind stress

ANTENNA ROTATOR BUYER'S GUIDE

Manufacturer	Model No.	Type	Control Accuracy	Price	Remarks
Alliance	K-22	manual	N/A	\$38.95	
	T-45	semi	5°	46.95	Meter direction indicator
	U-100	auto	10°	54.95	
	C-225	auto	3°	69.95	All-electronic control
Blonder-Tongue	SA-1000	manual	N/A	64.70	
	U-1000	auto	2°	86.60	All-electronic, SCR control
Channel Master	9513A	semi	4°	49.95	Available wired for 220 V ac
	9512A	auto	4°	59.95	Available wired for 220 V ac
Cornell-Dubilier	SA10L	manual	N/A	39.95	
	AR-20XL	auto	6°	49.95	
	AR-22XL	auto	6°	74.95	Heavy-duty version of AR-20XL
	AR-40	auto	3°	94.95	All-electronic control
	AR-33	auto	3°	114.95	All-electronic & preset controls
	CD-44	semi	2%	129.95	For ham and CB antennas up to 500 lb
Radio Shack (Realistic)	HAM-II	semi	2%	159.95	Same as CD-44 for antennas up to 1000 lb
	15-1223	auto	3°	39.95	Dial resettable for initial correction
	15-1220	auto	2°	49.95	All-electronic control
RCA	10W606	auto	3°	54.95	Dial resettable for initial correction
	10W707	auto	2°	64.95	All-electronic control

throughout the entire mounting assembly. The major disadvantage of the in-line arrangement is that it must be larger to accommodate the two masts end to end.

The overall strength of either type of arrangement depends on the quality of the materials used, which is generally quite high. Hence, strength need not be much of a concern for most conditions. Of course, where the wind and/or weight loading stresses are se-

vere, special thrust-bearing brackets (turnable brackets that clamp to the masts) will give additional support.

The offset systems are more susceptible to problems when it comes to water and icing because the top of the drive mast must be open to accept the top mast. Special gasketing and mounting hardware inside the drive unit provide water sealing.

To move a massive antenna and break through ice, and also to provide

reliable operation for a long time, most drive systems are equipped with high-torque drive motors. Within the first year, a rotator system's torque can decline by as much as 10%, due mainly to the loss of lubricant efficiency, hysteresis losses in the motor, and changes in the characteristics of the starting capacitor in the controller. By providing a high initial torque rating for the drive motor, a longer useful life can be expected. Typically, you can expect 12 or more years of operation from today's antenna rotator systems.

If you live near the ocean, salt air will become your biggest enemy. There are few materials that will bear up to the corrosive action of salt and water. Even though new alloys of aluminum and zinc are being used in modern rotator drive systems, salt air is likely to reduce the life expectancy of the system by as much as 25%.

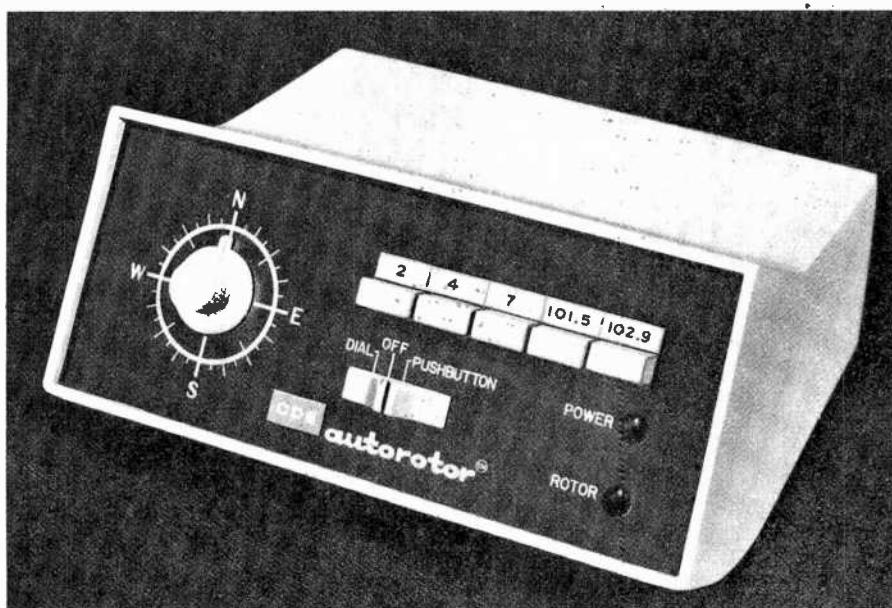
Installation Notes. For new antenna rotator installations, you'll have to plan on some extra-cost items, such as new masts, mounting brackets, and cable to connect the rotator's controller to the drive unit. These items are not usually included with the rotator system itself.

For runs up to 150' (45.7m), 20-gauge cable will be sufficient. For longer runs, use 18-gauge or larger cable. Also, if you're considering extra drops for control from several stations not located in a single room, you'll have to add wall jacks and additional cable when making your purchases.

When installing the rotator system, leave at least 24" (61 cm) of slack antenna cable to allow for the antenna's turning radius without interference. For initial alignment, check the drive housing for orientation marks.

The maximum heights of the top and bottom masts on the roof will depend on the type of rotator system and antenna you're using. To obtain greater antenna height than is recommended for your rotator/antenna setup, use extra guying and thrust bearings. However, before you take this step, check with your dealer to draw on his experiences with local wind and weather conditions.

According to most manufacturers, maintenance of antenna rotator systems is very easy—there's nothing to do. Actually, there is one thing you can do to extend the life of your rotator system — lubricate the drive unit periodically with the lubricant prescribed by the manufacturer.



Cornell-Dubilier's AR-33 permits preprogramming for special channels. Unit is all electronic.

A Simple Electronic Keyer for Sending Morse Code

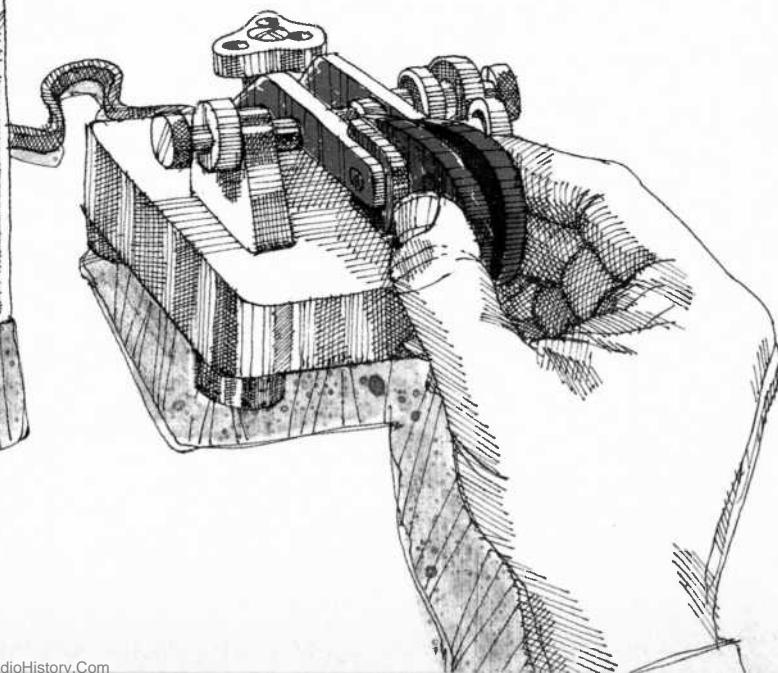
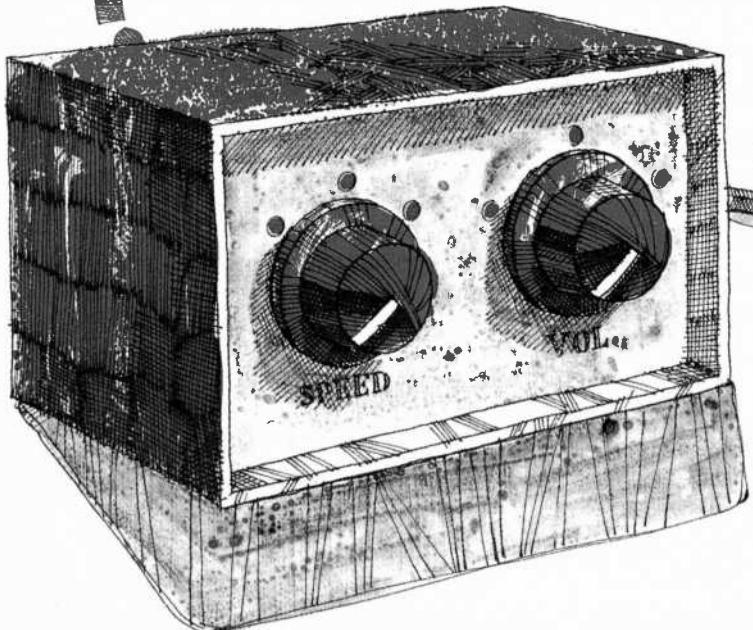
BY WILLIAM J. VANCURA, WB90BB

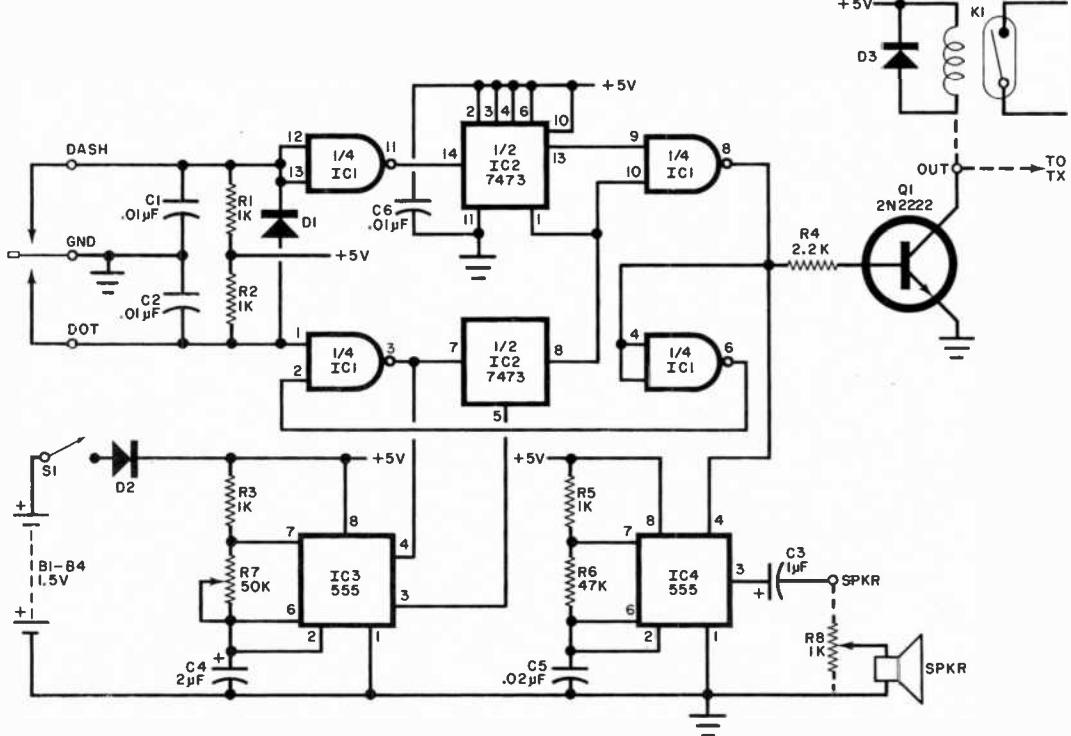
ONE WAY for the CW radio operator to send almost perfect Morse code is to use an electronic keyer. Most commercially available keyers are relatively expensive, but it is easy to build a low-cost keyer using TTL devices and a pair of 555 timer IC's.

The keyer features a variable clock (speed) rate and a side-tone oscillator. It can be used to key a CW transmitter

or as a CPO (code-practice oscillator). The circuit operates from any conventional 5-volt dc source. Since it draws only 40 mA of current, it can even be battery powered, providing many hours of operation from ordinary penlite (AA) cells.

Quad 2-input NAND gate *IC1*, as shown in the schematic diagram, eliminates most of the diodes commonly used in other keyer circuits and





Relay circuit is for negative-grid keying, and slide-tone oscillator for code practice.

PARTS LIST

B1,B2,B3,B4—1.5-volt cell
 C1,C2,C6—0.01- μ F disc capacitor
 C3—1- μ F, 16-volt electrolytic capacitor
 C4—2- μ F, 16-volt electrolytic capacitor
 C5—0.02- μ F disc capacitor
 D1,D2,D3—Silicon rectifier diode
 IC1—7400 quad 2-input NAND gate IC
 IC2—7473 dual flip-flop IC
 IC3,IC4—555 timer IC (can be a dual-timer IC)
 S1—Spst switch

K1—Reed relay (Potter & Bromfield JR 1000 or similar)
 Q1—2N2222 transistor
 R1,R2,R3,R5—1000-ohm, 1/2-watt resistor
 R4—2200-ohm, 1/2-watt resistor
 R6—47,000-ohm, 1/2-watt resistor
 R7—50,000-ohm, reverse-log taper potentiometer
 R8—1000-ohm potentiometer
 SPKR—8-ohm speaker

Misc.—Perforated or printed circuit board; suitable metal chassis box; battery holder; control knob; paddle assembly; hookup wire; solder; machine hardware; etc.

Note: Etched and drilled printed circuit board available for \$3.50 from: William Vancura, 4115 35 Ave., Moline, IL 61265

provides a TTL-level signal for the remainder of the circuit. Dual flip-flop IC2 generates the dashes and dots in a 3:1 ratio, with the spaces being one-dot wide. Timer IC3 serves as the system clock generator, with potentiometer R7 acting as the speed control. Timer IC4 generates an audio signal when gated, producing a side tone so that you can hear what you are sending.

Output transistor Q1 is required if you intend to use the circuit to key a transmitter. If negative grid keying is desired, add reed relay K1 to the circuit as shown. This relay isolates the keyer circuit from the voltages used in the transmitter.

The circuit can be assembled on a piece of perforated board, using a point-to-point wiring technique. Or you can design a printed circuit board. There is nothing critical about parts placement or lead routing.

If you prefer, you can substitute a dual-timer IC for the separate IC3 and IC4 timers shown. Speed-control potentiometer R7, which mounts on the front panel of the chassis box in which the keyer is to be housed, should have a reverse-log taper to improve linearity. The side-tone oscillator can be adjusted to produce a desired tone in the speaker.

If you plan to use the keyer with a transmitter, the circuit must be housed in a grounded metal chassis box to reduce the possibility of r-f interference. You can easily fabricate a paddle keyer. Mount it so that the contacts are inside the box, with the paddle arm exiting through a slot in the box. Make certain that the paddle arm moves freely, without contacting the metal chassis box.

After assembling the keyer, check out its operation in both the transmit and CPO modes. ◇



"You should listen more carefully, dear. Mother only called you a lazy CB."

IMPROVED GAS AND FUME DETECTOR

This high-sensitivity noxious-fume detector is for both home and mobile use.

BY C. R. LEWART

THE Taguchi Gas Sensor has made possible a number of gas and fire detectors (such as the "Poisoned Air Detector," POPULAR ELECTRONICS, February 1974). Now, there is an improved version of this very useful sensor that retains the high sensitivity, compact size, and low cost of its predecessor. The new sensor, however, has greater stability and an electrically isolated low-current 5-volt heater.

The new sensor is an ideal building block for inexpensive but very sensitive ac or dc gas alarms for the home, car, trailer, boat, etc. It also makes it possible to actually measure the gas concentration for mobile antipollution tuneups and for the detection of small gas leaks. Presented here are three ways in which you can put the new sensor to use.

Sensor Characteristics. The sensor consists of a piece of semiconductor material molded around a small filament heater. It is housed in a stainless-steel, wire-mesh-topped enclosure. The semiconductor material — mainly tin oxide (SnO_2) — is put through a sintering process during manufacture to increase the active area to be exposed to the air entering the sensor through the wire mesh cover.

When the semiconductor material is heated in the presence of combustible or oxygen-reducing gases or vapors, the material's resistance decreases. The sensor can respond to carbon monoxide, hydrogen, propane, gasoline, alcohol vapors, etc. A useful indication of the change in sensor

conductivity can be obtained with gas concentrations as small as 50 to 100 ppm (parts/million) of carbon monoxide, propane, or methane.

The reactions that occur in the semiconductor material are reversible so that the sensor can be used to make thousands of measurements before having to be replaced. After an initial warmup of 2 to 5 minutes, the sensor responds within a few seconds to the presence or change in concentration of a combustible gas. Recovery time after being exposed to fresh air is 2 to 3 minutes.

About 1 volt greater than the nominal 5-volt operating potential is recommended for the initial warmup and to clean the sensor after exposure to a noxious gas. At the 5-volt operating potential, the sensor's heater draws 130 mA of current. Its resistance in fresh air is between 20,000 and 100,000 ohms.

Home Gas Alarm. The circuit illustrated in Fig. 1 is a line-powered gas

detector for home use. Switch S_1 applies a potential of about 6 volts to the filament of gas detector TGS when in the CLEAN position and about 5 volts in the RUN position. Sensitivity is preset by placing S_1 in the RUN position and adjusting R_2 until the alarm sounds and then backing off on the adjustment until the alarm just cuts out. Repeat this procedure after a 5-minute warmup period.

You can now test the sensor by rubbing a drop of alcohol between your fingertips in the vicinity of the mesh-topped sensor. The alarm should sound. After the alarm has sounded, set S_1 to CLEAN for 2 minutes or so. Then adjust the sensitivity with R_2 .

To compensate for variations between gas sensors and SCR's, use a value between 1000 and 5000 ohms for R_5 so that potentiometer R_2 's rotation is approximately three-quarters clockwise when the alarm triggers in fresh air. Of course, when performing tests and making sensitivity adjustments, do not wear after-shave lotion.

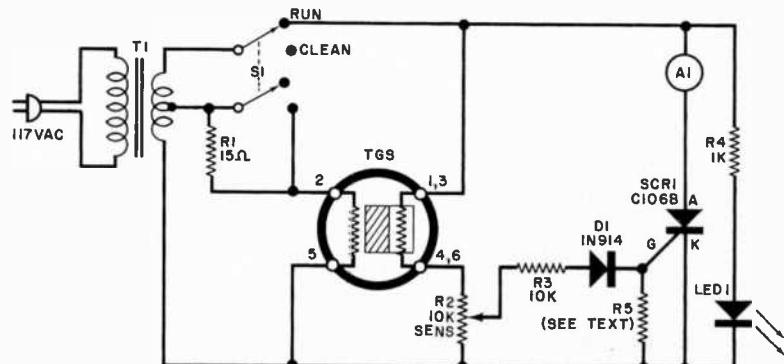


Fig. 1. Basic line-powered gas alarm causes SCR to fire passing current through a 12-volt bell, buzzer, or Sonalert.

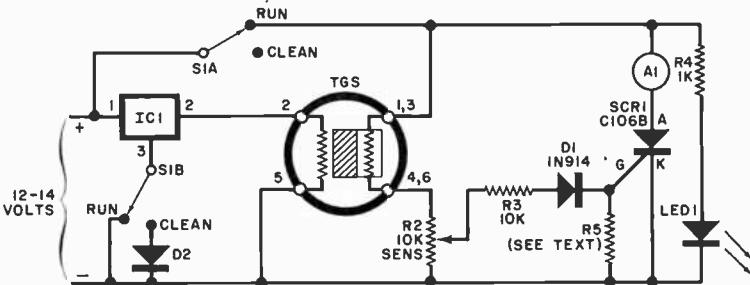


Fig. 2. Powered from a 12-volt dc source, this alarm is useful in trailers, campers, or boats. Operation is similar to home alarm.

(or perfume), or drink alcoholic beverages. If you do, the alarm will trigger falsely.

The entire circuit is simple enough to assemble with point-to-point wiring. Use a standard 7-pin vacuum-tube socket for the TGS gas sensor. The audible alarm device you use for A1 should be rated as 12 volts and not exceed the rating of the SCR in its current demand. If you plan to use this circuit in a potentially explosive atmosphere, use a noncontact type alarm, such as the Mallory Sonalert®. Also, R4 and LED1 serve as a power-on indicator system, which can be eliminated from the circuit if you wish to economize.

Mobile Alarm. The circuit for a gas alarm system for car, boat, trailer, etc., is shown in Fig. 2. This circuit is similar

to that shown in Fig. 1 except that it does not get its power from the 117-volt ac line. Regulator IC1 compensates for variations in the vehicle's battery voltage that occur when the generator/alternator cuts in and out. If such variations reach the sensor's filament, changes can occur in the sensor's resistance. Diode D2 increases the heater potential from the nominal 5-volt operating point to about 5.7 volts when S1 is set to CLEAN.

an amount proportional to the nearness to the source of the gas or concentration of gas.

The power supply for the gas measuring system is similar to that used in the mobile alarm circuit. The sensing element of TGS becomes one side of a bridge in this circuit, with the other sides consisting of R7 or R8 and both sides of potentiometer R10. The meter movement is connected across the bridge and R10 adjusted for bridge balance (0 indication on the meter). When gas is introduced to the sensor, the resistance of TGS decreases, unbalancing the bridge. When this occurs, the meter pointer starts moving upscale by an amount directly proportional to the amount of unbalance in the bridge. Resistor R6 limits the total current through the Taguchi Gas Sensor.

To operate the system, first set S1 to CLEAN for 2 minutes, switch to RUN, set S2 to the desired sensitivity range, and null the meter with R10. Accurate

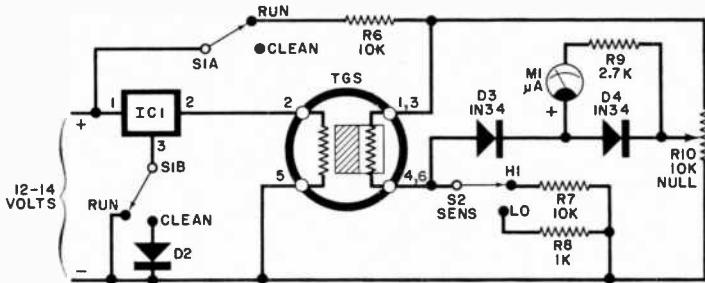


Fig. 3. This 12-volt dc detector uses a meter readout instead of alarm for quantitative leakage measurements and locations.

PARTS LIST

- A1—12-volt signalling device (buzzer, Mallory Sonalert®, etc.)
- D1—IN914 diode
- D2—50-volt, 1-ampere silicon diode
- D3,D4—IN34 germanium diode
- IC1—5-volt regulator IC (Radio Shack No. 276-2770 or similar)
- LED1—Any red light-emitting diode
- M1—50- μ A meter movement (Lafayette Radio No. 99R51146 or similar)
- The following resistors are $\frac{1}{2}$ -watt, 10%:
- R1—15 ohms
- R3,R6,R7—10,000 ohms
- R4,R8—1000 ohms
- R5—See text
- R9—2700 ohms
- R2,R10—10,000-ohm linear-taper potentiometer
- S1—Dpdt switch
- S2—Spdt switch
- SCR1—C106B silicon controlled rectifier (Radio Shack No. 276-1079 or similar)
- T1—12.6-volt, 1-ampere center-tapped transformer
- TGS—Model 812 Taguchi Gas Sensor (Available from Southwest Technical Products Corp., Dept. PE-1, 219 W. Rhapsody, San Antonio, TX 78216 at \$6.95 each)
- Misc.—Suitable enclosure; 7-pin tube socket for sensor; perforated board; machine hardware; hookup wire; solder; etc.

The value of R5 should be selected in the same manner as for the home alarm. Unlike the home system's alarm cannot be turned off via R2 because of the dc flowing through the SCR unless A1 is a mechanical buzzer that interrupts the current flow.

To operate the system, first place S1 in the CLEAN position for 2 to 3 minutes. Then set the switch to RUN.

Turning R2 down and flipping S1 to CLEAN, and back to RUN, will turn the buzzer off.

Gas Measuring System. The circuit shown in Fig. 3 is particularly interesting because it provides a quantitative measurement of gas concentration, rather than the simple go/no-go indication of the previous circuits. This circuit can be used for any gas measurement from vehicular engine tuneups to gas-leak detection. In use, the meter's pointer swings up-scale by

meter calibration requires specialized equipment, which your local service station might use to perform antipollution emissions checks.

The major problem with the sensor is that it does not differentiate between carbon monoxide and carbohydrates. However, comparing the exhaust readings of your vehicle's exhaust with those obtained with a commercial gas analyzer will give you reasonably good calibration.

In the gas measuring configuration, the gas sensor should be physically separated from the electronics package. Use a flexible four-conductor cable between sensor and electronic package.

When making measurements, you can set the detector to high sensitivity first and, if necessary, switch to the lower sensitivity range. Operated this way, the detector should be able to locate almost any gas leak along a complex arrangement of pipes. ◇

BUILD A LOW-COST 1-Hz to 1-MHz Frequency Counter

*Sophisticated,
low-cost counter
with 3-digit
readout uses
state-of-art
CMOS chips.*

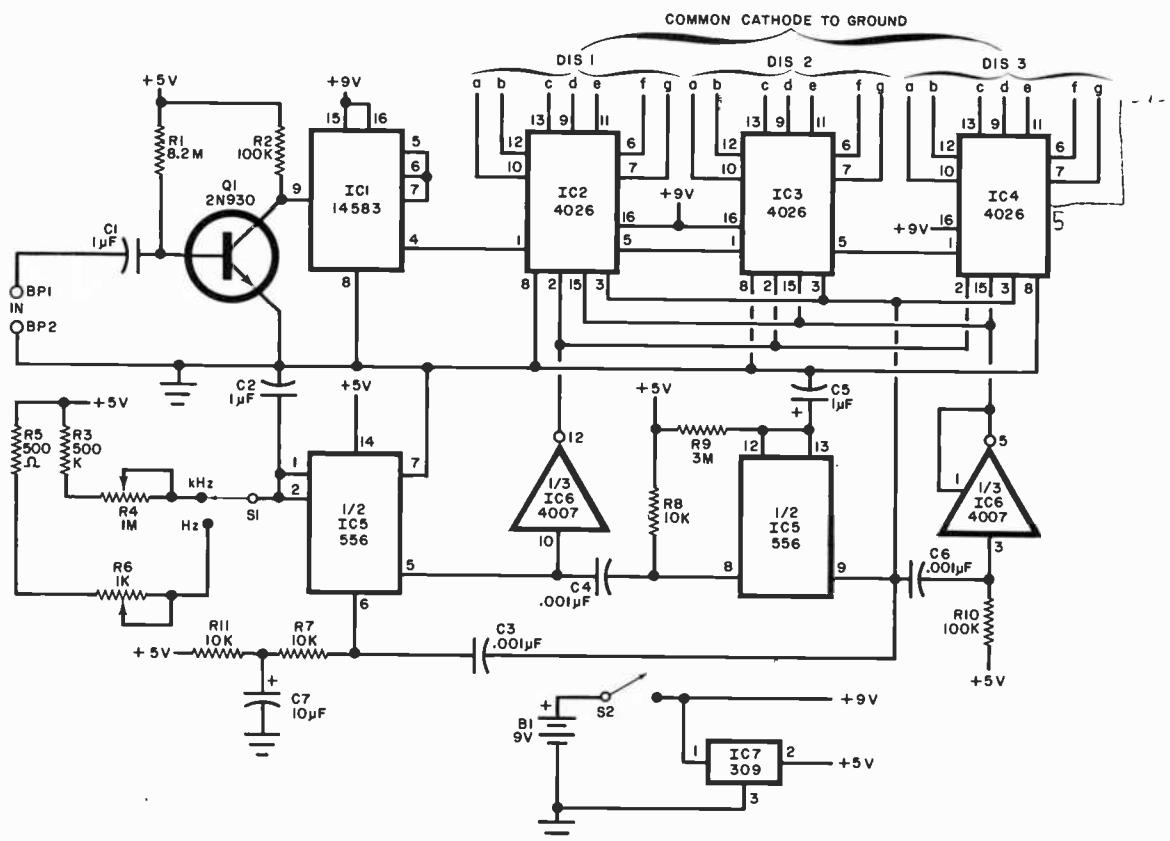
BY NORMAL P. HUFFNAGLE

A FREQUENCY counter can be as useful in working with electronic equipment as an oscilloscope, yet it is often the last piece of test gear the hobbyist and experimenter buys. The main reason for this save-for-last attitude stems from the fact that commercially made counters are relatively high priced. Now, however, the easy availability of inexpensive "surplus" IC's and low-current LED displays

makes it possible for you to build a low-cost, three-digit frequency counter with a range from 1 Hz to about 1 MHz. By shopping carefully (see the ads at the back of this magazine), you should be able to build your frequency counter for just about \$25 to \$30.

Circuit Operation. A frequency counter consists of a wave shaper that

should have a reasonably high input impedance and a series of decade counting units. The wave shaper "conditions" the input signal to give it the clean-edged waveform necessary to trigger the decade counting units. The outputs of the counters drive numeric displays. The entire operation is controlled by a time base that enables the counter for a precise period of time. During the enable in-



PARTS LIST

- ✓ B1—9-volt alkaline battery
- BP1,BP2—Binding post (one red, one black)
- C1,C2,C5—1- μ F ceramic, Mylar, or polystyrene capacitor
- C3,C4,C6—0.001- μ F disc capacitor
- C7—10- μ F, 16-V, electrolytic capacitor
- DIS1 through DIS3—Common-cathode 7-segment LED display (Motorola HEK-5 or similar)
- IC1—14583 Schmitt trigger IC
- IC2,IC3,IC4—4026 decade counter IC

- IC5—556 dual timer IC
- IC6—4007 dual complementary pair and inverter IC
- IC7—5-volt regulator IC (LM309 or similar)
- Q1—2N930 or similar transistor
- Following resistors are 1/4 watt:
- R1—8.2 megohms
- R2,R10—100,000 ohms
- R3—500,000 ohms
- R5—500 ohms
- R7,R8,R11—10,000 ohms

- R9—3 megohms
- R4—Subminiature 1-megohm potentiometer
- R6—Subminiature 1000-ohm potentiometer
- S1—Spdt switch
- S2—Spst switch
- Misc.—Perforated board; IC sockets (optional); battery holder; small Bakelite or plastic case; machine hardware; hookup wire; solder; etc.

terval, all events present at the input are counted and totalized. At the end of the count interval, the counts are stored and displayed. The counter is then inhibited from accumulating more counts until the display period ends. Then the frequency counter is reset and a new count cycle begins.

The complete circuit of the frequency counter is shown in the schematic. The input circuit can be modified according to the availability of components. Just keep in mind that the input should have a reasonably high impedance and that the input of the IC2 decade counter should have a clean positive-going leading edge.

Integrated circuit IC1 is a Schmitt trigger that conditions the input signal and converts it to logic levels suitable for the IC2 through IC4 counter chain. The tenth input count to IC2, at pin 1, generates a "carry" pulse at pin 5 to toggle IC3. At the instant the carry pulse is generated, IC2 causes DIS1 to display a 0, while IC3 causes DIS2 to display a 1. When a tenth input pulse is applied to the input of IC3, a carry pulse toggles IC4 and DIS2 displays a 0 and DIS3 a 1. In this circuit, the carry output of IC4 (pin 5) can be used to

turn on the decimal point of DIS1 to indicate an overrange condition.

The timing starts with half of the dual timer (IC5). Switch S1 enables either a 1-s or a 1-ms timing interval. During this interval, the second half of IC5 generates a 2- or 3-second display interval during which the counters are disconnected from the input and the display system is unblanked. At the end of the display, a reset pulse initiates the timing/counting interval.

Construction. Except for the input binding posts, switches, and displays, the entire circuit can be assembled on a piece of perforated board using point-to-point wiring. The only critical area of assembly is around Q1 and the input of IC1, where high-frequency signals will be present. Mount Q1 and IC1 at the end of the board nearest where the input jacks will be mounted on the case.

The displays, switches, and input binding posts should mount on the front of the enclosure. Mount the displays side by side in a slot just large enough to accommodate them and cement them in place. Then mount the binding posts and switches and com-

plete circuit wiring according to the schematic diagram.

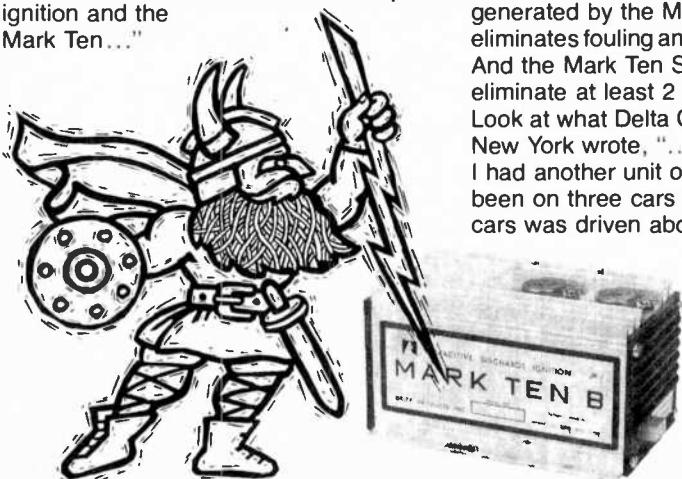
Calibration. You can use any frequency counter of known accuracy and a signal generator to make all frequency adjustments. Simply set S1 to the Hz position, drive the counter with some fairly low-frequency signal, and adjust the setting of R6 for the correct indication. If you are using a highly accurate frequency counter to monitor the output of the signal generator, adjust R6 so that the displayed numbers on both counters are the same. Repeat the procedure with a high-frequency signal.

If you do not have access to a highly accurate frequency counter, you can calibrate the dial of any audio signal generator using a 60-Hz source and Lissajous pattern (on an oscilloscope). Then use the outputs as a reasonably accurate signal source to calibrate the frequency counter.

If you have an older signal generator whose dial has a high degree of inaccuracy, you can build the low-cost frequency counter into it. Then you will always know at exactly what frequency the generator is operating. ◇

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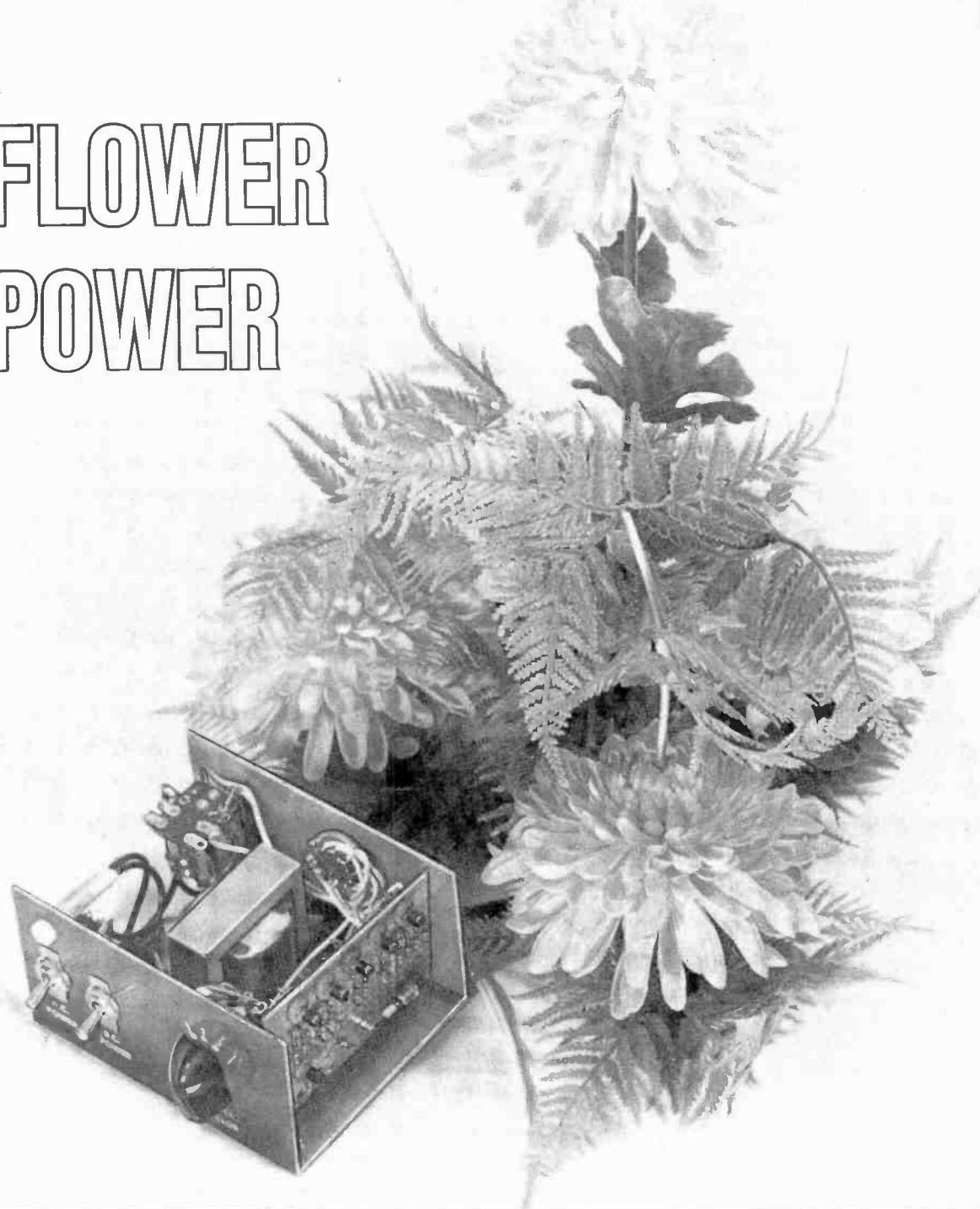
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FLOWER POWER



Photocell, transistor-diode ac power control system

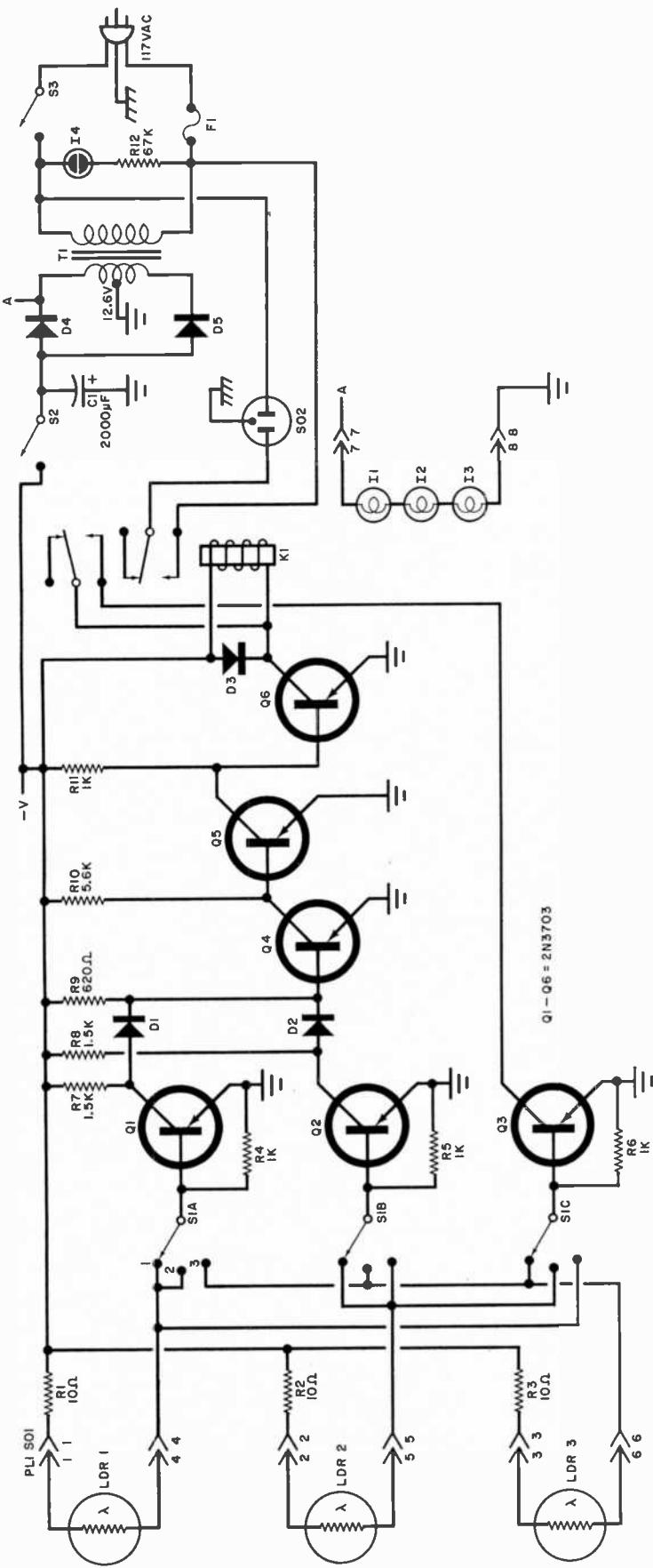
BY JIM SQUIRES

HERE is an electronic system which can be used to control up to 350 watts of ac power simply by varying the amount of light applied to a set of three photocells (light dependent resistors or LDR's). The latter can be mounted in any convenient location—in the case of the prototype, they were concealed in an arrangement of artificial flowers. (Hence the

name, "Flower Power.") The system acts as a safety device to prevent the activation of a potentially hazardous appliance by young children. The illuminated flowers also provide a decorative control system which can function as a night light.

About the Circuit. In the project (see schematic diagram), pilot lamps

*I*1 through *I*3 are attached to the bottoms of plastic flowers in line with light dependent resistors *LDR*1 through *LDR*3 mounted at the base of the arrangement. When an LDR is illuminated, its resistance is relatively low, on the order of a few hundred ohms. But when the LDR is placed in the dark or shade, its resistance goes up to a megohm or more. This in-



Light dependent resistors are energized by light from three lamps hidden among the flowers.

PARTS LIST

C1—2000- μ F, 15-volt capacitor
 D1,D2,D3—Germanium diode (IN56A, HEP R9134, or similar)
 D4,D5—Silicon Diode (IN692, HEP R0052, or similar)
 11,12,13—#222 lensed incandescent lamp
 I4—NE-2 neon lamp
 K1—6-volt dc relay, 15-A contacts (Lafayette 30 27042 or similar)
 LDR1—LDR3—Hobby-type photocell (Radio Shack No. 276-116 or similar)
 Q1-Q6—Silicon pnp transistor (2N3703, HEP S0019, or similar)
 PL1—Octal plug
 All resistors $\frac{1}{2}$ W, 10%
 R1,R2,R3—10-ohm resistor
 R4,R5,R6,R11—1000-ohm resistor
 R7,R8—1500-ohm resistor
 R9—620-ohm resistor
 R10—5600-ohm resistor
 R12—67,000-ohm resistor
 S1,S2—Spst toggle switches, 125-V, 3A
 S3—4-pole, 3-position, non-shorting rotary switch
 SO1—Octal socket
 SO2—Three-conductor power receptacle
 T1—12.6-volt center-tapped 1-A filament transformer
 Misc.—Power cord; perforated board; metal utility box (5" x 4" x 3" or 12.7 cm x 10.2 cm x 7.6 cm); fuse holder; green stranded hookup wire; solder; press-on heat sinks; sheet aluminum wire; plastic flowers and leaves; silicone cement; vinyl tape; florist's crepe green stem tape; florist's wire; terminal strips; machine hardware; solder; etc.

crease in resistance is used to turn transistors on and off to control appliance power.

Three combinations of two illuminated LDR's and one shaded LDR are afforded by switch S1. With switch S1 (the "Flower Selector" on the front panel) in position 1, shading LDR1 and LDR2 but not LDR3 causes Q1 and Q2 to cut off, leaving only Q3 conducting. Thus, the outputs (V_{ce}) of Q1 and Q2 are high. They are combined by diode AND gate D1/D2 to produce a high input to the base of Q4. This transistor saturates, and its V_{ce} goes low, cutting off Q5. In turn, V_{ce} of Q6 is high, and Q6 energizes K1.

One set of the relay's contacts is wired across Q6 through Q3. Since LDR3 permits base current to flow, Q3 saturates, keeping the bottom of K1's coil at ground potential regardless of Q6's state. Only by shading LDR3 will the relay drop out, since Q3 will cut off current through K1's coil. Diode D3 protects the switching transistors from the coil's inductive "kick".

The other set of K1's contacts apply line voltage across power socket SO2 when they close. Fuse F1 should be chosen to fit the peak current demand, while neon lamp I4 monitors the voltage on the fused side of the ac line.

The switching and lighting circuits

derive their power from a supply consisting of T_1 , and the full-wave rectifier/filter circuit made up of D_4 , D_5 , and C_1 . When only night light or TV light operation is desired, ac power switch S_3 should be closed and dc switch S_2 left open.

As mentioned earlier, three combinations are possible. Two LDR's, when momentarily shaded, turn the appliance on, while the remaining one cuts off Q_3 when its surface is shaded. This deenergizes K_1 and removes line voltage from S_2 , turning the appliance off. The proper grouping for positions of FLOWER SELECTOR switch S_1 follow:

S1	FLOWER 1	FLOWER 2	FLOWER 3
1	ON	ON	OFF
2	ON	OFF	ON
3	OFF	ON	ON

That is, shading the LDR's below flowers 1 and 2 will turn the appliance on when S_1 is set to position 1. Shading the LDR below flower 3 will turn it off. The two other positions dictate similar patterns — but note that both on LDR's must be shaded simultaneously. Another safety feature is the protection given the appliance from power surges after a power failure.

If the project is supplying ac line current to an appliance when power fails, it keeps the load isolated from the line even after power has returned. In such a case it will be necessary to go through the correct shading procedure to restore power to the appliance.

Construction. Flower Power is composed of two units — the power board and the flower assembly. Most of the components are mounted on the power board. Only the switches, LDR's and lamps are off the board.

Since the circuit is relatively simple, it can be wired on a piece of perforated board. For safety purposes, the board should be mounted inside a metal utility box. The box can be concealed inside a clay flower pot for a more aesthetic appearance. Mount two sockets on the utility box. Octal socket S_01 provides dc power for the LDR's and ac power for I_1 , I_2 , and I_3 . Socket S_02 is a standard three-conductor power receptacle, into which the appliance should be plugged.

You will probably find that Q_3 and/or Q_6 get a bit hot in continuous operation. If desired, use press-on heat sinks. Allow clearance when mounting the board in a metal box for

the leads from F_1 , T_1 , and the neon bulb I_4 .

Form three support flanges from sheet aluminum about 10" (25.4 cm) long to begin the flower assembly. Drill a $\frac{1}{4}$ " (6.35 mm) hole at the straight end of each flange, and form a y-shaped base by securing the flanges with machine hardware. Also bolt three lengths of aluminum wire, such as used for clothesline to this point. Mount a cluster of plastic leaves on each flange and cement an LDR (avoid shorts) to the center of each cluster. Then remove the wire stem from each of three plastic flowers and slide the piece onto the aluminum wires to form a three-flower arrangement.

Solder a 36" (1-m) length of green stranded hookup wire to each contact of three #222 lensed lamps and LDR's. Then, with a small bead of silicone cement, mount a lamp at the bottom center of each flower. Wrap a layer of vinyl tape around the base of each lamp and LDR lead.

Next, route the wire pairs along the stems, wrapping them securely with florist's crepe stem tape (green) to the stems. Tie all wires into a neat bundle at the base of the arrangement. Cut the free ends of the wire bundle flush and prepare for soldering. Identify the leads using an ohmmeter across the LDR's and a 6-volt battery across the lamps and connect and solder the appropriate leads to an octal plug (PL_1). Be sure to secure the bundle every few inches with florist's wire. Finally, bend the stems so the lamps are directly over and about 2" to 5" (5.1 to 12.7 cm) above the LDR's.

Testing. Double check all wiring and physical assembly. If everything looks OK, insert PL_1 into S_01 and turn on ac power switch S_3 . All lamps including I_4 should glow. Follow this by closing dc power switch S_2 , and place FLOWER SELECTOR switch S_1 in position 1. Shade LDR_1 and LDR_2 — you should hear the relay click as it latches on. Then shade LDR_3 — you should hear another click as the relay deenergizes.

Now, plug a lamp into power receptacle S_02 . Repeat the shading procedure. The lamp should turn on and off in step with the relay. Open S_2 and check each of the three combinations. As a rule, open S_2 before changing the combination or opening S_3 (when turning the system off) and close S_3 before S_2 when activating the system. And remember — please don't water the flowers! ♦

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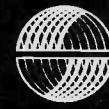


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DX PROGRAMS AND DX CLUBS ON SHORTWAVE

BY RICHARD E. WOOD

If you're a shortwave listener, perhaps you're a member of a local, national or international DX club which sends you a magazine or club bulletin once a month or better. The volunteer clubs are fine sources of information, ideal places to exchange reception tips and get to know other SWL's.

There's another type of club, however, which is also a useful source of timely information on the fast-changing shortwave broadcast bands. This is the DX club organized by a shortwave broadcast station. Many other stations, though they don't have clubs, do broadcast regular DX programs. In fact, only a few stations beaming daily to North America don't have any kind of club or DX program. (Radios Peking and Tirana and RAE Buenos Aires are three of the latter.)

Why should a big international broadcaster organize a club, and even transmit news about other stations with whose ideology it may disagree? Probably in order to try to catch that elusive character, the DX station hunter, and turn him into a regular listener. One way to do this is by offering DX tips. Another way is by challenging him to hear and report the same station several different ways. Radio RSA, Johannesburg, for instance, offers prizes for reporting reception in every shortwave band it is using. The

BBC World Radio Club occasionally challenges members to hear all its SW transmitting sites—rather an easy task, in most parts of the U.S.

Let's look at the twenty best DX and club programs that you can hear in English, and what they have to offer. We'll take them in rough order of popularity and usefulness as seen from here, though tastes may differ. Remember that times are in GMT, but dates refer to your local date; the GMT date will be the next day, from 0000 to 0600. The times are approximate. Except for one airing from Radio Nederland Bonaire, and the show from Budapest, the DX program is never the first item in a transmission, but follows the news and/or other features. So tune in a few minutes early, and watch for reshuffles and possible changes of date and time. Frequencies are for summer 1976. For changes in September, consult the regular listings of English-Language Shortwave Broadcasts to North America in *POPULAR ELECTRONICS* for that month.

1. "DX Juke Box," Radio Nederland. Dick Speekman is the host for this lively Thursday show. Its varied contents and bright musical items give it its "Juke Box" format. In between the records you'll find both DX tips and technical info, with an average of five minutes of straight DX tips



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CIRCLE NO. 48 ON FREE INFORMATION CARD

taped by experienced, competent DX'ers in four continents: North America (U.S.A.), Europe (Sweden), the Pacific (New Zealand) and Asia (Sri Lanka). The New Zealand contributor is the well-known blind DX'er Arthur Cushing, and the tips are the same as those on his "DX World" show heard a month earlier direct over Radio New Zealand. Much of the news from the four is taken from recent top loggings by active DX club members in their continent, and credited to them by name. Dictation-speed reading of frequencies makes it easy to make notes which can then lead to useful "catches." The DX Juke Box also commissions staff members and others to write and record valuable technical courses for study by listeners, with scripts or study guides often available free from Hilversum. Topics covered from season to season include propagation and the radio spectrum, transistor technology, DX'ing techniques and similar topics. The Juke Box is a pleasant, professional program with something for every listener.

THURSDAYS

Time, GMT	Freq., MHz
0645-0720	11.73 (via Bonaire)
0815-0850	9.715 (via Bonaire)
2015-2050	11.73 (via Talata)
2145-2220	9.715, 11.73
0215-0250	6.165 (via Bonaire)
0500-0535	6.165, 9.715 (via Bonaire)

2. "Sweden Calling DX-ers," Radio Sweden. Arne Skoog is the founder of this long-running show, whose 1361st issue was on the air as this was written. Arne himself compiles many of the programs; others are handled by experienced DX'er Bengt Dalhammar. Every two weeks, Radio Sweden generously airmails a transcript of the tips selected for broadcast. Single issues are sent to contributors of tips used, while DX editors, DX clubs and regular contributors receive bulletins by mail regularly. It is doubly useful to those who receive it because Radio Sweden's reception in North America at the convenient evening listening hours is often poor and the transcript contains tips not broadcast on the air in English, but only in other language editions such as Spanish or Russian. A word of caution: Arne believes in DX democracy, and often carries tips from beginners, those without accurate frequency calibration or those unable to distinguish Spanish from Portuguese. It's still a useful

show, 90 percent tips, the rest club news such as club-organized station popularity polls.

TUESDAYS

Time, GMT	Freq., MHz
1248-1258	15.305
1418-1428	15.305
2318-2328	6.035, 9.605, 11.705 (subject to change)
0248-0258	9.695, 11.705

3. "World Radio Club," BBC.

Here we come to the first DX program in our list which adopts the club format. The club issues membership cards, but there are no obligations or qualifications. The atmosphere is chatty, sociable and far from highbrow. As for the contents, let's quote from the BBC's magazine, *London Calling*: "Information for shortwave enthusiasts in language acceptable also for the non-technically minded. Membership is open to all who write to World Radio Club, BBC World Service, Bush House, London." Like *DX Juke Box*, but unlike *Sweden Calling*, the Club program has a mixed bag of contents, with a few DX tips (often meaty ones, mostly from the BBC Monitoring Service at Caversham Park), and technical questions answered in very elementary language mostly by the BBC's mellow-voiced chief engineer, Henry Hatch. He generally selects the type of question asked by beginners. A recent example: "Why do I hear the same BBC program on 15.07 and 15.26 MHz but with a few seconds' discrepancy in time of arrival of each, so that, if I switch quickly between the two frequencies, I hear the same words or musical notes over again?" Henry's answer to that one, by the way, was that, while 15.07 comes direct from England, 15.26 is the Ascension Island relay. Programs of music and other non-urgent material are shipped by air from the London studios to Ascension, to be played at pre-designated times, theoretically synchronized with the London studio. But human lapses and technical factors (different lengths of tape leader, for example) can cause less-than-perfect synchronization, hence the double broadcast effect.

WEDNESDAYS

Time, GMT	Freq., MHz
1330-1345	9.74, 11.75 (via Tebrau), 12.095, 15.07 15.40 (via Ascension), 17.79
2315-2330	5.975, 6.175 (via Sackville), 7.325, 9.41 9.51 (via

Sackville), 9.58 (via Ascension), 11.75, 11.78, 15.07, 15.26

FRIDAYS

2100-2115	9.41, 9.58 (via Ascension), 11.75, 12.095, 15.07, 15.26
-----------	--

SUNDAYS

0815-0830	9.60 (via Ascension), 9.64, 11.86 (via Ascension), 11.955, 15.07, 15.40 (via Ascension)
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4. "Swiss Shortwave Merry-Go-Round," SBC.

"The Two Bobs," Bob Thomann and Bob Zanotti, are the hosts. They are amateurs, and this is the first show in our list with mostly ham tips: ARRL competitions, DX'peditions, and rare countries now active. They play a tape each time with a "mysterious signal," and identify it, helping all-band listeners identify telemetry, LORAN, jamming, SSB, numbers stations, and other transmission modes. They answer technical questions, but not being broadcast DX'ers they simply do not know the SWBC bands and therefore may give misleading or wrong answers to questions. For instance, they recently gave an inquiring listener the schedule and name information on the "ORTF," Paris, oblivious to the fact that the station and the broadcast which they cited no longer exist. Unlike some DX programs which tend to be bland, the Two Bobs are firm in their views and pull no punches in their comments on such practices as DX'ing for country totals rather than program content.

2nd & 4th SATURDAYS

Time, GMT	Freq., MHz
1322-1345	15.14
2107-2130	9.59, 11.72, 11.87 15.305
0152-0215	5.965, 6.135, 9.725, 11.715
0437-0500	9.725, 11.715

5. "DX-ers Calling" and "Club Forum," Radio Australia.

The oldest DX program today dates from 1946. Like "DX Juke Box," it has alternating compilers of DX tips, from the west, south and east coasts of Australia. Like "Sweden Calling," it dictates DX tips clearly, giving the name and location of reporters. Some tips are fresh and original; others are taken from published sources, hence not so timely.

SATURDAYS

Time, GMT	Freq., MHz
2130-2140	11.84, 11.93, 15.16

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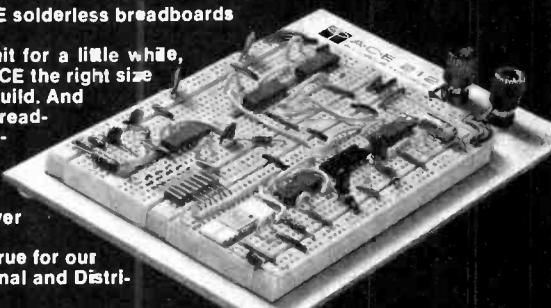
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"Club Forum" is the program of the Radio Australia Listeners' Club. To qualify for membership, you must send in twelve numbered reception reports at a rate of two per month over a period of six months. Members get a kangaroo lapel badge and membership certificate. Send to Listeners' Club, Radio Australia, Melbourne 3000, Australia; or to 1270 Ave. of the Americas, Suite 2708, New York, NY 10020. The "Forum" discusses club activities, welcomes new members, discusses the writing of reception reports, and generally provides a social hour for the members scattered around the world.

SATURDAYS

Time, GMT	Freq., MHz
0830-0845	9.57, 15.27
1200-1215	9.58
1230-1245	5.995, 6.005, 9.77, 11.81
1645-1700	9.77, 11.81
0215-0230	15.32, 17.795

6. "DX Corner," Radio RSA. Gerry Wood of Capetown is the presenter of this recently expanded show, now with two different editions weekly. Unlike the other DX programs offered more than once a week, "DX Corner" is written and presented with two distinct audiences in mind. The Saturday show is for the advanced DX'er, and the Wednesday offering is for the beginner and general listener. It's a little like "DX Juke Box:" there are regular courses on basic topics like shortwave receiver selection. DX tips emphasize stations in Africa, and there are spotlights on particular African stations. Like BBC's "World Radio Club," Radio RSA often talks about its own transmitting facilities at the H.F. Verwoerd station, now under expansion.

WEDNESDAYS & SATURDAYS

Time, GMT	Freq., MHz
1635-1645	11.90, 15.175
2135-2145	5.98, 7.27, 11.90
2305-2315	5.98, 9.585, 9.695, 11.90

7. "DX Party Line," HCJB Quito.

Clayton Howard, the host, is sometimes joined by his wife Helen for three different slow-paced, rather rambling half-hours. The "Party Line" is just the opposite of the rapid-fire tips programs from Sweden, Australia and Japan. Clayton takes his time, mander-

ing through tips, Andean folk music, letters from listeners, taped interval signals, complete articles read out from DX papers, and "Tips for Real Living," a series of evangelical spots intermingled with the DX. The American Short Wave Listeners' Club is the main source of the tips, but HCJB has its own DX club, ANDEX, similar to those described above. Write to ANDEX, c/o HCJB, Box 691, Quito Ecuador. The editor of another club bulletin, John Trautschold, tapes a weekly report. Despite the three weekly editions, the "Party Line" is not particularly timely in its reporting. Some listeners will like its folksy atmosphere, others may be turned off by its slow pace, lack of original material, or mixture of religion and music with the DX. Reception quality is great, though.

MONDAYS

Time, GMT	Freq., MHz
0930-1000	6.13, 9.745
1930-2000	15.30, 17.73, 17.855
0230-0300	6.095, 9.56, 11.915

WEDNESDAYS

Time, GMT	Freq., MHz
0230-0300	6.095, 9.56, 11.915

THURSDAYS

Time, GMT	Freq., MHz
0930-1000	6.13, 9.745
1930-2000	15.30, 17.73, 17.855

SATURDAYS

Time, GMT	Freq., MHz
0930-1000	6.13, 9.745
1930-2000	15.30, 17.73, 17.855

never have heard this DX show, yet it is a good one, and audible in the U.S., except the West. Reason for its lack of fame here is that it is not broadcast to this continent, and that its schedule and single frequency are subject to change without notice. Like HCJB, Adventist World Radio, also known as the Voice of Hope, is a religious broadcaster. The show is prepared by British DX'ers, mostly from the World DX Club. All tips are original, not quoted from other programs or bulletins. It is transmitted over both stations from which AWR leases time in southern Europe. Better reception here is from the Malta transmitter, which is used later in the day for broadcasts to North America by Deutsche Welle.

SATURDAYS

Time, GMT	Freq., MHz
2020-2045	6.035 (subject to change, via Malta)

SUNDAYS

Time, GMT	Freq., MHz
0935-1000	9.67 (via Sines, Portugal)

10. "Calling DX-ers & Radio Amateurs," Radio Budapest.

Another club program, this show carries reports from members of the Radio Budapest Shortwave Club (write simply to Radio Budapest, Hungary). As a so-called "liberal" communist country in its internal policies, Hungary does not shrink from broadcasting news of western stations, even from countries like Spain or South Africa, or from the Vatican Radio or HCJB. But the quality of hobbyist tips varies. Some are outdated, others seem dubious. At times there are letter sessions, and at others, amateur tips, as the title implies.

TUESDAYS & FRIDAYS

Time, GMT	Freq., MHz
0400-0415	6.00, 6.115, 9.585, 11.91, 15.22

11. "For the DX-ers" & "DX News," Voice of Turkey. Since Ankara extended its English transmission time last year it has had, like HCJB, a good deal of broadcast time to fill with, among other things, DX information. The idea of a daily DX program is a good one, but a challenge, of course, to obtain fresh timely material in sufficient quantity. Though Voice of Turkey tries, it does not really succeed in using the weekday five minutes valuably. Likewise, the longer Saturday show simply doesn't have the sources for good, original mate-

rial, and keeps on repeating the same information, on domestic stations in Turkey, VoT QSL cards and the like. Like HCJB and others, it uses the DX show as a mailbag, reading out letters and reception reports. Ankara's show is not specifically beamed to the U.S., but reception is often good here.

MONDAYS THRU FRIDAYS

Time, GMT	Freq., MHz
2230-2235	9.515, 11.88
	SATURDAYS
2215-2235	9.515, 11.88

12. "Calling All Listeners," IBA.

Not a full-fledged DX program, but a mixture of listeners' mailbag and features on radio-related topics. Recent programs have covered such areas as IBA frequency selection and why the frequency of 11.645 MHz, received by a listener in Texas during the 2000 GMT English show in the summer, is not even used in winter; interviews with personnel from Galei Tsahal, the Israel Defense Forces' station whose one-kilowatt transmitter on 2.442 MHz is an exceedingly difficult catch for North American SWL's; a talk about the Israeli manufacture of television receivers, and so on. Announcer Ben Dalfen is a professional who uses his five minutes to the full. It's interesting, but there are no DX tips.

SUNDAYS

Time, GMT	Freq., MHz
2250-2255	7.412, 9.82, 11.645, 12.025

13. "DX Program," Radio Moscow.

Moscow prefers to concentrate on amateur tips and short technical talks. Of course, even a listing of timely tips for Soviet domestic shortwave transmitters would be welcomed by the many U.S. SWL's who have chosen the challenging area of Soviet Union DX'ing as their specialty. They would all love to have authoritative information from Moscow on the identity of the Soviet transmitter sites in use and how to get QSL's for each of them; but that, too, is the last thing to expect on the "DX Program." Don't even hold your breath waiting for Radio Moscow to list its frequencies for the North American Service without truncating the last digit, rendering 9.685 MHz as "9.68."

THURSDAYS

Time, GMT	Freq., MHz
2320-2330	5.905, 7.10, 7.11, 7.33, 9.635, 9.665, 9.685, 11.72, 11.75, 11.87, 12.00, 12.05,

	15.21, 15.245, 17.72, 17.76, 17.90
0320-0330	5.905, 7.33, 9.53, 9.665, 9.685, 9.70 (via Sofia)
0350-0400	6.02, 9.635, 11.96, 12.05, 15.13, 15.18, 15.21, 15.245, 17.72
0520-0530	6.02, 9.635, 9.71, 11.96, 12.05, 15.10, 15.13, 15.18, 15.21

14. "Finn DX," Radio Finland.

Presented by the Friendly DX Club, "Finn DX" is produced by several experienced DX'ers, including Jyrki K. Talvitie, translator of this writer's book *Short Wave Voices of the World*, into its Finnish version. It is a lively mixed bag of station news, features, talks on DX techniques and propagation, reports on DX'peditions to remote receiving locations and remote stations, and straight DX tips. Drawbacks are at times rather heavily accented English and reception is variable (often poor in winter). There is interesting material on European commercial pirate and "hobby pirate" stations and on trans-polar reception of North American domestic AM stations in northern Scandinavia.

TUESDAYS

Time, GMT	Freq., MHz
1413-1428	15.185 (alternate 15.11)
2313-2328	15.185

15. "DX Program," Radio Prague. Like the other communist stations, except Budapest, listening to foreign stations today makes Prague jittery; so you'll hear mostly amateur material and features on the Czechoslovak Radio's domestic services.

THURSDAYS

Time, GMT	Freq., MHz
0140-0150	5.93, 7.345, 9.54, 9.74, 11.99
0340-0350	5.93, 7.345, 9.54, 9.74, 11.99

16. "DX Special," Trans-World Radio, Bonaire. Al Stewart's TWR show resembles Clayton Howard's from HCJB in its mixture of DX and evangelism. Its items about DX clubs and tips are of varying degrees of difficulty. Best feature is the language identification quiz. Also broadcast from TWR Monaco.

WEDNESDAYS

Time, GMT	Freq., MHz
0045-0100	11.925
1207-1222	11.815

17. "DX Program," Radio Bucharest. DX tips mostly from Rumanian listeners, and rather routine loggings. Combined with technical questions from listeners, it's rather dull listening. Reception tends to be poor in the West, especially in winter. Some frequencies in use are never readable, so only the better bets are listed.

WEDNESDAYS

Time, GMT	Freq., MHz
0215-0227	5.99, 6.19, 9.57, 11.94
0415-0427	5.99, 6.19, 9.57, 11.94

18. "DX Program," Radio Sofia.

Compiled by the national amateur radio club of Bulgaria, this show gives details of contests, rare DX amateurs active, etc. Dull presentation, little for the SWL.

FRIDAYS

Time, GMT	Freq., MHz
0015-0025	9.70
0415-0435	9.70

19. "DX-er Report," KDWN Las Vegas, NV.

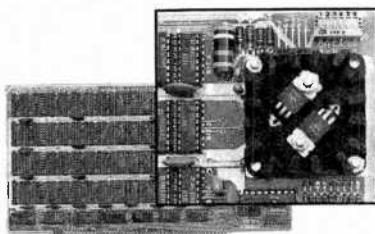
This 50-kW clear-channel station, which is not shortwave, spreads the DX hobby in the West and Southwest through a one-and-a-half-minute to two-minute spot. It is presented as a public service and compiled by members of the International Radio Club of America, the well-known medium-wave-only club. It naturally presents tips mostly on stations on the AM band and is intended as an introduction to the hobby for the many clear-channel listeners who have never heard of DX'ing. So it mixes general medium-wave news with interesting tips, particularly on easy foreign MW catches from western listening locations. Don't look for KDWN in the East or Great Lakes area. It has to put a deep null in its signal in the direction of the senior station on 720, WGN Chicago.

WEDNESDAYS

Time, GMT	Freq., MHz
0445-0447	(during Daylight Savings)
0545-0547	(in winter)
	0.72

20. Other DX Programs. The following stations carry DX programs, but they are either not regularly audible in North America or do not contain much of interest: Deutsche Welle, Radio Japan, Radio Kiev, FEBA Seychelles, ÖRF Austria, Radio Korea, Seoul, Sri Lanka B.C., Swazi Music Radio, and Radio Tashkent.

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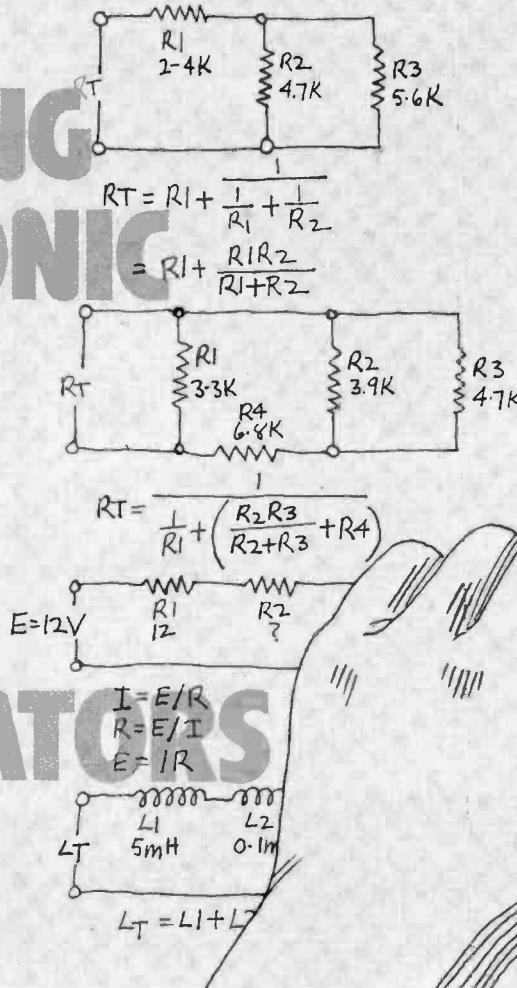


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LEARNING ELECTRONIC THEORY WITH HAND CALCULATORS

BY EDWARD M. NOLL



PART TWO: Reactance, Time Constants, and AC Calculations

IN THIS second installment on using the hand-held scientific calculator to learn electronics, we cover reactance, RC time-constants, and phasor calculations. As you will soon see, it is in the realm of ac mathematics that the scientific calculator is especially useful. Calculations involve finding squares and square roots of numbers. The numbers used in calculations are often very small, in the micro (10^{-6}) and pico (10^{-12}) ranges; while frequencies are in the megahertz (10^6) range. Right-triangle and phase calculations involve voltages, currents, and impedances in ac circuits.

Calculating Reactance. Simply defined, reactance (impedance) is the opposition an inductor (coil, transformer, etc.) or capacitor has to the flow of ac charges. It is expressed in ohms. Reactance is similar to the op-

position to the flow of current presented by a resistor in a dc circuit but is considerably more complex in nature.

Inductive reactance can be calculated from the equation $X_L = 2\pi fL$, where f is the frequency in hertz and L is the inductive value in henrys. Using this equation, what is the reactance of a 20-H choke at 60 Hz? Your keyboard entries for solving this problem would be:

$2 \times \pi \times 60 \times 20 =$
Display: 7539.82237

After rounding off, the answer would be approximately 7540 ohms.

Now, what is the inductive reactance of a 12- μ H coil at 4 MHz? The solution is:

$2 \times \pi \times 4 \text{ EE } 6 \times 12 \text{ EE } +/-$
 $6 =$ Display: 301.5928948

After rounding off, the answer would be 302 ohms.

To calculate capacitive reactance,

you use the formula $X_C = 1/(2\pi fC)$. Again, f is frequency in hertz, while C is capacitance in farads. Now, what is the reactance of an 8- μ F capacitor at 60 Hz?

$2 \times \pi \times 60 \times 8 \text{ EE } +/-$
 $6 = 1/x$ Display: 331.572798

The answer is roughly 332 ohms.

What is the reactance of a 100-pF capacitor at 4 MHz? The key sequence for solution of this problem is:

$2 \times \pi \times 4 \text{ EE } 6 \times 100 \text{ EE }$
 $+/- 12 = 1/x$
Display: 397.8873577

Rounded off, the answer is 398 ohms.

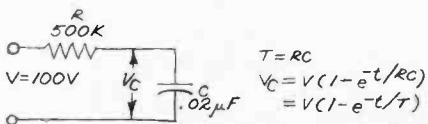


Fig. 1.

RC Time Constant. The time constant of a circuit is the product of resistance and capacitance and is expressed as $T = RC$, where T is in seconds, R is in ohms, and C is in farads. Therefore, if you wish to know the time constant for the component values shown in the Fig. 1, your keyboard entries would be:

$$5 \text{ EE } 5 \times .02 \text{ EE } +/- 6 =$$

Display: 0.01 (second)

The answer can also be expressed as 10 ms (milliseconds).

The instantaneous voltage across a capacitor is an exponential related to the base e (2.718281828 obtained by operating the e^x key twice). The formula $V_c = V(1 - e^{-t/RC})$ is used for determining the voltage across a capacitor at any given time after power is initially applied to the circuit. Therefore to determine the voltage across the capacitor in Fig. 1 50 ms (0.05 second) after power is applied, the keyboard sequence would be:

$$100 \times [1 - (+/- .05 \div 5$$

$$\text{EE } 5 \div .02 \text{ EE } +/- 6) e^x]$$

= Display: 99.3262053

Note however that if you already know the time constant, you can simplify keyboard entry using the formula $V_c = V(1 - e^{-t/T})$:

$$100 \times [1 - (+/- .05 \div .01$$

$$$$

In both cases, you obtain the same answer—about 99.3 volts.

If time constant T and time period t for the Fig. 1 circuit were both 0.01 second, $-t/RC = -0.1/0.1 = -1$. Using -1 as the exponent of e , we get:

$$100 - (100 \times +/- 1 e^x) =$$

Display: 63.2120559

This calculation verifies the rule that states that, in one time constant, a capacitor charges to 63.2% of the maximum voltage in the circuit.

Now, what is the voltage across the resistor when $-t/RC = -1$? Since $V = V_c + V_R$, $V_R = V - V_c$:

$$100 - 63.2120559 =$$

Display: 36.7879441

Hence, the voltage across the resistor at the end of one time period is approximately 36.8 volts.

Ac Time Constant. Time constant is important when sine waves are

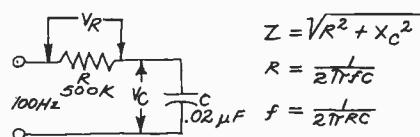


Fig. 2.

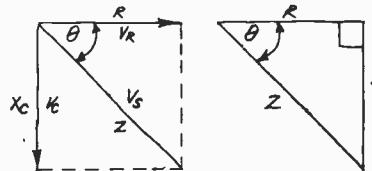


Fig. 3.

applied to resistor, capacitor, and inductor combinations. In the case of a sine wave, you cannot consider the voltage being applied as a constant as you do in dc circuits. Instead, the potential builds up gradually to peak amplitude. The reaction of the resistor-capacitor combination shown in Fig. 2 to the sine wave is a factor of frequency and the time constant of the network.

When the time constant is long compared to the period of the sine wave, the capacitor does not charge and discharge fully because the sine-wave variations are much faster than the time required to charge and discharge the capacitor by any appreciable amount. Consequently, the ac variations appear in their entirety across the resistor and not across the capacitor.

At low frequencies, where the sine-wave period is longer than the time constant, the capacitor does

same number system. Then continue to work the problem:

$$79.6 x^2 + 500 x^2 = \sqrt{x}$$

Display: 506.2965139

Hence, the circuit's impedance is roughly 506,300 ohms.

Now, at what frequency will $X_c = R$? The second equation in Fig. 2 allows us to derive the third equation, which is the one used for determining the frequency. Note that the denominator in the third equation contains the RC time-constant statement. Therefore:

$$2 \times \pi \times .01 = 1/x$$

Display: 15.9154943 (hertz)

If a 10-volt, 15.9-Hz signal is applied to the Fig. 2 circuit, how will the voltage divide? Inasmuch as reactance and resistance are basically the same, one might jump to the conclusion that 5 volts would appear across the resistor and 5 volts across the capacitor. This would be an incorrect assumption. Actually, 7.07 volts would appear across both elements. This does not

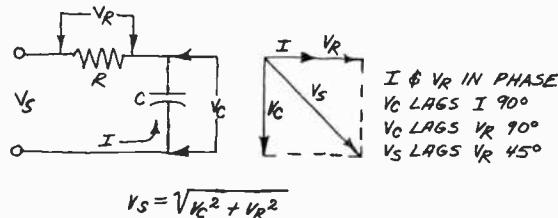


Fig. 4.

charge and discharge an appreciable amount. Therefore, there is likely to be a significant or even a great voltage variation across the capacitor, with a correspondingly lower variation across the resistor. To demonstrate this relationship, refer to Fig. 3. Note that capacitive reactance X_c lags resistance R by 90°. Therefore, the total impedance, Z , in the series RC circuit is a vector value somewhere between the resistive and reactive values. When you graph the values, a right triangle will result, with impedance Z becoming the hypotenuse.

To determine the impedance of the Fig. 2 circuit, use the first equation shown. Start by solving for X_c :

$$2 \times \pi \times 100 \times .02 \text{ EE } +/- -$$

$$6 = 1/x \text{ Display: } 79577.47151$$

Round off and convert the result to 79.6 k so that R and C are both in the

mean that the applied voltage is 14.14 volts because a vector relationship exists.

The angular relationship can be better understood by examining Fig. 4. The same current flows through both components. The voltage across the resistor is in-phase with the current, but the voltage across the capacitor lags the current by 90°. Therefore, the capacitor voltage lags the resistor voltage by 90°, which means that the resultant must fall between the two. To determine the value of applied voltage V_s , use the formula given in Fig. 4. So, assuming $V_c = V_R = 7.07$ volts:

$$7.07 x^2 + 7.07 x^2 = \sqrt{x}$$

Display: 9.998489885

This proves that with a source potential of 10 volts, the voltages across the resistor and capacitor are both 7.07 volts when $X_c = R$.

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The same phase relationships exist between resistance, impedance, and reactance as shown in Fig. 5. Again, the right triangle is the basis of the phasor. With this in mind, calculate the reactance of the capacitor in Fig. 2 when $f = 15.9$ Hz:

$$2 \times \pi \times 15.9 \times .02 \text{ EE } +/- 6 \\ = 1/x \quad \text{Display: } 500487.2423$$

Note that the answer, after rounding off, is very close to the 500,000-ohm value of the resistor. Assuming $R = X_C$ = 500 k, calculate Z:

$$500 x^2 + 500 x^2 = \sqrt{x}$$

Display: 707.1067811 (kilohms)

Ac Trigonometry. The modern hand-held scientific calculator permits the student of electronics to dispense with trigonometry tables when calculating angles. We find extensive use of sin, cos, and tan functions in ac vector calculations, as well as their arc functions (\sin^{-1} , \cos^{-1} , \tan^{-1}). The important relationships for the impedance vector are: $\sin \theta = X/Z$; $\cos \theta = R/Z$; and $\tan \theta = X/R$.

Knowing that reactance X_C is equal to resistance R , both being 500 kilohms, for the Fig. 2 circuit, $\tan \theta = X/R = 500 \text{ k}/500 \text{ k} = 1$. From this, we can calculate the phase angle, $\theta = \tan^{-1} 1$:

$$1 \tan^{-1} \quad \text{Display: } 45 \text{ (degrees)}$$

Once you know angle θ and resistance R , you can find the impedance from the formula $Z = R/\cos \theta$:

$$5 \text{ EE } 5 \div 45 \cos =$$

Display: 707106.7813 (ohms)

This proves that the impedance of the circuit is approximately 707,000 ohms and not the simple arithmetical summation of X and R .

The angle at which $X = R$ is 45° . For other frequencies and other reactance ratios, the same equations can be

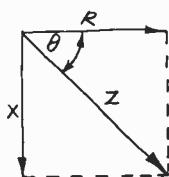


Fig. 5.

used. If any two quantities (X , R , Z) are known, angle θ can be calculated. The impedance can then be calculated. Likewise, when any two of the voltages are known, the third can be determined. A few examples will help to demonstrate these relationships in a series RC circuit.

First, in a series RC circuit that is to have an angle θ of 30° , X_C is 10,000

ohms. What resistor value is required? Using the formula $R = X_C/\tan \theta$, the calculator procedure would be:

$$10000 \div 30 \tan =$$

Display: 17320.50811 (ohms)

The answer is approximately 17,320 ohms.

Next, calculate the impedance of a series RC circuit when X_C is 2000 ohms and R is 4000 ohms. Using the formula $\theta = \tan^{-1}(X/R)$, we get:

$$2000 \div 4000 = \tan^{-1}$$

Display: 26.5650511

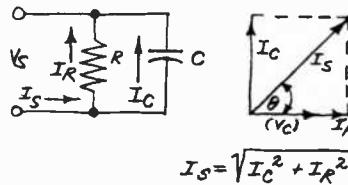


Fig. 6.

Then we find impedance using the formula $Z = R/\cos \theta$:

$$4000 \div 26.5650511 \cos =$$

Display: 4472.135954 (ohms)

Now, prove that the above answer is correct by using the impedance formula:

$$2000 x^2 + 4000 x^2 = \sqrt{x}$$

Display: 4472.135954

As you can see, the answer checks out down to the last decimal place.

Finally, in a series RC circuit, R is 150 kilohms and f is 12,000 Hz. At what value of C will X_C be 500 kilohms? Start by solving for angle θ using the formula $\theta = \cos^{-1}(R/Z)$:

$$150 \div 500 = \cos^{-1}$$

Display: 72.5423969

The tangent equation can then be used to determine the required reactance to obtain a 72.54° angle:

$$150 \times 72.5423969 \tan =$$

Display: 476.969601

The final step is to determine the value of C that will produce a 476.97-kilohm reactance at 12,000 Hz. Use the formula $X_C = 1/(2\pi fC)$:

$$2 \times \pi \times 12 \text{ EE } 3 \times 476.96901$$

$$\text{EE } 3 = 1/x$$

Display: 2.780659563 - 11

Hence, after rounding off the result, we know that the capacitor must have a value of 0.0278 μ F when used with a 150-kilohm resistor to provide the required impedance at 12,000 Hz.

Parallel RC Circuits. In a parallel resistor-capacitor circuit, the applied voltage appears across both elements. (In any parallel circuit, the same voltage appears across each

parallel leg.) The current, however, divides into separate components as a function of resistance and reactance. Likewise, the source current and the angle are related to the absolute and relative values of resistance and reactance.

In the resistive leg, the voltage and current are in-phase. Since source voltage V_s and capacitor voltage V_C are in parallel with resistor voltage V_R , they are in-phase with resistor current I_R as shown in Fig. 6. Capacitive current I_C must lead capacitor voltage V_C by 90° as shown. Therefore, in the parallel RC circuit, the source current must also lead resistor current.

The above relationship demonstrates that source current is not a simple summation of the resistor and capacitor currents. It is the vector sum:

$$I_s = \sqrt{I_R^2 + I_C^2}$$

Since the voltages across R and C are the same as the source, we can deal simply with impedances, so that

$$(I/Z)^2 = (I/R)^2 + (I/X_C)^2$$

$$\text{or } Z = RX_C / \sqrt{R^2 + X_C^2}$$

Impedance, therefore, is a product over sum relationship, much as is the case in which two resistors are connected in parallel. However, note that instead of a simple sum, a vector sum is required in the denominator.

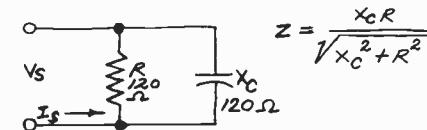


Fig. 7.

Calculate the impedance of the Fig. 7 circuit:

$$120 1/x x^2 + 120 1/x x^2 =$$

$\sqrt{1/x} \times 1/x$ Display: 84.85281381

$$\text{or } 120 \times 120 \div (120 x^2 + 120 x^2) \sqrt{x} = \text{Display: } 84.85281378$$

For all practical purposes, both answers are identical. Since R and X_C are equal, the calculations could have been simplified as follows:

$$120 1/x x^2 \times 2 = \sqrt{1/x} \times 1/x$$

$$\text{or } 120 x^2 \div (120 x^2 \times 2) \sqrt{x} =$$

$$\sqrt{x} =$$

Answers in all cases will be within six-digit accuracy.

What is the source current if the source potential is 24 volts in Fig. 7? From Ohm's Law, we know that $I_s = V_s/Z$. Therefore

$$24 \div 84.8528138 =$$

Display: 2.828427123 - 01

Translated, I_s is approximately equal to 283 mA.

A right triangle shows the vector relationship with angle θ between source current I_s and resistor current I_R , as in Fig. 6. The appropriate equations are: $\tan \theta = I_c/I_R = R/X_C$; $\cos \theta = I_R/I_s = Z/R$; and $\sin \theta = I_c/I_s = Z/X_C$. Now, using the $\tan \theta$ formula, determine angle θ for the Fig. 7 circuit:

$$120 \div 120 = \tan^{-1} \text{ Display: } 45$$

Again, as in the series RC circuit, $= 45^\circ$ when $X_C = R$.

Calculate I_c and I_R for the Fig. 7 circuit. Use the $\sin \theta$ and $\cos \theta$ formulas

$$I_c = I_s \sin \theta:$$

$$.282842712 \times 45 \sin =$$

$$\text{Display: } 1.999999993 -01$$

$$\text{and } I_R = I_s \cos \theta:$$

$$.282842712 \times 45 \cos =$$

$$\text{Display: } 1.999999996 -01$$

Now find the vector sum of I_c and I_R :

$$.19999999 x^2 + .19999999 x^2$$

$$= \sqrt{x} \text{ Display: } .282842711$$

When X_C and R are not equal, the current in the circuit divides in accordance with the ohmic values of the reactance and resistance. With this in mind, calculate Z and I_s for the Fig. 8 circuit:

$$100 x^2 1/x + 10 x^2 1/x =$$

$$\sqrt{x} 1/x \text{ Display: } 9.950371903$$

$$\text{or } 100 \times 10 \div (100 x^2 + 10$$

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

$$\text{Display: } 9.950371903$$

Source current I_s can then be calculated:

$$100 \div 9.950371903 =$$

$$\text{Display: } 10.04987562$$

Phase angle θ becomes:

$$100 \div 10 = \tan^{-1}$$

$$\text{Display: } 84.2894069$$

From the answer obtained, it is obvious that this circuit is highly capacitive, since angle θ is much greater

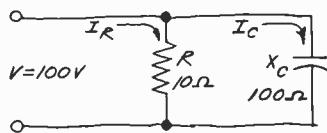


Fig. 8

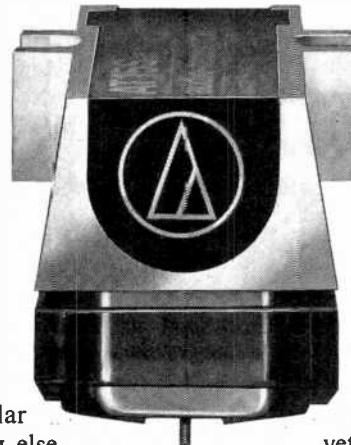
than 45° . Reactive current I_c is 10 times greater than resistive current I_R and source current I_s leads source voltage V_s by a substantial amount.

Coming Up. This ends the second part of our series on using the handheld scientific calculator for learning electronics. In the third and final part of the series, we will be covering frequency response and resonance, RC coupling, basic amplifier calculations, and RLC circuits. ◇

The phono cartridge that doesn't compromise any modern record.

AT15Sa

UNIVERSAL
BEST FOR 1/2/4 CHANNEL

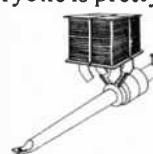


Choosing an AT15Sa can add more listening pleasure per dollar than almost anything else in your hi-fi system. First, because it is one of our UNIVERSAL phono cartridges. Ideally suited for every record of today: mono, stereo, matrix or discrete 4-channel. And look at what you get.

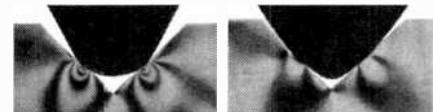
Uniform response from 5 to 45,000 Hz. Proof of audible performance is on an individually-run curve, packed with every cartridge.

Stereo separation is outstanding. Not only at 1 kHz (where everyone is pretty good) but also at 10 kHz and above (where others fail). It's a result of our exclusive Dual Magnet* design that uses an individual low-mass magnet for each side of the record groove. Logical, simple and very effective.

Now, add up the benefits of a genuine Shibata stylus. It's truly the stylus of the future, and a major improvement over any elliptical stylus. The AT15Sa can track the highest recorded frequencies with ease, works in



any good tone arm or player at reasonable settings (1-2 grams), yet sharply reduces record wear. Even compared to ellipticals tracking at a fraction of a gram. Your records will last longer, sound better.



Stress analysis photos show concentrated high pressure with elliptical stylus (left), reduced pressure, less groove distortion with Shibata stylus (right).

The AT15Sa even helps improve the sound of old, worn records. Because the Shibata stylus uses parts of the groove wall probably untouched by other elliptical or spherical styli. And the AT15Sa Shibata stylus is mounted on a thin-wall tapered tube, using a nude square-shank mounting. The result is less mass and greater precision than with common round-shank styli. It all adds up to lower distortion and smoother response. Differences you can hear on every record you play.

Don't choose a cartridge by name or price alone. Listen. With all kinds of records. Then choose. The AT15Sa UNIVERSAL Audio-Technica cartridge. Anything less is a compromise.

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Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

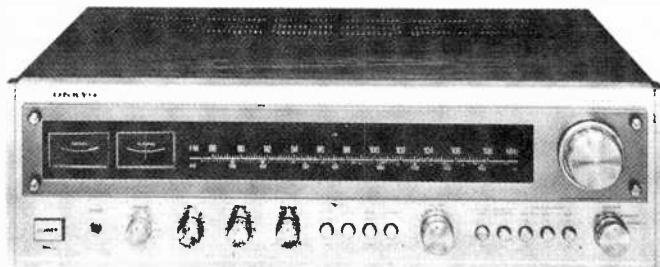
In addition to being an outstanding performer, Onkyo's Model TX-4500 AM/stereo FM receiver features a novel and highly efficient aid called "Quartz Lock Tuning." Combining some of the characteristics of AFC and synthesized tuning, though it is neither, the system makes it literally impossible to tune in any FM station incorrectly.

From Denmark comes Bang & Olufsen's Beogram Model 1900 record player that provides foolproof operation. A single control combines speed selection, record indexing, arm lift, and vernier speed adjustment functions. Technologically, the record player is notable for its extremely low-mass tonearm (the arm and pickup are integrated), which enhances the ability to play warped discs.

—Julian D. Hirsch

ONKYO MODEL TX-4500 AM/STEREO FM RECEIVER

Phase-locked loop reduces FM tuning error to zero.



The Onkyo Model TX-4500 "Quartz Locked" stereo receiver features a novel and highly effective tuning aid that makes it virtually impossible to incorrectly tune in an FM station. Unlike conventional automatic frequency control (AFC) that partially reduces tuning errors, the Quartz Lock is a phase-locked loop system that can reduce such errors to zero.

A 10.7-MHz crystal oscillator supplies the reference signal for the tuning system. The average i-f output from a received signal is compared to the reference signal, and any phase error produces a correcting voltage that "locks" the tuning to produce an i-f at exactly 10.7 MHz. The tuning knob is insulated from the panel and chassis. Touching it or even bringing a hand near it disables the PLL system

to permit conventional tuning. When a signal is within locking range, the legend **LOCKED** appears in red above the dial scales. (If the broadcast is in stereo, a **STEREO** legend also comes on in red.)

Releasing the tuning knob allows the PLL circuit to take over after about 0.7 second, solidly locking the receiver to the signal. When this happens, the **TUNED** legend appears in green over the dial scales.

The receiver measures a fairly large 21 1/4" W x 17" D x 6 1/2" H (54 x 43.2 x 16.5 cm) and weighs about 36.5 lb (16.6 kg). Price is \$450.

General Description. A pushbutton switch on the front panel of the receiver can be used to disable the Quartz Lock tuning system and interstation muting to permit tuning in very weak signals. Other pushbutton switches are assigned to the Low and

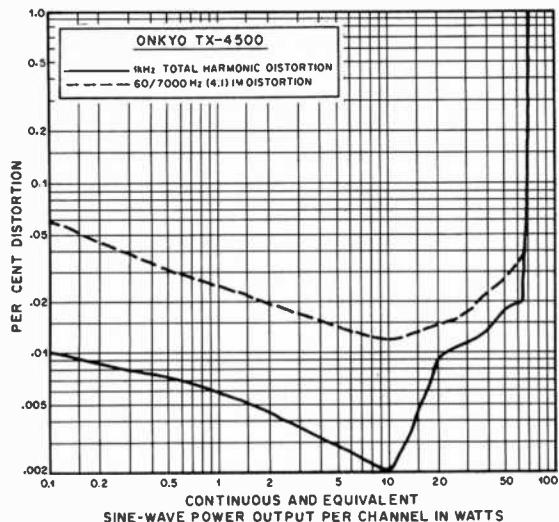
HIGH audio filters and LOUDNESS compensation. There are terminals on the rear of the receiver for connecting an external FM Dolby unit. The Dolby unit is inserted into the audio signal path by operating another pushbutton, simultaneously changing the FM deemphasis from 70 μ s to the 25 μ s required for proper Dolby operation.

The input **SELECTOR** has positions for AM, FM AUTO, PHONO 1, and PHONO 2. Its settings are keyed to corresponding illuminated legends above the dial scale. Unlike most receivers, this one has no AUX input dedicated to an external high-level program source. Instead, there are three tape recorder circuits, each of which is controlled by its own **MONITOR** pushbutton. One or two of these circuits can be used for AUX sources, leaving facilities for one or two tape decks. By pressing the appropriate buttons, it is possible to dub from recorder 1 to recorder 2 or 3 or from recorder 2 to recorder 3.

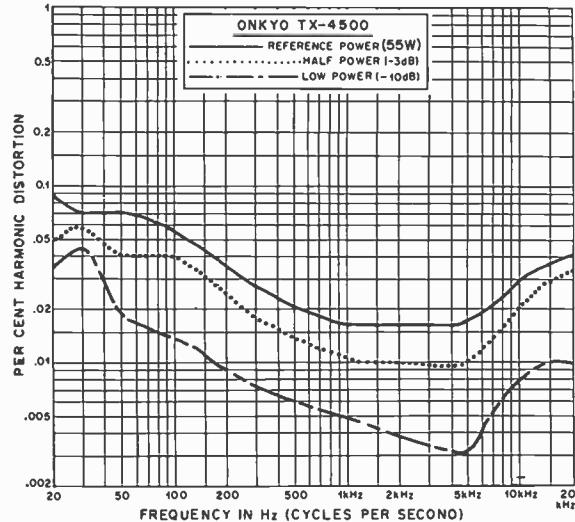
At the lower left of the control panel are a large **POWER** pushbutton and a headphone jack. All remaining controls are operated by turning knobs. They include a **SPEAKERS** selector that controls up to three pairs of speaker systems. Any pair or two combinations of two pairs of speaker systems can be activated. Alternatively, all speaker systems can be silenced for private headphone listening. The **BASS** and **TREBLE** tone controls each have 21 click-stop positions. The **BALANCE** control is center detented, and the **VOLUME** control has 41 click-stop positions.

Most of the upper half of the front panel is given over to the tuning dial scales and signal-strength and FM center-channel tuning meters. The dial area blacks out when power is turned off. It is clearly lit in white when power is on. The linear FM dial scale is unusually long, spanning 9" (about 23 cm), and has markings at 0.2-MHz intervals. To the right of the dial area is the large tuning knob that drives a very smooth flywheel mechanism.

On the rear apron of the receiver are separate preamplifier output and main amplifier input jacks that are normally joined together with removable jumper links. There is also a 4CH FM output ahead of the deemphasis circuits (for use with a future discrete demodulator) and a three-position slide switch that permits adjustment of the sensitivity of the Quartz Lock disabling circuit activated by the tuning knob. The antenna inputs permit



1 kHz total harmonic and 60/7000-Hz IM distortion (left). Harmonic distortion at 55 W, $\frac{1}{2}$ power, and low power (right). Noise and sensitivity curves for FM section are given below.



the use of either a 75- or a 300-ohm FM antenna and a separate wire-type AM antenna. There is also a hinged, but not pivoted, ferrite-rod AM antenna. The speaker terminals are insulated spring clips, and one of the three available accessory ac outlets is switched.

Laboratory Measurements. Following the standard FTC preconditioning period, the amplifiers delivered slightly greater than 70 watts/channel into 8 ohms at 1000 Hz before clipping occurred. Into 4 and 16 ohms, the measured power was 87.4 and 42.3 watts, respectively. At 1000 Hz, the THD was less than 0.01% between 0.1 and 30 watts and measured as low as 0.002% (the residual of our generator) at a 10-watt output. It increased gradually to about 0.11% at 70 watts, just before clipping. The IM distortion was between 0.01% and 0.02% at most power levels between 1 and 40 watts. It was only 0.43% at 70 watts. At very low power outputs, the IM rose slightly, to 0.4% at 2 mW.

At the rated 55 watts output into 8-ohm loads, the THD was less than

0.02% at middle audio frequencies. It rose to a mere 0.09% at 20 Hz and was 0.04% at 20,000 Hz, well within Onkyo's ratings. At lower power levels, the distortion was even less, typically between 0.002% and 0.01% at 5.5 watts output.

A phono input of 1.0 mV or a high-level input of 61 mV was required to drive the amplifier to a reference 10-watt output power level. Through either input, the unweighted noise level was 76 dB below 10 watts. Phono overload occurred at a high 225 mV.

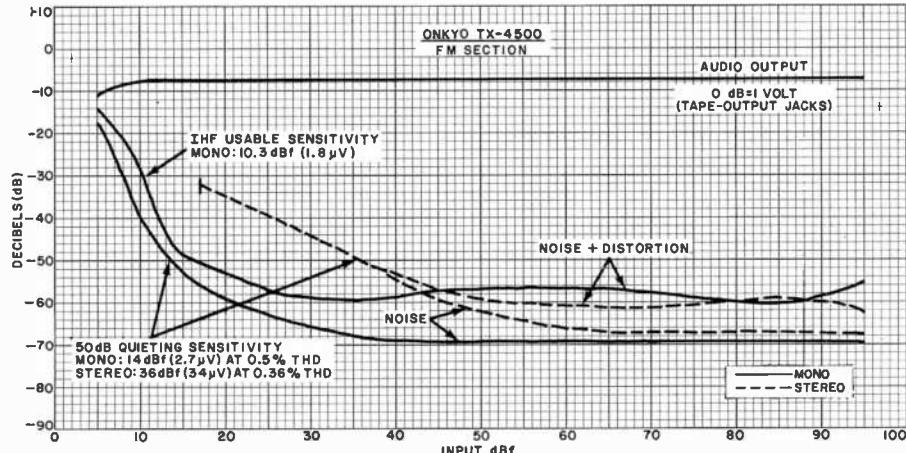
The tone controls had a moderate, but adequate, range of about +7 to -10 dB, with a sliding bass turnover frequency and a treble response hinged at about 3000 Hz. The filters had 6-dB/octave slopes, with -3-dB response frequencies of 45 and 9000 Hz. The loudness compensation boosted both low and high frequencies. Phono equalization was accurate to within ± 0.25 dB from 40 to 20,000 Hz and was virtually unaffected by cartridge inductance — less than 0.5 dB response change at any frequency when measured through high-inductance cartridge coils.

The performance of the FM tuner was equally impressive. The IHF usable sensitivity was as rated: 10.3 dBf (1.8 μ V) in mono. The stereo sensitivity was set by the automatic switching threshold of 3 to 4 μ V (about 16 dBf), which was also the muting threshold. For 50 dB of noise quieting in mono, a signal input of 14 dBf (2.7 μ V) was required, yielding a THD of 0.56%. In stereo, the 50-dB quieting sensitivity was 36 dBf (34 μ V), with 0.36% THD.

The ultimate S/N ratio at 65 dBf (1000 μ V) input was 69 dB in mono and 67 dB in stereo, with respective distortions of 0.15% and 0.09%. (A lower distortion in stereo than in mono, although not usual, does occur occasionally.) We also measured the stereo distortion at the three frequencies called for in the IHF tuner standards. At 100 Hz, it was 0.44%, at 1000 Hz, 0.05%, and at 6000 Hz, 0.14% (all measured with L - R modulation at 100%).

The FM tuner section had a frequency response flat within ± 1 dB from 30 to 14,500 Hz, with most of the deviation occurring between 2000 and 10,000 Hz. The channel separation was equally good, measuring better than 45 dB from 50 to 500 Hz and still an excellent 33.5 dB at 15,000 Hz. The capture ratio was about 1.8 dB, AM rejection was 58 dB, and image rejection was 74 dB. Alternate-channel selectivity was asymmetrical, measuring 65 dB above the signal frequency and 82 dB below it, for an average of 73.5 dB. Adjacent-channel selectivity was 6.4 dB on the average.

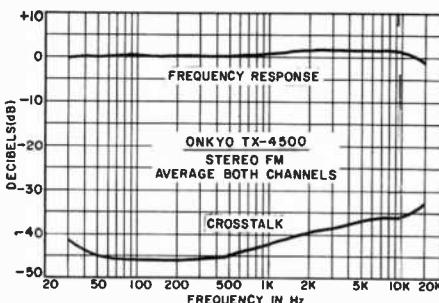
It should be noted that the selectivity measurements, as with all other measurements, were made with the Quartz Lock system disabled. With it in use, the effective selectivity is greatly increased, since the phase



locking prevents a stronger signal from breaking through or from "capturing" the receiver. Using the Quartz Lock system, the effective rejection of either adjacent or alternate channel signals was in excess of 80 dB. The 19-kHz pilot carrier leakage was 66 dB below full modulation.

The only measurement we performed on the AM tuner section was frequency response, which was typical of most AM tuners we have tested. The AM response was 6 dB down at 65 and 3000 Hz.

User Comment. The test data clearly reveals that the Model TX-4500 is a very good receiver in every respect. Although a few high-priced FM tuners may surpass it in some selectivity and distortion characteristics, the differences are trivial. There can be no doubt that the sound quality in FM reception with this receiver will be determined only by the quality of the broadcast program. As for the audio amplifiers, harmonic and intermodulation distortion measurements are in a class with highly regarded audio amplifiers.



Frequency response and crosstalk averaged for both channels in stereo FM of Onkyo TX-4500.

Although the Quartz Lock system might appear to be merely a super afc, it is actually much more than that. We verified that the tuning system invariably resulted in the lowest possible distortion and noise and the best stereo separation of which the receiver is capable. The automatic disabling system works so unobtrusively that one soon forgets it is there. Muting action is perfect, with total silence until the red LOCKED light comes on and the program is heard. Regardless of the reading of the tuning meter, which can be appreciably off center at the lock point, releasing the knob

brings it to dead center as the green TUNED light comes on. The "pull-in" range of the Quartz Lock system appears to be about ± 50 kHz. The dial is very accurately calibrated so that when the meter is centered, there is no doubt as to the channel to which the tuner is set.

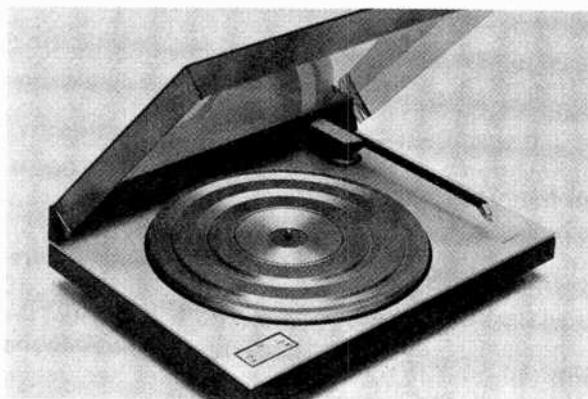
We noted that when playing records the sound had a definition and clarity that were unmistakable. To some extent, this might have been due to the maintenance of a true high-frequency response, instead of the couple of decibels of roll-off that often occurs above 10,000 Hz due to cartridge inductance interaction with the phono equalization. It has also been claimed that the exceptional dynamic range afforded by the receiver's high overload capability contributes to this result.

We did check the phono section with preequalized square waves, using a spectrum analyzer to detect any increase in the even harmonics in the output. We found no change in the spectral content of the square waves after they had passed through the phono preamplifier circuits.

CIRCLE NO. 80 ON FREE INFORMATION CARD

BANG & OLUFSEN BEOGRAM MODEL 1900 RECORD PLAYER

Integrated semiautomatic player handles beautifully.



HIRSCH-HOUCK LABS REPORT

The new Beogram Model 1900 record player, consists of a 33 1/3- and 45-rpm automatic single-play turntable and integrated tonearm/phono cartridge system. Beyond this, it has few similarities to its competitors. The conventionally pivoted tonearm has a rectangular, slim, magnesium alloy tube designed for high rigidity and low mass. The only phono cartridge it will accept is the B&O Model MMC4000, which is only a fraction of the size and

weight of most conventional cartridges (to maintain a very low arm/cartridge mass characteristic).

There is only one operating control, a flat plate that measures about 2 1/4" x 1" (57.2 x 25.4 mm). It is mounted flush with the surface of the motorboard and provides all of the operational functions.

The record player comes mounted in a handsome rosewood veneered wood base. A tinted plastic dust cover that hinges open at any angle up to a full 90° is standard equipment. The system measures 17 3/8" W x 13" D x

3 3/8" H (44.1 x 33 x 8.6 cm) and weighs about 14 lb (6.4 kg). System price is \$325.

General Description. The tone-arm's counterweight is located over the pivots, with the arm tube fastened to its side. A plastic slider that moves along a calibrated scale on the arm is used for setting the tracking force over a range of 0 to 2.5 grams, the recommended force being 1 gram. The arm is balanced at the factory, but a screwdriver adjustment is available should it ever be necessary to reset it. The antiskating compensation system is built into the pivot design and is factory set to provide the proper compensation at the rated tracking force of the pickup.

The B&O cartridge does not have a user-replaceable stylus. If the stylus must be changed, the entire cartridge must be unplugged from the tonearm and returned to the company or one of its authorized service agencies. As with other B&O cartridges, the Model MMC4000 employs a moving-iron design with a "micro-cross" armature that varies the distribution of magnetic flux between its four pole pieces and is inherently symmetrical for all directions of stylus movement.

The 1.5-lb (0.68-kg) aluminum turntable platter is driven through a belt by an asynchronous induction motor, the speed of which can be adjusted over a nominal range of $\pm 3\%$ by an eddy-current brake. Speed selection is obtained by means of an idler wheel that moves to contact either of two different diameters of the motor shaft. A pulley on the idler shaft drives a larger central pulley, on which the platter rests, through a soft belt.

The platter has concentric rings to support the record and a ring of stroboscope markings in its label area. The turntable and tonearm support are rigidly linked by a subchassis, which is floated on compliant mounts from the motorboard to isolate the playing system from external vibration and shock and from motor vibration.

The single operating control is labeled 33 and STOP on the left side and 45 and PAUSE on the right. At the rear center of the control plate is the legend TURN, with + and - markings. The edge of a knurled wheel can be seen in the small gap between the control plate and brushed aluminum motorboard when the TURN section of the control plate is pressed.

To play an LP disc, 33 is pressed. The platter begins to rotate at 33 1/3 rpm, the tonearm swiftly indexes to the lead-in groove of a 12" (30.5-cm) disc, and after a couple of seconds lowers gently to the record surface. The audio outputs are muted whenever the pickup is not on the record. At the end of play, the arm lifts and returns to its rest position and the motor shuts off automatically. At any time during play, pressing the PAUSE side of the control lifts the pickup and in a few seconds shuts off the motor. Another touch of the 33 side of the control restarts the motor and lowers the pickup to resume play at the point from which it was lifted. Alternatively, if the tonearm is moved to another position, pressing the 33 portion of the control will cause the system to resume play at the selected point.

To play a single 45-rpm disc, a similar procedure is followed. (A large center hole adapter is provided.) The turntable is activated by pressing the 45 section of the control, where indexing is for 7" (17.8 cm).

Special disc combinations, such as 7" 33 1/3-rpm and 12" 45-rpm, cannot be played automatically, since the arm's indexing mechanism is internally coupled to the speed selected. Clearly, B&O did not intend for the sys-

tem to be played manually, since the tonearm has no finger lift and is not easily cued when in its position.

When the TURN portion of the control plate is pressed and held down, the platter rotates but the tonearm does not leave its rest position. This function can be used for cleaning a disc before playing or for adjusting the rotational speed of the platter with the knurled vernier control that becomes accessible when the plate is depressed.

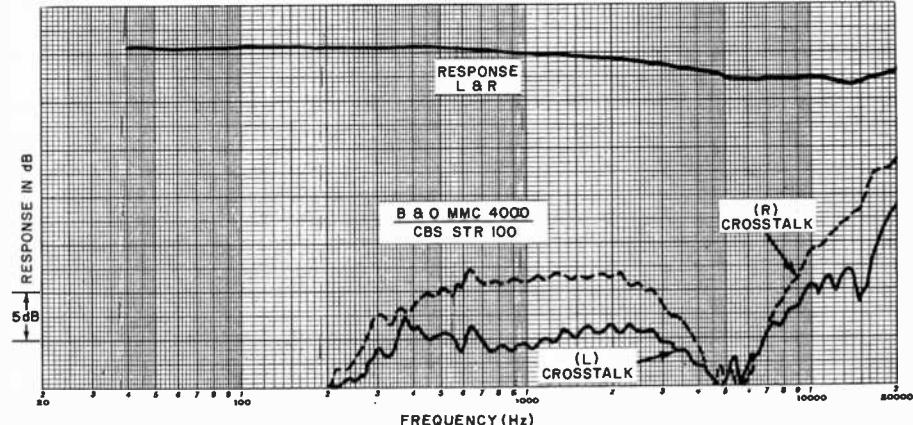
The stroboscope markings on the platter are for 33 1/3 rpm only. The 45-rpm speed is adjusted automatically once the slower speed has been accurately set.

Laboratory Measurements. When we set the stylus force to 1 gram on the tonearm's scale, the measured force was exactly 1 gram. The cartridge did not lose contact with the heavily modulated low-frequency grooves of our Cook "60" test record, although it was on the verge of doing so.

The 100-Hz, 30-cm/s tones of the Fairchild "101" test record were reproduced with symmetrical peak clipping, revealing that this very high velocity was beyond the linear operating range of the cartridge. The 300-Hz test tones of the German Hi-Fi Institute test record could be played up to the 70-micron level without serious mistracking, but some distortion was encountered in the right channel on the 50-micron band. This indicates that the antiskating compensation was insufficient for equally effective tracking of both channels.

When playing the Shure "Audio Obstacle Course—Era III" test record, the cartridge handled the highest levels of the musical bell and violin sections without audible mistracking. On the very difficult sibilant section, a trace of "sandpaper" quality could be heard

Cartridge response for L & R are the same. Crosstalk curves are shown below.



on level 4 and definite mistracking on the maximum level 5. The maximum bass drum level also revealed a slight "crackle" that indicated incipient mistracking. These characteristics were not significantly improved by increasing the tracking force to 1.5 grams.

The frequency response of the cartridge, using the CBS STR100 record, was very smooth, with a gentle downward slope as the frequency increased from 500 to 15,000 Hz and a slight rise between 15,000 and 20,000 Hz. The overall frequency response was within ± 2 dB over the full audio range. Channel separation was typically 20 to 25 dB and was down to about 10 dB at 20,000 Hz. The advantages of the very low mass of the tonearm were evident in the low-frequency resonance, which occurred at about 12 Hz, with a 5-dB amplitude.

IM distortion measurements with the Shure TTR-102 record revealed a low 1% to 2% distortion at velocities up to about 14 cm/s, a very high recorded level for most commercial recordings, and a smooth rise to 10% at 22.6 cm/s. The maximum level of this record (27.1 cm/s) could not be tracked by the cartridge. The distortion was somewhat less at a 1.5-gram tracking force, but not enough to justify its use. The high-frequency tracking distortion, playing the shaped 10,800-Hz tone bursts of the Shure TTR-103 record, was typical of most of the better cartridges we have checked. It increased smoothly from 0.8% to 2% as the velocity increased from 15 to 30 cm/s.

The output of the cartridge was 3.9 mV at a 3.54-cm/s velocity, with the channel levels matched within 0.5 dB. The vertical stylus tracking angle was 24°. The tracking error of the tonearm was less than 0.4%/in. for radii between 2 1/2" and 6" (6.35 and 15.24 cm).

We were able to adjust turntable

speed over a range of from +3.8% to -3.2%. When we set the 33 1/3-rpm speed exactly, the 45-rpm speed was 0.8% high. Increasing the line voltage from 117 to 135 volts ac increased the speed by only 0.3%. Decreasing the line to 95 volts lowered the speed by 4.4%, most of the change occurring as the potential fell below 100 volts.

Wow and flutter measured 0.04% and 0.035% (unweighted rms), respectively. The unweighted rumble was 32-dB down (-36 dB with vertical components cancelled), and with RRLL weighting, it was 54-dB down. The isolation from vibration transmitted through the base was somewhat better than we have measured with most record players.

User Comment. The 1900's basic playing characteristics are those of a competent product. Judging from our lab tests, the cartridge itself couldn't be called "state-of-the-art" in its tracking ability. But this is not truly a limitation since we're only talking about

very extreme velocities not found on commercial music recordings.

The downward sloping frequency response gives the cartridge a very neutral, uncolored sound, especially when it is compared to cartridges with peaked, or rising high ends (which gives a somewhat "sparkly" sound). Obviously, personal taste is an important factor in assessing these sonic differences. When played through speaker systems with a strong but smooth top-end response, the B&O cartridge leaves nothing to be desired with respect to clarity and musical quality.

The Model 1900 is undeniably one of the finest handling record players on the market. The operation of the control plate is so simple and effortless that playing discs becomes more automatic than on a record changer. Simply put a disc on the platter, touch the control plate, and lower the cover. Everything thereafter is automatic.

The absence of a finger lift or a lever to manually cue the pickup seems

strange at first, but most manual cueing operations can be performed successfully with the arm in its raised position.

Of special import to us is the outstanding ability of the low-mass arm/pickup system to play the most severely warped records without a sign of distress. Our collection of warped discs is completely unplayable by any other pivoted tonearm we have used. (Only a low-mass radial arm, such as the one in the B&O Model 4002 record player, had been able to cope with them in the past.) Considering the prevalence of warpage in most discs, the importance of this feature cannot be overestimated.

In our view, the Model 1900 is an ideal choice for anyone who wants to listen to his records without aggravation and does not care to play the "battle of specifications" game. Additionally, it is an especially handsome unit, and its integrated construction eliminates the matching and assembly hassle usually faced.

CIRCLE NO. 81 ON FREE INFORMATION CARD

REALISTIC MODEL TRC-57 NAVAHO CB TRANSCEIVER

AM/SSB base station features PLL and digital clock.



THE REALISTIC Model TRC-57 Navaho from Radio Shack is a 23-channel AM/SSB CB transceiver with a number of features to recommend it. Foremost among these features is a phase-locked frequency synthesizer that eliminates the need for channel crystals. Adding to the rig's sophistication is an electronic digital clock with LED display.

Private listening is conveniently available via a phone jack on the transceiver's front panel. Separate S/r-f and SWR meters make it possible to monitor SWR while observing relative output power. A noise blanker or a conventional noise limiter can be individually switched in and out. Additional facilities include r-f gain, a-f gain, variable squelch, and clarifier

controls; LED's that indicate the mode of operation selected (AM/USB/LSB); PA service; external speaker jacks; detachable dynamic microphone; and front-facing speaker.

A built-in electronically regulated power supply permits the transceiver to be operated from conventional 117-volt 60 Hz ac power lines. Alternatively, a nominal 13.8-volt dc, positive-or negative-ground, power source can also be used, while providing full regulation. Hence mobile operation is possible with this essentially base-station transceiver. (Mobile mounting hardware is supplied.) The transceiver measures 13.75" W x 11.2" D x 5.8" H (35 x 28.5 x 14.7 cm). Price is \$399.95.

Receiver Section. The receiver

employs single conversion to a 7.8-MHz i-f, where selectivity and sideband selection are obtained with a crystal lattice filter. The front end consists of a diode-protected r-f stage and mixer. The i-f strip contains two stages. These are followed by the AM detector and an SSB product detector with bfo, amplified agc and squelch stages, audio amplifier, and an IC output stage that is also used as the AM transmitter modulator.

The noise blanker has two r-f stages, voltage-doubling pulse detector, and three-stage pulse amplifier with gating pulses applied to the collector circuit of the mixer. The r-f stages are tuned to 23 MHz, rather than to 27 MHz, to avoid triggering by CB signals.

A voltage-controlled oscillator (vco) furnishes the heterodyning signals for the receiver's mixer. It is set to the required frequency for each channel by means of the phase-locked loop (PLL) system. In the PLL system, a 10,000-Hz signal derived from the vco through a programmable dividing setup is compared at a phase discriminator with a 10,000-Hz standard signal derived from a crystal-controlled oscillator operating at 1 MHz. If the vco is not at the correct frequency, its derived comparison

signal will be other than 10,000 Hz (according to the dividing factor set up by the channel selector). An error voltage then appears at the discriminator to shift the vco until the exact 10,000-Hz signal is produced. The two 10,000-Hz signals are then locked in phase with each other, holding the vco at the proper frequency.

Our measurements on the receiver indicated a sensitivity of 0.5 μ V on AM for 10 dB (S + N)/N at 30% modulation using a 1000-Hz signal. On SSB, sensitivity measured 0.15 μ V at 500 Hz and 0.2 μ V at 1000 Hz. Overall response was 300 to 2900 Hz on AM and 200 to 4400 Hz on SSB. Adjacent-channel rejection and desensitization were a minimum of 60 dB, while unwanted-sideband suppression was 50 dB at 1000 Hz.

Better-than-usual overload characteristics were exhibited by the receiver, which maintained good signal-handling capabilities with signals up to 10,000 μ V in strength. Spurious unwanted-signal rejection was better than 60 dB, except at about 30.8 MHz, where it was 50 dB. If signal and image rejection were better than 80 dB.

The squelch was adjustable for thresholds between 0.5 and 1500 μ V on AM and between 0.2 and 1500 μ V on SSB. Excellent agc characteristics held the audio output to within 10 dB with an input signal change of 80 dB (at 1 to 10,000 μ V), 6 dB of which change occurred at 1 to 10 μ V. With very strong SSB signals, the release time was a bit fast, resulting in slight "pumping." However, this can be minimized by reducing the r-f gain. A 50- μ V signal registered S9 on the meter.

Maximum sine-wave audio output power in both the receive and PA modes was 3 watts at 4% distortion into 8 ohms using a 1000-Hz test signal. We noted exceptionally good noise blanking. Using our impulse noise generator, the noise blanker attenuated noise peaks of 1000 μ V or more (+60 dB above 1 μ V) down to inaudibility in the presence of a 0.5- μ V signal. The anl functions only on AM; its performance was highly effective.

Transmitter Section. The output of the receiver's bfo is combined with the vco signal by a balanced transmitter mixer to produce the on-channel carrier for AM transmissions. The SSB signal is generated by combining the bfo and microphone signals in an IC

balanced modulator and filtering out the unwanted sideband with a crystal filter. The signal is then amplified and combined with the vco signal in the transmitter's mixer.

The r-f section of the transmitter consists of a predriver stage, driver and power amplifier stages, and a multi-Pi output network. The output amplifier works with the driver stage to function as a collector-modulated setup on AM and as a linear amplifier on SSB.

Speech compression, or amc, is obtained with a "bootstrap" setup around the microphone amplifier that, in effect, acts as an audio-frequency agc. On SSB, r-f output limiting (or automatic level control) is incorporated by using a rectified sample of the output to control the gain of the 7.8-MHz SSB amplifier.

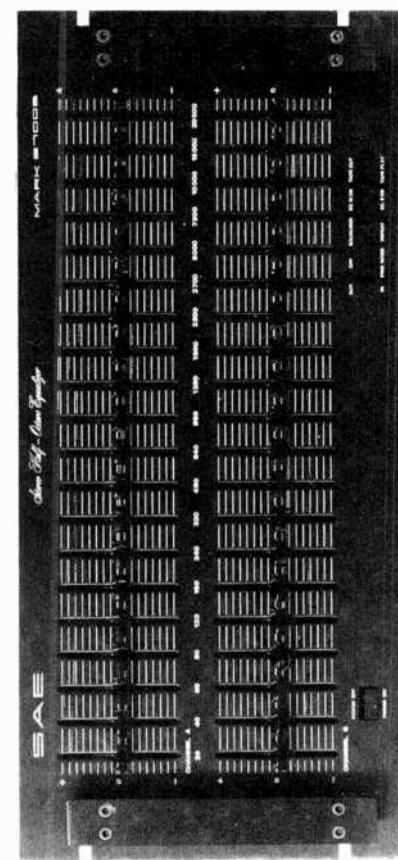
The carrier output power on AM measured 3.8 watts. Using a 1000-Hz test tone and greater than 40 dB of amc compression, the modulation held to 90% and the sine-wave signal exhibited only 3% THD. Under dynamic (voice operation) conditions, due to a slightly slow amc attack time, the modulation tended to go to 100%, with a bit of overshoot on the negative peaks. Nevertheless, the adjacent-channel splatter held to at least 55 dB down.

On SSB, using a two-tone test signal, the output power measured slightly greater than 12 watts pep. Third-order distortion products were an excellent 24 dB below the test tones (30 dB below pep), which is about the best performance we have ever obtained from a solid-state transmitter. However, with our voice test and using 40 dB of compression, the pep output initially tended to go to about 15 watts pep, with some flattopping and deterioration of third-order distortion to 24 dB below pep. This was due to a slow alc attack time. Splatter was still way down, carrier suppression was 45 dB, and unwanted-sideband suppression was 50 dB at 1000 Hz.

The overall response on AM was 200 to 3500 Hz at the 6-dB points and was 300 to 3200 Hz on SSB. As might be expected from the PLL synthesizer system, the transmitter's frequency tolerance was the same on all channels, measuring nominally about minus 200 hertz.

User Comment. The transceiver is well styled and is easy to operate. Con-

Flexible alternative



The SAE 2700B Half-Octave Stereo Equalizer

The 2700B can bring to your system the clarity & definition you have been looking for. Wayward sounds (booming bass, missing highs, blaring horns, or stifled solos) are all put in their place with the SAE 2700B Half-Octave Equalizer. The flexibility of 20 controls per channel only begins to tell the story. Some facts:

- * 0.02% THD & IM
 - * -100dB S/N Ratio
 - * Can drive any system
 - * FREE 5 YEAR Service Contract
- PLUS, long-throw oil-damped slide pots for better accuracy, precision wound toroid inductors for low distortion & a pink noise generator for system balance. Built with SAE quality, the 2700B is value packed with the capability and performance you need to control your system.

PRICE: \$550.00 (suggested list)

SAE

Scientific Audio Electronics, Inc.

P.O. Box 60271, Terminal Annex
Los Angeles, Calif. 90060

Please send me more information on the
SAE 2700B Half-Octave Equalizer.

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

trol knobs are large and easy to grip. The meters are large in size and illuminated for easy readability.

The digital clock can be set up to display time in either 12- or 24-hour format. The clock does not function when the transceiver is powered from

a dc source. The setting time may be quickly or slowly advanced or held to allow the actual time to catch up with the display.

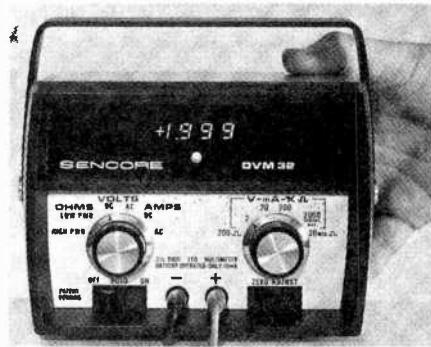
From the results of our tests and description of the various operating facilities, it should be evident that this

transceiver is capable of superb performance. If you are looking for a full-feature AM/SSB transceiver that can do double duty as a base station and a mobile rig, this one is certainly worth serious consideration.

CIRCLE NO. 82 ON FREE INFORMATION CARD

SENCORE MODEL DVM32 PORTABLE DMM

Rugged, autopolarity, 3½-digit multimeter with large LED readout.



A FEW YEARS AGO, the typical digital multimeter was a relatively expensive, bulky piece of test gear. It required a lot of power, which tied it to the ac line and made it into a bench instrument. By contrast, the modern DMM has all the versatility, portability, compact design, and light weight of the traditional VOM. Prices have also come down considerably since the first DMM's were introduced.

Typical of the latest DMM's is the Sencore Model DVM32, which is priced at only \$198. This battery-powered portable instrument measures only 7" W × 5" H × 4" D (17.8 × 12.7 × 10.2 cm) and weighs 2¼ lb (1 kg). The instrument is housed in an impact-resistant Cyclocac® case, the front edge of which forms an overlap surround to protect the controls and display from damage. The DMM's carrying handle doubles as a tilt stand.

The Model DVM32 is an autopolarity instrument. It is designed to measure both ac and dc voltage and current and high- and low-power ohms. The function and range are selected by separate rotary switches.

Technical Details. The numeric display consists of 3½ digits of 0.3" (7.62-mm) seven-segment red LED numerals, plus a LED +/- indicator. Plus is displayed, not implied. Current drain from the four C cells, which can be ordinary carbon zinc or rechargeable types, is only 15 mA to ensure long battery life. (An optional No. 39G90 ac power adaptor is available

for \$9.95 to permit the DMM to be line powered for bench use.)

There are four dc voltage ranges that provide a maximum indication of ±1999 volts. Accuracy is 0.5% of full scale. Input resistance in the dc voltage function is 15 megohms. All ranges are protected to 2000 volts dc plus peak. Ac rejection is specified at 40 dB between 50 and 60 Hz.

Ac potentials up to 1000 volts rms can be measured in four ranges with an accuracy of 1.5% at 60 Hz and 3% for the three digits. The frequency range on the ac voltage function is from 40 to 3000 Hz ±1 dB. Input impedance is 1.8 megohms shunted by 18 pF. The input is protected to 1000 volts rms plus dc on all of the voltage ranges.

There are two resistance-measuring functions, one for low-power ohms with 80 mV at the test probes and the other for high-power (conventional) ohms with 800 mV at the probe. The low-power mode has five ranges that go up to 1.999 megohms and provide a measuring accuracy of 1% of full scale. The high-power ohms mode also has five ranges, this time to 19.99 megohms, with an accuracy of 1% on all ranges except the highest, where the accuracy is stated as being 5%. In both resistance-measuring modes, the circuit is protected for inputs of up to 1000 volts dc plus peak on all ranges.

Both ac and dc current measurements can be performed on four ranges, with a maximum measuring capability of 1999 mA (1.9 amperes). Accuracy on both ac and dc is stated at 1%. The input is protected by a diode and a fuse.

The instrument has an interesting AUTO mode. With the front panel switch set to this mode, the power-consuming display comes on only when an actual measurement is being made (thus the reason for the long bat-

tery life). On standby, the internal circuits are operating, but the display is extinguished. Of course, if desired, the AUTO feature can be switched out, in which case, the display remains constantly on.

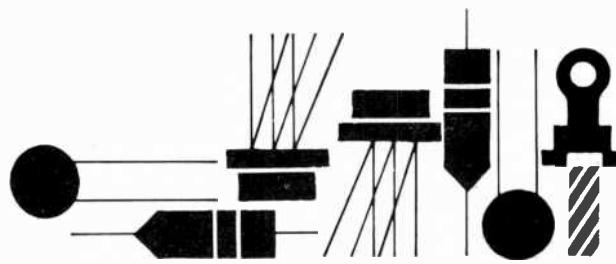
A 200,000-ohm isolation probe comes with the DMM. If potentials up to 50 kV must be measured, an optional No. 39691 high-voltage probe is also available.

User Comment. We performed our usual battery of accuracy tests on the DMM, using high-precision voltage sources and resistors. In all cases, the multimeter easily met or bettered its published specifications. Our use test of the DMM included a week at a busy workbench and an extended stint in the field. Our conclusion is that this instrument is as easy and automatic to use in either environment as any DMM we have tested in the recent past.

The large, bright display is easy to read under just about every ambient lighting condition and over a wide range of viewing angles. The controls operated with positive action and were large enough for a comfortable grasp. On several occasions when the DMM was used on battery power over a period of several hours, we came to really appreciate the battery-saving AUTO mode. We also found that replacing depleted batteries was a simple procedure. Simply remove one screw and the upper rear plate of the housing to remove the old and then replace with fresh cells.

We would not hesitate to recommend the Sencore Model DVM32 to anyone — service technician or hobbyist/experimenter — as an all-in-one test and measurements instrument for bench and field use. It is a practical size for lugging along on field jobs. It is ruggedly built to bear up under rough handling.

CIRCLE NO. 83 ON FREE INFORMATION CARD



Solid State

By Lou Garner

SIMPLE STOPWATCH SPLITS SECONDS!

ALTHOUGH electronics may be one of your major hobbies, if you're a typical reader, chances are you're interested in a number of other things as well . . . track, perhaps, or wrestling, boxing, swimming, skiing, sailing, horse racing, skating, skeet, target shooting, rally driving, archery, chess, photography or chemistry. In many of these activities, it may be desirable to time an event or series of events with reasonable accuracy and, for this, a stopwatch is a virtual necessity. Fortunately, there's a wide choice of commercial instruments available for nearly all timing applications, from chemical reactions to photographic exposures, from sports matches to the single lap of a race, and from a chess move to the driving (or sailing) coverage of a measured distance. You can choose a conventional mechanical hand-wound type or a sophisticated digital electronic unit at prices ranging from less than fifty to more than two hundred dollars, depending on the accuracy and operational features needed for your application. On the other hand, if you prefer to "roll your own," you can assemble a versatile multi-function digital stopwatch at modest cost and with minimum effort by using an IC introduced late last year by Intersil, Inc. (10900 N. Tantau Ave., Cupertino, CA 95014). The resulting instrument features a timing range of up to 59 minutes 59.99 seconds in one-hundredth of a second increments, a low-battery indicator, crystal control, and two operating modes, yet requires, in addition to the IC, only a six-digit LED display, four spst

switches, a quartz crystal, a small trimmer capacitor, and three penlight cells, plus a case and customary hardware.

Designated type ICM 7205, Intersil's stopwatch IC is a single chip CMOS device designed to interface directly with a six-digit/seven-segment common-cathode LED readout, and is capable of furnishing a multiplexed drive current of up to 13-mA per segment with a nominal 3.8-volt dc source. It is suitable, however, for use on 2-to 5-volt dc supplies and is fully protected internally against damage from static charges, thus eliminating the need for special handling and wiring precautions. The unit has a maximum power dissipation rating of 0.75 watts and a specified operating temperature range of from -20°C to +70°C. The device contains an integral oscillator, high- and low-frequency dividers, a multiplex generator, control logic, counters, a decoder, digit and segment drivers, and a low-battery sensor/indicator driver. In operation, the circuit divides the 3.2768-MHz signal generated by the crystal controlled oscillator by 2^{15} to obtain 100 Hz, which is then fed to the fractional seconds, seconds and minute counters. An intermediate frequency is used to develop a one-sixth duty cycle 1.07-MHz signal for multiplexing the display drivers. The blanking logic provides leading zero blanking for seconds and minutes independently of the clock.

Described in Intersil's 6-page technical bulletin for the ICM 7205, the stopwatch schematic shown in Fig. 1 is

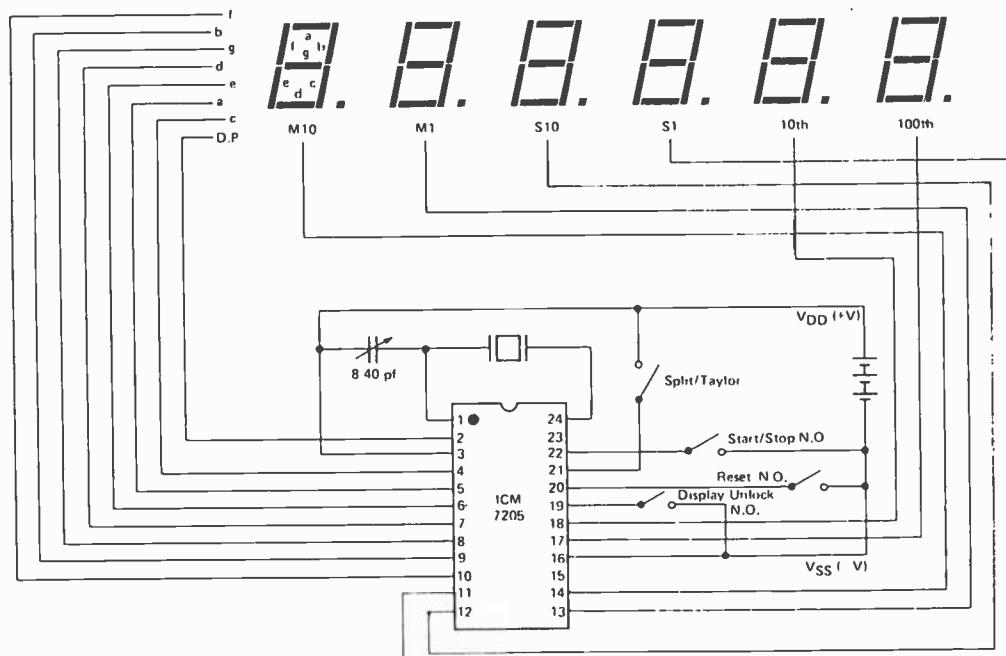
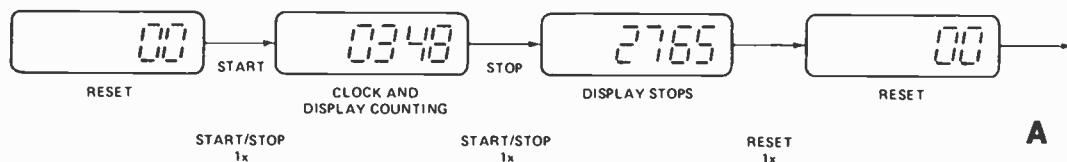
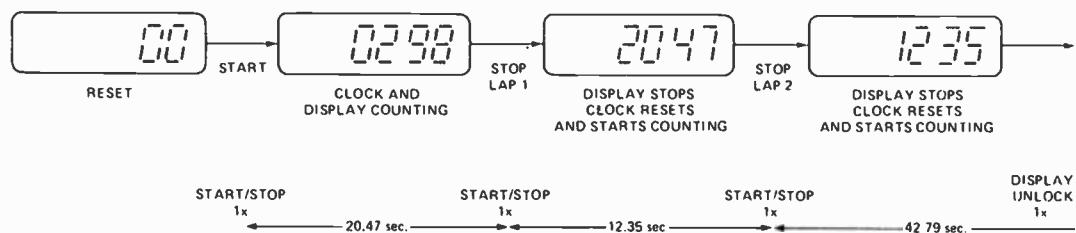


Fig. 1. Circuit for stopwatch using the 7205 chip.



A



B

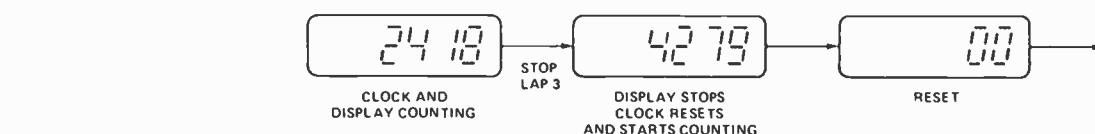
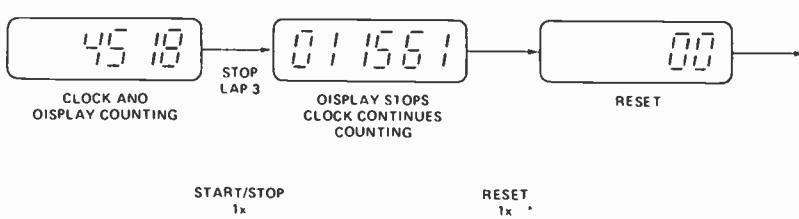


Fig. 2. Stopwatch operating modes:
(A) Standard;
(B) Taylor; and
(C) Split.

C



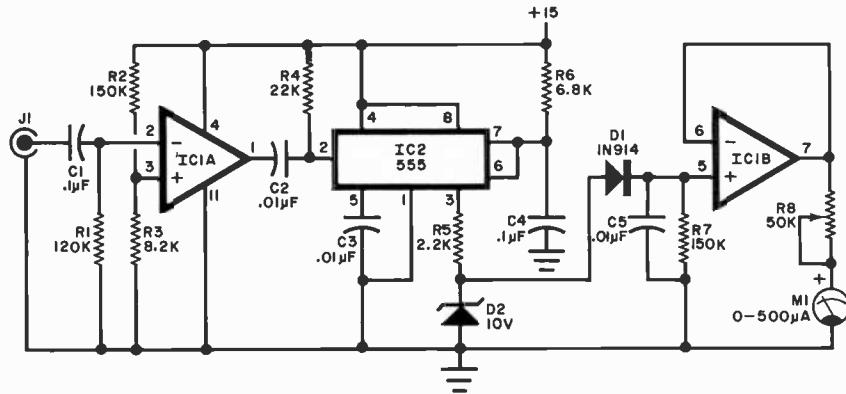
complete except for an optional "on-off" power switch. If used, this may be a spst unit connected in series with either power supply lead. The power source consists of three series-connected AA cells or equivalent rechargeable NiCd units. Since standard components are specified, most of these should be readily available through local dealers. However, depending on the individual's location, it may be necessary to order the IC and crystal through one of the larger mail-order distributors. The manufacturer specifies that the quartz crystal used to control the oscillator's frequency should be a 3.2768-MHz unit with an R_s of 50 ohms and a load capacitance of 15 pF. If a different crystal is used, it may be necessary to change the trimmer capacitor's value (shown as 8 to 40 pF) to achieve optimum performance.

With neither parts layout nor lead dress critical, the individual builder may use either PC or perf board construction techniques when duplicating the circuit, as preferred. Good wiring practice should be followed, of course. For best performance, the spst START/STOP switch should be a high-quality, normally open pushbutton type with low

"bounce" (less than 15 ms) characteristics. After assembly and checkout, the oscillator trimmer should be adjusted for precise operation, checking the unit against an accurate standard, if available.

In practice, switching the stopwatch "on" will reset the circuits and display "00" in the fractional seconds position, with all other digits blanked. This display always indicates that the stopwatch is ready for operation. The instrument may be used in either of two modes in addition to that of a standard stopwatch. All three operational modes are illustrated graphically in Fig. 2. For timing a single event, the START/STOP and RESET switches are used. As shown in Fig. 2(A), depressing the START/STOP switch starts the clock and display counting. At the end of the timed event, depressing the START/STOP switch stops the display, permitting a readout of the time interval. Initially, only fractions of seconds are displayed, with seconds shown after one second and, finally, minutes after the first minute, providing a full display. Since the maximum range is 59 minutes 59.99 seconds, the user must remember the number of hours if the timed event exceeds an hour. Lead-

Fig. 3. Ted Reiter's frequency-to-voltage converter circuit.



ing zeros are not blanked after the first hour. Once the event is timed, the instrument can be reset for another measurement by operating the RESET switch. The TAYLOR (or sequential) mode is used when timing a series of rapidly occurring events where the individual time for each event is of immediate interest, rather than the total time. Here, the SPLIT/TAYLOR switch (Fig. 1) is left open and the instrument is controlled using the START/STOP, DISPLAY UNLOCK, and RESET switches. As depicted in Fig. 2(B), depressing the START/STOP switch initially starts both the clock and display counting. At the end of the first event, depressing the START/STOP switch stops the display and resets the clock, which starts counting again. The display remains stationary after the first interval, showing the last previous time, until the START/STOP switch is actuated, which causes the display to show the next interval. Operating the DISPLAY UNLOCK switch will permit the display to show the running clock at any time. Upon completion of the timing tests, the stopwatch is reset by actuating the RESET switch. Finally, for those events where the user is interested in the cumulative time intervals for a series of events, the stopwatch can be operated in the SPLIT mode. Here, the SPLIT/TAYLOR switch is closed. Afterwards, depressing the START/STOP switch starts the clock and display counting, as shown in Fig. 2(C). At the end of the first event, the START/STOP switch stops the display but permits the clock to keep counting. Thereafter, the cumulative time can be read after each succeeding event by operating the START/STOP switch. Whenever desired, the DISPLAY UNLOCK switch may be used to let the display "catch up" with the running clock. At the end of the series of events, the RESET switch reestablishes initial starting conditions but, of course, this control can be used at any time.

The optional on-chip low battery indicator (LBI) is intended for use with a separate LED or with the decimal points of the digital readout. Its output (pin 2) is a p-channel transistor of approximately half the size of one of the segment drivers. The circuit is designed to maintain a voltage difference between the LBI trigger level and the minimum operating voltage. Thus, the lower the LBI trigger voltage, the lower the minimum operating voltage. In practice, this means that the stopwatch will provide at least 15 minutes of accurate timekeeping after the LBI turns on, assuming that the power pack consists of three size AA cells.

Readers' Circuits. A previous contributor to these pages, Ted Reiter (1442 Brook Drive, Titusville, FL 32780), suggests the circuit illustrated in Fig. 3 as an alternative frequency-to-voltage converter for experimenters who may not have access to Raytheon's new 4151, described in the April column. Ted developed his circuit for use in con-

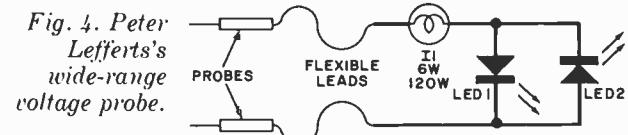
junction with a project involving the measurement of solar intensity levels translated into varying audio tones. Requiring a 3-volt rms input signal, the circuit drives a standard 500- μ A meter and is designed for optimum performance between 100 and 500 Hz.

In operation, the input signal is applied through coupling capacitor C1 to op amp /C1A, biased by voltage-divider R2-R3 for operation as a modified Schmitt trigger. The amplified output signal is applied through a differentiation network, C2-R4, to a one-shot, /C2, which delivers fixed width output pulses to a peak limiting circuit, R5-D2. The pulses are then coupled through detector diode D1 to a pulse integrator, C5-R7. Since the pulses applied to the integrator are of constant width and amplitude, the instantaneous voltage developed across C5 will be directly proportional to the pulse repetition rate and hence to the frequency of the original signal. This voltage is amplified by a second op amp, /C1B, and used to drive the output meter, M1. Potentiometer R5 is used to set the meter's full scale reading at the highest frequency measured (500 Hz).

Ted has specified standard, readily available components in his design. Op amps /C1A and /C1B are two sections of a type 324 quad op amp (the other two sections are available for other circuit applications), while /C2 is a familiar 555 timer. Zener diode D2 is a 10-volt, 400 mW type. All resistors, except for calibration potentiometer R8, are 1/4- or 1/2-watt types, and the capacitors are small ceramic, plastic film or paper units. Operating power, nominally 15 volts, is actually furnished by a pair of series-connected 9-volt transistor batteries. Neither component layout nor wiring dress should be overly critical and the builder, therefore, may follow his own inclinations regarding construction methods when duplicating the circuit.

Peter Lefferts (1640 Decker Ave., San Martin, CA 95046), one of our more prolific west coast contributors, has submitted another interesting design . . . a wide range voltage probe. Pete's circuit, given in Fig. 4, requires but three basic components: a 6-watt, 120-volt incandescent lamp, /I1, and a pair of type NSL 5023 or NSL 5024 light emitting diodes, LED1 and LED2. Despite its simplicity, the probe can indicate the presence of *any voltage from 1.5 to 150 volts ac or dc*, with either the lamp (/I1) or one (or both) of the LEDs illuminated. The circuit depends, for its operation, on the unique characteristics of the incandescent lamp's filament. At lower voltages, only the LEDs are activated, with their currents limited by the incandescent lamp

Fig. 4. Peter Lefferts's wide-range voltage probe.



serving here as a simple series resistor. At higher voltages, the rapidly increasing resistance of the lamp's filament limits the LEDs' currents to about 50 mA at full line voltage, or about 25 mA average for an ac input. If desired, one of the probes can be "polarized" for dc checks, with the corresponding LED illuminated at correct polarity. For example, if the upper probe (Fig. 4) is considered *positive*, LED1 is illuminated when correct polarity is applied, with LED2 indicating reversed polarity. The circuit can be assembled in a small metal chassis box with test jacks, in a plastic case with flexible test leads, or self-contained within a cylindrical tube, at the builder's option.

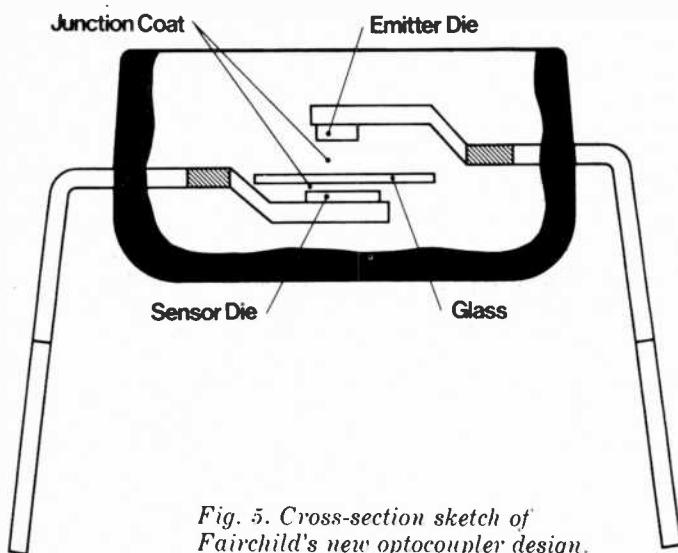


Fig. 5. Cross-section sketch of Fairchild's new optocoupler design.

Data Up-Date. The National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051) has released a number of new handbooks which should be of major interest to serious hobbyists and experimenters. The handbooks, listed below, may be purchased through the firm's franchised distributors or ordered directly from the manufacturer's Marketing Services Department (California residents should add 6% sales tax to the indicated prices):

The *PACE Technical Description* is a 96-page handbook describing the firm's "PACE" single-chip, 16-bit microprocessor. The volume describes both the full-feature CPU and the entire complement of hardware and software items that comprise the "PACE" (Processing And Control Element) system, showing in detail the family of support chips, application cards, software support (including program examples), and microprocessor development systems. Applications as well as operations are described, along with product and instruction summaries. The PACE manual is priced at \$3.00/copy.

Interface Integrated Circuits is the title of a 464-page data handbook which gives specifications on the firm's complete line of interface products, including peripheral/power drivers, level translator/buffers, line drivers and receivers, memory and clock drivers, sense amplifiers, display drivers, and optocouplers. The text is supported by graphs, charts and diagrams. Also included is a 72-page section of application notes covering such topics as transmission lines, data transmission in high-noise environments, and driving gas discharge and LED displays, together with product selection guides listing specifications for LED drivers, peripheral drivers and transmission

drivers, and two cross reference guides comparing product type numbers of other manufacturers. The *Interface handbook* carries a price tag of \$4.00/copy.

The *TTL Data Handbook* describes National's complete line of bipolar logic devices, giving full specifications and electrical performance characteristics on standard 54/74 TTL, low-power 54L/74L, high-speed 54H/74H, ultrahigh-speed Schottky 54S/74S, low power Schottky 71LS/81LS, Series 9000 TTL, Series 10,000 ECL, and Series 930 DTL. It covers gates, buffers, drivers, flip-flops, latches, registers, counters, selector/multiplexers, multipliers, comparators, decoders, parity generators, and related devices. A Tri-State selection guide, an industry cross reference guide and a functional index also are included, as well as package outlines. The *TTL Data Handbook* may be obtained for \$4.00/copy.

The *Memory Data Book* is a 544-page volume covering the manufacturer's memory and memory-related products, including bipolar, MOS, CMOS RAMs, field and mask programmable ROMs (bipolar and MOS), MOS shift registers and PLAs. In addition, the book describes interface/support circuits for memory operation and includes pertinent application notes, cross reference guides and a production status guide on National memories as well as complete specifications, characteristics, diagrams and special features of the products. The price is \$3.00/copy.

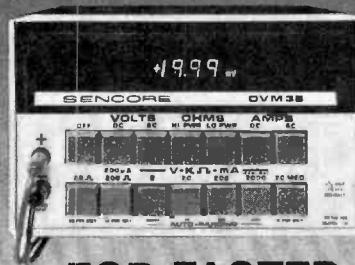
Finally, the *SC/MP Technical Description* is a 65-page handbook which describes the firm's single-chip 8-bit "SC/MP" (Simple-to-use, Cost-effective, MicroProcessor), a CPU requiring only one memory chip to form a complete, fully-programmable system. Starting with a general introduction to "SC/MP" for non-technical users and following up with complete details for preparation of a preliminary design of "SC/MP"-based applications, the book includes 6 tables and 35 illustrations. The software described includes cross assemblers, loader/debug utilities, and input/output routines. Also outlined is a description of three application modules. The volume is \$3.00/copy.

Device/Product News. Both Fairchild's Linear Integrated Circuits Division (464 Ellis St., Mountain View, CA 94042) and Optoelectronics Division (4001 Miranda Ave., Palo Alto, CA 94304) have introduced new devices of potential interest to experimenters and hobbyists, including a line driver and receiver, a series of Darlington arrays, a family of high-voltage opto-couplers, and what is claimed to be the largest single digit LED display available in the industry. The 9636 and 9637 are monolithic circuits intended for applications in data communication and data terminal equipment. Of these, the 9636 is a dual single-ended line driver that provides TTL and CMOS compatible inputs and features an output slew rate that can be controlled with a single external resistor as well as short-circuit protection for all outputs. The 9637 is a Schottky dual differential line receiver providing a TTL compatible output and offering an input threshold accuracy of ± 200 mV over a ± 7 -volt common-mode range. Both the 9636 and 9637 are supplied in 8-pin miniDIPs, making it possible to insert two devices in a single 16-pin DIP socket for use as a quad-input assembly. The new series of Darlington arrays comprises six high-voltage, high-current units intended for interfacing TTL and MOS logic circuits with such devices as solenoids, relays, lamps, small motors and LED displays. The basic devices, types 9665, 9666 and 9667, are rated at 50 volts, with 80-volt units available and identified

by an "A" suffix (i.e., 9665A, etc.). All six devices feature seven high-gain Darlington transistor pairs per package, each capable of furnishing output currents of up to 350 mA, with suppression diodes provided for use with inductive loads. Outputs may be paralleled to increase load capabilities. The 9665 is a general purpose array which can be used with DTL, TTL, PMOS or CMOS logic and features input current limiting set by means of external resistors. The 9666 eliminates the need for external resistors and is specifically designed for direct interfacing with PMOS logic to solenoids and relays; it operates at supply voltages from 14 to 25 volts. The 9667 has a series base resistor connected to each Darlington pair for direct operation with TTL or CMOS logic powered by 5-volt sources. The Darlington arrays are available in either plastic or ceramic DIPs. Fairchild's new family of phototransistor couplers offers a minimum isolation voltage of 5,000 volts for all device types. This high rating, more than twice that of standard couplers, is achieved by using glass as an internal insulating spacer between the light source and phototransistor, as shown in Fig. 5. Finally, the firm's Optoelectronic Division is offering a group of 0.8-inch high LED display digits readable at distances of up to 30 feet. The new displays are available in common cathode or common anode versions with either a left or right-hand decimal point. Common-cathode types are the FND800, right-hand decimal, and the FND850, left-hand decimal. Common-anode types are the FND807, right-hand decimal, and the FND847, left-hand decimal. With an average intensity per segment of 0.15 millicandela, the displays require a 1.7-volt source and an average drive current of 5-mA per segment.

If your plans include projects involving telephone dial tone control, you'll want to investigate a new pair of ICs announced recently by the MOSTEK Corporation (1215 W. Crosby Road, Carrollton, TX 75006). The new devices, designated types MK 5085 and MK 5086, combine CMOS logic, D to A converters, an operational amplifier, and bipolar transistors on a single chip, and are designed to use an inexpensive 3.58-MHz crystal reference to produce eight distinct audio sinusoidal frequencies, which are mixed together on chip to provide high accuracy tones suitable for dual tone dialing. Both circuits are identical except for keyboard configuration. The MK5085 utilizes a self-scanning technique to interface directly to a class-A or 2-of-8 keyboard, while the MK5086 interfaces to either a 2-of-8 keyboard or other electronic systems. Common key functions such as switching out the transmitter and switching in muting resistance are accomplished electronically. The MK 5085 was designed using CMOS primarily for integration into telephone systems where it is possible to derive the necessary power directly from telephone lines; non-telephone hobbyist applications may use a fixed dc supply such as four AA cells or a single 9-volt battery. In operation, distinct audio frequencies are obtained when keyboard entries select the proper digital dividers to divide the 3.58-MHz crystal signal. These signals are processed by a conventional ladder network, and current-to-voltage transformation is made by an on-chip amplifier. This conventional D/A converter yields sine waves of sufficient purity that they require little or no filtering. The same amplifier accomplishes summing of the low and high group tones to obtain the required dual tone signal. ◊

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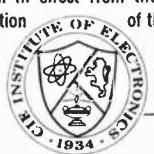
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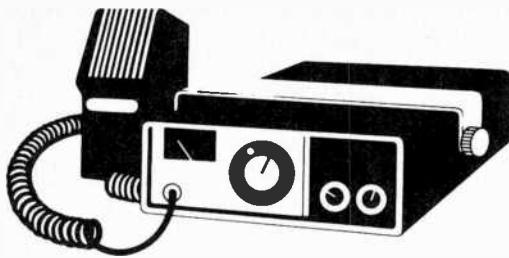
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CB Scene

By Ray Newhall, KWI6010

IS CLASS E DEAD?

MY FEBRUARY column touched briefly on "Class E," a proposed new division of the Citizens Radio Service, first suggested in 1968 by the Electronic Industries Association. My mail bag tells me that I touched a tender nerve with at least a few of PE's "Ham" readers. Some letters have been in polite disagreement, but others contained emotional outbursts claiming that undisciplined CB'ers will soon blanket the entire radio spectrum with illegal linearers. All responses were from radio amateurs who oppose any further expansion of the Citizens Band because CB'ers have abused Class D and have not "earned the right to use two-way radio."

I believe that the vast majority of the licensed CB'ers today are decent, law-abiding citizens who should not be spoken about in such a manner. Most use CB to conduct their personal communications, and, when needed, to help others. There are many more CB mobiles cooperating with law enforcement officers than those who try to harass them.

What Is Class E? As originally proposed by the EIA, Class E would consist of FM communication in the vhf region (specifically, on the lower 2 MHz of the 220-to-225-MHz band currently assigned to Amateur Radio). There would be a total of 80 channels, most designated for specific uses (mobile, in-plant, road condition information, etc.). The Class E band would be very similar to the new vhf-FM Marine band, but personal communications could be conducted on it between your vehicle and home or office. That type of communication is not permitted on Marine frequencies.

Unlike Class D, it would be nearly devoid of skip, heterodynes, and ignition and other types of noise. Above 100 MHz, nearly all radio propagation is "line of sight." That is, once the radio wave reaches the horizon, it

merely flies off into space rather than bouncing off the ionosphere and returning to the earth as skip. Hence, more output power could be authorized for reliable communications without disturbing distant stations.

Another advantage is the FM "capture effect." An FM receiver will track the most powerful signal it receives, and suppress weaker ones on the same channel. In practice, you could either make solid contact or none at all. Between calls, the speaker is fully squelched and silent. FM lends itself to both tone-encoded squelch systems and phone patches, as Amateur practice on the 2-Meter band has demonstrated.

The original intent of the Citizens Radio Service was to provide short-range personal or business communication to any citizen. It was expected that most would use it between their cars or boats and homes or offices. (In keeping with that idea, only members of the licensee's immediate family or his direct employees can operate under the authority of his license.) Most important, CB was intended for those people who have no specialized technical knowledge or experience. Finally, the original CB concept excluded "hobby" operations (use of a CB radio for rag chewing, skip chasing, etc.)

Unfortunately, the inherent characteristics of AM signals and the 11-Meter band defeated these intentions as soon as the Service was established. It simply wasn't suitable for short-range, personal use, and many operators were hobbyists who got their "kicks" trying to pick out signals between the heterodynes, diathermy, and skip transmissions! Is it any wonder that manufacturers soon made linearers available to anyone with the money to pay for them, and that Class D became the bandit band? How could anyone ask his wife or secretary to listen to that pandemonium all day while waiting for a call?

Would Class E Be Disciplined? I don't believe Class E would be abused as Class D has been, primarily because it would not attract the hobbyist who wants to DX half way across the country. Linearers would not be any major advantage because enough power would be authorized (10 to 25 W) to put out a solid signal to the radio horizon. Also, a large increase in power (bootlegging it) would not boost effective range.

As it became popular, I believe the vhf band would be used by motorists just as they use the Class D band now. Safety and motorist assistance is a legitimate personal use, but in the Class E proposals to date, highway use would be restricted to relatively few channels. All transmitters should be of high quality and be rigidly controlled through type acceptance and mandatory periodic inspections. Automatic transmitter identification would enhance both regulatory powers and respect for FCC Regulations. It would also make the organized larceny of equipment far more difficult.

We must consider the radio spectrum as much a resource as air, water, coal, or petroleum. It must be conserved, but it must also be shared. The right to use it by the ordinary citizen cannot be refused because a minority has abused it. Do we close the beaches to the public because some thoughtless persons throw trash about? Do we refuse to issue new driver's licenses because some persons already licensed drive rather recklessly at times?

It is true that Class D privileges have been badly abused by a minority of users, but the overwhelming majority of licensed CB'ers try to operate their rigs legally. (I don't consider the unlicensed ones CB'ers — they would even drive their cars without a license if they thought they could get away with it!) Many legitimate operators have equipped their mobiles with CB just for the added safety it offers. I have noted that it is usually the newcomers on the band who show their exuberance by transmitting "Smokey" reports. But the band is maturing. Now, many truckers use their rigs more to assist law-enforcement agents than to try to "spot" them.

Where Do We Stand Today? For the moment, Class E is seemingly at an impasse. While the FCC recognizes

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the justification for this new vhf-FM service, authorization has been temporarily blocked by Canada and Mexico by virtue of international treaties to which the U.S. is a party. Since our government cannot guarantee that the use of Class E transmitters by our citizens in border areas will not disrupt their use of these frequencies, those governments have refused to permit changes in the existing treaties which currently do not allow a Citizens Radio Service in this band.

There is also concern in this country that Class E would interfere with government radio-location services which share the 220-MHz band. And understandably, radio amateurs are cool to the ideal of Class E if it means losing 2 MHz of their spectrum allocations.

However, there are alternative courses of action the FCC could take. For example, it could allocate Class E a portion of the spectrum in which it would not conflict with the international treaties. Or it could try to negotiate a change of our neighbors' attitudes. It's not surprising that the Canadians are apprehensive, since they have experienced difficulties in controlling their own CB service.

Are The Objections To CB Valid?

If CB is judged by traditional values, the radio amateurs who wrote to me are justified in their criticism of CB. But I feel that many of the traditional "ham" values may no longer be valid. Although some hams are experimenters and make contributions to the technical advancement of radio, they cannot compete with government and industry financed R & D. Most hams no longer build their own equipment, and are mainly interested in communicating. Of course, their outstanding efforts in times of natural and man-made disaster are well documented.

Admittedly, their frequency allocations have been eroded, and the 11-Meter band was taken from them to set up the Class D band. But amateurs still hold 46.5 MHz of the entire spectrum below 450 MHz. We CB'ers do not begrudge them their 10.3% of the hf, vhf, and low uhf portion of the spectrum, but we do feel that it is a bit unfair when some of 285,000 amateurs complain so bitterly about the greater than four million licensed CB'ers who are crowded into less than 0.5 MHz of spectrum, and who want just a bit more!

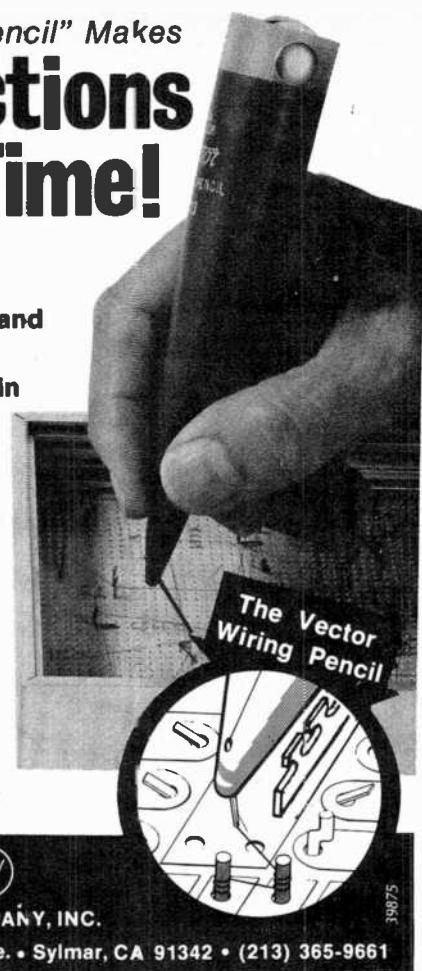
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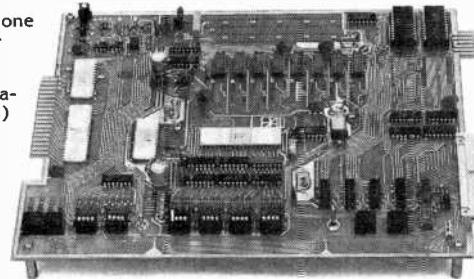
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However, there is one important thing to keep in mind — CB and Amateur Radio are compatible! Although there have been strained relations in the past, more and more amateurs and CB'ers are getting to meet each other. They often find that the prejudices on both sides are not reflected in reality. Today the CB'er is not a "frustrated ham," but the guy down the block who uses radio for personal communications, not hobby operating. Evidence of this change of heart on the part of radio amateurs lies in the editorials of *QST* and *ham radio* for April, 1976.

Local amateur and CB clubs can work together to set up emergency communication systems, operator training sessions, etc. It is in the best interest of *both* services that there be mutual understanding and appreciation for the potentials of each group. So let's put aside any hard feelings and work together for our common goal — the efficient and proper use of frequencies allocated for individual use by private citizens, be they radio amateurs, CB'ers, or both!

To this CB'er, the facts are plain. One of every 30 Americans uses CB today. We represent a fair share of our country's total population. Collectively, the people are the ultimate authority under our Constitutional system. I believe that the Federal government should not deny us orderly and proper access to any of our nation's natural resources, including radio communications. I believe that the FCC *must* place a high priority on finding and allocating a suitable portion of the radio spectrum below 450 MHz for the personal use of the public.

Things to Come: The FCC is now considering a Citizens allocation in the vicinity of 910 MHz, twice the frequency that I consider the upper limit for practical use by citizens who have little or no technical competence in radio communication. I believe that that choice of frequencies would be as ill-advised as the original allocation of 27 MHz for Class D. The experience with the uhf Class B service only confirms my opinion. It was never accepted by the public as a viable frequency allocation and was eventually withdrawn. Equipment suited to operate at 910 MHz would be very expensive. Furthermore, I think it is ludicrous to consider an allocation which requires installation and maintenance support facilities that are beyond the

means of most two-way radio service establishments now in existence. All in all, that frequency region is totally unsuitable for allocation to the Citizens Radio Service.

The intent of this article is to lay Class E right on the line. I, for one, am acutely aware of the need of many thousands of citizens who have a need for high-quality, personal two-way radio, but who are *not* radio hobbyists. These people are not yet on the CB rolls and cannot be counted. They have not yet been offered a service which meets their needs.

We should all write and urge the FCC to continue its search for an adequate frequency allocation for a service such as it had in mind when Citizens Band was first authorized. Our citizens deserve no less than a first-class service with all the facilities that modern technology can provide. That includes private call facilities (tone-encoded squelch), phone-patch facilities, direct public service and correspondence channels, and possibly repeaters. However, along with these added privileges should come a strictly enforced system of equipment standardization, including a periodic inspection program such as most states have for motor vehicles.

I recommend the annual licensing of all transmitters, with the requirement of annual inspection before renewal. I support automatic (on-the-air) transmitter identification. There is no reason why the legitimate operator should fear it, and ATI will enhance enforcement of channel usage restrictions and reduce equipment theft (by making it more difficult to "fence" stolen CB equipment). I also believe that the FCC charter should be extended by the Congress to include new minimum receiver standards. This new aspect of the law would protect CB users as consumers, and would protect the public as a whole against TV and other receivers with insufficient off-channel rejection characteristics.

Class E would be a different service than Class D, and would draw a different group of licensees. In no way do I suggest any reduction in the Class D service, which has its own separate and useful function.

As usual, I invite comments, but I cannot personally answer all letters. I particularly would appreciate comments from the CB community, or those who would use Class E if it were authorized as I propose. ♦



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Amateur Radio

By Herbert S. Brier

LIGHTNING AND THE RADIO AMATEUR

MOST OF US are familiar with the indirect effects that lightning produces on amateur communications—tremendous static crashes can make 80 Meters (and above) almost unusable on some summer nights. But every so often, we hear of the direct consequences of a lightning strike at an amateur's station. Among the reported effects are vaporized antenna elements, burned-out rotator motors, melted insulation in control and coaxial cables, and fused conductors.

Inside the shack, a number of things can happen. The antenna coils in the receiver can melt, or the contacts on the band switch weld together. Tubes and transistors can be destroyed. Diodes and capacitors, especially in the power supply, can blow. From the outside, the rotor control box might look fine, but it can be a shambles of burned out and shorted components on the inside. Half the lights in the house might be blown, and the rest will glow whether they are switched on or off. Electrical receptacles can be blown half out of their wall boxes. If a fire ensues, the firemen can do as much damage ripping out equipment and cutting cable as the original lightning strike caused.

This type of damage that has been experienced by amateurs whose antennas were struck by lightning does not mean that an outside antenna invites disaster in an electrical storm. On the contrary, a properly installed antenna is said to create a "cone of protection" whose diameter is approximately equal to the height of the antenna itself. Many amateurs have operated for years and years with antennas that are the highest objects in the vicinity of their homes without lightning damage (Fig. 1).

The secret of protecting antennas and the equipment connected to them is to provide a direct path from the antenna to the earth so that the elec-

trical charges picked up from the atmosphere will be discharged harmlessly into the earth, rather than blasting a path to the earth through the equipment to which the antenna is connected. The most familiar static discharge units (popularly called "lightning arrestors") are inserted in the feedlines of TV and radio receiving antennas and are grounded at the point where they enter the building. The units are usually miniature spark gaps. The weak received signals flow past the gap without difficulty, but high-voltage static charges jump the gap and are diverted to the earth. Coaxial units with trade names such as "Blitz Bugs" can be connected in series with a coaxial cable. They are usable in transmitting applications when the SWR on the line is not too high. However, they are not really necessary when a properly-installed coaxial line is used with a dc-grounded antenna. A typical

homemade arrestor for open-wire line is shown in Fig. 2.

If coaxial cable is used to feed an antenna, the National Electrical Code's provisions for lightning protection are met by connecting its shield directly to ground where the cable enters the building. One method of doing the job is to mount a type 83-1F or UG-363/U coaxial "bulk adapter" on a corrosion-resistant metal bracket just outside or inside the opening through which the cable comes into the radio room. Connect the coaxial cable from the antenna to one end of the 83-1F adapter using a PL-259 connector on the cable, and the cable from the transmitter to the other end. Clamp the bracket to a ground electrode through a heavy conductor running in as straight a line as practical.

Ground Conductors. The N.E.C. specifies that a ground conductor must have a minimum cross-sectional area at least as large as all conductors being grounded through it. In any event, it should not be smaller than No. 10 and should be composed of copper, bronze, copper-clad steel, or equivalent. The conductor may be bare or insulated and should be protected from mechanical injury. It should go to the ground electrode in the shortest practical path with no sharp bends. Otherwise, the heavy current flowing through it during a lightning strike may ionize the air at

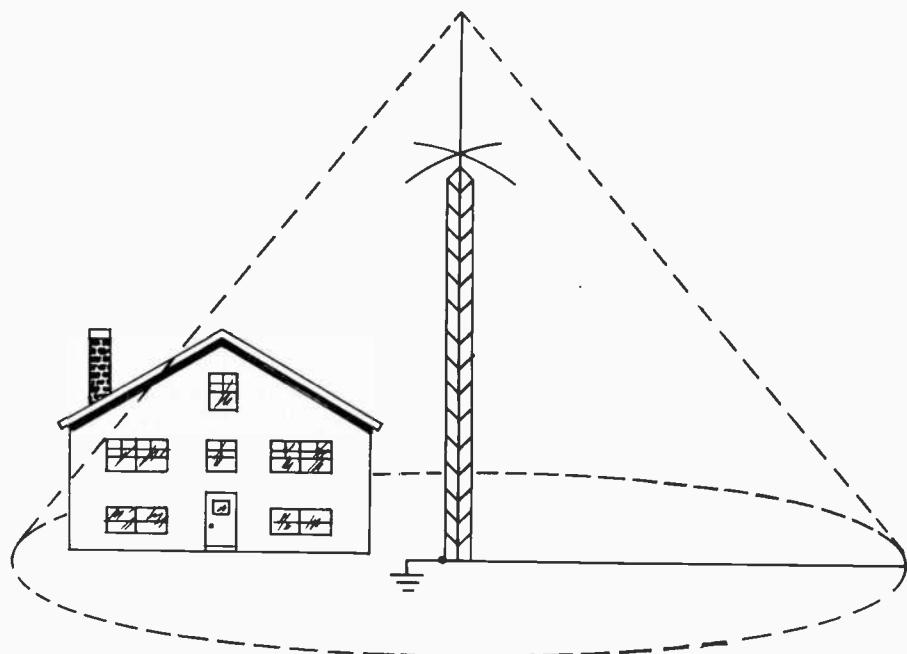


Fig. 1. Grounded antenna and tower create "cone of protection" for nearby structures.

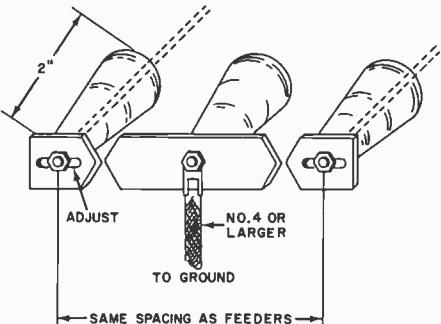


Fig. 2. Spark-gap lightning arrestor for feedline.

the bend and leave the conductor at that point to find its own path to ground, doing much damage in the process.

When available, a metal underground water pipe should always be used as the ground electrode, regardless of its length; however, if its underground section is (or is likely to be) less than 10 feet in length, it should be supplemented by an additional grounding electrode. This electrode can be a heavily galvanized iron or steel pipe a minimum of 1.25 inches, outside diameter, a ½-inch copper rod or other approved ground electrode driven into the ground a minimum of eight feet. Such a driven electrode can replace the buried, water-pipe ground, if the latter is unavailable. If the soil is dry and sandy, two or more driven electrodes spaced a minimum of six feet apart and bonded together can be used to achieve a lower ground resistance. In fact, all available ground electrodes should be bonded together to lower the ground resistance as much as possible.

It's interesting to note the differences in ground systems for lightning protection and a buried radial system for a vertical antenna's ground plane. The former uses electrodes driven or buried deep in the earth; the latter is burned only a few inches. There is no objection to connecting the ends and centers of the radials for additional lightning protection, however.

Ground all supporting structures, including those mounted on roofs of buildings. Metal towers are usually adequately grounded, but run a heavy conductor to the hardware at the top of a wooden structure supporting a horizontal antenna to the ground electrode. If the mast supports only a wire antenna, extend a metal rod a foot or so above its top as a lightning rod. Any elevated "ground plane" radial wires and the shield of the coaxial feed line

should be grounded before adjusting the antenna to the desired operating frequency. When the feed point of the vertical radiator is isolated from the radial system, a coaxial static discharge unit ("Blitz Bug") may be inserted between the PL-259 connector and the feed line to help drain static charges off of the vertical radiator of the antenna.

Unfortunately, grounding a multi-band "trap" antenna at the feed point does not protect its traps from high-intensity static currents in the event of a strike. The obvious solution to the problem is a spark gap across each trap, adjusted to the minimum spacing that does not arc under normal operation. However, many amateurs would merely repair or replace the trap if it is damaged by lightning.

Inside The Shack. For maximum safety, bond all metal cabinets, microphones, keys, and control boxes to a common ground bus. Homes built in the past few years or so often contain 3-terminal wall outlets with the third (round) terminal connected to the grounded neutral point of the power line. By using appropriate power cords with the third conductors connected to all chassis, they will be automatically grounded as the power plug is inserted in the receptacle.

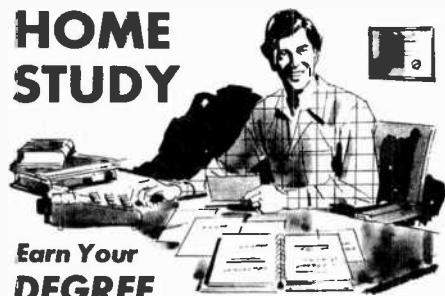
I wish I could say that these suggestions guarantee that lightning will never damage any of your equipment. The sad truth is that a lightning strike or near miss creates such a high-energy field in the vicinity that induced voltage spikes up to several thousand volts have been measured on local power lines during severe electrical storms. Occasionally, these surges find their way to ground through equipment plugged into the lines, popping components in the process. Cautious operators pull the power plugs and disconnect their antennas whenever a bad storm is brewing, or when they leave their equipment unattended. If you decide to follow their lead, don't just disconnect the antenna lead-in and leave it lying on the floor. Whether connected or disconnected, the only safe conductor in a storm is a grounded conductor. If your antenna selector switch grounds all positions except the one in service, turn the switch to an unused position whenever you leave the room. Finally, don't forget to unplug the rotor control cable and plug it into a socket with all terminals connected to the main ground electrode. ♦

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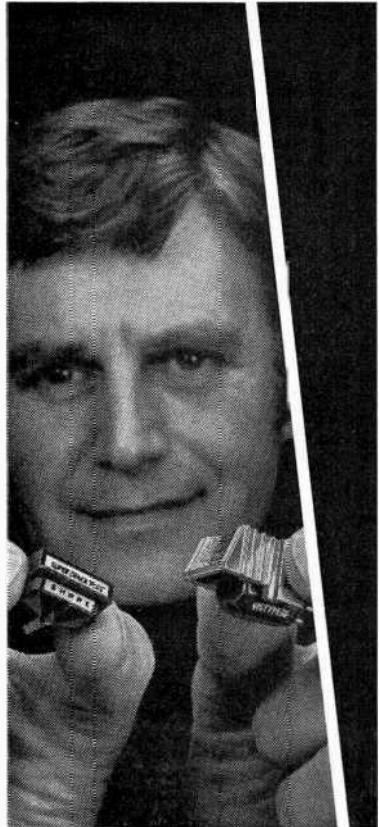
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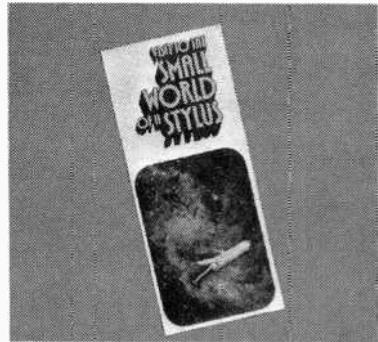


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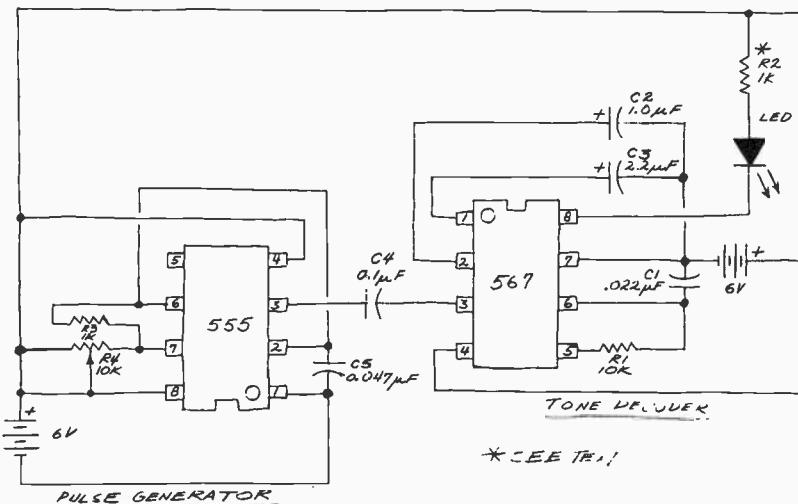


Fig. 2. Tone decoder demonstration circuit.

values speeds up the repetition rate.

With the component values given in Fig. 2, f_i should be $5000 \text{ Hz} (1.1/10,000 \times 0.022 \times 10^{-6})$. The test circuit, however, gave an f of 4480 Hz . I measured R_1 with a digital multimeter and found its actual resistance to be $10,320 \text{ ohms}$. This new value gave an f of 4845 Hz , which is within 3% of the predicted frequency, and any error is traceable to the tolerance of C_1 .

After you put the circuit together, experiment with the adjustment of R_4 while watching the LED. The LED should turn rapidly on and off as you rotate R_4 's shaft past the point where the 555 oscillates at the f of the 567. If you dim the room lights, you may notice the LED flickering just before and after it turns full on and off. Resistor R_2 limits LED current to about 3.5 mA . If your workbench is brightly illuminated or your LED inefficient, you can reduce the value of R_2 (say, to 500 ohms) to get more current through the LED. In any event, be sure to use a regulated dc supply or fresh batteries.

Frequency Response. A graph

showing the response of the circuit in Fig. 2 in the acceptance bandwidth region is shown in Fig. 3. The graph shows the input frequency from the 555 versus the output current through the LED. Note that the bandwidth is fairly wide when the input frequency goes high to low and vice versa.

After you've tried changing the frequency of the input tone, replace R_1 of the tone decoder with a 2000-ohm fixed resistor in series with a $20,000\text{-ohm}$ or $25,000\text{-ohm}$ potentiometer and readjust R_4 to provide an unknown input tone. You should easily be able to lock onto the unknown input frequency by adjusting the potentiometer. You can arrive at a rough estimate of the frequency of the unknown tone without using a scope or counter by measuring the total resistance of the potentiometer and its 2000-ohm series resistor and using the center-frequency formula.

At this point, the 567 would appear to work just fine, since it triggers an LED in response to any desired tone. But if you actually build the test circuit, you'll soon discover that the 567

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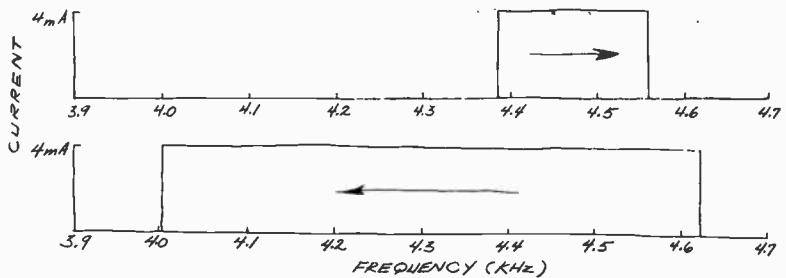


Fig. 3. Frequency response of circuit in Fig. 2. Arrows indicate positive and negative frequency changes.

has a tendency to trigger on what appear to be harmonics of the center frequency. The 567 will, in fact, lock onto frequencies corresponding to input signals near f_c ($4n + 1$) (where $n = 0, 1, 2, 3, \dots$). Also, the square pulses from the 555 will cause an output for $f_c/2$.

Fortunately, the response of the 567 to tones other than f_c is usually of no consequence. And if false triggering to undesired tones becomes a problem, you can either change the center frequency of the 567 or attenuate the offending tone with a notch filter.

Other Applications. After you have experimented with the 567 using the basic circuit in Fig. 2, you will probably think of lots of interesting applications. One fascinating possibility is a secret photoelectric lock activated by a tone-modulated LED. A phototransistor connected to the input of the 567 can be used to receive the signal from the LED, as shown in Fig. 4. This circuit has an optical range of a few centimeters without external lenses at either the LED or phototransistor. This is all the distance you need for most lock applications, but for more range

you can add an amplifier between the phototransistor and the 567 and use a lens at each end.

Whether checking out a potential application or just for fun, don't hesitate to experiment with the basic 567 circuit in Fig. 2. For best results, Signetics recommends that the resistance of R1 be between 200 and 20,000 ohms. Capacitor C2, the loop low-pass filter, should be selected from the Bandwidth versus Input Signal Amplitude graph given in both the National and Signetics data sheets on the 567.

At very low input frequencies, the time required for the 567 to lock onto the input tone can become relatively long. For example, I found that an input tone of 500 Hz required a full second for lock to occur. These and other eccentricities of the 567 are covered in detail in the manufacturer's (Signetics) data sheet, and I urge you to obtain this well-prepared document to assist you while experimenting with the 567. Another excellent source of information on the 567 is found in the Signetics Digital/Linear/MOS Applications book (Section 6, "Phase Locked Loop Applications").

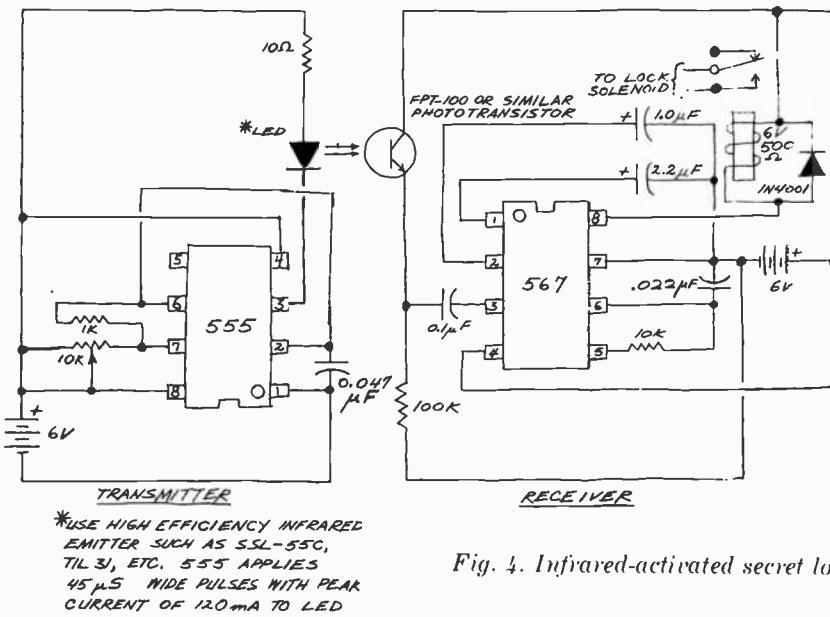
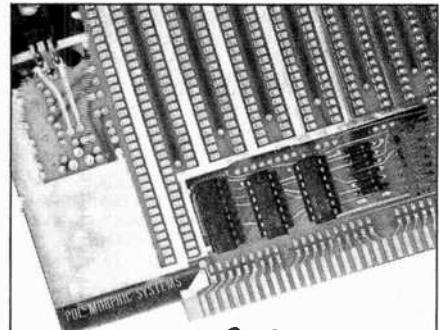


Fig. 4. Infrared-activated secret lock.



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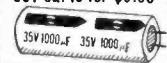
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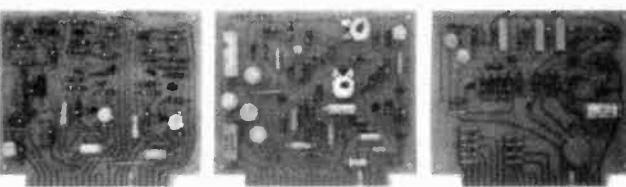
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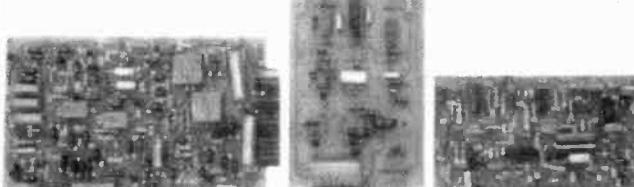
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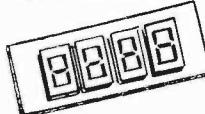
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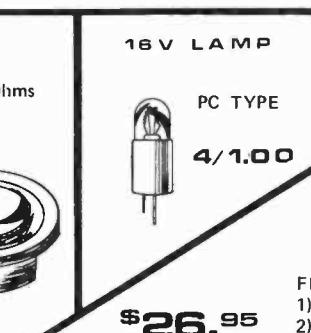
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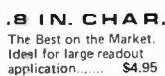
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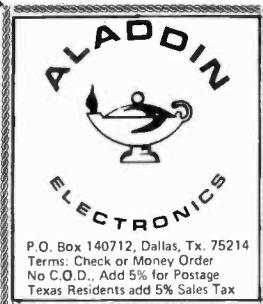


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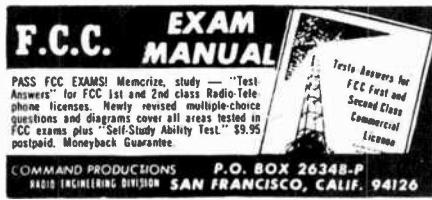
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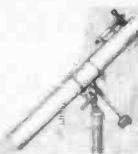
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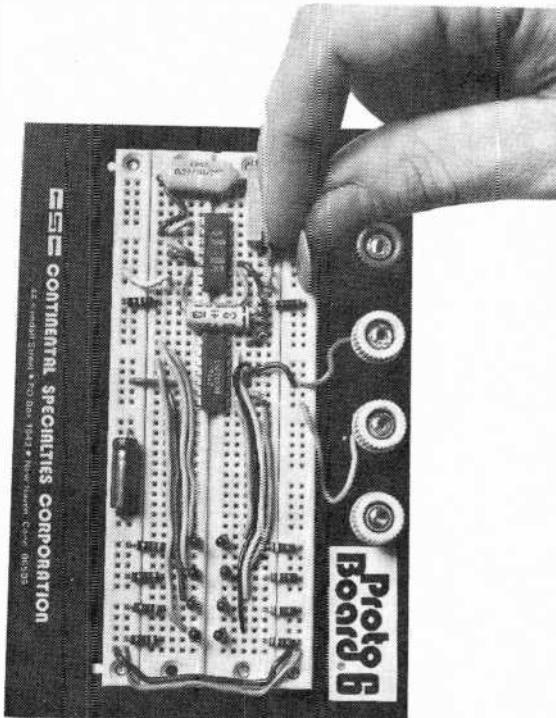
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If you're still designing and testing breadboard circuits the conventional way, you're doing a lot of extra work, and getting a lot of grief in return. You've got to think as much about manual labor as you do about the circuit. Maybe even more.

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With the CSC Proto-Board breadboarding system, connecting components is as simple as pushing a lead into a hole. Rugged 5-point contacts insure low-resistance connections, and where jumpers are needed, components are interconnected with standard #22 AWG solid wire.

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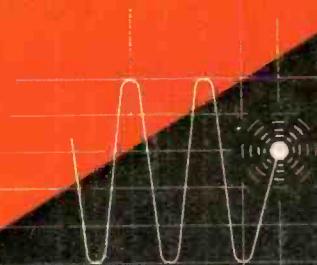
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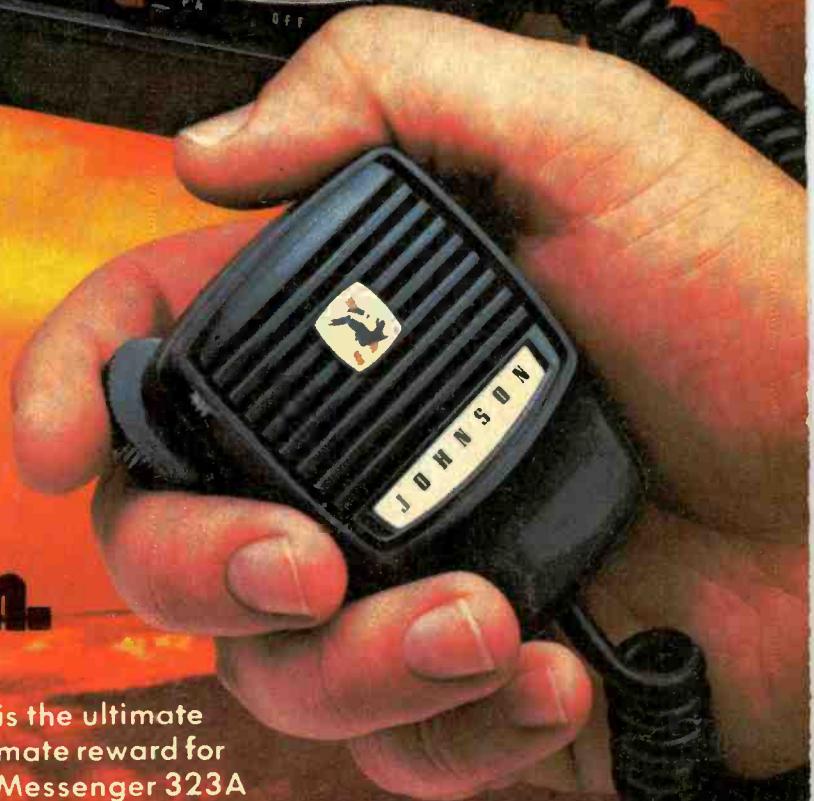
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