Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE FEBRUARY 1975/75c

HOW PHASE-LOCKED LOOPS WORK

A VU Meter with No Moving Parts

Shortwave Newscasts in English

Build a Minicomputer, Part II

"Tug of War" Electronics Game

TEST REPORTS:

Marantz 4270 Receiver

Garrard Zero 100SB Turntable

Ortofon VMS-20E Phono Cartridge

Lafayette Com-Phone 23 CB Transceiver

Data Technology Models 20 & 21 DMMs

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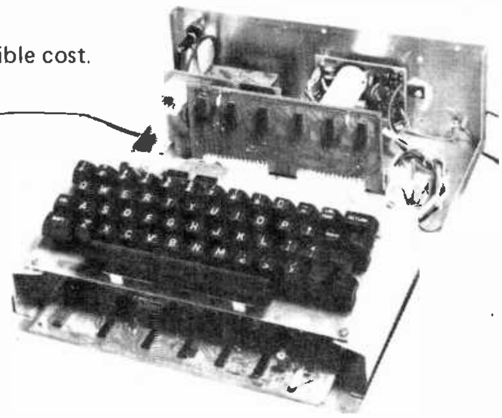

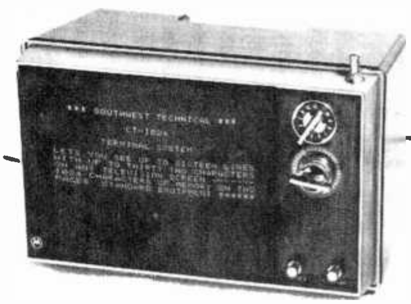

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At last we can tell you about the most versatile, video-display terminal kit available anywhere; the Southwest Technical CT-1024. Our terminal is designed around a basic mother board and a 6,144 bit memory that will display two pages of data on any standard television set, or monitor. The two pages consist of 16 lines with 32 characters on each line. Input may be any source of parallel ASCII code; keyboard, computer, etc. If the system is to be used for a display, teaching aid, deaf communicator, or other similar purpose; this is all you will need.

Other applications of a terminal system such as remote time share, RTTY, etc require an interface having a serial output. For these applications you add our# CT-S plug-in UART card to the mother board. This allows you to transmit and receive ACSCII coded data in serial form at a rate of 110 baud. (300 and 600 baud options are available). The standard RS-232 type interface connects directly to your transmitter FSK modulator, modem system, or what have you.

If you are going to use the CT-1024 directly with a computer I/O port that requires a parallel ACSCII input, then you will want our parallel interface card, #CT-P which allows either the keyboard, or the computer to access the terminals memory and display data on the screen.

For those applications where it is useful, we also have an "off line edit", or "screen read" plug-in circuit #CT-E. This allows you to compose a program, or, message on the terminals display screen and transmit it out a line at a time when you are finished and satisfied that everything is correct.

If you would like the convenience of complete cursor control, we have our #CT-CM plug-in board. This gives you Move Right, Move Left, Move Up, Move Down, Home Up, Erase to end of line and Erase to end of frame functions. These are operated by keyswitches, or any other type switches you may wish to use, giving you complete manual control of the cursor.

If the terminal is to be part of a computer system, you might prefer our automatic cursor control circuit #CT-CA. This plug-in not only allows you to control the cursor and to perform the functions listed above, but makes possible computer control of these same functions through the machines software.

# CT-1024 Terminal System Kit with 1024 Memory Card—less cabinet or power supply	$175.00 PPd
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# CT-M Manual Cursor Control Plug-in Card Kit	$ 11.50 PPd
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CIRCLE NO. 35 ON READER SERVICE CARD

Now there's a CB radio with too much talk power.

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It's all wrapped up in a beautiful, compact cabinet only 6" wide x 2½" wide x 7½" deep. Meets FCC requirements.

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CIRCLE NO. 8 ON READER SERVICE CARD

FEBRUARY 1975 VOLUME 7, NUMBER 2

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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CONSTRUCTION ARTICLES

COLUMNS

PRODUCT TEST REPORTS

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Editorial

IT'S A TOUGH WORLD OUT THERE

An electronics editor sometimes gets spoiled. Parts are almost always available, delivery is generally speedy, etc. However, to corroborate some reader reports that it isn't as easy as it once was to be an electronics hobbyist, I set out to build some projects without my protective cloak. Here are some of my experiences.

Failing to find a particular $3 component locally—retail electronics stores didn't stock it and industrial distributors wouldn't sell me just one—I found an industrial mail-order supplier that carried it. However, since I didn't meet a minimum purchase requirement, I had to pay a 50% premium ($1.50 handling charge) on the part, plus postage. I also used mail order for a single 750k-ohm, 5%, ½-watt resistor because it wasn't available at local outlets. And I purchased a 556 dual timer that turned out to be defective (which I learned after troubleshooting an inoperative module). After quickly wiring in a replacement without referring to an application note, I discovered that the second device had a different pin configuration.

Running out of solder, I hurried to a local electronics retailer and asked for a pound. The clerk's eyes widened as he advised me that tin prices had gone sky-high and a pound would cost $9.85, plus tax. Nine-eighty-five indeed, I thought! So I tried another electronics store, where I was able to buy a pound of name-brand, rosin-core solder for only $4.95. Happily, I took my bargain home, only to discover that the solder required more time than usual to melt. Furthermore, spread was poor, the liquified alloy looked slurry and the solidified joint was dull and crusty rather than bright and shiny. Distressed, I examined the spool. It was 40/60. What I wanted, naturally, was 60/40, which has a lower melting point (370°F vs. 460°F).

I could go on, but the idea is clear. It *is* more difficult today than it used to be to gather parts at the right price—for a variety of reasons. But in many ways, our lot today is better than it ever was. We have many more devices available, with numerous circuit application possibilities. Prices on many devices are low and getting lower (an anomaly in today's inflationary market). Using pc boards and multi-function chips, it is easier to assemble a complicated circuit today than it was to put together a simple one years ago. The result is more satisfactory also.

Facing up to the fact that no single outlet carries all parts and that some suppliers are not interested in small-quantity orders, how can one ease the parts procurement problem? One sensible way is to write to all companies that sell components and have catalogs available. Many of them advertise in this magazine. Be sure, also, to check mail-order suppliers at the back of the magazine. Arm yourself with cross-reference and replacement guides, too. This may sound basic, but we recently received a host of letters asking where one could get 200-PIV diodes for a solder-iron heat reducer hint we published, when practically every electronic parts catalog lists them!

Also, there's nothing wrong with using higher-rated components (a 2-watt resistor if a 1-watt isn't available); totem-poling zeners; paralleling capacitors; etc. Yankee ingenuity can often provide a helpful assist.

Art Salsberg

Get the news before it's news...

with a "behind-the-scenes" Scanner Radio from Radio Shack!

Realistic® scanners seek and lock-in on exciting police, fire and emergency calls, even continuous weathercasts.* There's one to cover the "action" in your area — 10 models in all.

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Continuously, automatically scans up to 4 crystal-controlled channels on 148-174 or 30-50 MHz. It stops on each active channel until the conversation ends, then resumes scanning. You don't miss a thing — it's like 4 radios in one! Lighted channel indicators, switches for bypassing any channels, scan/manual switch, variable volume and squelch, built-in speaker and antenna, earphone jack. With 4 "AA" cells. Requires up to 4 crystals. #20-171

PRO-5 — UHF "Metro" Band
Same as the PRO-6, but covers 450-470 MHz now used in many larger cities. Requires up to 4 crystals. #20-169

Accessories Available. Plug-in antenna, 12VDC adapter or AC adapter/battery charger, nickel cadmium batteries.

Pocket Size, Both Models 119⁹⁵ each

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The PRO-16 — a Super Scanner for the ultimate at-home or mobile listening post

229⁹⁵

Scans up to 16 crystal-controlled channels, in any combination, on 30-50 and 148-174 MHz VHF and 450-470 MHz UHF. Like 16 radios in one! Lockout buttons and indicator lights for each channel, manual selector, squelch, variable scan rate, scan-delay in/out button, 12 VDC/120 VAC operation, mobile mounting bracket. Requires up to 16 crystals. U.L. listed. #20-165

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CIRCLE NO. 29 ON READER SERVICE CARD

Letters

FEEDBACK ON SALT METER

The data on sodium chloride content of baby foods and other hypothetical intake cited in the POPULAR ELECTRONICS article ("An Electronic Salt Meter For Family Health," October 1974) are not unreasonable, but they do not give an accurate or complete picture of the salt intake of infants.

About 20 years ago, one of our physical chemists designed and built conductance meters for controlling salt addition in our production operations. Although these meters represented an advance at the time, their use has been abandoned because conductance is influenced by too many food factors other than salt. Salt addition is carefully controlled by weighing or accurate metering devices. The sodium levels in Gerber Foods are determined by atomic absorption or electron emission methods and have been published periodically for more than 20 years.

ROBERT A. STEWART, PH.D.
Director of Research
Gerber Products Company
Fremont, Mich.

PRO'S AND CON'S OF TECH REPPING

I enjoyed your article about tech reps ("Career Opportunities for the Tech Rep," November 1974). I feel it was a straightforward and honest account of the profession. Let me encourage anyone contemplating such a career—the future looks good. I would suggest an associate degree in electronics or computer science for the first-rate positions, as this would be a distinct advantage over either military or trade school training, with the added plus of having college hours should further education be desired. With "sheep-skin" in hand, you can literally write your own ticket.

MICHAEL P. TOWERS
Field Engineer
Singer Aerospace & Marine Systems
Binghamton, N.Y.

I have just finished reading "Career Opportunities for the Tech Rep," and as a former tech rep, my message to all is to stay out of the business. Tech repping is a job whose duration is only as long as the contract you are on lasts. Your job experience will not be recognized when you look for employment back in the U.S. — no matter what your title was as a tech rep. The pay offered for tech reps is not all that hot either.

BERNHARDT SANDLER
Gardena, Calif.

AND NOW A WORD FROM AN SWL

I am happy to see that the "Shortwave Broadcasts to North America" schedules are again being published quarterly in POPULAR ELECTRONICS. However, there is one criticism I feel I must make. The experienced DX'er knows that stations periodically change their schedules of operating frequencies—often without previous notice. To help correct this fault, a simple note should be prominently placed on the page to inform the reader that frequencies might be changed without notice.

I also question the use of a Collins receiver in preparing this listing. After all, how many newcomers to SWL'ing have an expensive Collins? With the receivers neophytes do have, they are lucky they can receive HCJB with good quality.

Kenneth Zichi, WDX8KWT
Bay City, Mich.

Your recommendation about a word of caution on frequency changes is hereby adoped. Thanks. With regard to the use of a Collins receiver, the information is supplied simply as a frame of reference. Unless one is seeking out a 5-kW station, less costly gear should display similar reception quality. The antenna is only a simple end-fed Hertz type. If one can't receive HCJB, which boasts one of the strongest and cleanest signals, he must have a defective receiver and/or antenna.

ERRATUM

A drafting error seems to have slipped into Fig. 2 of my "Photo Tachometer" story (August 1974). For transistor *Q2* (in Fig. 2), the S and G legends were shown transposed. Most people who build this project will correctly place the leads of *Q2* in the proper holes (they conform to the transistor's lead basing configuration), but we should clear up this confusion for anyone who may have doubts.

A.A. MANGIERI
New Kensington, Pa.

WHEN DOES $10 EQUAL $100?

I have built the "Large-Port Speaker System" described in the August 1974 issue and have only words of praise. This is not only the most unique speaker system that I know of, but it is also the best sounding system I have heard next to $100 and $200 systems with which I compared it. Considering that my Large-Port Speaker System cost only $10 to build, the results are remarkable.

SCOTT E. PERSSON
Omaha, Neb.

"ELECTRONICS AUSTRALIA" SCOOPS PE

In "Build a Laser TV System" (November 1974), it was claimed that POPULAR ELECTRONICS published details of the world's first hobbyist/experimenter's laser in December 1969. I beg to differ! We published construction details for such a project in our August 1969 issue and gave details of the modifications necessary to use it for light-beam communications in our October 1969 issue.

J. ROWE
Editor
ELECTRONICS AUSTRALIA
Sydney, Australia

We were surprised to learn that we were scooped on another continent back in 1969. Congratulations EA.

SETTING UP CB SERVICE SHOP

I enjoyed "How to Set Up a Home TV Service Shop" (August 1974). Now, I would like to see you publish an article on how to set up a home CB service shop.

BOB J. LATHIM
Dwight, Ill.

DISCRETE IS BETTER THAN INTEGRATED

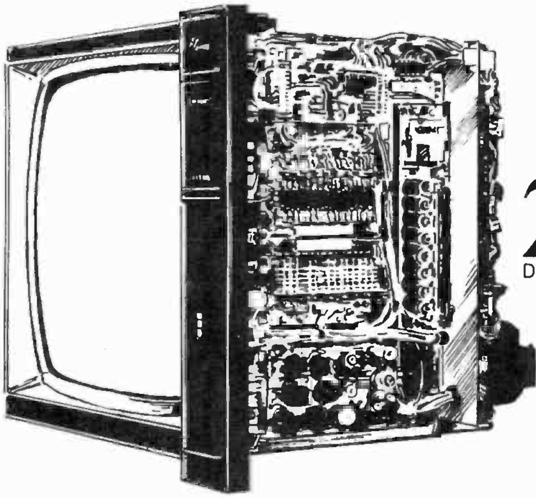
In Don Lancaster's article on selecting an electronic music synthesizer (October 1974), our company was omitted from the list of manufacturers.

There is one portion of the article to which we would take exception. That is his statement that present-day IC's will provide economies in future synthesizers. Our engineering staff has yet to find an integrated circuit currently on the market (except for the 741 op amp) that will perform as well in EM circuits as do our discrete designs. We have been told by almost all our competitors that they have found the same thing in their research.

O. D. WILLIAMS
General Manager
Steiner-Parker
Salt Lake City, Utah

Out of Tune

In "Measure Low Millivolts with a Multimeter" (November 1974), capacitor C1 is listed correctly as 3 pF in the Parts List, but is shown incorrectly as 33 pF in the schematic. Resistor R10 is a 100,000-ohm fixed resistor, not a potentiometer.



You get the same 25" hobby-kit color TV from three different schools.

DIAGONAL

You get this designed-for-learning 25" color TV only with NRI training.

DIAGONAL

No other home-study school gives you a TV like the one you build with NRI's Master Course in Color TV/Audio servicing. Some schools give you three or four plug-in sub-assemblies off the production line to put together a commercial set. Others give you a hobby-kit bought from outside sources. And because neither type was originally designed to train people for TV servicing, lessons and experiments must be "retro-fitted" to the set as it comes.

That's why we went to the trouble to engineer our own, exclusive solid-state TV. It's the only way a student can (1) get the feel of typical commercial circuitry, (2) learn bench techniques while building a complete set from the "ground" up, (3) perform over 25 "in-set" experiments during construction, and (4) end up with a 25" diagonal solid-state color TV with console cabinet and all the modern features you'll find on sets you'll service. Nobody else can give you this combination of advantages because nobody else invested the time and money to design a set with learning in mind.

More know-how per dollar

That's what it all boils down to, the quality of training you get for the money you spend. In our 60-year history, more than a million students have come to NRI and we're fully approved for career study under the G.I. Bill. We must be teaching something right.

Some of those "right" things are bite-size lessons to ease understanding and speed learning . . . personal grading of all tests, with comments or explanations where needed . . . a full-time staff of engineer/instructors to help if you need it . . . plenty of "real-life" kits and experiments to give you hands-on training . . . and fully professional programs oriented to full- or part-time career needs.

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You don't pay a big premium to get this unique TV as part of your training, because NRI engineering eliminates the cost of buying from an outside source. And we pay no saleman's commission. We enroll students by mail only. We pass the savings along to you in the form of low tuition fees, extras like a cabinet for the TV, a solid-state radio you learn on as you build, and actual instrument kits for servicing TVs . . . triggered sweep oscilloscope, integrated circuit TV pattern generator, and 3½ digit digital multimeter. You can pay hundreds of dollars more for a similar course and not get a nickel's worth more in training and equipment.

Widest choice of career opportunities

NRI offers not one, but five excellent TV/Audio servicing courses so you can tailor your training to your budget. Or, you can study other opportunity fields like Computer Electronics, Communications, Aircraft or Marine Electronics, Mobile Radio, and more. Free catalog describes them all, showing lesson plans, equipment and kits, and career opportunities. There's no obligation and no salesman will ever call, so send for your copy today. See for yourself why NRI experience, selection, and exclusives give you something no other school can.

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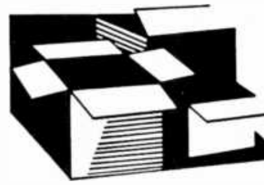


New Products

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.

PEARCE-SIMPSON COUGAR 23B TRANSCEIVER

This mobile CB transceiver by Pearce-Simpson features 23-channel capability, built-in SWR bridge, r-f noise blanker with manual override and a multi-purpose meter that indicates r-f output and acts as a receive/transmit indicator, S-meter, modulation monitor, and forward/reflected

power meter. Other features are a high-Q ceramic filter, PA capability, squelch, receiver offset tuning, and noise limiter. Specifications include 5 watts input power and a rated sensitivity of 0.5 μV for 10 dB S+N/N. A noise-cancelling dynamic microphone is included with the rig. It measures 6⅞" × 2³⁄₁₆" × 9¼" (17.3 cm × 5.5 cm × 23.2 cm) and operates from a 13.8-V positive or negative ground source.

CIRCLE NO. 70 ON READER SERVICE CARD

BLONDER-TONGUE FM ANTENNAS

Two new antennas for the FM broadcast band have been introduced by Blonder-Tongue. Both the eight-dipole Stereo-8 and the five-dipole Stereo-5 are log-periodic designs whose dipole elements operate in the half-wave mode. This design is said to provide good gain and directivity and an impedance that is essentially uniform across the band. The Stereo-5 has a claimed average gain of 4 dB across the band, 16-dB front-to-back ratio, and 70° horizontal beamwidth. The respective figures for the Stereo-8 are 6.5 dB, 26 dB, and 60°. For rotor-equipped installations, the turning radii are 52 in. (1.32 m) for the Stereo-5 and 65 in. (1.65 m) for the Stereo-8. The respective retail prices are $27.28 and $40.29.

CIRCLE NO. 71 ON READER SERVICE CARD

DYNASCAN RF SIGNAL GENERATOR

Dynascan announces introduction of the B & K Model 2050 RF Signal Generator. The unit is totally solid-state, and provides

three outputs—r-f, 400-Hz modulated r-f, and externally modulated r-f. Accuracy is said to be 1.5% of dial setting. A combination high-low switch, plus continuously variable r-f output control provides up to 20-dB change in output level. Features include zener-regulated power supply, FET oscillators, 4½-in. dial with anti-backlash drive, and shielded leads terminated with a banana plug and insulated clip. Measures 7½" × 6⅛" × 9¾" (19.1 × 15.6× 24.8 cm). Price is $107.00

CIRCLE NO. 72 ON READER SERVICE CARD

HEATHKIT EXHAUST GAS ANALYZER

With the new Heathkit CI-1080, persons can check exhaust emissions of their own cars, and adjust engine tuning for minimum pollution levels and maximum operating efficiency. The Exhaust Gas Analyzer indicates air-fuel ratio, percentage of carbon monoxide present, and relative combstion efficiency of four-cycle automotive engines. Color-coded battery clips attach to any 6- or 12-volt auto battery. A flexible stainless steel tubing directs exhaust gas from the tailpipe to the sensor. The kit is mail-order priced at $59.95.

CIRCLE NO. 5 ON READER SERVICE CARD

CASTLE MASTER TUNER SUBBER

The Master Subber Mark V is the latest addition to Castle's line of instruments for TV service technicians. It is a signal-substitution type of analyzer that can be used to test all signal stages of color and monochrome TV receivers. Substitution signals allow tests of: vhf tuner, uhf tuner, video i-f amplifiers, video detectors, video amplifier, 4.5-MHz sound i-f amplifier, sound limiter, sound detector, audio amplifier. A loudspeaker, video-carrier level meter, and telescoping antenna are included with the subber. The unit can be operated from the 117-volt ac line or from its internal 9-volt alkaline battery supply.

CIRCLE NO. 73 ON READER SERVICE CARD

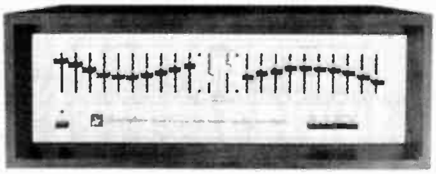
BURWEN NOISE FILTER

The Burwen Model DNF 1200 is a dynamic noise filter that is compatible with any program source. Thus, it does not require encoded program sources. Employing a filter whose bandwidth is varied according to the spectral content of the program material, the filter attenuates the high-frequency content when the program level is low—when the noise is most noticeable. At other times, the spectral configuration of the program material is not disturbed since the level of the signal is sufficient to mask the noise. The threshold at which dynamic filtering is engaged is determined by a sensitivity control. Switches are provided for program source selection, switching the filter in and out of the signal path, and for power. A slide control is used for setting the filter's threshold. Two LED's monitor the activity of the filter: dynamic filtering (suppression) and unaltered spectral balance (Wide Band). The noise filter is claimed to produce only 0.2 percent harmonic distortion.

CIRCLE NO. 74 ON READER SERVICE CARD

SOUNDCRAFTSMEN TAPE RECORD/PLAYBACK EQUALIZER

The Model RP 2212 stereo 10-octave equalizer allows the owner of a hi-fi system to introduce flexible audio response without loss of tape-monitoring facilities when



only one set of jacks is available for patching purposes. In addition to extra outputs for tape recording and playback, the equalizer features LED indicators for input/output balance adjustments, front-panel pushbutton selectors, separate equalized zero-gain controls with a range of +6 to −12 dB and ±12−dB response adjustments for each octave. The RP2212 is packaged in a walnut-grained vinyl case. Price is $349.50.

CIRCLE NO. 75 ON READER SERVICE CARD

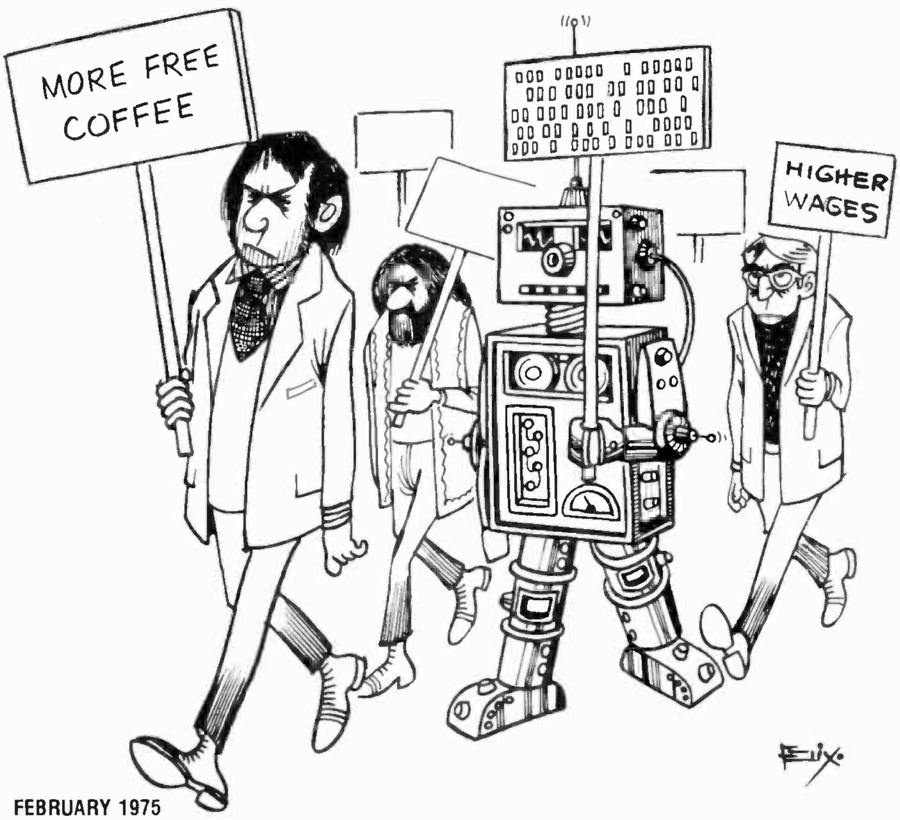
ASCOM MULTITESTER FOR VHF

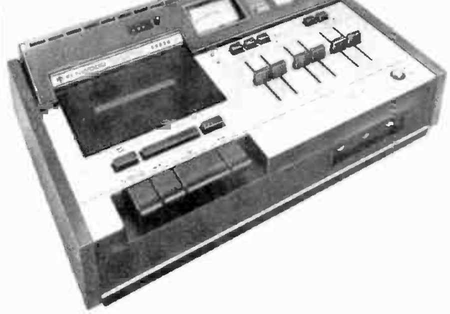
Ascom Electronic Products has introduced a new multitester for use with vhf communications systems. The Model AMSR100 tester is useful for monitoring transmitter and antenna operation over a frequency range of 144 to 174 MHz (contains vhf marine band, land mobile channels, and 2-meter amateur band). The instrument functions as a wattmeter, field-strength meter, and VSWR indicator. It has 0-25- and 0-50-watt power ranges. Transmitter output power is read directly on either scale with a claimed ±8-percent accuracy. VSWR is measured, with meter calibration from 1:1 to 3:1. Using this function, antenna adjustments and matching network operations can be checked. To monitor overall system operation and antenna directivity characteristics, the field-strength meter is used. Price is $69.95.

CIRCLE NO. 76 ON READER SERVICE CARD

KENWOOD DOLBYIZED CASSETTE DECKS

Kenwood has introduced two new high-performance cassette decks with Dolby noise reduction. The decks, KX-910 and KX-710, boast a number of special features, including a high-torque motor, belt-driven large (90 mm) flywheel, and precision-machined capstan. Flutter and wow is





specified as 0.1%. Use of a special ferrite head extends high-frequency response to 16 kHz. Automatic tape selector and Auto Memory, an Automatic Level Control, and LED peak-level indicators add to operating flexibility and performance.

CIRCLE NO. 77 ON READER SERVICE CARD

GLENBURN RECORD CHANGER

A new record changer, the Model 351, has been introduced by the Glenburn Corp. A wide umbrella spindle has been incorporated into the unit to correct double record drop, record hang-ups and unbalanced-record slanting tendencies. Other features

include bi-directional viscous-damped cueing, slide-in cartridge adapter, dual anti-skating scales, gravity stylus pressure adjustment, and a four-pole synchronous motor. The unit is equipped with a Shure M91E elliptical stylus. Price is $160.

CIRCLE NO. 78 ON READER SERVICE CARD

ADD-ON FOAM SPEAKER GRILLES

Do-it-yourself speaker grille kits with sculptured-foam speaker material are offered by Republic Systems. This flexible urethane foam can be sprayed with latex paint if the standard black color is not suitable to the user's decor, and cut with scissors for a custom fit. Foam is available in 8" × 15" (20.3 × 38.1 cm) and 14" × 24" (35.6 × 61 cm) sizes. Each kit contains sculptured foam grille, self-sticking attachment material, and instructions. Address: Republic Systems Corp., 9160 Green St., Chicago, IL. 60620.

MIDLAND 23-CHANNEL HAND-HELD CB RIG

Midland Electronics' Model 13-796 is a 23-channel, hand-held transceiver with 5 watts input power. The dual-conversion superhet receiver includes agc and a three-way meter for indicating signal strength, output power and battery condition. Includes a jack for use with an optional external microphone/speaker. The transmitter can be run at full legal power input or in a "battery saver" 2.5-watt input mode. It operates on 12-V dc penlight cells (dry-cells or nickle-cadmium), ac adapter, or auto cable. $190.95.

CIRCLE NO. 79 ON READER SERVICE CARD

FLUKE MULTI-FUNCTION FREQUENCY COUNTER

The John Fluke Co.'s new Model 1900A frequency counter has an upper limit of 80 MHz, and contains autoranging and autoreset functions. Autoreset controls all functions and gate times, and autoranging is available in both the frequency and period measurement modes. The 1900A

uses advanced LSI/MOS circuitry, has four over-riding gate times for manual selection of resolution down to 0.1 Hz. The frequency counter can also be used to totalize, with event counting up to 10^6 events. Results are displayed on six LED digits with leading zero suppression, automatic annunciation and overflow. A switchable 1-MHz low-pass filter and attenuator are included. Sensitivity is 25 mV, and dynamic range is 5 Hz to 80 MHz. An optional rechargeable internal battery pack is available. $349.

CIRCLE NO. 80 ON READER SERVICE CARD

SOLDERING IRON TIP CLEANER

The RE-TIP (No. 9482) from GC Electronics is designed to instantly clean any contam-

inants or excess solder from iron and pencil tips. It accommodates tips up to ¼-inch diameter. The tip cleaner has a self-adhesive bottom for workbench installation. A refill cartridge, catalog No. 9484, is also available.

CIRCLE NO. 81 ON READER SERVICE CARD

CIRCLE NO. 33 ON READER SERVICE CARD

New Literature

EDSYN SOLDERING TRAINING MANUAL

A new training manual for soldering techniques has been prepared by the Edsyn Company, a manufacturer of soldering tools. Using the Fanovision[tm] method (flipping the pages creates a nickelodeon effect), correct soldering practices are illustrated, supplemented by text. Also included in the 144-page publication are Color codes for resistors, Ohm's law, Series and Parallel Resistance tables, and inch/millimeter conversion tables. Available at participating dealers for $7.95, or free with a $7.95 or more purchase.

NATIONAL LED DRIVER SELECTION GUIDE

National Semiconductor offers a short-form device summary to designers in selecting LED drivers. The LED Driver Selection Guide lists 23 National driver types. Organized as a four-unit matrix, the guide has rows for common anode and common cathode configurations, and columns for segment and digit drivers. Thus the user can tell at a glance exactly which LED driver is needed. Available from Marketing Services, National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, CA 95051.

PACE COMMUNICATIONS CATALOG

A new four-color, full-line catalog from Pace Communications, displays its equipment for CB, Marine, Scanning Monitor, and Business/Industry Communications. Each unit is illustrated, described, and specifications and available accessories are listed. Available from Pace Communications, 24049 S. Frampton Avenue, Harbor City, CA 90710.

FORDHAM SERVICEMAN/TECHNICIAN CATALOG

A new 48-page, illustrated discount mail-order catalog is available from the Fordham Radio Supply Company. This catalog has been designed as a quick reference ordering guide for Radio/TV Servicemen, Electronic Technicians, and Hobbyists. Included are tools, repair kits, tubes, test equipment, phono cartridges, speakers and mikes, antennas, and components. Available from Fordham Radio Supply, 558 Morris Avenue, Bronx, N.Y. 10451.

EICO TEST EQUIPMENT CATALOG

A 6-page condensed catalog featuring a broad line of electronic test and measuring devices is now available from Eico. The publication includes a large selection of oscilloscopes, VTVM's, FET VOM's, signal tracers, signal injectors, bridges, grid dip meters, automotive engine analyzers, and battery eliminators/inverters. Accessories such as test probes, and carrying cases are also listed. In all, more than 100 electronic kits and factory-assembled units are described. Address: Eico Electronic Instrument Co., Inc., 283 Malta St., Brooklyn, NY 11207.

EDMUND SCIENTIFIC CATALOG

The latest in items that conserve energy, save money, plus things that are unusual or just plain fun are crammed into Edmund Scientific's Catalog No. 751. Over 300 new products and a total of 4500 items are included in the 164-page publication. Products include devices for reclaiming chimney heat, brain-wave monitoring, metal detection and Kirlian photography, as well as Edmund's well-known line of telescopes. Address: Edmund Scientific Co., 555 Edscorp. Bldg., Barrington, NJ 08007.

SPRAGUE INTEGRATED CIRCUIT GUIDE

Sprague Electronic's Semiconductor Division has published a guide to its line of "ion-implanted" integrated circuits, desinged for application in the audio, radio, and TV fields. IC's are offered to implement many functions — from chroma demodulators and oscillators, TV sound systems, to stereo decoders for FM receivers and audio amplifiers and preamplifiers. Includes "quick selector" and cross-reference tables. Address: Sprague Electric Co., 115 Northeast Cutoff, Worcester, MA 01606.

SWITCHCRAFT SHORT-FORM CATALOG

Switchcraft, Inc. announces the publication of its 1974/75 Short-Form Catalog. Contains more than 4000 product listings, with a special alphabetical/numerical index. The 42-page booklet provides product data and prices of major Switchcraft product lines, including telephone jacks, plugs, switches, connectors, molded cable assemblies, and audio accessories. Available from Switchcraft, Inc., 5555 No. Elston Ave., Chicago, Il. 60630.

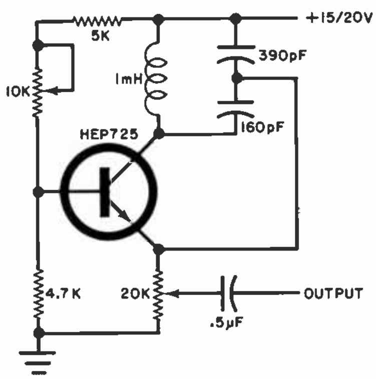
HEATH/SCHLUMBERGER INSTRUMENTS CATALOG

Test instruments for the advanced electronics experimenter, engineer, and scientist are listed and fully described in the latest Heath/Schlumberger catalog. Featured are such instruments as frequency/events counters, oscilloscopes, multimeters (both digital and analog), signal generators, substitution boxes, etc. For the engineering and science labs, there are chart recorders and accessories, an analog/digital designer breadboarding system, plug-in circuit cards, and pH meters. Address: Heath/Schlumberger Instruments, Benton Harbor, MI 49022.

Hobby Scene

BEAT OSCILLATOR FOR CODE

Q. ***I have an excellent AM-FM-Shortwave receiver that I would like to use to help me learn Morse code. How could I arrange a low-cost beat oscillator to use with my set?***



A. The circuit shown here can be added to your receiver either at the antenna, the i-f strip, or the detector. Adjust the 10,000-ohm potentiometer for maximum output amplitude and the 20,000-ohm potentiometer for the desired level. The coil shown is for a 455-kHz i-f.

CDI INTERFERENCE

Q. ***I have installed a CDI system in my 1967 VW Bug and have the typical problem of ignition interference with my AM radio (Sapphire V). I've shielded all CDI leads, the ignition coil, and installed "Mag Wire." The noise is the distinct sound of the unit's multivibrator, which varies with engine speed, and seems to come through the speaker even when the radio is off. Any suggestions?***—*R. Schweder, La Habra, Cal.*

A. CDI systems do not use variable-frequency multivibrators, but run at a fixed frequency set by an RC combination. You must be hearing something else. More likely the voltage regulator, the generator, or the ignition coil is the trouble source. Add 0.5-μF feed-through (coaxial) capacitors to the armature and battery connectors on the regulator, and attach the leads to them. Connect a 5-ohm, 1-watt resistor and a 0.002-μF capacitor in series from the regulator's field terminal to ground. Generator leads to the regulator should be well shielded. If interference is still a problem, install a 0.5-μF bypass capacitor from the battery terminal of the ignition coil to ground, and/or a 0.1-μF coaxial feed-through capacitor to the coil's battery terminal, attaching the battery lead to the capacitor's top post. That should take care of any interference problems. It is not unusual for a solid-state radio to produce audible interference at the speaker when power is off, because a transistor junction can rectify an r-f signal even when not supplied with operating voltage.

ULTRASONIC INSECT REPELLER

Q. ***I live in an area where the mosquitoes are ferocious. Could you show me a simple circuit for an ultrasonic insect repeller. I have seen them advertised and would like to construct one. P.S. Where can I get a 1N3716 tunnel diode?***—*M. Rehorst, Cudahy, Wis.*

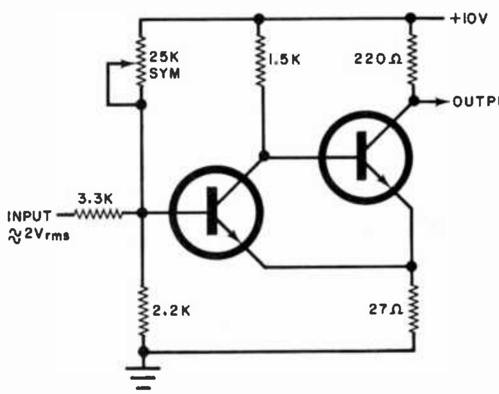
A. See "Electronic Pest Control," a construction project in POPULAR ELECTRONICS July 1972. The tunnel diode is listed in the Newark Electronics catalog. Nearest branch is at 3695 No. 126th Street, Brookfield, Wis., 53005. (414) 781-2450. However, a $25 minimum order must be sent.

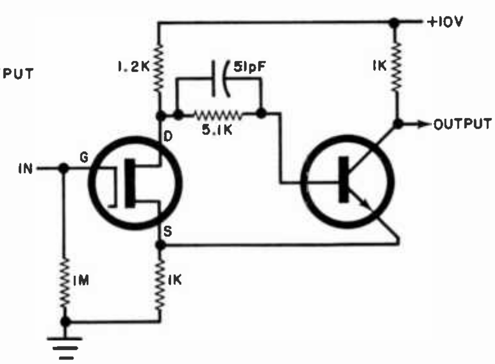
SQUARE WAVES FROM SINE WAVES

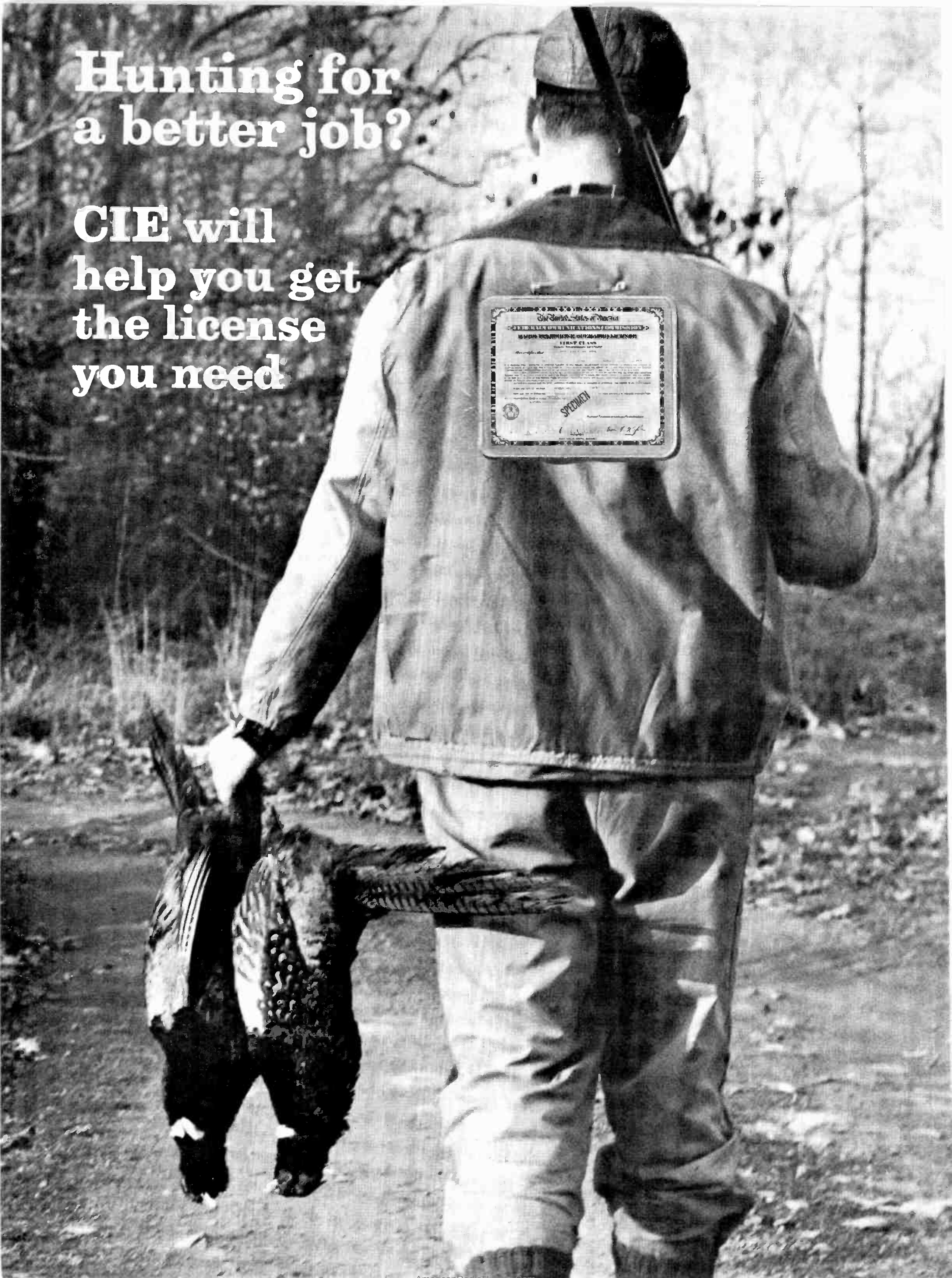
Q. ***I have a decent solid-state sine-wave generator that I use quite often. Is there a simple circuit that I can use with the generator to get clean square waves? The circuit should be small enough to mount within the present case.***

A. There are several approaches to this problem. You can use a low-cost TTL flip-flop (with a +5-volt supply) driven from the sine-wave source. Although the square waves will be clean, they will be at half the dial frequency. (The flip-flop divides by two.) You can also use a TTL Schmitt trigger; or, you can use the simple circuit shown here. Any decent silicon switching transistors can be used. Set the potentiometer for the desired symmetry. Once adjusted, this potentiometer should not have to be reset. The circuit will cover the audio range from about 10 Hz to 100 kHz. It requires a drive of about 2 volts.

Another reader asked the same question, but he was also concerned with the loading of the square-wave converter on his audio generator. The second circuit shows a high-input-impedance Schmitt trigger using a MOS front end. Because of the high input impedance, the circuit should not load the generator. The trip point is between 3 and 3.5 volts.






Hunting for
a better job?

CIE will
help you get
the license
you need
SPECIMEN

Stereo Scene

By Ralph Hodges

TAPE HEAD ALIGNMENT

WHEN it comes to aligning tape recorders, I favor the support-your-factory-serviceman approach. A practiced technician with a bench equipped for alignment can make short work of even a complicated machine; but an untrained amateur taking his first crack at the job is almost certain to find it tedious and outrageously time consuming. So there's no disgrace, as I see it, in saving the alignment (and other routine chores of maintenance) for a periodic factory return, where your machine can be fussed over by capable and sympathetic hands.

But how do you know *when* your recorder needs such care? And worse, once it's given, how do you know it was administered properly, or that it survived the trip back to your local freight depot, the ride home in the trunk of the car, or the fall from the coffee table that took place several days later?

Many experts suggest that, as a check on the day-to-day health of your recorder, you make and save a reference recording (a dubbing of a phonograph record, for example), and assure yourself periodically that the machine is still capable of recording the same disc with equal fidelity. This is actually a fairly sensitive test. But some people are reluctant to trust their ears that far, and others will have long since updated their phono cartridges or other components in the system, changing the reference point. Finally, the reference-recording test is not at all diagnostic; you may *hear* that something is wrong, but you won't necessarily know what. Clearly it would be good to have some additional techniques for isolating specific problems.

The alignment of a tape recorder refers to both electrical and mechanical adjustments, and these affect its frequency response (particularly *high*-frequency response), signal-to-noise ratio, distortion, and drop-out rate (drop-outs are brief signal losses caused by imperfect tape-to-head contact): Many of the adjustments are interdependent. Therefore, if you ever feel ambitious enough to make one, you may find yourself forced to make all the rest.

This is precisely what you're trying to *avoid*. So the idea behind recorder check-ups at home is to find out as much as possible about what's right and wrong with the machine without disturbing any of its adjustments too much. This is not easy, I assure you, but there are ways.

Mechanical Alignment. This refers to the orientation of the tape heads relative to the tape passing over their faces. Not only should each head be positioned properly, but, since most serious recordists' tape recorders have at least three interdependent heads (erase, record, and playback), they should all be positioned properly relative to one another. The *azimuth* adjustment—getting the record and playback head gaps precisely perpendicular to the edge of the passing tape—has been well publicized because it is critical for extended high-frequency response. However, there are other alignment factors (Fig. 1) that can affect audible performance much more. The *height* adjustment, for example, which determines how accurately the playback and erase heads line up with the tracks the record head lays down, is vital for a good signal-to-noise ratio, and can even affect the drop-out rate. The same is true of the *tilt* adjustment.

As a preliminary check on alignment, put a reel of tape on the machine and record a 1,000-Hz tone from your audio generator on both channels, watching the recorder's output on a scope. Use a fresh reel of good tape for this, since any deformation of the tape edges will grossly influence results. It's also a good idea, in this and subsequent tests, to run through the reel at least once beforehand at normal playing speed, so that the machine has had a chance to wind the tape the way it normally does on the take-up reel. Do not use a fast-wound tape for this test and watch out for any rubbing of the tape on the reel flanges.

Set the scope for a slow sweep so that you can observe the envelope of the signal rather than individual cycles. As you switch the scope from one channel to the other, small differences in level will be readily apparent, and you'll also see drop-outs as momentary gashes in the envelope. The ideal is for both channels to be equal in level and drop-out severity—an achievable goal for a half-track machine, but not always for a quarter-track recorder, which may have a consistently poorer left channel.

The level difference between the two channels should be well within one decibel. Otherwise, some electri-

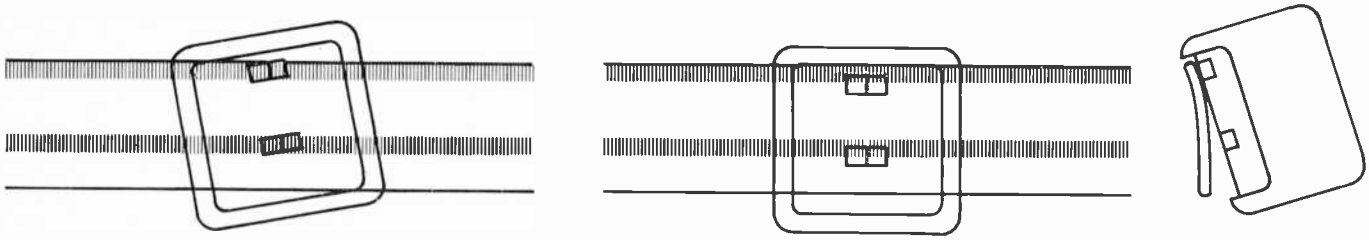


Fig. 1. An azimuth error, as indicated at (A) is a common cause of losses at the extreme high frequencies. A height error is shown at (B), with the head gaps missing the tracks somewhat. At (C) is a tilt error. All illustrations are exaggerated for clarity.

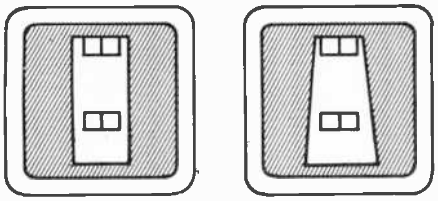


Fig. 2. A tilt error produces a trapezoidal wear pattern on the head. Correct pattern is at left.

cal portions of the machine—meters, or recording or playback electronics —are miscalibrated, or there is a tilt problem with one of the heads. If, on a quarter-track machine, the right channel is lower in level (and all other possible causes have been eliminated), the trouble is very likely tilt, which causes the top edge of the tape to press closer to a head than the bottom. A tilt error should also produce more drop-outs on the weaker channel.

A height misalignment is less likely to show up as a level difference between channels. What can happen, however, is a high drop-out rate on the left channel of a quarter-track machine, usually caused by a record or playback head that is too low (and therefore recording or playing right on the upper edge of the tape, which is the most irregular part).

The Magic Marker Test. To get an idea of the tilt situation, as well as a general picture of tape-to-head contact, try gently painting the head faces with dark-color ink from a felt-tip pen and running a few seconds worth of tape over them. Once the tape has worn away some of the ink, you'll be able to see a contact patch, which should be perfectly rectangular in shape and well centered on the head face (Fig. 2). If the patch is trapezoidal (i.e., wider at the top or bottom of the head), there is a tilt misalignment, although it may not be obvious which head is misaligned. Any head of the three can give the tape a little skew that will show up in the contact patterns of the other two. But probably the responsible head will have a patch that is larger in area. (As a general rule, you can expect patches of equal size on the record and playback heads of a properly aligned machine.)

On a brand new recorder, or an especially old one, the contact patches may be roughly rectangular, but irregular in shape or even streaky. In the new machine's case, this is caused by a slight roughness of the head faces that will disappear after a few reels of tape have polished them down. With an older machine, it may indicate severe and uneven head wear.

A tilt misalignment may be responsible for an error in height, since the tilt can bow the tape away from its proper path, or even cause it to "ride up" on the angled head surface. Conversely, if the machine was originally aligned with a tilted head, correcting the condition may cause a height error to appear. You can readily appreciate from this how head alignment tends to be an "all or nothing" task.

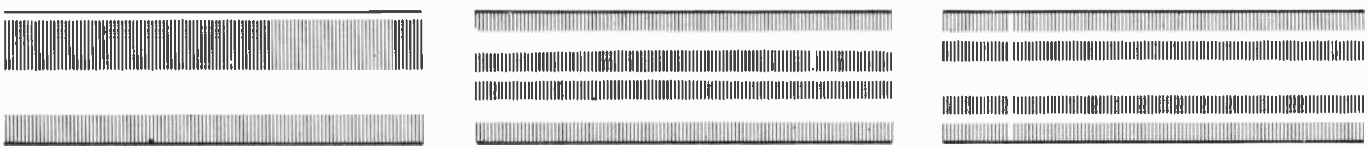
After you've completed the magic marker test, clean the heads according to the manufacturer's recommendations and, since it's probably not a good idea to reuse it, snip off and discard the length of tape used to develop the contact patch.

Looking at the Recording. When you suspect a height problem, the first questions is: which head is responsible, the record or playback head? About the only way you can determine this (short of buying an expensive test tape and fiddling with playback-head alignment) is to invest in the Soundcraft Magna-See kit, which costs about $7 and is not always easy to find. The main ingredient of the kit is a can of volatile (but not flammable) solvent in which is suspended a gray iron-oxide powder. Swirl a bit of recorded tape around in this fluid, let it dry, and Shazam! the recorded tracks appear in a dusty pattern on the tape surface. An alternative to the Magna-See, less messy and easier to obtain (through mail order) but more expensive, is 3M's Plastiform Magnetic Viewer Type BX-1022. With this device, the fluid is contained in a thin-wall plastic case that is placed directly on the tape surface. One drawback, according to a 3M spokesman, is that the case's seal, critically thin to ensure adequate sensitivity, must be maintained by storage in a moist environment (such as a sponge in the viewer's box). Order from 3M Industrial Electrical Products Div., P.O. Box 33365, 3M Center, St. Paul, MN 55101. Price is $24.95 plus 75 cents for postage.

For a half-track machine with both channels of the tape recorded, a height misalignment of the record head exists if the guard band between tracks is not perfectly centered on the tape (Fig. 3). A quarter-track tape, which should be recorded on both channels in both directions, shows a record-head height error when all three guard bands are not of the same width. A too-wide center guard band means the head is too low, which may actually give acceptable performance as long as the tracks don't touch or overlap. A too-narrow center band indicates a high head, which risks drop-outs of the tracks near the edge of the tape. (If your recorder is a *four-channel* machine, you'll find this test easier to interpret if you record only the two front channels, in both directions.)

So much for the record head. If it passes this test and you still suspect a height problem, you'll have to start thinking of the playback head, or possibly some misalignment of the tape guides.

Some Simple Adjustments. The only way you can learn much more about the alignment condition of your machine is to start fiddling with the head adjusting screws. This can be a tempting idea, particularly if you believe that only one head is at fault, and that fixing it might cause everything else to snap into place. Well, it doesn't always work that way. It may be, for example, that at one time the other heads were aligned to the incorrectly



A B C

Fig. 3. A height error of the record head on a half-track machine creates an off-center guard band (A). Diagrams (B) and (C) show results of a quarter-track record head positioned too ligh and too low, respectively.

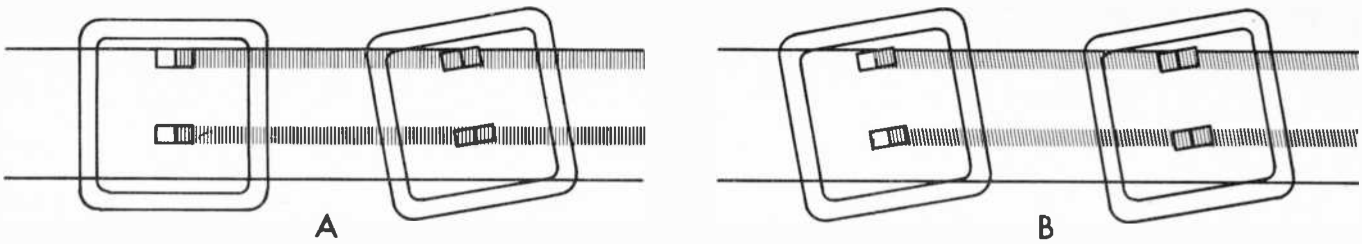


Fig. 4. Azimuth errors between record and playback heads produce high-frequency losses (A). Misalignment of both heads (B) causes no losses for tapes made on that machine.

positioned head, in which case a change in any one of them is likely to degrade the performance of the rest. Also, there's the problem of making sure that when you change one alignment factor—height, for example—you don't also change tilt or azimuth. (As far as I know there is no way to be sure of this, except by going back and checking tilt and azimuth after you've made the adjustment.) Finally, depending on the way the manufacturer has set up the machine, a readjustment of equalization or bias may be necessary.

Looking at the brighter side, however, it is true that you usually have the option of returning to the original adjustment if your attempted improvements do more harm than good—provided you have marked the original screw positions carefully! When you take off the cover to expose the heads, you'll probably find some or all of the alignment screws (protruding through the little platform on which each head is mounted) sealed with lacquer or whatever. If not, you can apply your own at this point, since the broken edges of the disturbed seal are a much better guide for returning to the starting point than a pencil mark.

Next, it's a great comfort to have on hand the recorder's service manual (frequently an expensive item), or at least some specific instructions from the manufacturer on head alignment. Sometimes the screws are readily identifiable as to their precise function, but there may be some sequence in setting them that will greatly simplify the whole business.

And now to proceed. With the simple checks described above and a few others, you're in a position to do a respectable alignment job on every parameter *except* the azimuth of the playback head. Playback azimuth must be set with a reproducer alignment test tape if it is to conform to tapes made on other, properly adjusted machines. If this is not a requirement, you can get by with a reasonable error in playback-head azimuth as long as the record head has exactly the same error (Fig. 4). But where possible, it's best to avoid touching the playback head at all, on the assumption that whatever its actual azimuth alignment, it is more accurate than you could achieve without a test tape.

In making height and tilt adjustments on the record head, you'll have to resort to the magic marker test on both the record and playback heads to make sure that what you're doing isn't adversely affecting either one. If one contact patch changes appreciably in size relative to the other, it means that one head is beginning to lose contact with the tape. Shifting the entire record head closer to or farther away from the tape will usually serve to equalize things again.

You'll also have to keep constant tabs on the playback head, making sure that what you do to the record head does not diminish its output (indicating that the tracks laid down by the record head are beginning to miss the playback-head gaps). To do this you must have tape running through the machine virtually at all times, and being recorded with a steady 1000-Hz tone. Monitoring the playback-head output on a scope or meter will alert you to any loss of level (an *increase* in level is a good sign, provided it takes place in both channels). There will be a short delay before any adjustment you make on the record head shows up in the playback-head output, and you'll simply have to get used to that. On the other hand, if the playback-head gaps are significantly longer than the width of the recorded tracks, you may be able to make minor height adjustments on the record head without observing any changes in playback level.

Assuming you can get the height and tilt of the record head squared away without introducing further problems, you can go on to matching the record head's azimuth to the playback head. For a test signal, I just use the audio generator to drive the record head, running it up in frequency until the playback-head output begins to drop. Then I tweak the record-head alignment to see if I can raise the output level at that point. (Note that the results may well be different for the two channels, necessitating an intermediate setting.) Usually I use the 7½-ips tape speed, although the other speeds should work as well on most machines. (The one exception I can think of had its response electronically rolled off above 20 kHz. Since the heads were presumably capable of going beyond that at 7½ ips, I probably would have chosen a slower tape speed to make sure I was seeing the effects of head alignment and not electronic filtering.) However, be sure to keep the recording level for the test tone down to -20 dB or lower. Otherwise, high-frequency tape losses are likely to occur at most speeds.

I've saved the erase head for last because it's easy. Azimuth doesn't really matter, and tilt can be handled through the magic marker test. The height adjustment is best accomplished by running a previously recorded tape with the machine in the record mode (record-level controls at minimum and no input signal being fed to the machine) and going for minimum playback output.

The Last Word. So it is possible to perform a good deal of recorder alignment with a minimum of specialized equipment. This is not to say, however, that all these tests will give you nice, neat, unambiguous results, or that you'll find satisfaction in devoting to them the time they require. Those seeking the last word in tape performance regularly go to greater lengths, and are often rewarded by audibly improved performance. For others, these tests can serve as indicators of something wrong. ◈

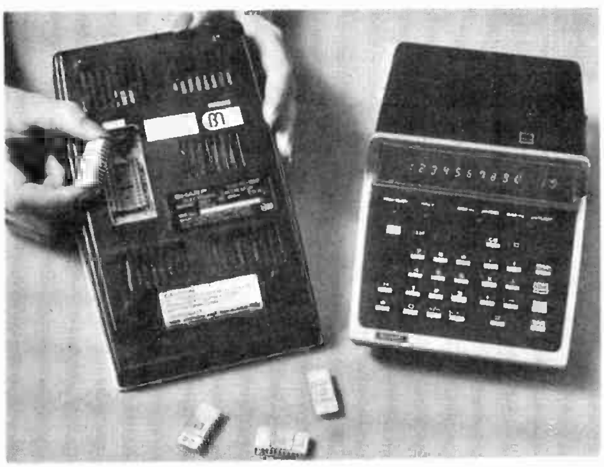
news HIGHLIGHTS

FCC CB & Experimenter Proposals

In response to a ruling by the Supreme Court, the agency has proposed a reduction in station license fees for CB operations from the present $20 to $6. The new amount is based on recovery of the cost associated with application processing. In another move, the Commission has proposed the establishment of a license-free, 5-channel band adjacent to the 6-meter (50-54 MHz) amateur band. Transmitters would operate on 49.91, 49.93, 49.97 and/or 49.99 MHz. AM, SSB, and FM emissions would be allowed, when confined within a 20-kHz channel centered on each of the above frequencies. Total input power would be limited to 100 mW and the antenna (single element, one meter or less in length) would have to be permanently attached to the transmitter or transceiver enclosure.

Plug-In P-ROM Calculator

Using a P-ROM (Programmable-Read Only Memory) system, Sharp Electronics introduced a calculator that can be designed to a user's specialized interest. The first "customer-designed" calculator, Model PC-1002, is a fifteen-function scientific unit with four extra-function keys and a receptacle for accommodating a P-ROM plug-in module. The program of the P-ROM, which is tailored to the user's application, is controlled by the



extra-function keys. While the "design-your-own" calculators can be programmed for a wide range of specialized scientific, engineering, and business uses, standard chips are now available for four basic applications: statistics, mathematics, metric conversion, and surveying. Additional programs are currently being readied, covering the structural and electrical engineering, and financial fields, among others.

Information Bank

Individuals can now retrieve general information from the Information Bank of the New York Times. The computerized on-line, time-shared system provides the user with an abstract of a wide range of material published every day in the newspaper and in a number of other magazines and periodicals. The abstract includes the date of publication and page number so that the user may obtain the complete article. One taps into the computer, a System 370/145, via a video display terminal. The abstract appears on the display screen, but a hard-print copy is also available. The entire process of locating a desired abstract is said to take about a minute. The user can begin his search with a broad category and narrow the field down until the specific subject is reached. The number of subject terms is about 11,000, not including names of people, places and organizations.

CMOS Prices Drop 20 to 51%

Two major manufacturers of CMOS logic, RCA and National Semiconductor, are reducing the prices on gates to a point where they are competitive with TTL on a piece-by-piece basis. RCA has reduced gate prices more than 30% and MSI prices more than 20% for standard CD4000 series devices in quantities of 100 to 999 units. National has reduced prices on two product lines, the MM7CXXN series, and Series-4000 equivalent MM56XXAN, from 25 to 51%. Price reductions affect every Series 74C molded, commercial-grade and Series-4000-equivalent devices. Price cuts are attributed to increased efficiency in high-volume production.

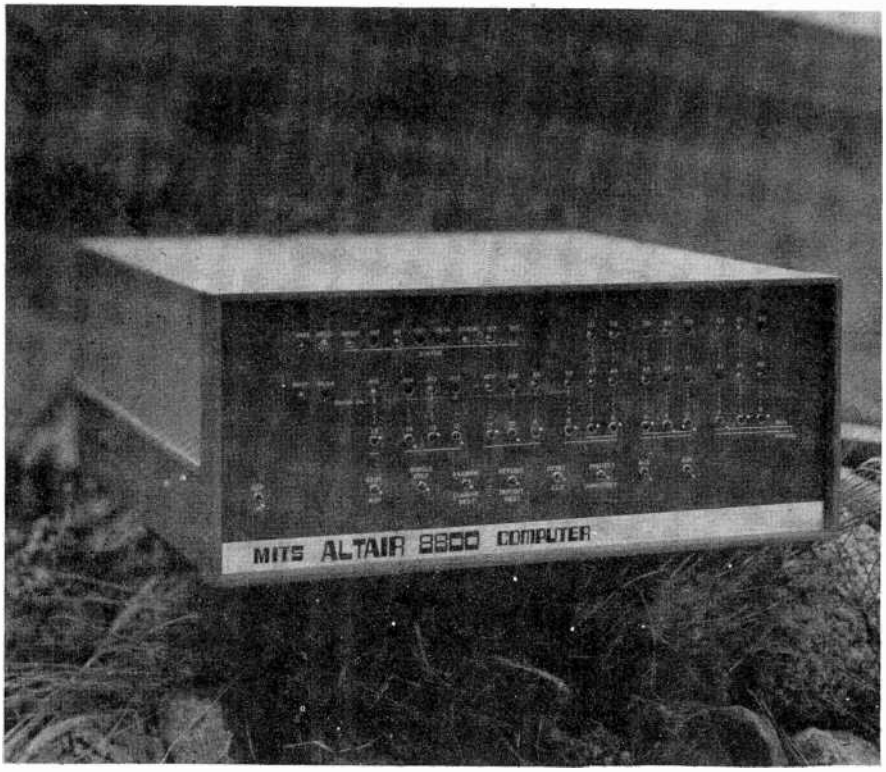
NYC Doubling Voice Communication Boxes

The City of New York is adding 3000 two-way voice communication boxes to its emergency reporting system. This brings to about 6000 the number of Norelco voice communications devices ordered since 1971. The city plans to replace all of its 15,000 older fire alarm boxes with such two-way voice boxes over the next few years. The audio boxes allow the user in the street to speak directly with fire or police officers simply by depressing a button on the call box. The system also provides a printed record (time, operator and box number) of all incoming calls. Each box can be tested automatically from the central station.

An Electronic Weed Killer

Zapper III, a device which kills weeds by electronic rather than chemical means, has been developed by the Oceanography International Corporation. The editorial board of *Industrial Research*, which includes rocket pioneer Werner Von Braun and inventor William Lear, has selected the weed killer as one of the 100 most significant new technical products of the year. The Zapper III is a 13-ton, self-propelled machine with a 155-kW diesel generator and two Klystron microwave sources which produce 60 kW of microwave energy. Microwaves cause the molecules of an organism to rotate very rapidly. This causes fatal internal structural damage to the organism. The effects on plants, seeds, and fungi are said to be immediate and lasting.

MITS



A COMPUTER CONCEPT BECOMES AN EXCITING REALITY.

Not too long ago, the thought of an honest, full-blown computer that sells for less than $500 would have been considered a mere pipe dream.

Everyone knows that computers are monstrous, box-shaped machines that sell for 10's and 100's of thousands of dollars.

Pipe dream or not, *MITS*, the quality engineering oriented company that pioneered the calculator market, has made the *Altair 8800* a reality. It is the realization of that day when computers are accessible to almost anyone who wants one.

The heart (and the secret) of the *MITS Altair 8800* is the *Intell 8080* processor chip. Thanks to rapid advances in integrated circuit technology, this one IC chip can now do what once took thousands of electronic components (including 100's of IC's) and miles of wire.

Make no mistake about it. The *MITS Altair 8800* is a lot of brain power. Its parallel, 8-bit processor uses a 16-bit address. It has 78 basic machine instructions with variances up to 200 instructions. That's more than enough to program all the street lights in a major city.

And the *MITS Altair 8800 Computer* is fast. Very fast. It's basic instruction cycle time is 2 microseconds.

Combine this speed and power with the *Altair's* flexibility (it can directly address 256 input and 256 output devices) and you have a computer that's competitive with most mini's on the market today. And sells for a fraction of their cost.

The Altair 8800 has been designed to fullfill a wide variety of computer needs. It is ideal for the hobbyist who wants to get involved with computers. Yet, it has the power and versatility for the most advanced data processing requirements.

It's basic memory of 256 words of static RAM memory can be expanded to 65,000 words of directly addressable memory. Static OR dynamic memory. OR PROM or ROM memory. OR a floppy disc system. All supplied by *MITS*.

Using standard *MITS* interface cards, the *Altair 8800* can be connected to *MITS* peripherals (computer terminals, line printers, audio-cassette interface) to form the core of a sophisticated time-share system.

The *Altair 8800* can be a process controller. It can be an educational device. Or it can be expanded to be an advanced, custom intrusion system. A programmable scientific calculator. Automatic IC tester. Automated automobile test analyzer. Complete accounting system. "Smart" computer terminal. Sound and light system controller.

OR it can be all of these things at *the same time*. It could be the beginning of new business opportunities. The list of applications is literally endless.

MITS wants to service your individual computer needs.

You can buy an assembled *Altair 8800*. Or you can start by building the computer yourself. The *MITS Altair 8800* is the ultimate kit. Its assembly isn't much more difficult than assembling a desktop calculator.

OR you can start with an *Altair 8800* complete data processing system. *Altair Systems* come in 4 basic configurations.

For those users who are not familiar with computers, *MITS* offers free consultation service. Just describe your requirements to our engineering staff and we will specify the additional cards and the system configuration you need to do the job.

The MITS Altair 8800 is backed by complete peripheral and software development programs. There is even a high level language available.

Order your Altair 8800 Computer today. As a special introductory offer, *MITS* is offering the *Altair 8800* at a discount of $100. This offer is good on all orders postmarked prior to March 1, 1975.

PRICES:

Altair 8800 Computer (assembled with complete operation instructions) **$750.00**
Altair 8800 Computer (kit form) **$495.00**
Subtract $100.00 from above prices on all orders postmarked prior to March 1, 1975.

MITS INC.®
"Creative Electronics"

Warranty: 90 days on parts and labor for assembled units. 90 days on parts for kits.
Prices, specifications and delivery subject to change without notice.

☐ Enclosed is a Check for $ ____________
or ☐ Bank Americard # ____________
or ☐ Master Charge # ____________
Credit Card Expiration Date ☐ Kit
Include $8.00 for Postage and Handling ☐ Assembled
☐ ALTAIR 8800
☐ Please send complete Altair System Catalogue.
NAME ____________
ADDRESS ____________
City ____________
STATE & ZIP ____________
MITS / 6328 Linn, N.E., Albuquerque, New Mexico 87108 505/265-7553

CIRCLE NO. 23 ON READER SERVICE CARD

Popular Electronics
FEBRUARY 1975

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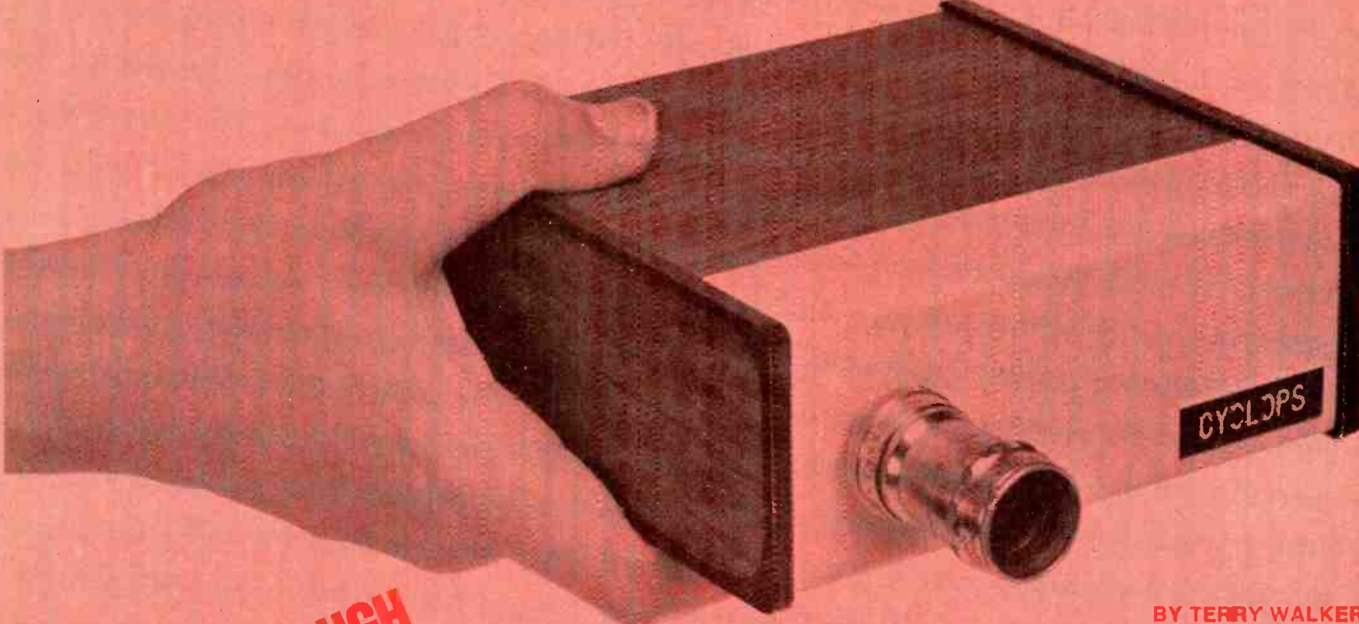


BY TERRY WALKER,
HARRY GARLAND & ROGER MELEN

BREAKTHROUGH PROJECT!

BUILD CYCLOPS FIRST ALL SOLID-STATE TV CAMERA FOR EXPERIMENTERS

Using an MOS array and digital electronics eliminates vidicon and yoke.

SOLID-STATE image sensors, which were discussed in detail last month, may one day supplant vidicon tubes in TV cameras. They promise small size and easy camera construction, have a low power requirement and operate in a wide range of light conditions. Cost, however, has been prohibitive—until now!

Presented here is "Cyclops," the first all-solid-state TV camera project using a special MOS photoelement array as the image sensor—and, it can be built by electronics experimenters at an affordable price. (A complete kit of semiconductors, including the MOS device, is available for $55, for example.)

Any image that can be picked up by a conventional TV (or movie) camera can be picked up by Cyclops. Unlike conventional cameras, however, Cyclops is sensitive to infrared radiation and is thus able to "see" in the dark when an infrared light is used to illuminate the scene.

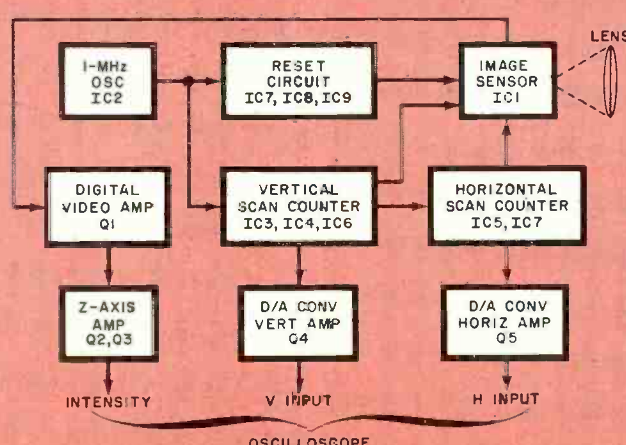
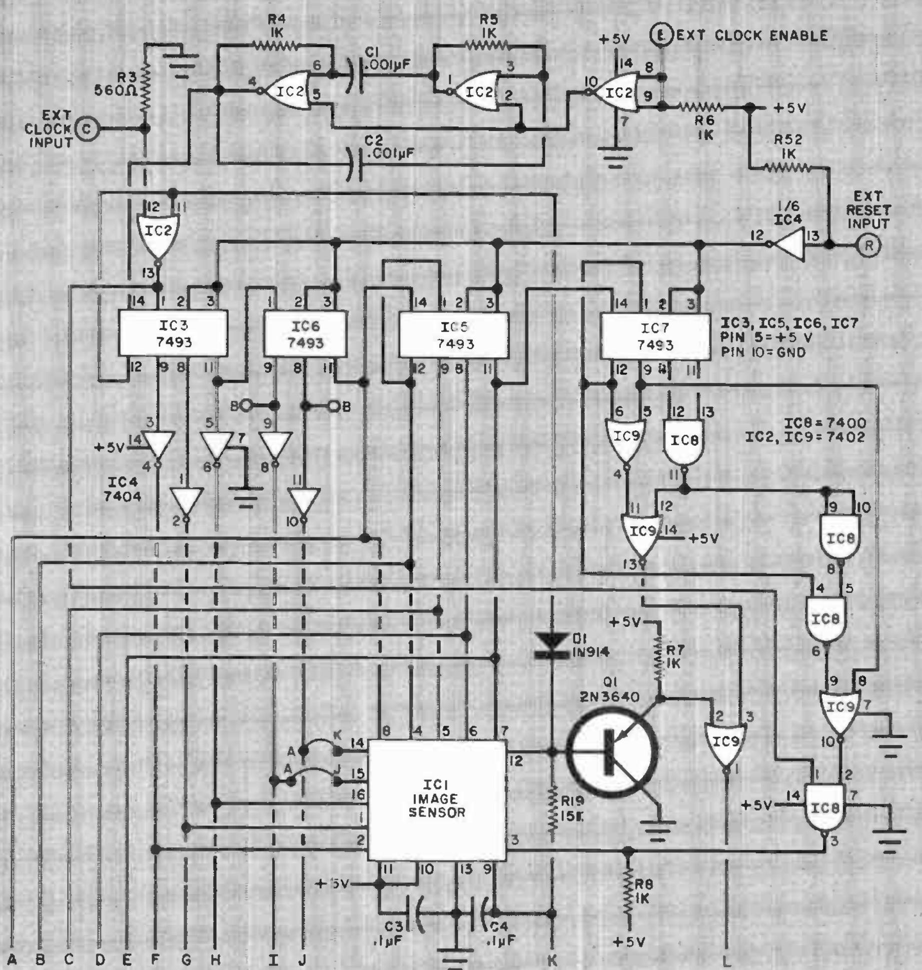


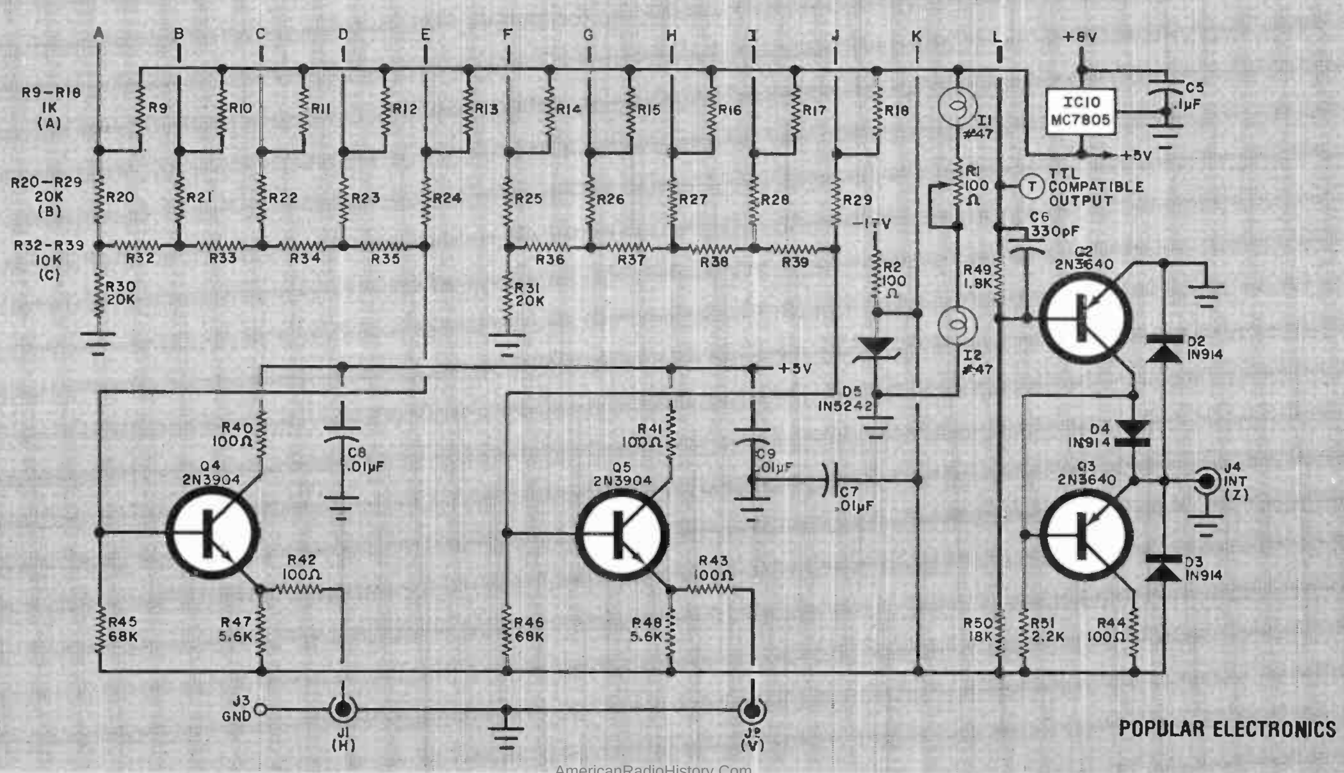
Fig. 1. Logic diagram of the camera shows how scan counters address camera and also generate sweep signals for the scope.

PARTS LIST

C1, C2—0.001-μF disc capacitor
C3, C4, C5—0.1-μF disc capacitor
C6—330-pF disc capacitor
C7, C8, C9—0.01μF disc capacitor
D1 to D4—1N914 diode
D5—1N5242 12-volt zener diode
IC1—1024-element image sensor
IC2, IC9—7402 TTL quadruple 2-input NOR gate
IC3, IC5, IC6, IC7—7493 TTL 4-bit binary counter
IC4—7404 TTL hex inverter
IC8—7400 TTL quadruple 2-input NAND gate
IC10—MC7805CP 5-volt regulator
I1, I2—#47 pilot light
J1 to J4—Banana jacks
Q1, Q2, Q3—2N3640 transistor
Q4, Q5—2N3904 transistor
R1—100-ohm, ½-watt miniature potentiometer
R2—100-ohm, ½-watt resistor
R3—560-ohm, ¼-watt resistor
R4 to R18 and R52—1000-ohm, ¼-watt resistor
R19—15,000-ohm, ¼-watt resistor
R20 to R31—20,000-ohm, ¼-watt 5% resis.
R32 to R39—10,000-ohm, ¼-watt 5% resis.
R40 to R44—100-ohm, ¼-watt resistor
R45, R46—68,000-ohm, ¼-watt resistor
R47, R48—5600-ohm, ¼-watt resistor
R49—1800-ohm, ¼-watt resistor
R50—18,000-ohm, ¼-watt resistor
R51—2200-ohm, ¼-watt resistor
Misc.—IC socket (9), ¾" variable-length spacers, lens (see text), suitable chassis, mounting hardware, line cord, etc.
Note—The following are available from H. Garland and R. Melen, 26655 Laurel Lane, Los Altos, CA 94022: kit of all IC's (including image sensor), diodes, and transistors at $55; pc board at $5; all postpaid. California residents, please add sufficient sales tax.

Fig. 2. Complete schematic of the camera. Letters between sections are merely for showing interconnections. Letters in circles are terminals for use with optional circuits.





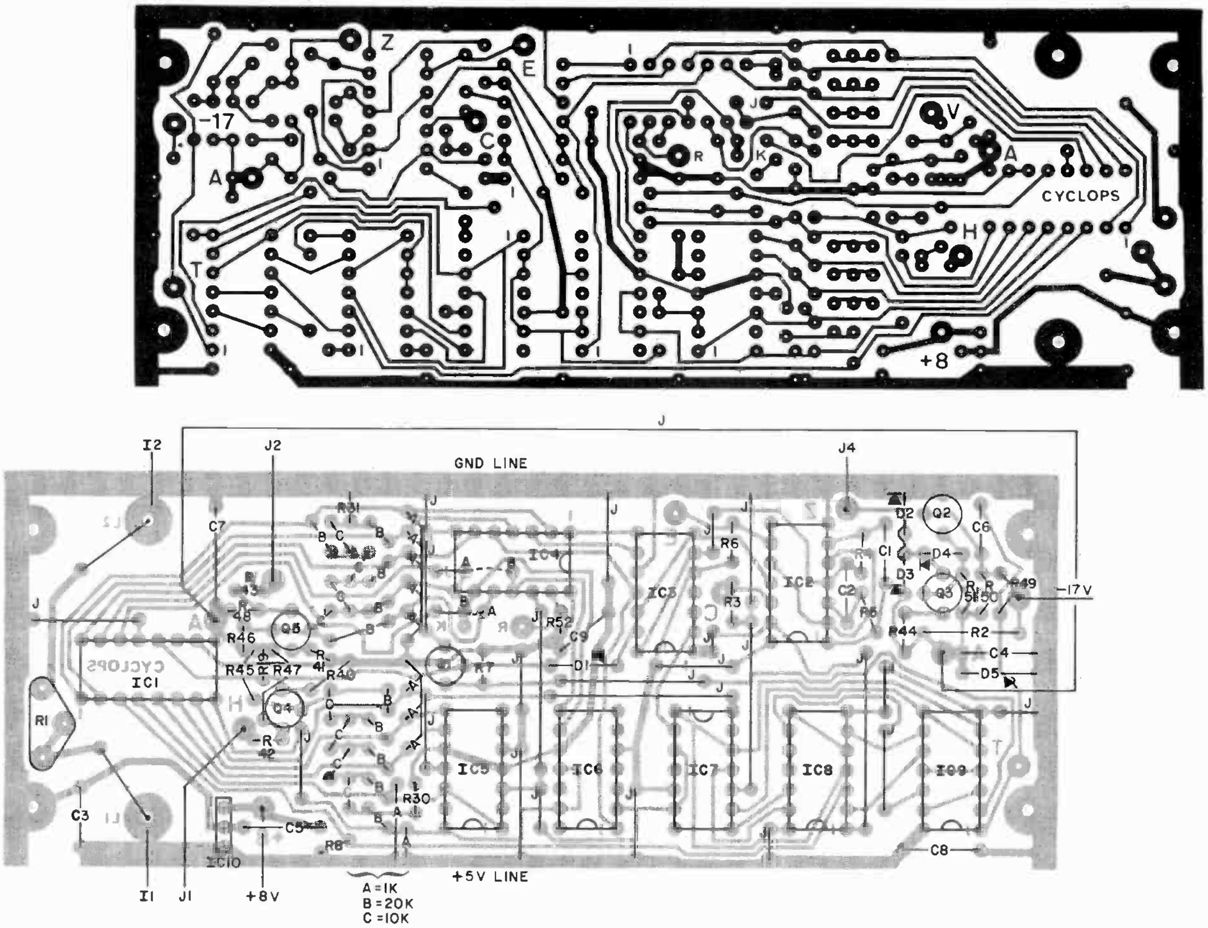


Fig. 3. Actual-size foil pattern (top) and component placement. Note that most resistors are mounted on end to conserve space.

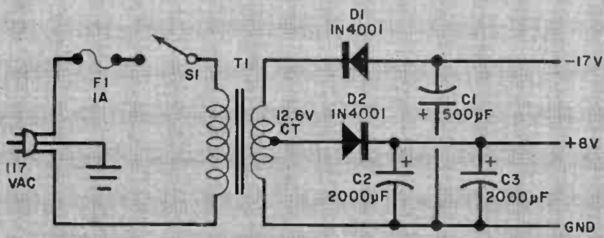
The MOS array has 1024 separate photosensitive elements fabricated on a single chip and mounted in a conventional 16-pin DIP case with a transparent cover. Although similar sensing devices have cost up to several hundred dollars in the past, new techniques and volume production have made it possible to reduce prices. With just 1024 elements (in a 32 by 32 array), Cyclops can't be expected to match the resolution of a vidicon camera; but it is quite useful for many applications. The circuit described here is for using Cyclops with a conventional oscilloscope, but it could be altered for a display on a TV tube. (Among other things, a sync generator would be needed.)

A little imagination will enable the experimenter to come up with a number of novel uses for Cyclops. For example, if a fiber-optic light pipe is used with the sensor, it could pick up conventional printed material for transmission or to excite a type of tactile device for use by the blind. Consider also the possibility of using Cyclops in conjunction with the Altair 8800 Minicomputer (POPULAR ELECTRONICS, January 1975). The combination could be used to build a security system that would operate on the basis of a person's appearance. This approach also opens up a brand new and exciting area for the advanced experimenter—a digital computer that has "vision." For example, the Cyclops/Altair combination, with 256 independent inputs/outputs could be the basis for a robot that could be programmed to do a number of things, while also being able to "see" its environment and make any necessary corrections in its actions.

Circuit Operation. The Cyclops logic diagram is shown in Fig. 1. A part of *IC2* is used as a 1-MHz timing oscillator. One output of the oscillator drives the vertical scan counter, which drives the horizontal scan counter. The binary outputs of the scan counters are used to address the rows and columns of the MOS array.

As each of the 1024 elements is addressed, two events occur within a period of less than two microseconds. First, the outputs of the vertical and horizontal scan counters are processed by a ladder-type digital-to-analog (D/A) converter, then amplified by *Q4* and *Q5*, respectively, to produce the scope vertical and horizontal sweep. This creates the raster on the CRT. The second event occurs when the video information on the image sensor is read out, amplified and used to vary the brightness of each of the 1024 dots that make up the raster and produce the intensity-modulated image on the CRT. Since both sweeps (H and V) and the video (brightness) information are "in step" at all times, each of the 1024 elements on the sensor has a corresponding point on the raster, and the charge on each element determines the brightness of its raster dot.

A novel coding scheme is used for the video information. Thirty completely new frames are displayed on the scope each second, with each frame made up of 16 separate and complete scans of the image sensor. The first of these 16 scans is used to reset the 1024 photoelements, with



PARTS LIST

C1—500-μF, 15-volt electrolytic capacitor
C2, C3—2000-μF, 15-volt electrolytic capacitor
D1, D2—1N4001 diode
F1—1-ampere fuse and holder
S1—Spst switch
T1—12.6-VCT filament transformer (Triad F-25X or similar)

Fig. 4. Power supply for camera can be wired point-to-point and mounted anywhere in chassis.

the reset pulses generated by *IC7, IC8,* and *IC9*. On subsequent scans, the video information is read out.

When a particular photoelement is illuminated by a bright light (from the image being sensed), a video output pulse is developed each time that element is addressed. The video output pulses are amplified by *Q1* and, after gating, by *Q2* and *Q3* to produce the scope intensity (Z) axis signal. If there is no light on a particular element, no video pulse is generated when that element is addressed. For grey portions of the picture, the number of video pulses generated for each frame is determined by the intensity of the grey in the original image.

Several inputs and outputs are provided on the pc board as shown in Fig. 2. These are for possible use in advanced projects. For normal operation, no connection is necessary at these points. Point "T" provides a TTL-level signal to facilitate interfacing with external digital circuits. By connecting point "E" to ground, the 1-MHz oscillator is disabled and an external oscillator can be applied to point "C". An external reset pulse can be applied through point "R" to reset the scan counters at any point in the scan cycle. Since both position and intensity information are available in digital form, Cyclops can very easily be interfaced with a digital computer.

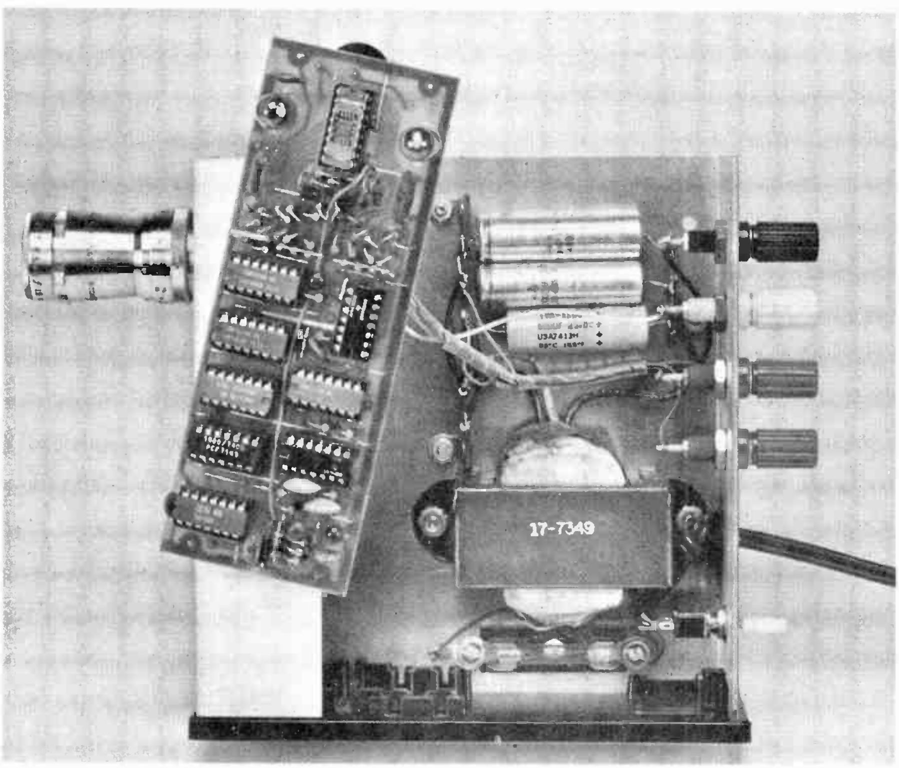


Photo shows chassis with the printed circuit board pulled out.

The external oscillator input can be used to synchronize Cyclops with the computer or with a TV display.

Construction. The logic circuits of Cyclops are on a single pc board (Fig. 3). Use sockets for all of the IC's except *IC10* which is soldered in place. Be sure to observe the correct polarities on all IC's, diodes, and transistors.

For the pilot lamps (*I1* and *I2*), drill holes in the board just large enough to accommodate the metal portions of the lamps so that, when they are inserted from the nonfoil side, the glass portion just touches the board. The metal portions of the lamps are then soldered to the pads, and small lengths of wire are soldered to the center connectors on the lamps and the appropriate pads.

Miniature potentiometer *R1* is mounted on the foil side of the board so that the two lamps can be adjusted when the pc board is mounted in place. The purpose of *I1* and *I2* is to bias the image sensor with a dim, uniform background light. Although this is not absolutely necessary, the bias light improves the low-light-level sensitivity and provides better picture contrast.

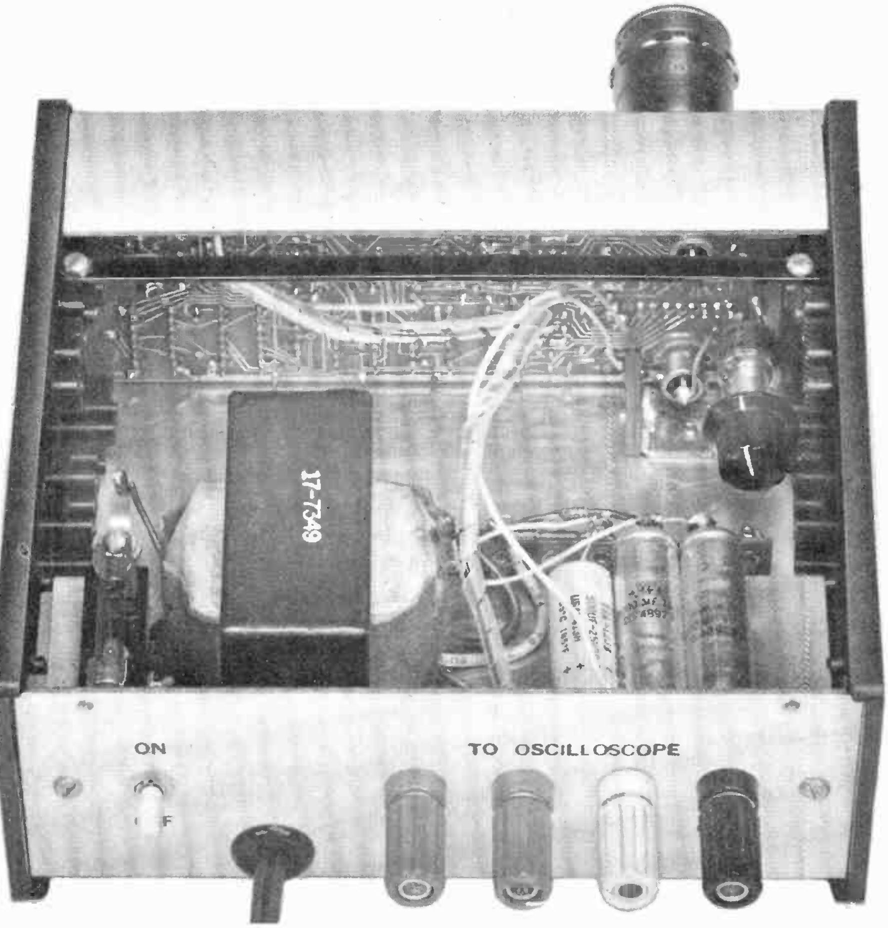
Note that many resistors are mounted on-end to conserve space on the board.

The power supply circuit is shown in Fig. 4. This supply is wired point-to-point (using a terminal strip) and can be mounted anywhere within the selected chassis.

The pc board is mounted on ¾" adjustable standoffs behind the front of the chassis. Mount the board temporarily and mark a spot on the front panel that is directly in line with the center of the image sensor *(IC1)*. Remove the board and drill (or cut) a hole just large enough to accommodate the selected lens. Before mounting the board permanently, make sure that the distance between it and the lens can be adjusted slightly to permit focussing.

Connect the ground, +8-volt and −17-volt lines from the power supply to the board. Connect the four leads from the board (ground, vertical, horizontal, and intensity) to their respective color-coded jacks on the rear panel. The power switch *(S1)* is also mounted on the rear panel, and the line cord goes through a grommeted hole in the same panel.

Either one of two image sensors



Jacks for scope connections and on/off switch are on chassis rear.

may be supplied for use in Cyclops. The two are identical except for the way pins 14 and 15 are connected to the circuit. Note that, on the pc board, *IC1* pin 15 goes to pad J, and pin 14 goes to pad K. If your image sensor is marked "Type A," connect pad J to pin 8 of *IC4* and pad K to pin 10 of *IC4*. If the image sensor is marked "Type B," connect pad J to pin 9 of *IC4* and pad K to pin 11 of *IC4*.

Lens Selection. Almost any movie camera lens will work with Cyclops. The two important factors to consider in choosing a lens are focal length and *f*-number. The focal length determines the viewing angle of the camera, while the *f*-number determines how much light can be collected.

The lens used with Cyclops should have a variable aperture so that the *f*-number can be adjusted to suit the lighting conditions. The minimum *f*-number, when the aperture is wide open, determines the lowest light level at which Cyclops will operate. An *f*-2.8 lens should be adequate for most applications, though some additional lighting may be required for indoor operation. (We purchased an under-$10 used *f*-2.8 normal motion-picture-camera lens with variable stops for this project.)

Both new and used movie camera lenses are available from photography stores and mail-order houses. A 12.5-mm, *f-27* lens is available from Edmund Scientific (300 Edscorp Bldg., Barrington, NJ 08007) for less than $10 (stock No. 41,146).

Setup and Operation. Connect Cyclops to an oscilloscope (set to external horizontal) as follows: *J1* to horizontal input, *J2* to vertical input, *J3* to ground, and *J4* to intensity input. If your scope does not have provision for an intensity input, modify it according to Fig. 5.

With power applied to both Cyclops and the scope, adjust the scope's horizontal and vertical gain until a 32-by-32 pattern of dots forms a square array on the screen. Cover the lens of Cyclops and then turn the scope's intensity control down until the dots just disappear. Now, expose the lens to a lamp. The dots on the CRT will illuminate.

To adjust the focus between the image sensor and lens, turn the bias lamps down *(R1* at maximum resistance) and expose the lens to a simple, illuminated test pattern such as a black cross on a white background. If the lens can be focussed, adjust it for the distance between the lens and the test pattern. Set the lens to its widest opening (smallest *f*-number). Use a 50-watt lamp to illuminate the test pattern and position the lamp until an image appears on the screen. Adjust the distance between the image sensor and the lens by varying the spacers until the test pattern is in the sharpest focus. Then secure the pc board in place.

To adjust the bias lamps, darken the room so that no ambient light reaches the image sensor. Make sure that *R1* is at maximum resistance (lamps out). Adjust the scope's brightness control until the dot pattern can just be seen, and then increase the brightness of the bias lamps until the scope pattern just starts to get brighter. This is the correct setting of *R1*. Place the cover on the chassis so that no ambient light reaches the image sensor.

Cyclops is now ready for use. Although the resolution may seem to be on the low side for observing fine details, you will note that the apparent resolution seems to increase when viewing a "live" scene—especially one with motion.

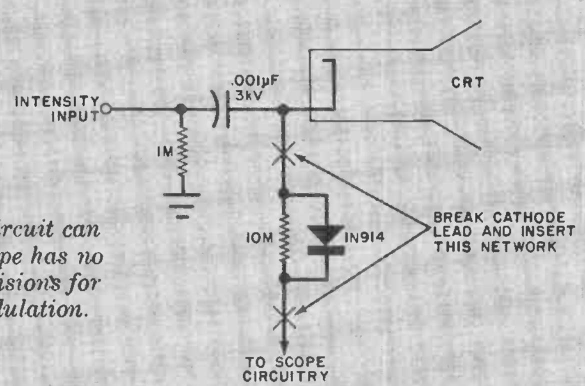


Fig. 5 This circuit can be used if scope has no internal provisions for intensity modulation.

HOW PHASE-LOCKED LOOPS WORK

BY HERB COHEN

Theory and applications of an old circuit, revitalized and refined by IC technology.

PHASE-LOCKED loop circuitry has been popularized by its current use in high-quality FM stereo tuners and by publicity accompanying the Dorren Quadraplex system of discrete 4-channel FM (a quadraphonic FM broadcasting contender).

Though the advantages of PLL in FM reception have been used for many years in sophisticated military and space applications, integrated-circuit versions weren't introduced until 1970. Lowered costs have spurred applications in many consumer-electronics areas.

The phase-locked loop is analogous to a servo system—in the FM range. Its behavior as a servo permits it to find and lock on signals, tracking them 6 dB under the noise level. As an electronic filter, it can present a 1% passband to any frequency from 0.1 Hz to the r-f region with excellent stability. Using programmable dividers in its oscillator loop, the PLL becomes a frequency synthesizer that can reproduce practically any frequency from only one crystal. This throws the door open to digital tuning of receivers and transmitters.

These are only a few of the areas where PLL is useful. There are, in addition: frequency shift keying for RTTY, motor control, FM generators, touch-tone telephone, and stereo and four-channel decoding. Now that the price of PLL IC's has dropped below $5.00, the hobbyist and experimenter can add the PLL to their store of basic building blocks.

PLL Basics. The PLL is a feedback system comprised of four basic elements (Fig. 1): a phase detector or comparator; an external low-pass filter; an error correction amplifier; and a voltage controlled oscillator (vco).

The vco is a free-running form of multivibrator whose center frequency is determined by an external timing capacitor and resistor. The vco output is presented to the phase comparator, where it is compared to the incoming signal. The result is an error correction voltage whose magnitude is a function of the phase and frequency differences of the two signals.

This signal is then filtered in an external low-pass filter and amplified in the error correction amplifier. The output of the latter is fed back to the voltage-control input of the vco to complete the loop and cause the oscillator frequency to approach more closely the frequency of the input.

Once the vco starts to change frequency, it is in the "capture" state; and it continues to change frequency until its output is exactly the same frequency as the input. The circuit is then "locked" so that the loop frequency varies exactly with the input frequency.

Thus, the loop has three states: free-running, capture, and locked or tracking. The capture state is highly complex. Interestingly, the capture range (frequency band above and below the vco center frequency) is not as wide as the locking range.

A closer look at the capture state will provide an explanation. Figure 2 shows the waveform of the voltage at the output of the error-correction amplifier. As capture starts, a small sine wave appears. This is the "beat" between the vco and the input signal. Note that the negative half of the waveform is slightly larger than the positive half. This is the dc component of the beat, which drives the vco toward lock. Each successive cycle causes the vco to move closer to the input signal.

There are two results of this action which help the vco to lock. First, the closer the vco approaches the input signal, the lower the beat frequency. This allows the low-pass filter to pass more of the beat frequency to the vco with a correspondingly larger portion of the dc component. The vco is now skipping two steps toward lock and one step back. At the same time, the closer the vco nears lock, the longer it wants to stay there, and the more reluctant it is to move away. This extends the negative half of the cycle, reduces the positive half, and increases the dc component to speed up the process. The vco finally locks and the beat frequency is zero.

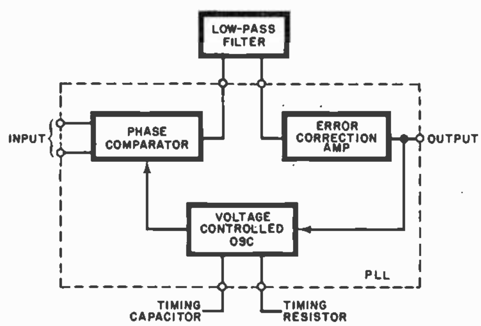
The low-pass filter is an important factor in controlling the capture range. If the vco is too far away from the signal, the beat frequency will be too high to pass through the filter and the signal is out of the capture band.

Once lock has been achieved, the filter no longer restricts the PLL. It can track a signal well past the capture band, being restricted only by the output range of the phase comparator. However, the filter does limit the speed at which the PLL can track. If the signal frequency changes too rapidly, the PLL can become "unlocked."

The low-pass filter is an engineering trade-off. On one hand, it restricts the capture band and reduces tracking speed; but, without it, the PLL would have great difficulty locking. The filter supplies the PLL with a short-term "memory" of where it was with respect to the signal, providing a sort of fly-wheel effect. It also "memorizes" the rate-of-change of the signal frequency. Even if the signal should drop into a noise level for several cycles, the filter will continue to shift the vco at the same rate until it picks up the signal again. This produces a high noise immunity and locking stability.

The 560 Family. The most popular family of PLL IC's is the Signetics 560 series. The table lists the important specifications for various units in the series. The first three are high-frequency devices, with typical vco operation of 15 MHz and a maximum of 30 MHz. Above 15 MHz, its opera-

Fig. 1. Four basic elements of a phase-locked loop.



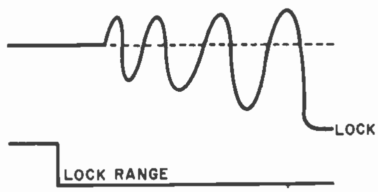


Fig. 2. Upper trace shows beat between vco and input. Lower trace is the lock range.

tion becomes critical, and great care is needed to get them to perform properly. Its input sensitivity is very good—the device can lock on to signals of 100 to 200 microvolts. The 561 is a duplicate of the 560, but it has an added product detector for synchronous demodulation. The 565 has an exceptional lock range (typically ±60%); however, its input sensitivity is only fair (1 millivolt for lock). The 565 has one added advantage over the high-frequency units: its vco is tuned with an RC network, and frequency is directly proportional to the change in the resistance. This permits tuning over a 10-to-1 frequency range using a potentiometer.

The 567 is primarily a narrow-band filter. Its interesting feature is a built-in synchronous switch which turns on when the unit goes into lock. The switch is able to handle up to 100 mA and can be used to turn on an SCR, a relay, or a lamp for indication of the lock condition. Another feature of the 567 is its low power-supply voltage (4 volts minimum), making it ideal for battery operation. However, it is less input-sensitive than the others in the series.

Working with the 565. The 565 PLL is the only member of its family that is not internally stabilized with a zener diode. Therefore, a well-regulated supply or a zener diode should be used to keep the power stable.

Suppose you want to use a 565 as an SCA background music decoder. A suggested circuit is shown in Fig. 3. The SCA signal is 14-kHz FM on a 67-kHz subcarrier. Note that a single-ended power supply is used and the resistor network made up of *R3* through *R6* is used to bias the inputs at 3.2 volts. Thus only one comparator input (pin 2) is used for the signal.

The two input capacitors (*C2* and *C3*) and resistor *R2* act as a high-pass filter to remove the lower-frequency stereo subcarrier from the SCA input. Capacitor *C1* and resistor *R1* determine the operating frequency of the internal vco by the expression 1.2/(4*R1C1*). Since we know that the vco should operate at the SCA frequency of 67 kHz, and we would like *R1* to be about 5000 ohms, we can calculate the value of *C1* needed. This works out to be 0.000895 or 0.001 µF.

Tuning resistor *R1* is made up from a 1000-ohm fixed resistor in series with a 10,000-ohm potentiometer. (Remember that we assumed a value of 5000 ohms for *R1*.) Using this larger potentiometer will enable tuning over a wide range around the center frequency (in case the tolerance of *C1* is very broad), while the 1000-ohm fixed resistor will act as a current limiter if the potentiometer resistance is reduced to zero.

The demodulated output (pin 7) is passed through a three-stage low-pass filter (*C5* to *C7* and *R7* to *R9*) to provide the necessary de-emphasis and attenuate the high-frequency noise that often accompanies the SCA transmission. The demodulated output signal is approximately 50 mV and the frequency response extends to 7 kHz.

The locking range is determined from $\pm 8F_o/V_{cc}$ which comes out (±8 X 67)/10 or ±53.6 kHz. Since the bandwidth of the SCA subcarrier is only 14 kHz, there is more than enough locking range available. This expression applies only when the input signal is high enough to saturate the comparator. If the input signal decreases, the correction voltage also decreases, thereby reducing the locking and capture ranges.

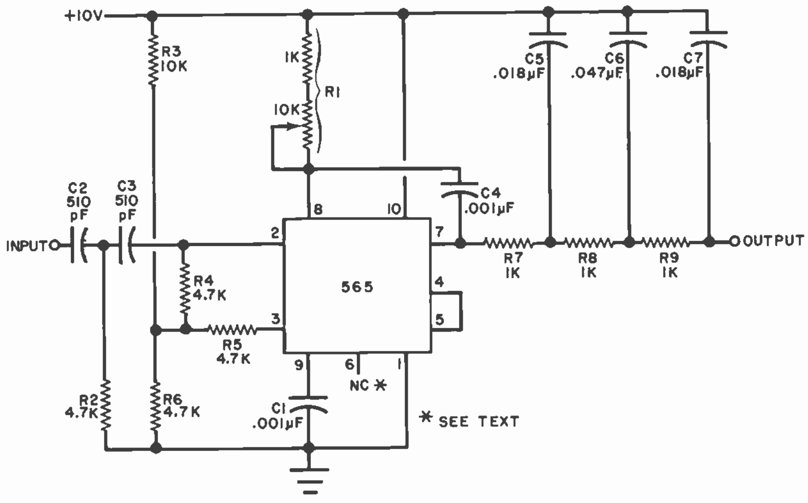


Fig. 3. Typical phase-locked circuit for decoding SCA background music on FM broadcast.

The curve in Fig. 4 shows the locking range versus the input signal level. Since the SCA decoder requires a 20% locking range, the curve shows that a 10-mV input will be enough to drive the phase lock.

The 565 provides a method of limiting the locking range. A tap on an internal voltage divider is used as a reference output (pin 6). This voltage is the same as the output voltage (pin 7) when F_o is equal to the incoming signal. Connecting a resistor between pins 6 and 7 differentially loads the output without changing the dc level or shifting the vco. A resistance change from 25,000 ohms to zero between these points will shift the locking range from ±60% to ±20%. Since the output is loaded, one can expect a corresponding decrease in the level of the output signal.

PLL SPECIFICATIONS

Type	Min. Input For Lock	VCO Freq. (MHz)	Lock Range	V_{cc} Min.	V_{cc} Max.
560	120 µV	15	15%	16	26
561	120 µV	15	15%	16	26
562	200 µV	15	15%	16	30
565	1 mV	0.5	60%	10	26
567	20 mV	0.1	12%	4	10

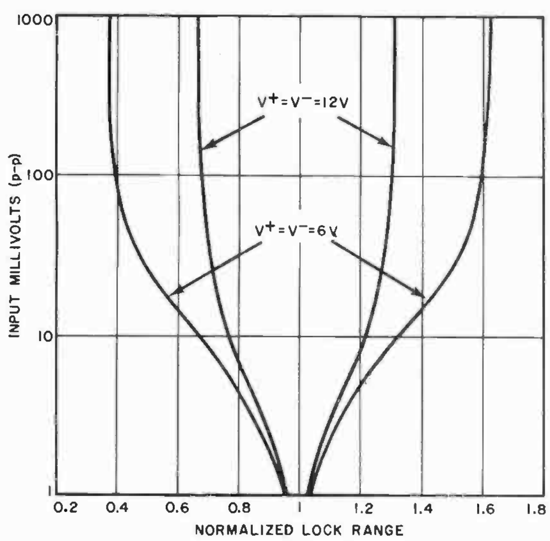


Fig. 4. Lock range versus input signal level for the 565 phase-locked loop.

The differential output (pins 6 and 7) is useful in frequency-shift keying. This is a method of reproducing digital pulses by shifting the frequency of the input signal, generally 1 kHz for a zero state and 2 kHz for a one state. By connecting a voltage comparator across pins 6 and 7, the output pulses are cleaned and shaped. They can then be interfaced with the following digital circuitry.

The 565 has two outputs that can be useful in some applications. A triangle waveform is available at pin 9 with an output of 2.4 V and 0.5% linearity. Because even light loading at the output will distort the triangle wave, a high-impedance buffer is recommended when using it.

Note that there is a short between pins 4 and 5. Pin 5 is the output of the vco while pin 4 is the input to the comparator. In the SCA adapter, these two pins are not used. The output at pin 5 is a square wave with an impedance of 5000 ohms and a level of 5.4 V p-p.

As shown in Fig. 5, pins 4 and 5 provide a convenient way to insert a programmable frequency divider for frequency synthesis. If the input, F_{ref}, is a 10-kHz crystal-controlled source, and the divider is programmable from 1 to 10, the vco output, F_{out}, is 10 to 100 kHz in steps of 10 kHz, all having the same stability as the crystal. If a divider is programmed from 100 to 110, the vco becomes programmable from 1 MHz to 1.1 MHz in 10-kHz steps. Unfortunately, the 565 can only operate to 1 MHz, so this discussion serves only to illustrate how you can use a phase-locked loop and a programmable counter to synthesize almost any desired frequency.

This, in essence, is how frequency-synthesized CB and FM devices work. If you have a synthesized local oscillator, you can receive almost any channel on any band, provided they are evenly spaced. ◈

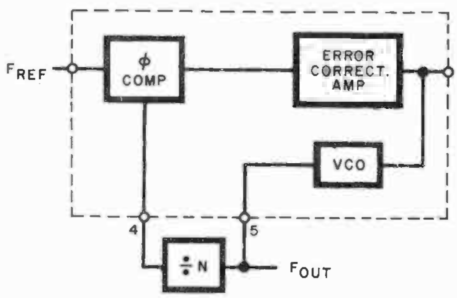


Fig. 5. Adding a divider permits frequency synthesis.

HISTORY OF PHASE-LOCKED LOOPS

In 1932, a group of British physicists was working on a new method of radio reception to compete with the superheterodyne system. This new approach would require only one tuned circuit and would have greater fidelity and selectivity than the superhet circuit.

The theory was deceptively simple. When an r-f oscillator and an incoming signal are mixed at the same phase and frequency, the output product will be a perfect audio reproduction of the transmitted modulation. An adjacent carrier, 20 kHz away, will be demodulated as a 20-kHz signal and could easily be filtered out of the desired audio.

The system was constructed using a simple untuned r-f amplifier to feed the mixer. The results were astonishing—perfect reception with no adjacent-channel interference. The only problem was that the local oscillator would slowly drift off frequency, producing a beat note which made reception intolerable.

One member of the group then theorized that if the oscillator frequency could be compared to the signal frequency in a phase-detector circuit, a correction voltage could be produced to return the oscillator. This could be done by having the correction voltage drive a Miller-effect (electronic variable capacitance) amplifier connected across the tuning circuit of the oscillator. The same feedback idea had worked in servo systems. So, why not an electronic servo?

The new oscillator circuit was built and connected to the receiver system. It not only stayed in frequency with the incoming signal, it locked itself in. When the tuning was changed to a new signal, the oscillator would hold onto the old until the new one got too strong and then it would switch to the new signal. When the system was tuned between carriers, it hunted for the stronger one and locked on to it.

The receiving system, which originally had been named the homodyne circuit, was renamed the syncrodyne circuit.

The circuit, though superior to the superhet in many ways, could not compete where cost was concerned. The oscillator locking circuitry was too expensive. Though the syncrodyne receiver circuit was never used in AM receivers, it attracted the attention of FM receiver designers who were looking for a method of stabilizing the mixer/oscillator at 100 MHz. The FM receiver already had a form of phase discriminator to demodulate the i-f signal. By connecting the dc component of the discriminator output to a Miller-effect tube across the local oscillator, the latter could be forced to lock in 10.7 MHz above the incoming signal to produce an exact 10.7-MHz i-f. The system was called automatic frequency control.

The budding TV-receiver industry, looking for a way of locking the horizontal oscillator, developed several phase-locked circuits—notably the "Syncro-Guide" and "Syncro-Lock."

By the mid 1940's, phase-lock was being used in military microwave and radar receivers. When NASA fired the first space capsule, its 10-milliwatt, 108-MHz transmitter signals were received by a phase-locked receiver, whose ability to follow a signal below the noise level was considered phenomenal.

SHORTWAVE NEWSCASTS IN ENGLISH

BY RICHARD E. WOOD

A SHORTWAVE receiver is a passport to a world of information. On the shortwave bands, headline news stories can be heard as they happen. Try listening to some of the broadcasts listed here. Though frequencies are subject to change without notice, this list includes most of the major newscasts (in English) copyable in North America. These broadcasts are not necessarily beamed here and reception will depend on many factors—your receiver and antenna, ionospheric conditions at any given moment, and your location.

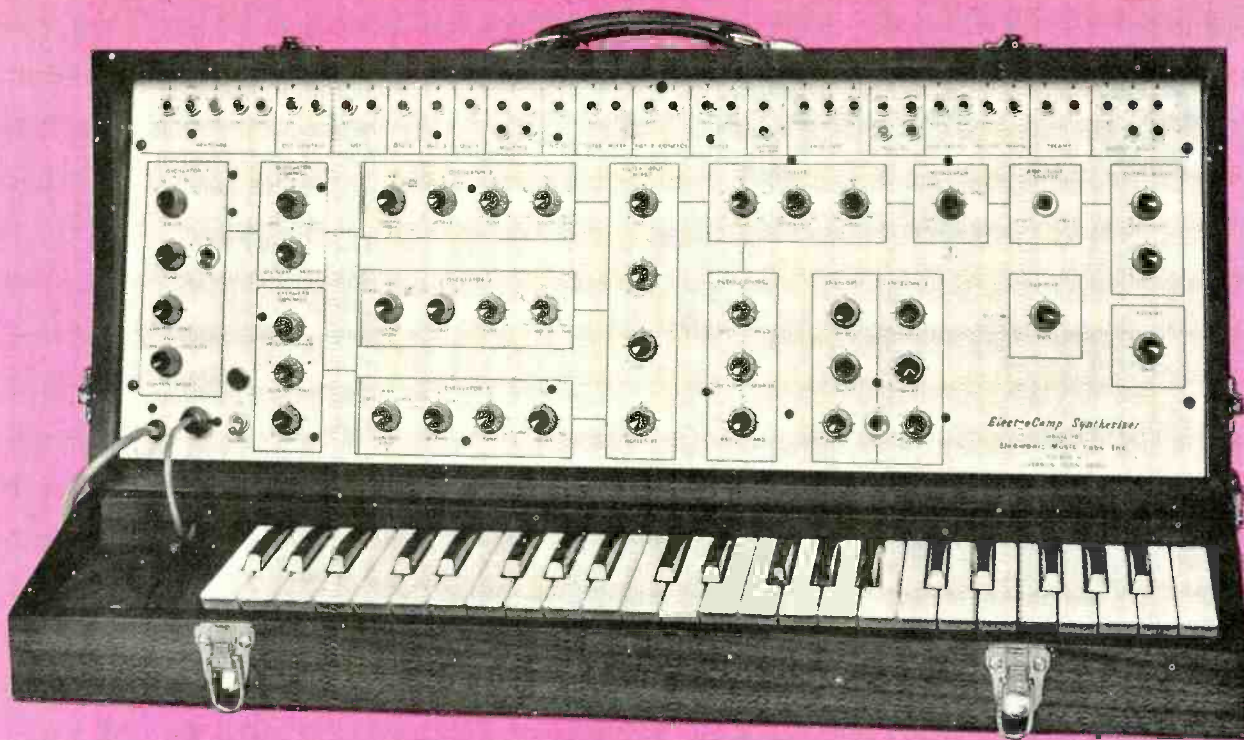
In addition to the stations listed, the Voice of America, the AFRTS (Armed Forces Radio and Television Service), and the CBC Northern Service provide many newscasts, throughout the day, on a number of frequencies.

The listings here are based on the author's experience and proven reception—with one exception. The Israel BA station has done many flip-flops in scheduling in the past few months (perhaps as a result of the installation of a new 300-kW transmitter). So the times and frequencies listed for this station are the latest obtainable.

Time (GMT)	Station	Frequency (MHz)
0000	BBC	15.260*, 11.750, 9.740†, 9.580, 9.510*, 9.410 7.325, 6.175†, 5.975
	R. Japan	15.105
	R. Norway	11.860, 9.645 (Mon)
	R. Moscow	9.665, 7.440, 7.355, 7.205, 7.185, 7.150, 7.105, 5.940
	R. Peking	15.520, 15.060, 11.945, 11.685, 8.300, 6.810
	R. Tirana	9.755, 7.065
	R. Sofia	9.700
0030	R. Sweden	6-MHz band (subject to change)
	V. of Chile	15.150, 9.590, 9.560, 6.190
	HCJB, Quito	11.915, 9.560, 5.970 (weekdays)
	R. Kiev	9.655, 9.530, 9.520, 7.150, 5.940 (Tu, Fri, Sat)
	R. Prague	9.540
	R. Vilnius	9.685, 7.105 (Sun, Mon)
0100	Vatican R.	9.605, 6.165, 5.995
	Deutsche Welle	9.690, 9.545, 6.040, 6.010
	R. Japan	15.105
	R. Canada	9.755, 6.085
	RAI, Rome	9.575, 6.010
	R. Berlin Int.	9.730
	R. Havana	11.930, 11.725
	R. Moscow	See 0000 listings.
	R. Peking	17.855, 17.715, 15.060, 11.945, 11.445, 9.780**, 9.390, 7.120**
	Spanish Nat. R.	11.925, 6.065
	R. Budapest	9.833, 7.220, 6.165
	R. Television Dominicana	9.505 (weekdays, irregular)
	Trans-World R.	11.815***
	R. Prague	11.990, 9.630, 9.540, 7.345, 5.930
0130	R. Japan	17.825, 17.725, 15.235, 15.195
	R. Australia	17.795, 15.320, 11.970
	R. Moscow	See 0100 listings, with 9.700††
	R. Austria	9.770, 6.155
	R. Bucharest	11.940, 9.570, 6.190, 5.990
	R. Tirana	7.300, 7.070, 6.200 (7.300 may vary to 7.290, all times)
0145	Swiss BC	11.715, 9.535, 6.120, 5.970
0200	BBC	15.260*, 11.750, 9.580, 9.510*, 7.325, 6.175*, 5.975
	R. Japan	15.105
	R. Portugal	11.935, 6.025
	R. Grenada	11.975 (weekdays)
	HCJB	11.915, 9.560, 5.970 (weekdays)
	R. Moscow	9.785, 9.700††, 9.665, 9.610, 7.440, 7.355, 7.205, 7.185, 7.150
	R. Peking	17.715, 15.060, 12.055, 11.945, 11.445
	Spenish Nat. R.	11.925, 6.025
	R. Nederland	6.165*** (weekdays)
	R. Norway	9.645, 6.180 (Mon.)
0230	R. Australia	17.795, 15.320, 11.970
	R. Sweden	6.135
	R. Bangladesh	15.520, 11.650
	R. Berlin Int.	9.730
	R. Moscow	See 0200 listings
	R. Beirut	9.675 (may be changed)
	R. Cairo	9.475
	UN Radio	21.630, 17.850, 15.365
0240	R. Australia (Australian Newsreel)	See 0230 listings (weekdays)
0250	Voice of Chile	15.150, 9.590, 9.560, 6.190
0300	BBC	15.260*, 9.580, 9.510*, 7.325, 6.175*, 5.975
	R. Japan	15.105
	R. RSA	9.525, 7.270, 5.980, 3.995
	R. Finland	9.720 (Subject to change)
	R. Moscow	9.700††, 7.440, 7.355, 7.205, 7.185, 7.150
	R. Kiev	9.610, 9.520, 7.205 (may be changed) (Tu, Fri, Sat)
	R. Peking	15.095, 15.060, 12.055, 11.650, 11.445, 9.780**, 7.120**
	RAE, Argentina	9.690
	R. Budapest	9.833, 7.220, 6.165
	R. Portugal	11.840
	R. Prague	11.990, 9.630, 9.540, 7.345, 5.930
	R. Bucharest	11.940, 9.570, 6.190, 5.990
	Spanish Nat. R.	11.925, 6.065
	Deutsche Welle	9.545, 6.185, 6.075, 6.040
0320	R. Erevan	17.900, 17.720, 15.180 (via Soviet Far East) (Mon, Wed, Fri, Sun)
0330	R. Berlin Int.	11.970, 11.840
	R. Havana	11.930, 11.760, 11.725
	R. Moscow	See 0300 listings, plus 17.775, 15.180, 15.140, 11.860, 11.690, 9.785, 9.735, 9.700††, 9.610, 9.580, 9.540
	R. Austria	9.770, 6.155
	R. Tirana	7.300, 6.200
0345	R. Portugal	11.935, 6.025 (not Mon)
0400	BBC	11.750, 9.580, 9.510*, 5.975
	R. Japan	9.505
	R. Canada	9.655, 6.135
	R. Sofia	9.700
	R. Norway	9.645, 6.180 (Mon)
	R. Portugal	11.935, 6.025 (Mon)
	R. Moscow	See 0330 listings but delete 9.700, add 9.655, 5.940
	New Zealand BC	15.110
	R. Peking	15.385, 15.060, 11.650, 9.640
0415	R. Budapest	9.833, 7.220, 6.000
	RAI, Rome	7.265, 5.990
0430	R. Tirana	7.300, 5.945
	R. Bucharest	11.940, 9.570, 6.190, 5.990
	Swiss BC	11.715, 9.725
	R. Moscow	See 0400 listings
0445	Deutsche Welle	9.545, 6.185, 6.075
0500	BBC	11.750, 9.580, 9.510*, 6.050, 5.975
	Israel BA	12.000, 9.495, 9.009, 7.395
	R. Japan	9.505

Time (GMT)	Station	Frequency (MHz)
	R. Korea, Seoul	9.640
	R. Canada	9.655, 6.135
	HCJB	11.915, 9.560, 5.970 (Tu, Th, Sat)
	R. Nederland	9.715***, 6.165*** (weekdays)
	R. Moscow	17.775, 15.180, 15.140, 11.860, 11.690, 9.785, 9.735, 9.610, 9.580, 9.540, 7.260, 7.170, 7.150, 5.985
0515	HCJB	11.915, 9.560, 5.970 (Wen, Fri)
	ORTF, Paris	11.735, 11.710, 9.710, 9.680, 7.135
0530	R. Kuwait	15.345
	R. Moscow	See 0500 listings, but delete 17.775, 15.140, 11.860, 11.690
	ETLF, Addis Abeba	11.890, 9.730
0535	Deutsche Welle	9.765, 9.605†, 9.545, 6.145, 6.085†, 6.075
	V. of Nigiria	15.185, 11.900, 7.255
0600	BBC	15.400*, 15.070, 11.750, 9.640, 9.600*, 9.580, 6.005*
	R. Japan	9.505
	R. Norway	11.860 (Mon)
	R. Moscow	See 0530 listings, add 11.690, 7.300
	New Zealand BC	11.780, 9.540 (BBC News)
	RAE, Argentina	9.690
0615	R. RSA	17.780, 15.220, 11.900
0630	R. Havana	9.525
	R. Nederland	11.730*** (weekdays)
	R. Moscow	See 0600 listings
	V. of Malaysia	15.295, 11.900
	UN Radio	9.530, 6.055 (Tu-Sat)
0700	BBC	15.400*, 15.070, 11.750, 9.640, 9.600*, 9.580, 6.005*
	R. Japan	9.505
	R. Moscow	See 0600 listings
0707	UN Radio	9.520, 6.055 (Tu-Sat)
0715	R. Australia	9.570, 7.280
0745	UN Radio	9.520, 6.055 (Tu-Sat)
0800	BBC	15.070, 11.955, 11.860*, 9.640, 9.600*, 7.150
	R. Japan	9.505
	R. Nederland	9.715*** (weekdays)
	New Zealand BC	11.780, 9.540
0815	R. Australia	9.570, 7.280
0830	V. of Malaysia	15.295, 11.900
0845	UN Radio	9.565, 5.955, (Tu-Sat)
0900	BBC	15.400*, 15.070, 11.955, 9.640, 7.150
	R. Canada	9.625, 5.970
	R. Japan	9.505
	R. Korea, Seoul	15.335, 9.640
1000	R. Japan	9.505
	R. Pyongyang	12.075, 9.895, 7.405
	R. Hanoi	15.012
	UN Radio	9.650, 6.145
1040	V. of Chile	15.150, 9.590, 9.560, 6.190
1100	BBC	15.070, 12.095, 11.905
	R. Japan	9.505
	Vatican Radio	21.485, 17.840 (weekdays)
	R. RSA	21.535, 15.220, 11.900
	R. Korea	15.335, 9.640
	R. Tirana	11.985, 9.500
	V. of Indonesia	11.715 (varies)
1115	R. Canada	11.825, 9.655, 5.970
1130	Israel BA	17.690, 15.130, 15.100, 12.025, 9.009
1145	Vatican Radio	21.485, 17.840 (weekdays)
1200	R. Japan	9.505
	R. Tashkent	15.460, 15.115, 11.925, 11.730
	R. Peking	11.685, 9.480, 8.260, 5.250, 4.130
1205	Trans-World Radio	11.815*** (Sat, Sun)
1220	R. Ulan Bator	17.780 (variable), 15.440, 8.990
1230	R. Australia	9.580
1245	Vatican Radio	21.485, 17.840 (weekdays)
1300	BBC	21.710, 17.790, 15.070
	R. Japan	9.505
	R. Pyongyang	9.515
	R. RSA	21.535, 15.220, 11.900
	R. Hanoi	10.040
	Trans-World Radio	15.255***, 11.815*** (Sat)
1315	Swiss BC	21.520, 15.140
1400	BBC	21.710, 17.840*, 17.790, 15.070 (Sat)
	R. Japan	9.505
	R. Sweden	17.710
	R. Finland	15.185
	R. Tashkent	15.460, 15.115, 11.925, 11.730
1415	Trans-World Radio	15.255*** (Sun)
1450	Vatican Radio	11.825
1500	BBC	21.710, 17.840*, 17.790, 15.260, 15.070 (Radio Newsreel)
	R. Japan	9.505
	HCJB	17.880, 15.115, 11.740 (weekdays)
	R. Bucharest	15.250, 11.940
1530	R. Belgrade	15.240, 11.735
	R. Hanoi	7.038
1600	BBC	17.840*, 17.790, 15.070, 12.095
	R. Japan	9.505
	R. RSA	15.155, 11.900
	R. Norway	17.825, 15.175 (Sun)
1700	BBC	15.070, 12.095, 9.410
	R. Japan	9.505
	R. Tahiti	15.170, 11.825 (except Sun)
1720	Vatican Radio	17.900, 15.210, 11.705
1730	R. Kuwait	15.415
1800	BBC	15.070, 12.095, 9.410
	R. Canada	15.325, 11.865, 9.480, 5.930
	R. Japan	9.505
	R. Finland	15.185
	UN Radio	21.670, 18.275, 15.410 (weekdays)
	V. of Nigeria	15.210, 11.770
1810	Vatican Radio	17.900, 15.210, 11.705
1830	R. Belgrade	9.620
1900	R. Japan	9.505
	R. Algiers	17.745, 15.420 (both variable)
1930	R. Baghdad	9.745
2000	BBC	15.400*, 15.260*, 15.195, 15.070, 11.750, 9.410
	R. Japan	9.505
	R. Nederland	11.730††† (weekdays)
	R. Belgrade	9.620
	R. Ghana	11.850
	V. of Iran	15.084, 6.022
	Israel BA	17.690, 15.490, 15.100, 12.025, 9.815, 9.495, 9.009, 7.395
2010	R. Havana	15.155
2030	R. Grenada	15.105 (weekdays)
2035	Vatican Radio	15.260, 11.740, 9.625
2045	ELWA, Monrovia	11.940
2050	R. Havana	17.705, 11.970
2100	R. Japan	9.505
	R. Canada	9.480, 5.930
	R. RSA	15.155, 11.900
	Swiss BC	15.430, 15.305, 11.870, 11.720
	All India Radio	11.620, 9.912, 9.525
2130	R. Nederland	9.715, 5.965 (weekdays)
2200	BBC	15.260*, 15.195, 11.780, 11.750, 9.580, 9.410, 5.975
	R. Japan	15.105
	R. Norway	15.175 (Sun)
	R. Moscow	7.390
	R. Belgrade	9.620, 7.240, 6.100
	R. Cairo	9.805
	All India Radio	11.620, 9.912, 9.525
	R. Canada	11.990, 9.480, 5.930
	RAI, Rome	11.905, 9.710, 5.990
	V. of Turkey	11.880
2210	V. of Chile	15.150, 9.590, 9.560
2230	R. RSA	15.155, 11.900, 9.695, 9.525
	R. Vilnius	11.980, 9.655, 9.530, 7.105 (may be changed) (Sat, Sun)
2300	BBC	15.260*, 11.780, 11.750, 9.740†, 9.580, 9.510*, 7.325, 6.175†, 5.975
	R. Japan	15.105
	R. Moscow	9.665, 7.440, 7.400, 7.355, 7.205, 7.185, 7.150, 7.105, 5.940
2330	R. Moscow	See 2300 listings
2345	R. Japan	15.445, 15.270

*Via Ascension
**Via Tirana
***Via Bonaire
†Via Sackville
††Via Sofia
†††Via Madagascar
★Via Greenville



KEYING & VCA CIRCUITS FOR ELECTRONIC MUSIC INSTRUMENTS

PART 2

Gain-block IC, JFET, MOSFET, CMOS and digital keyers

By DON LANCASTER

LAST MONTH, Part I discussed what a keyer does and several different types of keyers and vca's used in electronic musical instruments. We continue here with descriptions of other types of keyers, including the digital variety.

A Special Gain Block. The CA3080 is a special, inexpensive gain-block IC made by RCA. It can serve either as a voltage-controlled amplifier (vca) or as a two-quadrant multiplier, making it almost ideal for use in electronic musical instruments.

A typical circuit in which the CA3080 is used is shown in Fig. 1. While the IC looks like an ordinary operational amplifier (the connections are about the same as for the 741 op amp, in fact), there are some important differences. First, the output is a bilateral current coming from a very high impedance source. Second, the internal current gain is linearly variable from zero up by controlling the current fed into pin 5 of the IC. Zero current provides zero gain, while +100 μA provides a maximum useful gain.

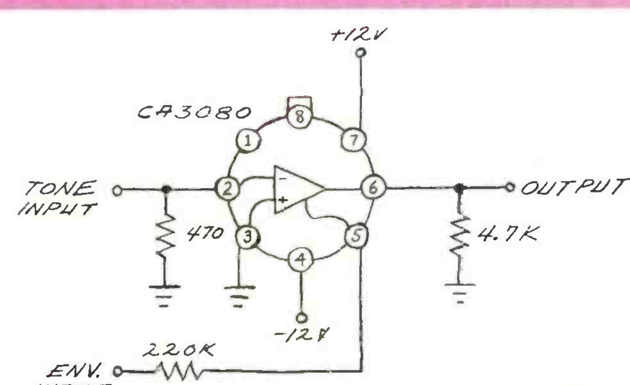


Fig. 1. The CA3080 gain-block IC used as a vca. Cost of unit in large quantities is about 50 cents.

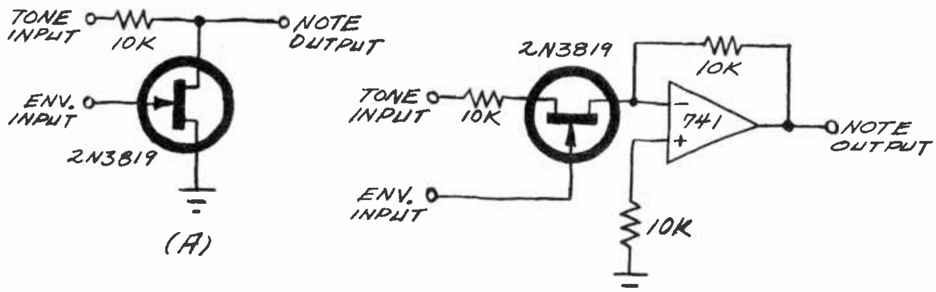


Fig. 2. The JFET can be used in the shunt mode (A) or the series mode circuit (B).

There are two inputs to the IC, inverting (−) and noninverting (+). The IC amplifies the difference voltage on these inputs and converts it to an output current. When an output load resistor is put into the circuit as shown, the output current is converted to an output voltage. Therefore, the overall voltage gain is set by the load resistor *and* the control current fed into pin 5.

There are three important things to remember when using the CA3080: (1) always keep input signal levels below 100 mV to prevent distortion and clipping; (2) always current-limit the input to pin 5 with not less than 100,000 ohms; (3) the voltage gain obtained depends on the output load resistor.

The JFET. The junction field effect transistor (JFET) can serve as a small-signal, electrically variable resistor. JFET's are low in cost. Texas Instruments' 2N3819 is a typical example of such devices. Also, there is a wide variety of custom JFET's for variable-resistance applications, with Siliconix offering several devices and some good application notes.

The ac input signal to a JFET must be kept very low in amplitude, preferably less than 10 mV peak-to-peak. Grounding the gate input of an n-channel JFET causes the device to conduct heavily. As the gate is made more and more negative, the equivalent resistance increases until the cutoff voltage is reached, at which point the JFET acts as an open circuit.

A JFET must be used in a shunt mode (Fig. 2A), or the signal into the virtual ground of an operational amplifier in the series mode (Fig. 2B) must be summed to keep the control or envelope voltage from appearing at the output.

The input impedance on the control line is very high because a reverse-biased diode is being driven as an input. One problem is that the cutoff voltage varies quite a bit from one JFET to another. Thus, it may be necessary to adjust the envelope amplitude and off level to suit the particular JFET in use.

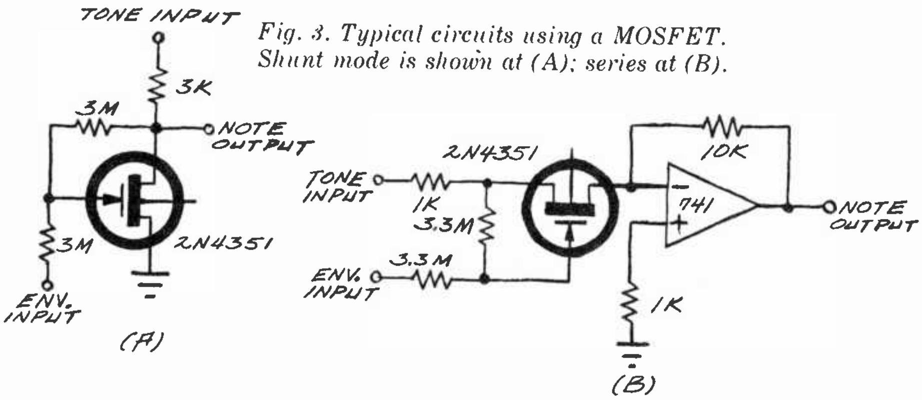


Fig. 3. Typical circuits using a MOSFET. Shunt mode is shown at (A); series at (B).

The MOSFET. Enhancement-mode MOS (metal-oxide silicon) FET's with insulated gates can also be used as variable resistors. MOSFET's cost a bit more than conventional JFET's, but they have a number of distinct advantages.

Shown in Fig. 3 are typical circuits in which the 2N4351 MOSFET is used in the shunt (A) and series (B) modes. If the substrate lead is permitted to float and the two-resistor feedback network is used exactly as shown, the circuits can be operated with up to 10 volts of peak-to-peak audio signal.

A voltage must be applied to the gate of a MOSFET to drive the device (unlike the depletion-mode JFET that requires that a voltage be removed from the gate to turn it off). This permits the use of positive envelope and control voltages.

The MOSFET remains cut off until the envelope input signal reaches +4 volts or so. Between +4 and +8 volts, control of gain and resistance is more or less linear. Any potential beyond +8 volts or so does not significantly change the resistance.

The input impedance to the MOSFET is essentially infinite on the envelope line. However, the feedback resistors reduce the impedance to about 6 megohms, a value low enough to permit the use of small capacitors in the envelope shaping circuitry. At $2

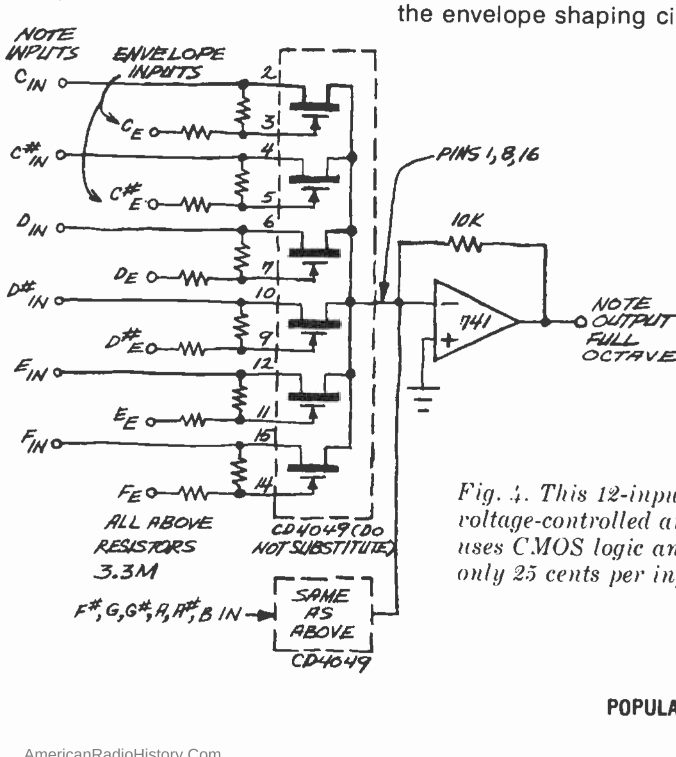


Fig. 4. This 12-input voltage-controlled amplifier uses CMOS logic and costs only 25 cents per input.

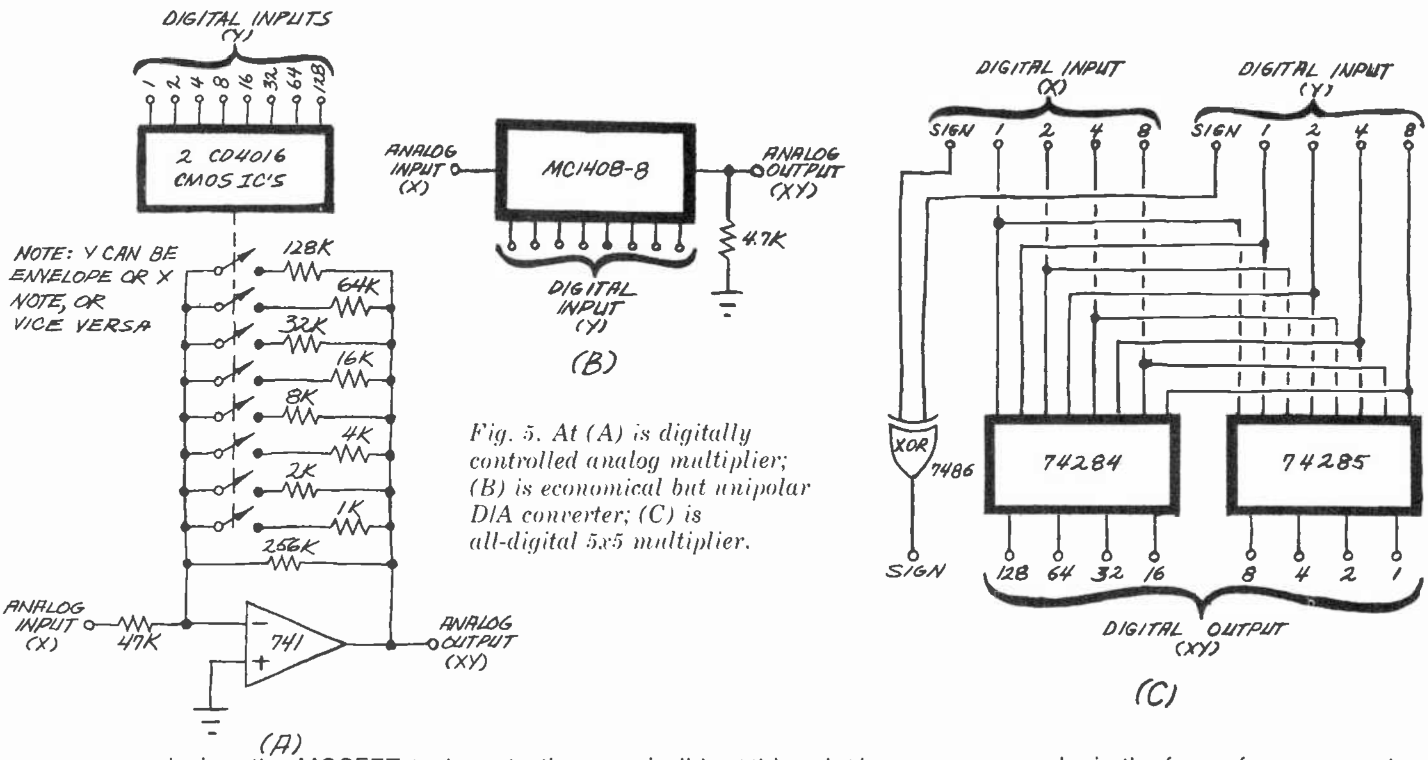


Fig. 5. At (A) is digitally controlled analog multiplier; (B) is economical but unipolar D/A converter; (C) is all-digital 5x5 multiplier.

or so per device, the MOSFET technique can be economically used on smaller polyphonic instruments.

The CMOS Technique. There are many games you can play with the CMOS digital-logic family of devices, especially the industry standard CD4000 series. One obvious thing to do is to bias a hex inverter to obtain six n-channel MOSFET's, yielding six keyers in a $1 or $2 package. The resultant unit keyer cost will then be 15c to 30c, which is the pricing you must aim for when considering a fully polyphonic keying system on a large but reasonably priced instrument.

The only catch to the above is that ordinary CMOS hex inverters contain input-protection diodes that make this essentially impossible. But the new RCA CD4049 or Motorola MC14049 IC's eliminate the problem. The circuit for using these new IC's is shown in Fig. 4. It is simply the circuit shown in Fig. 3 repeated 12 times for a full octave's worth of keying (12 notes), accomplished with three low-cost integrated circuits.

The signals must be limited to very low levels at the note inputs, preferably to between 50 and 100 mV rms from a 400-ohm source. Thanks to the operational amplifier, the output impedance from the system is low. The output signal level is 2 volts peak-to-peak. The resistors provide a linearizing effect. Depending on your system, however, you may be able to eliminate the resistors. It all depends on the distortion permissible at this point in your system. Since each keyer works on only one note, distortion changes the harmonic structure of only the one note and does not intermodulate.

The most important advantages of the CMOS keying approach include very simple circuit design, low parts cost and, electronically, very high impedance on the envelope input lines. (A fully custom version of the Fig. 4 circuit technique is used by one major electronic organ manufacturer.)

While you are looking at CMOS devices, check out the quadrature analog gate CD4016 IC. It cannot be used in a variable-gain mode, but it is great for on/off control of electronic music signals. Even in single-quantity prices, it costs only about 25¢ per channel.

Going Digital. So far, only analog keying and control techniques have been described. Digital techniques can also be used in electronic music. You will be seeing more EM digital circuitry in the future. Let us take a brief look at some of the possibilities:

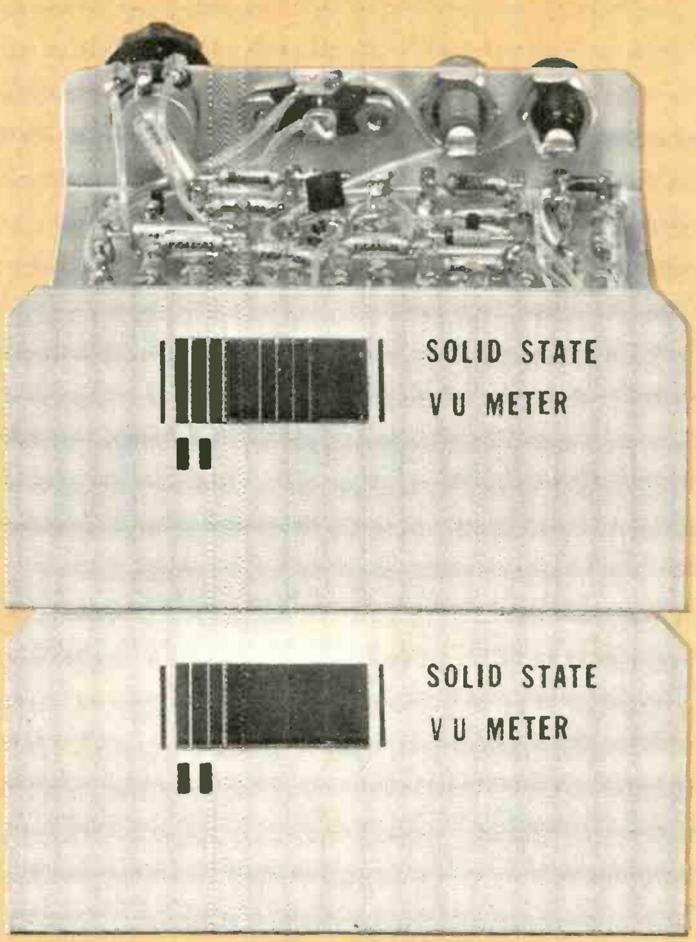
In Fig. 5A, eight stages of CD4016 CMOS IC switching are used to set the gain of an operational amplifier to one part in 256. The gain can be set to any of 256 discrete values that are close enough that they appear to continuously change in amplitude.

The tone signal is fed to the input of the operational amplifier, and envelope information is derived from a mask or a digital memory. The memory can be in the form of a permanent store, program card, or programmable information store. One benefit of this approach is the ability to generate *any* envelope you want, including waveshapes that would be physically impossible with conventional acoustical instruments. Precision resistors are required for this particular circuit.

In Fig. 5B, all switching is accomplished inside the Motorola MC1408P-8 IC. An analog input current and a digital word are applied to the inputs. The output current is a ratio of the input current from zero to full value in one of 256 discrete steps. This circuit is also useful for changing a digital to an analog envelope waveform, or for converting digital timbre information into an equivalent analog waveshape. One limitation of the device is that the input current must be single-directional with respect to ground; so, an MC1408P-8 cannot be used directly for keying operations.

In Fig. 5C is a 5-bit by 5-bit (5X5) digital multiplier that provides a digital word as the product of an input envelope word and an input tone word. The five bits are derived from a pair of 4X4 multipliers and an exclusive-OR gate to take care of the sign bits. Though we would like to see more bits than this, the cost rises considerably if you shoot for greater accuracy.

There you have the keying and vca techniques commonly used in electronic musical instruments. Good luck in applying these to your own instrument designs. ◈



CONSTRUCTION

A VU METER WITH NO MOVING PARTS

New bar-graph device provides signal-strength readouts, accurate peak signals

BY TERRY L. MAYHUGH

VU METERS cannot accurately read out momentary peaks due to meter-movement inertia. For example, the ballistics of a professional VU meter is standardized so that about 0.30 second is required before a steady-state reading is reached. Obviously, this is too slow to register the fast peaks that occur in music. A peak-responding LED is sometimes used to indicate the presence of such transients.

Here is a "VU" meter that combines the features of a standard VU and the peak indicator. It is a meter with no moving elements. The all-solid-state circuit is designed around a new incandescent bar indicator that instantaneously shows relative signal strength, including sharp peaks, over a wide dynamic range.

The readout element resembles a conventional DIP IC (in shape) and displays up to ten discrete signal levels on parallel filaments. In this case, it has a dynamic range of 30 dB, with each sequential filament illuminating fully at 3 dB over the preceding one. The tenth filament (the final 3 dB) is the peak signal indicator.

Circuit Operation. As shown in Fig. 1, potentiometer *R1* sets the level of the audio input to a precision full-wave rectifier that uses both halves of *IC1*. The rectified output is coupled to 10 parallel voltage comparators in *IC2*, *IC3*, and *IC4*.

Each of the 10 filaments in the display operates at 5 volts and 10 mA. The first nine are driven directly by the comparators. The tenth is controlled by a one-shot multivibrator (*IC5*) to indicate the peaks.

Two other comparators in *IC2* are used as voltage regulators to supply a reference voltage. A third regulator made up of *D3* and *Q1* supplies the higher current required for the display filaments.

The resistor network made up of *R24* through *R42* is arranged as an R-2R ladder that allows a precision voltage divider to be constructed using only two different values of precision resistors. The consecutive reference voltages for the noninverting inputs of the comparators are selected to increase in 3-dB steps from the low end to the high end of the range. As the rectified audio voltage to each comparator's inverting (−) input reaches that of the associated noninverting (+) input, the comparator switches to turn on its associated display filament. Thus, the number of filaments turned on (illuminated) at any instant is determined by the level of the audio input.

Construction. The circuit can be assembled on a pc board or a perforated board. All of the components except for the power supply and the display can be on the board. Sockets should be used for the IC's.

When laying out the board, be sure that wires carrying the comparator outputs and inputs are not too close to each other to avoid oscillation. Since the output pins of the comparators are at one end of the package, there should be no problem in getting a satisfactory layout. The $+V_{cc}$ pin of each IC should be bypassed to ground by a 0.1-μF disc capacitor mounted as close to the pin as possible.

Output indicator *DIS1* and its socket are cemented in a suitable rectangular cutout on the front panel. Since the incandescent filaments emit a white light, a filter of almost any color can be used in front of the display. In the prototype, a green filter was used.

Any power supply delivering 12 volts at 200 mA can be used.

Diode *D3* must be selected by trial and error. First, tack-solder a standard 1N914 into the circuit. Apply an input audio signal of about 1 or 2 volts rms to *J1* and adjust *R1* until all 10 segments are lit. All 10 segments should be bright, but there is a possibility that the first nine may not have equal brightness due to different current-sinking capabilities of the com-

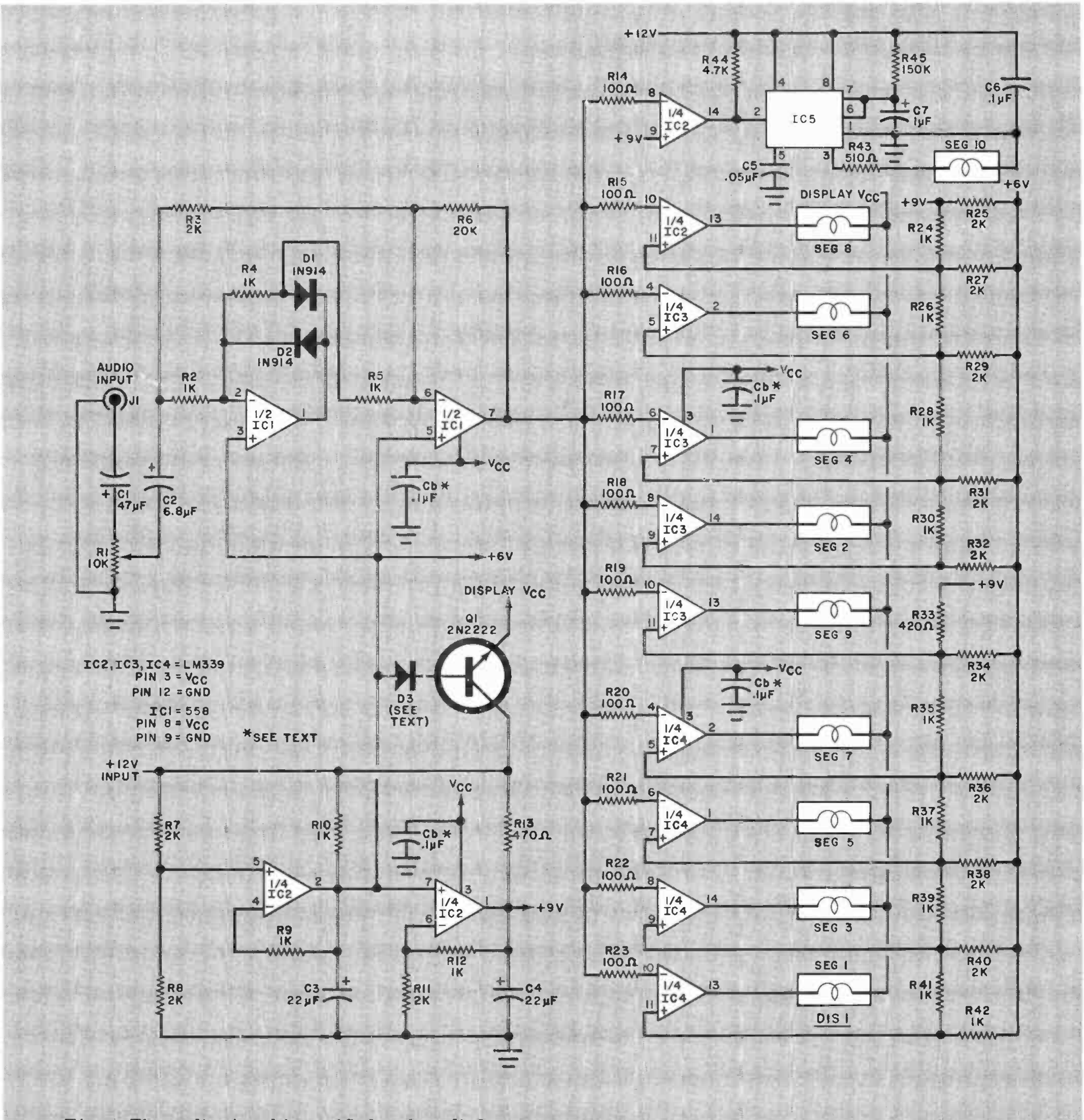


Fig. 1. The audio signal is rectified and applied to sequential comparators, which turn on filaments in display.

PARTS LIST

(Two of each needed for stereo)
C1—47-μF tantalum capacitor
C2—6.8-μF tantalum capacitor
C3,C4—22-μF tantalum capacitor
C5—0.05-μF ceramic capacitor
C6—0.1-μF ceramic capacitor
C7—1-μF tantalum capacitor
D1,D2—1N914 diode
D3—See text
DIS1—Bar indicator light (see note)
IC1—558 dual op amp
IC2,IC3,IC4—LM339 quadruple comparator (National)
IC5—555 timer
J1—Phono connector
Q1—2N2222 transistor (or similar)
R1—10,000-ohm potentiometer
R2,R4,R5,R9,R12,R26,R28,R30,R32, R35,R37,R39,R41,R42—1000-ohm, 1% resistor
R3,R7,R8,R11,R25,R27,R29,R31,R34, R36,R38,R40—2000-ohm, 1% resistor
R6—20,000-ohm, 5% resistor
R10—1000-ohm,5% resistor
R13—470-ohm, 5% resistor
R14 to R23—100-ohm, 5% resistor
R33—420-ohm, 1% resistor
R43—510-ohm, 5% resistor
R44—4700-ohm, 5% resistor
R45—150,000-ohm, 5% resistor
Misc.—IC sockets (6), transparent filter, cement, mounting hardware, power supply.
Note—Bar indicator (3015Q) is available from Readouts, Inc., Box 149, Del Mar, CA 92014, for $4.25, plus postage.

parators. If there is a noticeable difference in segment brightness, use two diodes in series for *D3*. Recheck the brightness. At least one diode must be used for *D3*; but as many as three (connected in series) may be used to get the desired brightness.

Use. Since the meter has a relatively high input impedance, it can be connected directly across the speaker terminals of any audio amplifier. In fact, two meters can be used for stereo balance tests.

Adjust potentiometer *R1* so that the last segment flickers on the required audio peaks. ◈

POWER SURGES AND SEMICONDUCTORS

BY LESLIE SOLOMON
Technical Editor

MOST repair problems on electronic equipment can be traced to failures of parts due to simple things like overheating, vibration, or even sheer carelessness—as when a screwdriver gets stuck in the wrong place. These faults are relatively easy to locate and correct; but sometimes (particularly when semiconductors are involved) we hit a real "puzzlement." These problems can't be solved even with the aid of the most sophisticated test gear.

In such cases, the problem is: though semiconductors have no known wear-out mechanism when operated within specified limits, how can they suddenly fail catastrophically?" How can a piece of equipment containing all the correct components, with a well-regulated power supply and proper voltages, suddenly drop dead? It can happen anywhere, even in mobile equipment located far from an ac power line.

Line Surges. The answers to some of these questions were provided in a recent paper written by engineers at General Electric. Their findings are worth bearing in mind.

In monitoring the power lines of about 400 locations in 20 cities, these engineers found some astoundingly high voltage surges. A few were as high as 2500 or even 5600 volts and in six locations, there were surges over 1200 volts more than once a day. These were not prolonged peaks, of course, but extremely short transients that suddenly appeared on the power line.

What causes these sudden surges? In some cases, they have been traced to the operation of an oil burner, a fluorescent lamp bank, a pump motor, a refrigerator, etc. In other cases, no amount of deliberate load switching could produce the transients. Some surges were traced to local lightning storms. (Film recordings, made on oscilloscopes, showed distinct oscillatory characteristics of approximately 300 kHz. This suggests shock oscillation of the home power system.)

The question of the amount of energy involved in the surge is related to the impedance of the system, which usually falls in the range of 100 to 300 ohms for a branch circuit. This means that, in a typical home, the impedance at the common service entrance could be about 5 to 10 ohms. However, this low value exists only for a small fraction of a microsecond of pulse travel time. Connected loads have a lower impedance than a branch circuit and will be dependent on frequency where inductive components are present. These loads will absorb part of the energy, thus lowering the peaks. Electric motors and transformers have substantial insulation, which may account for their rare failures. Defective wiring practices may cause flashover, without the 60-Hz power follow.

Other Types of Surges. High-voltage surges also spring from other-than power-line sources. For example, take the simple case of an on-off switch in the primary circuit of a transformer. If the transformer is suddenly energized, or de-energized, at the peak of the input power waveform, a transient of approximately twice the normal peak voltage of the secondary can occur. If there is any contact bouncing when energizing the transformer, much higher transients may occur. These transient voltages are due to the interruption of the magnetizing current. Transients in excess of 10 times the normal voltage have been observed across rectifiers if there is no load on the system. Unless a low-impedance path is provided, this can be generated across the load. If the rectifiers have insufficient PRV ratings, they can be destroyed.

If there is any inductance in a power-supply circuit (such as a choke), interrupting the power line can produce transients as the magnetic field collapses. It is also possible to get large transient voltages on the dc side of the rectifier as opening the dc load circuit can produce an amount of energy proportional to the stored energy of the ac line and transformer. This is greatest when the dc circuit is opened with a high current flowing. The stored energy in the ac circuit is the source of the destructive energy as the dc stored energy is dissipated through the forward path of the rectifiers. If high-current rectifiers are used, a higher dc current will flow in the load circuit; and if this is suddenly interrupted, large transients can be generated.

Keep in mind that these sudden transients may be many times larger than the maximum peak voltages of the various semiconductor junctions. Also keep in mind that semiconductors are not like vacuum tubes that can tolerate some overvoltage without sustaining permanent damage. A fast peak, that may occur only once, may be enough to blast a semiconductor junction out of existence, yet not damage any other parts. That is why, in some inoperable circuits, all components except the semiconductors, are in good condition. This is also one reason diode protection is found in some signal circuits. The diodes allow up to 0.5 V to pass, yet look like shorts when the voltage exceeds this value.

Mobile Equipment. Consider a whip antenna mounted on a fast-moving vehicle in dry air. Think of the amount of static voltage being built up on the antenna. Couple this with the possibility of lightning-produced charges in the air. Or consider what happens if the car passes under a high-tension line just as a large transient goes down the line. To protect mobile equipment, a neon lamp can be connected between the antenna and ground to act as a "short" when the static voltage exceeds a certain value. An r-f choke can also be connected between the antenna and ground to act as a short to the static voltage, yet present a high impedance to received signals.

As for power-line transients in the home or shop, it is pretty difficult to turn a power supply on or off exactly at the zero crossing. One solution is to use one of the transient suppressors now being offered by a number of manufacturers. These can be found in the pages of most of the larger electronics catalogs. ◈

TUG-OF-WAR

BY ROBERT C. FROSTHOLM AND ROGER LUNDEGARD
Signetics Corp.

Built around popular 555 timer devices, this electronic game project will challenge your reflexes.

FOR THE person who likes a challenge, the spirit of friendly competition, and tinkering in electronics, here is a new electronic game to build. It's called "Tug-of-War."

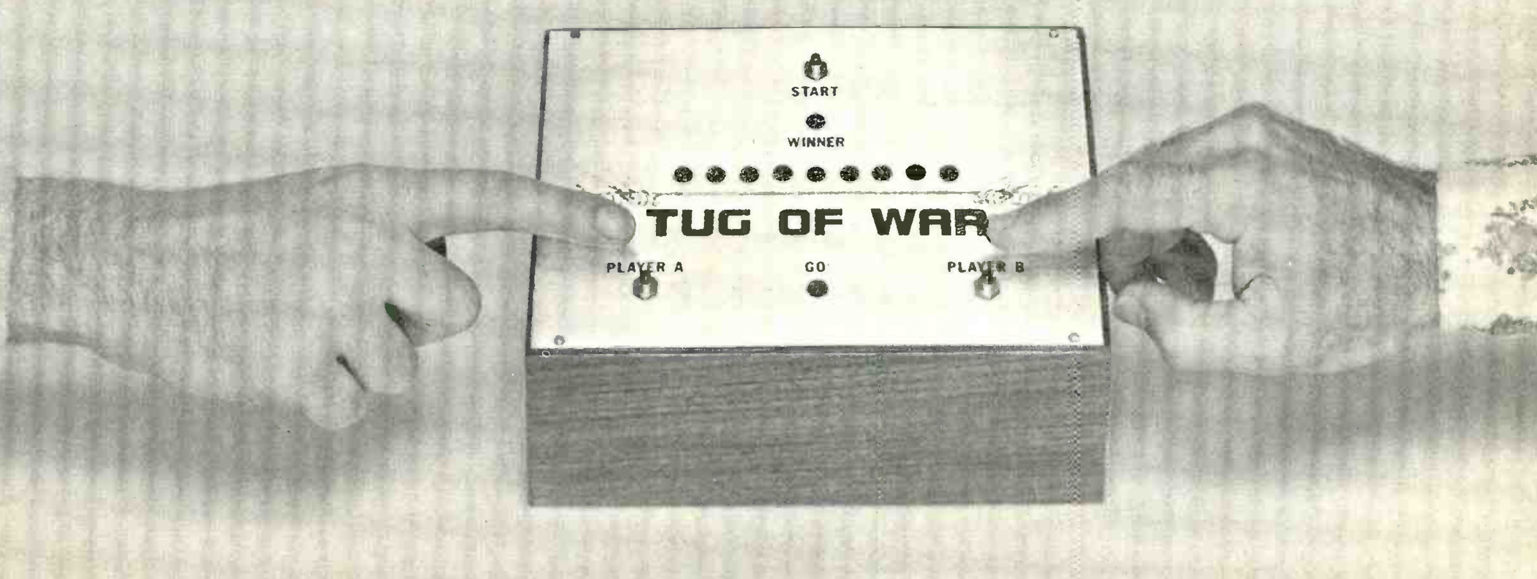
When the START button is pressed, the middle light in a chain of nine LED's lights up. At approximately five-second intervals, a GO LED blinks on for a moment. Each player has a pushbutton which he operates to try to "pull" the illuminated LED over to his side. This is accomplished by being the first one to push the PLAYER button after the GO light comes on. However, there is a catch. If a player pushes his button before the GO light, the lit LED will advance one position toward the opponent's end.

When one player succeeds in advancing the lit LED all the way to his end, the WINNER light comes on and the game is over. A new game can be started by pushing the START button.

You can also add a circuit and speaker to give an audible signal indicating who won the game.

Circuit Operation. The project uses a total of 10 timing circuits (built around three dual 555 timers), an up-down counter, and some logic gates.

As shown in Fig. 1, *IC1A* is a clock oscillator that generates a pulse approximately every five seconds. The timing is determined by *R1*, *R2*, and *C1*. During the short period of time



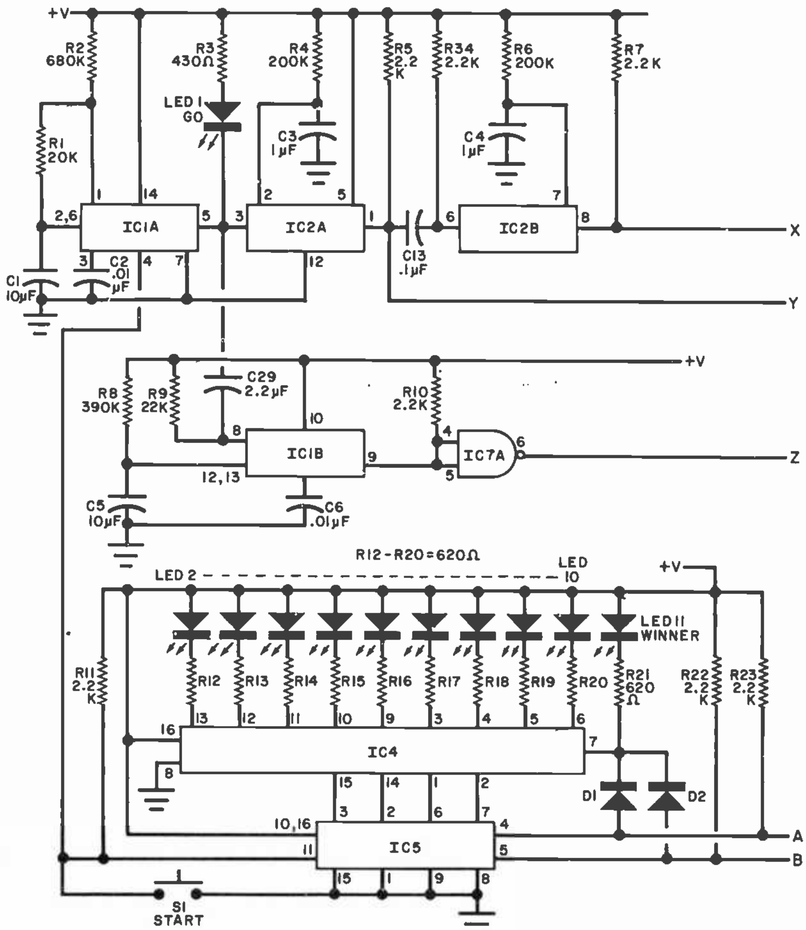


Fig. 1. Clock oscillator IC1A drives IC2A and IC2B to generate two successive gate intervals. Output of IC1B is 4.3-s pulse, inverted to a 0.7-s pulse by IC7A. Up/down counter (IC5) and BCD-to-decimal circuit (IC4) drive LED's.

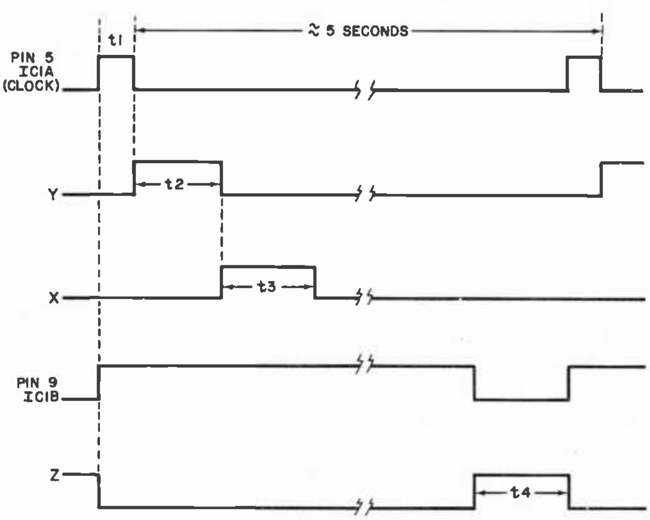


Fig. 2. Timing diagram shows relationship between pulses at X, Y, and Z. If a player operates switch before LED1 is lit (during t1), he is penalized.

PARTS LIST

C1,C5—10-µF electrolytic capacitor
C2,C6,C17,C19 to C23—0.01-µF capacitor
C3,C4,C8,C11—1-µF electrolytic capacitor
C7, C10, C13, C14, C15, C16, C27, C28—0.1-µF capacitor
C9,C12—0.001-µF capacitor
C18—Not used.
C24,C25,C26—47-µF, 15-volt electrolytic capacitor
C29—2.2-µF electrolytic capacitor
C30—500-1000µF, 15-volt electrolytic capacitor
D1 to D8—1N914 diode
D9 to D12—1N2071 diode
IC1,IC8,IC9—556A dual timer (Signetics)
IC2—553B quadruple timer (Signetics)
IC3,IC7—7400 quadruple NAND
IC4—8251B BCD-to-decimal (Signetics)
IC5—74192 up/down counter
IC6—8241A quadruple exclusive OR (Signetics)
IC10—LM309DB 5-volt regulator (Signetics)
LED1,LED11—Green MV5253 (Monsanto)
LED2 to LED10—Red MV5053 (Monsanto)
R1—20,000-ohm, ¼-watt 10% resistor
R2—680,000-ohm, ¼-watt 10% resistor
R3—430-ohm, ¼-watt, 10% resistor
R4,R6—200,000-ohm, ¼-watt 10% resistor
R5,R7,R10,R11,R22,R23,R27,R32,R34—2200-ohm, ¼-watt 10% resistor
R8—390,000-ohm, ¼-watt 10% resistor
R9,R25,R30—22,000-ohm, ¼-watt 10% resistor
R12 to R21—620-ohm, ¼-watt 10% resistor
R24,R29—2700-ohm, ¼-watt 10% resistor
R26,R31,R38,R40—2000-ohm, ¼-watt 10% resistor
R28,R33—510-ohm, ¼-watt 10% resistor
R35,R36—130,000-ohm, ¼-watt 10% resistor
R37—75,000-ohm, ¼-watt 10% resistor
R39—120,000-ohm, ¼-watt 10% resistor
S1,S2,S3—Spst temporary-contact push-button switch
Spkr—8-ohm speaker
T1—6.3-volt filament transformer (Triad F-14X or similar)
Misc.—Suitable Cabinet, line cord, rubber grommets (11), press-type, mounting hardware, IC sockets (9), clip-on heat sink for IC10, solder, wire, etc.
Note—The following are available from Four Seasons Mfg. Corp., 1071 Peninsular, Los Altos, CA 94022: IC package containing IC1 through IC10 for $24; etched and drilled pc board (TW202) for $6.95; wood case with metal top plate screened and drilled (TW206) for $9.95. California residents add sales tax. All prices include shipping in U.S. only.

that this oscillator "sinks" current, *LED1* is turned on. The pulse also triggers *IC2A* and *IC1B*. The former is a one-shot multivibrator whose "on" time is determined by *R4* and *C3*. Since this timer is edge-triggered and the state of the trigger has no effect on the output pulse, *IC2A* can be coupled to *IC2B* to provide a second pulse of equal duration (determined by *R6* and *C4*). The outputs at points X and Y are sequential pulses of equal duration.

When *IC1B* is triggered, it produces a one-shot output pulse of about 4.3 seconds, determined by *R8* and *C5*. This pulse is inverted by *IC7A* to produce a pulse of about 0.7 second duration just prior to each clock pulse. The pulse at point Z is used to penalize the player who attempts to anticipate the clock and jumps the gun. The timing diagram in Fig. 2 shows the sequence of events.

The circuitry for the players is shown in Fig. 3. The two circuits are identical except that their outputs are reversed to enable one to drive an up/down counter *(IC5* in Fig. 1) in one direction and vice versa. The players' positions are keyed around one-shots *(IC2C* and *IC2D)*.

To see how the circuits work, assume player B does not touch his button when the GO light comes on or that player A is very fast and is able to press his button during time period t2 (Fig. 2). Then the pulse generated by *IC2C* is applied to an AND gate with the pulse from point Y. Two exclusive OR gates *(IC6A* and *IC6B)* act as a frequency doubler and provide two pulses at point A, which are applied to pin 4 of *IC5*. This causes *IC5* to count down two steps. The BCD-to-decimal decoder *(IC4)* takes the output of *IC5* and causes the lit LED to move two positions toward the A end.

If player A is not quite as fast and pushes his button during period t3, the output of *IC2C* and the pulse at

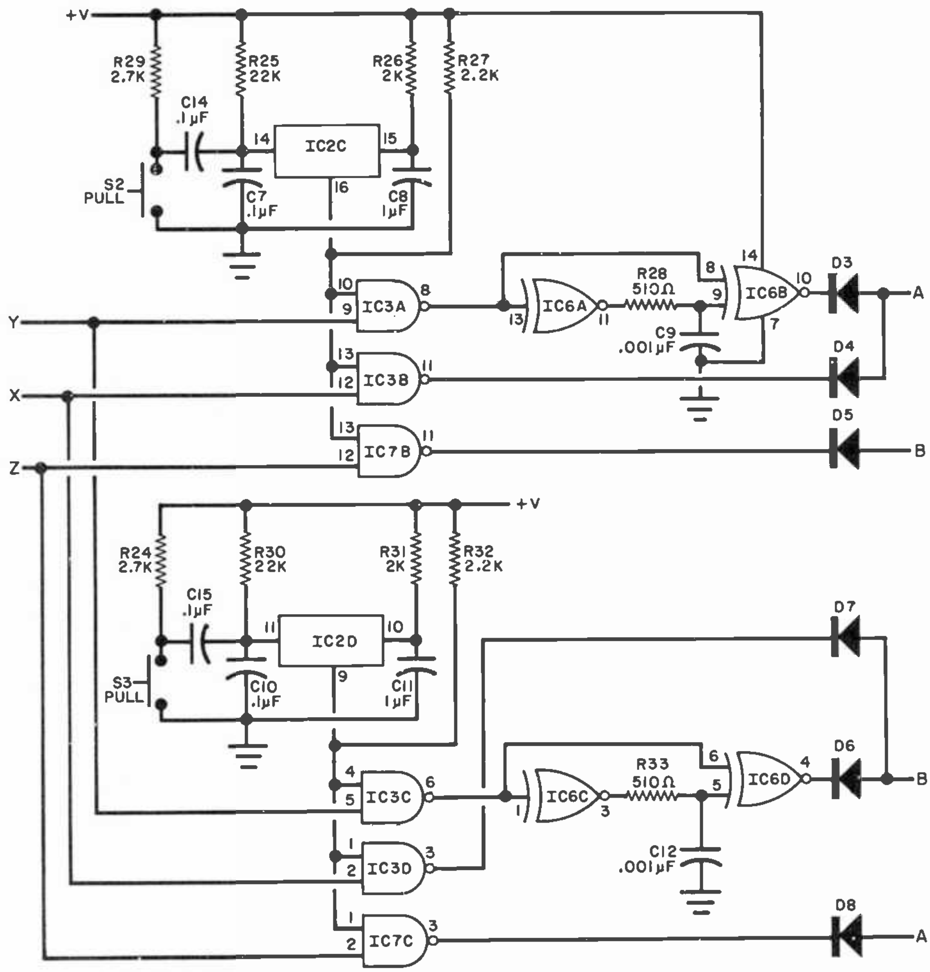


Fig. 3. Player circuits are identical. Outputs of one-shot circuits are compared with timing pulses on X, Y and Z.

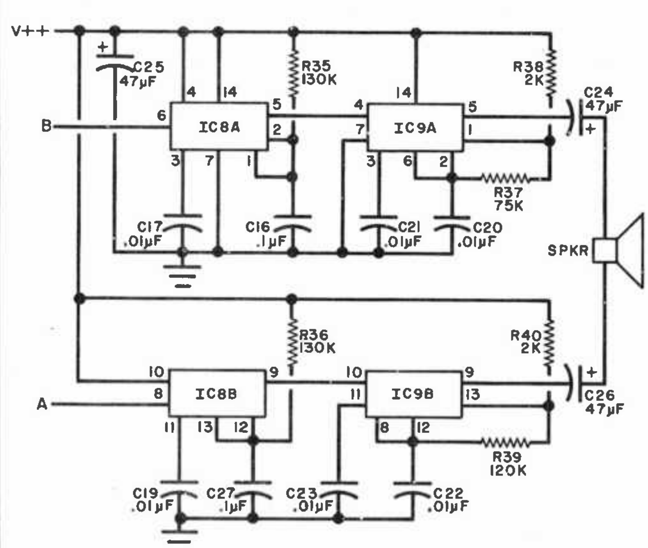


Fig. 4. Optional sound-output circuit is two gated tone-burst generators, each having a different frequency to create separate sounds for players.

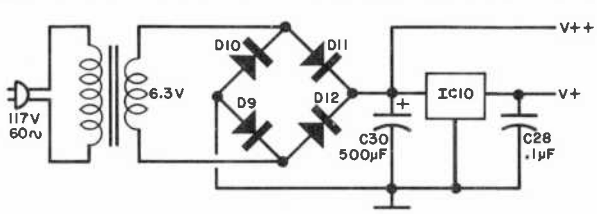
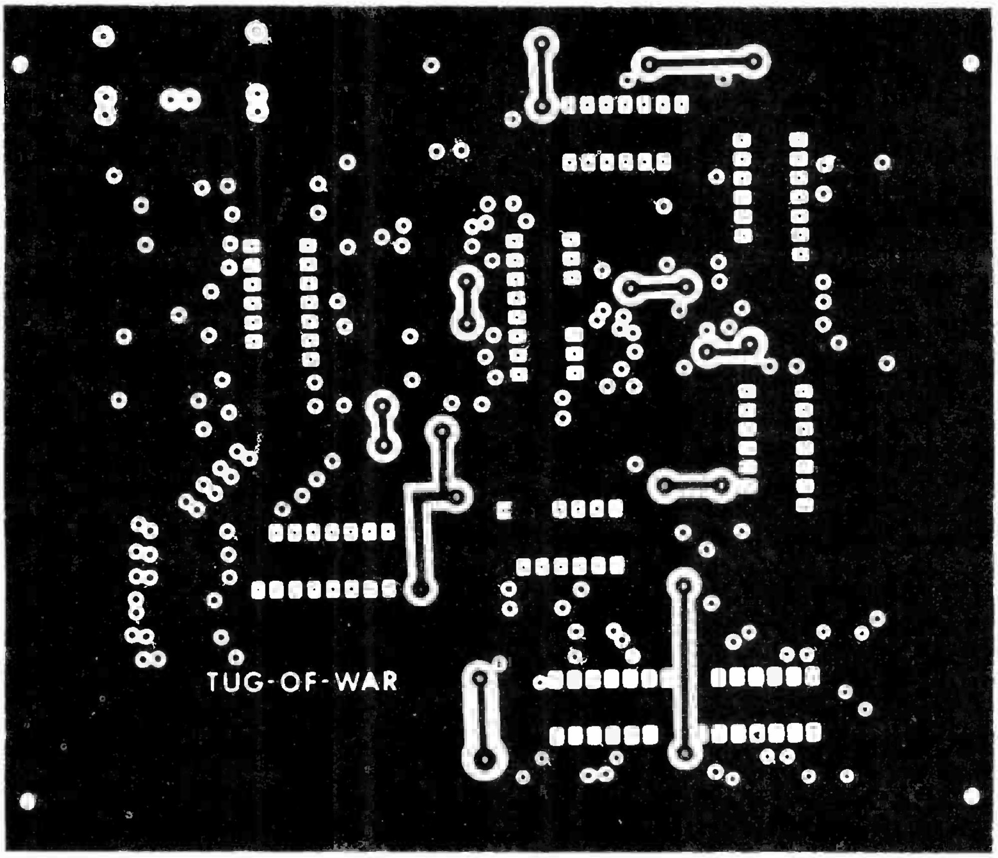
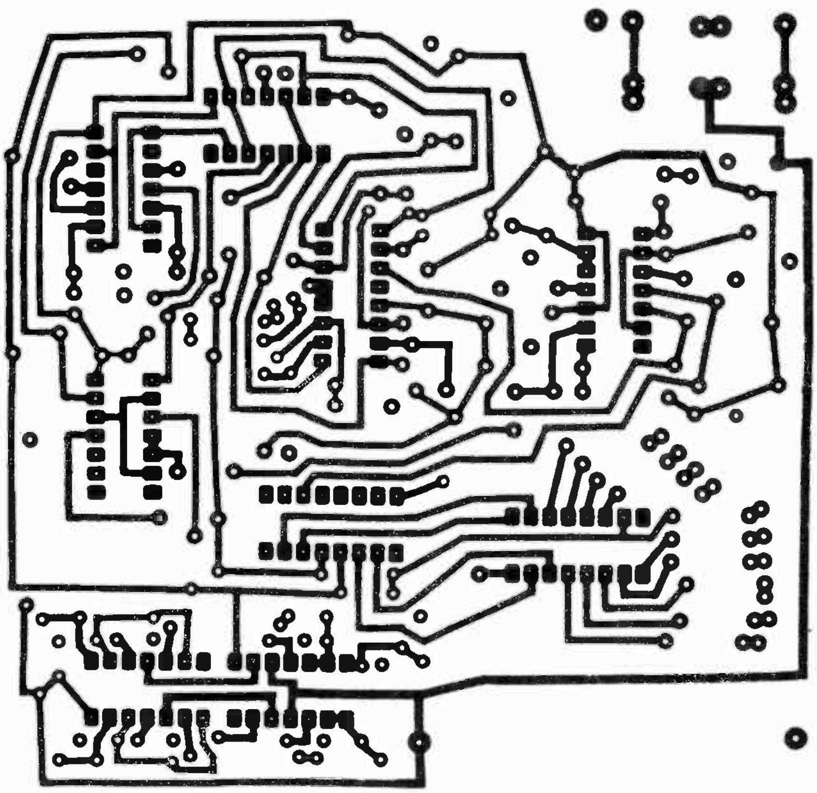


Fig. 5. Power supply delivers two different voltages for the project.

Fig. 6. Foil patterns for the double-sided pc board are shown at right and below.





point X are applied to AND gate *IC3B*. Then only one pulse appears at point A, and the lit LED advances only one position toward A.

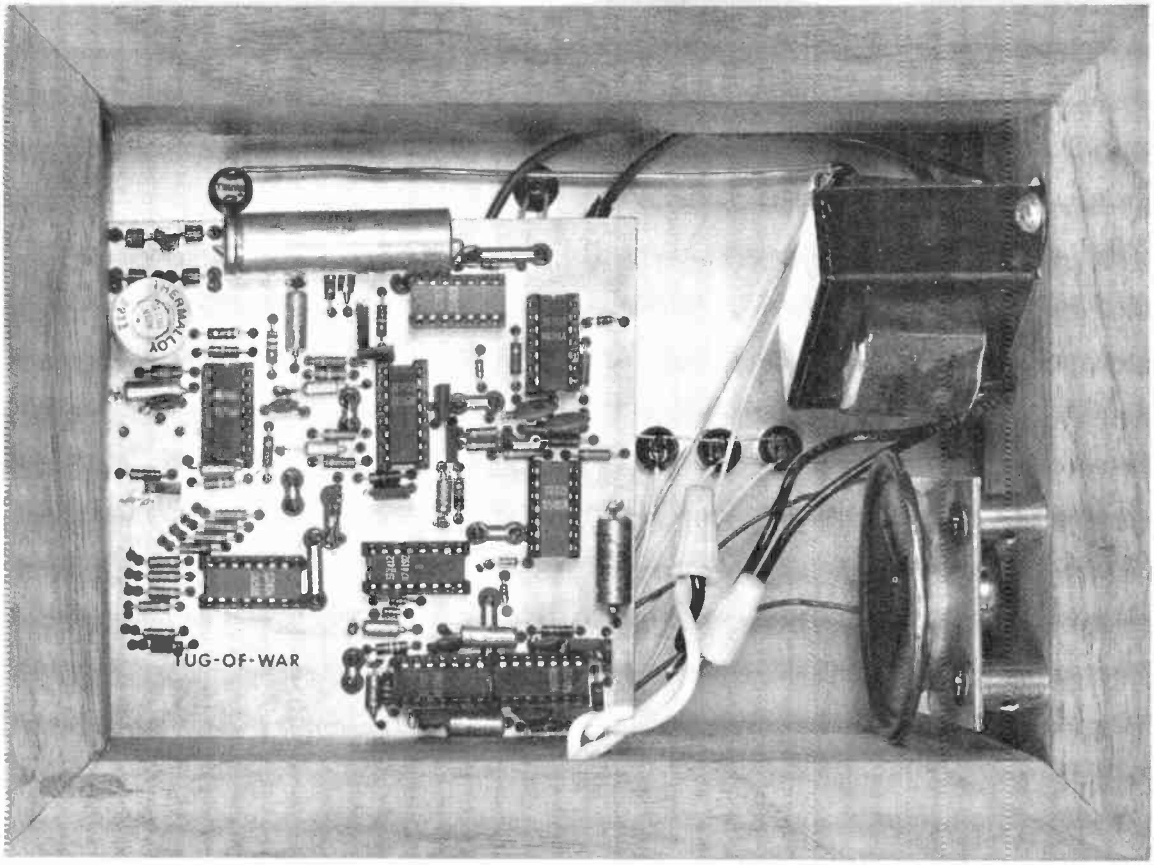
When player A tries to anticipate the GO light and presses his button too soon, the pulses from *IC2C* and point Z are applied to AND gate *IC7B* and the output at point B causes the counter to go in the other direction.

The circuit for player B operates in the same way as that for player A. If both players press their buttons at the same time, the signals cancel each other. After playing the game for some time, the players' reflexes will appear to have improved to the point where the game becomes a standoff. In this event, reduce the values of *R4* and *R6* to shorten t2 and t3. Resistors *R26* and *R31* should be reduced by the same percentage as *R4* and *R6* to reduce the possibility of confusion in the AND gates, since the pulses at X and Y will be much shorter.

When one player has moved the lit LED to his end, *LED11* is lit and diodes *D1* and *D2* prevent any further action until the START button is operated.

The game can be made more exciting by adding a circuit to provide an audible indication of which player has won. The circuit is shown in Fig. 4. Tone bursts are generated by *IC8* and *IC9*. Each half of *IC8* acts as a one-shot which determines how long the associated half of *IC9* is activated. The two halves of *IC9* are oscillators with outputs of different frequencies. When a player wins a game, the signal at A or B causes the appropriate circuit to provide a sound through the loudspeaker.

The simple power supply shown in Fig. 5 can be used for the Tug-of-War.



Photograph of interior of the Tug-Of-War shows mounting of printed circuit board with power supply transformer and optional speaker for sound at right.

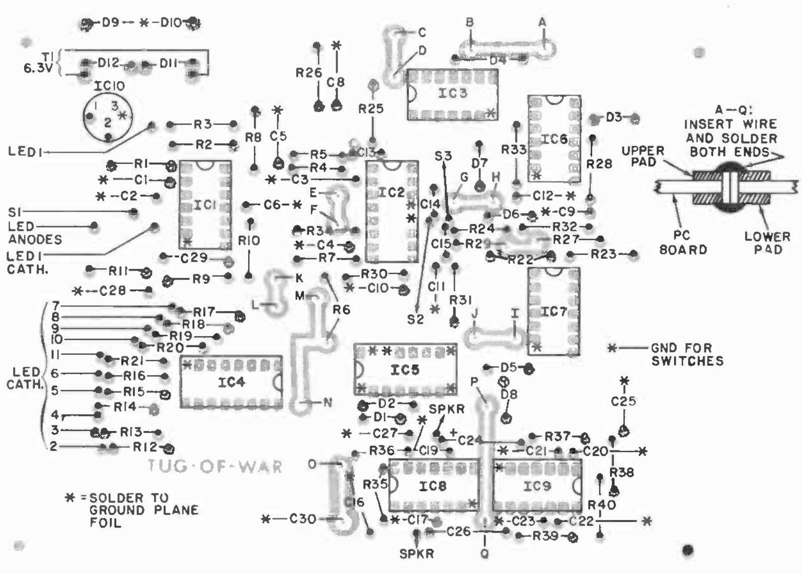


Fig. 7. Components must be mounted carefully since the top of the pc board is primarily a ground plane. Some connections, however, are made to the top side of board (asterisk).

Construction. A double-sided pc board such as that shown in Fig. 6 can be used for the Tug-of-War. Don't use sockets for the IC's. Since the top of the pc board is primarily a ground plane, it is important to remember that components must be carefully mounted so that their leads do not touch the ground, though some components and IC pins are soldered on the top side of the board to provide a ground. These points are indicated in Fig. 7 with an asterisk.

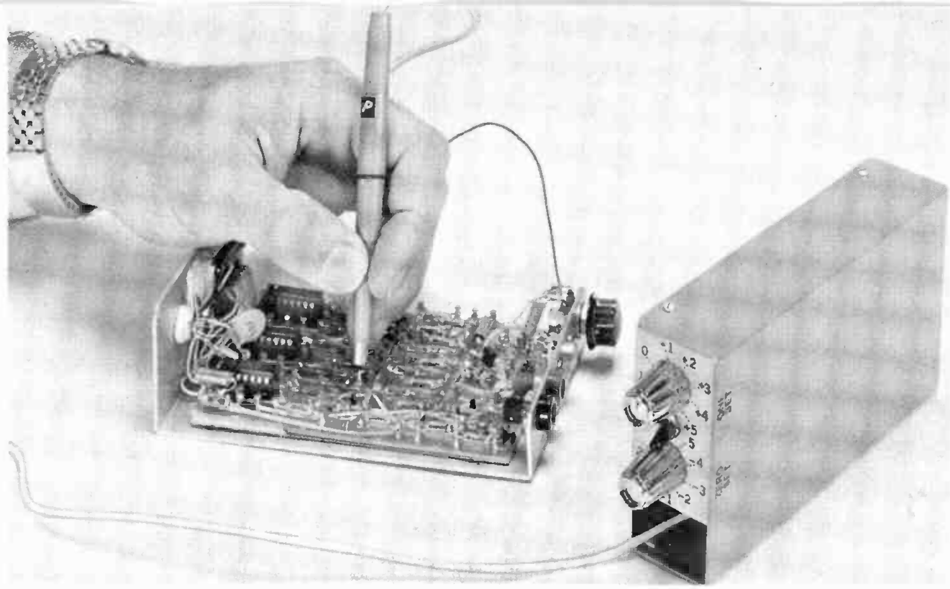
Since the board does not have plated-through holes, coincident pads (A-Q) on both sides should be interconnected by small lengths of wire through the holes and soldered on both sides. Use a clip-on heat sink for integrated circuit *IC10*.

The LED's and switches are mounted on the top cover as shown in the photograph. All use ¼" holes with grommets for the LED's. Short lengths of insulated wire are used to connect the LED's and switches to the board.

Mount the LED's so that proper positioning and polarity are observed —with *LED6* at the center of the line, *LED2* toward player A end, and *LED10* at the other end. Green LED's are used for the WINNER and GO indicators, while the others are red. ◈

PE TESTED

BUILD A "UNIVERSAL" DIGITAL PROBE



Tests virtually any digital logic family at speeds to 10 MHz.

BY JAMES P. TIERNEY

MANY different designs for digital logic test probes have appeared in the past few years. Most tend to favor a specific logic family, with TTL getting the most attention. Few, if any, are capable of checking ECL and MOS devices and circuits. The logic probe described here is designed for testing virtually all the logic families currently in use, including RTL, DTL, TTL, ECL, and MOS devices and circuits.

The universal logic probe, while larger than "ordinary" testers, is also completely self-contained. It has its own built-in battery power supply to simplify test hookups. (Most popular test probes derive their power from the circuit under test.)

An important factor to be considered in logic probe design is frequency response. Most testers will not respond to high frequencies. Thus extremely short duration pulses are lost and, in some cases, cause signal degradation in the circuit being tested. The universal probe solves this problem by being able to respond to frequencies in excess of 10 MHz. Furthermore, it will check for a logic 1 or logic 0 within 5 mV of a set value.

About the Circuit. The tester is made up of two parts: a small case containing all of the electronics (including two controls that permit you to preset the logic levels) and a probe assembly with attached cable. The probe itself contains a 7-segment LED display. The ground lead is attached to the body of the probe for easy connection to the circuit being tested.

The heart of the circuit is dual differential comparator integrated circuit *IC1* in Fig. 1. The *IC1B* half checks for a logic 1. Its pin-8 output is held low until the input on pin 5 from the probe is 5 mV (or greater) above the voltage applied to pin 6. The latter is determined by the setting of *R5* and ranges from −1 V to +5.25 V dc. When the input is greater than the voltage on pin 6, the output of the comparator sends *Q1* into conduction to cause a 1 to be displayed.

The 0 part of the circuit operates in the opposite manner. The input on pin 13 must be more negative than the preset voltage on pin 12, determined

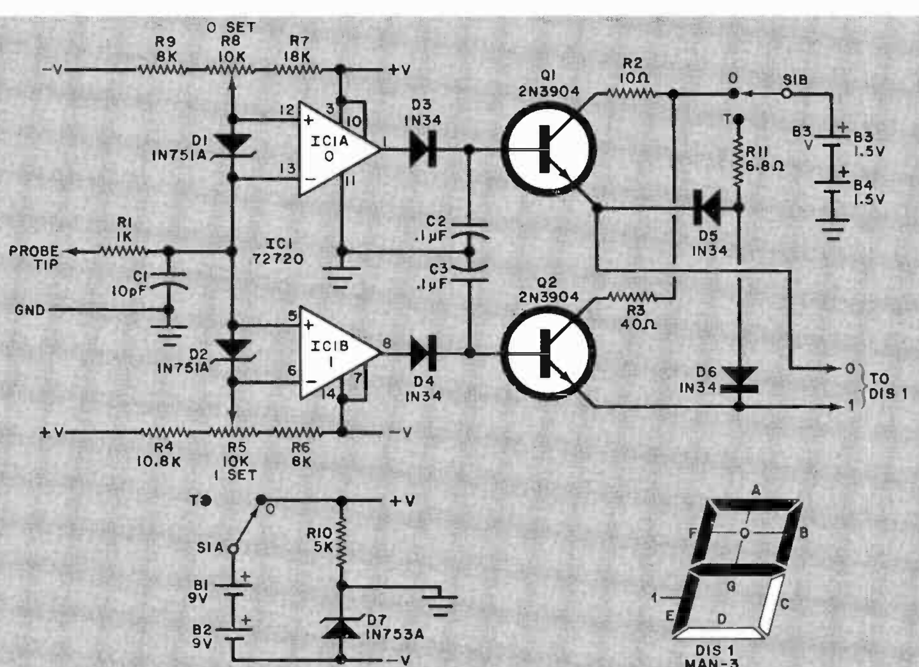


Fig. 1. Dual comparators sense the voltage at probe tip.

PARTS LIST

B1,B2—9-volt battery
B3,B4—1.5-volt battery (AA cell)
C1—10-pF, 10-volt capacitor
C2,C3—0.1-μF, 10-volt capacitor
D1,D2—1N751A zener diode
D3 to D6—1N34 diode (or similar)
D7—1N753A zener diode
DIS1—Seven-segment LED display (Monsanto MAN-3 or similar)
IC1—72720 dual differential comparator
Q1,Q2—2N3904 transistor (or similar)
The following resistors are ⅛ watt:
R1—1000 ohms
R2—10 ohms
R3—40 ohms
R4—10,800 ohms
R6,R9—8000 ohms
R7—18,000 ohms
R10—5000 ohms
R11—6.8 ohms
R5,R8—10,000 ohm miniature potentiometer
Misc.—Length of three-conductor shielded cable, plastic felt-tipped pen, cement, needle tip, knobs (2), press-on type, battery connectors, chassis, mounting hardware, etc.

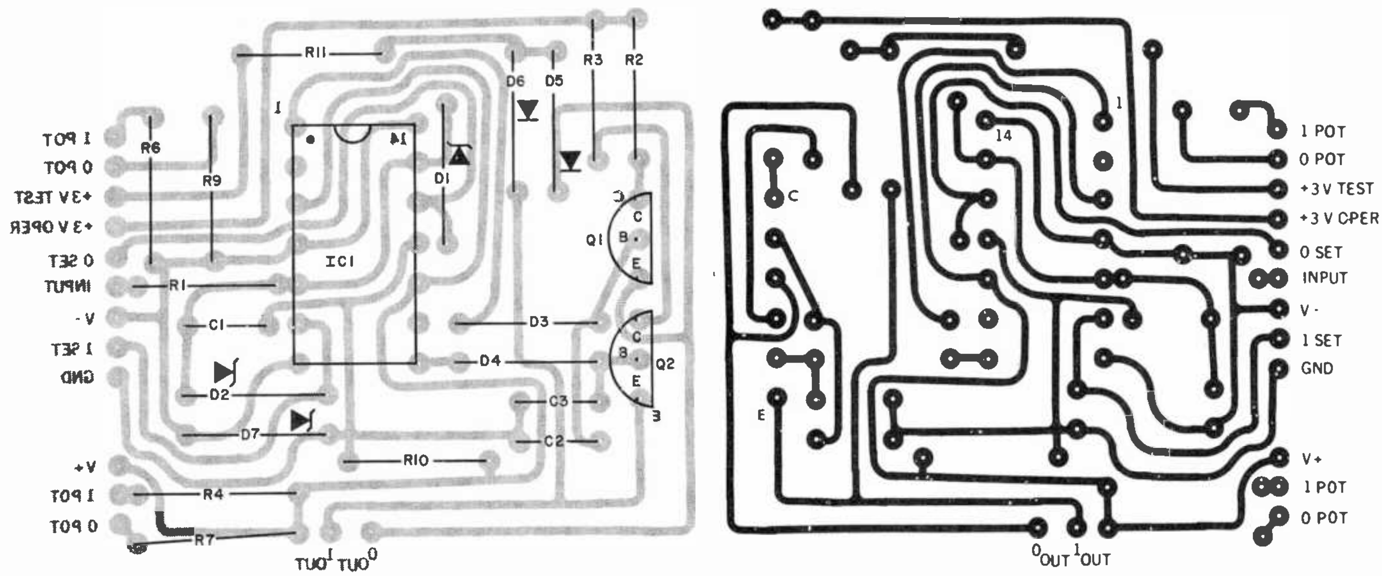


Fig. 2 Foil pattern (right) and component installation.

by the setting of *R8*. The range here is from −2 V to +3 V dc. When this section of the comparator turns on, *Q1* saturates, and the 0 portion of the display is illuminated.

Diodes *D3* and *D4*, in conjunction with capacitors *C2* and *C3*, ensure that, once the indicator is activated, it will remain on long enough to be seen, even with reasonably high pulse repetition frequencies. Resistors *R2, R3,* and *R11* provide current limiting for the display. Diodes *D5* and *D6* form a gate that allows testing the indicator before operation. Diodes *D1* and *D2* protect the IC inputs. Resistor *R10*, with *D7*, converts the 18 V from batteries *B1* and *B2* to −6 V and +12 V for the IC. Batteries *B3* and *B4* provide the higher current required for the seven-segment display.

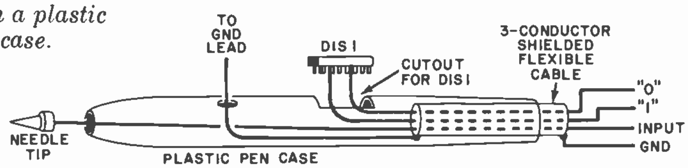
Construction. The tester can be assembled on a printed circuit board using the actual-size etching and drilling guide shown in Fig. 2. However, if care is exercised, the circuit could be assembled on perforated board using point-to-point wiring.

Mount the board and batteries in an enclosure approximately 1½" by 3" by 5½" as shown in Fig. 3. Note that part of the box is used to store the probe and cable when not in use. The two potentiometers and switch are mounted on one end of the chassis with appropriate identifications made with press-on type.

The probe can be made from a used plastic felt-tipped pen case as shown in Fig. 5. Using a three-conductor shielded flexible cable, identify the leads as 0, 1, and tip. Make the tip lead long enough to go through the end of the plastic case. Cut an opening on the side of the case slightly smaller than the LED display. Feed the 0 and 1 leads through this hole. On the display, interconnect segment leads A, B, F, and G. Solder the 0 lead to this combination. Solder the 1 lead to the E segment. Connect the display common to the coax shield. Feed the shield lead through a small hole below the readout and wrap it around the plastic case. Feed the tip lead through the front opening on the case. Seat the display in place and cement it securely. Fabricate a needle tip and solder it to the probe tip lead. Cement this in place.

When assembly is complete, connect a voltmeter between the rotor of potentiometer *R5* and ground. Rotate this potentiometer between its two extremes and mark the 1-volt calibration points on the front panel at the rotor of *R5*. Do the same for *R8*. Don't forget to indicate the polarity. Also make sure that the rotor of *R8* is always more negative than the rotor of *R5*.

Fig. 4. The probe can be fabricated from a plastic felt-tipped pen case.



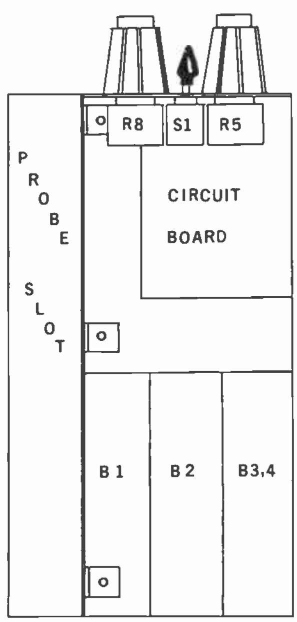


Fig. 3 Layout of chassis as used in prototype.

Operation. To check a logic circuit, determine the high and low voltages for the 1's and 0's of the circuit being tested. Set the two potentiometers accordingly. Attach the probe ground to the circuit ground. Place *S1* in the test position (T). The display should indicate both a 0 and a 1 (which looks like the letter P). Place *S1* in the operate position and touch the probe tip to the circuit being tested. A logic 0 or a logic 1 should be properly displayed; or, if the circuit is transitioning between 0 and 1, both sections of the display will light. If the display remains blank, the test point is operating somewhere between 1 and 0, which means something is wrong. ◈

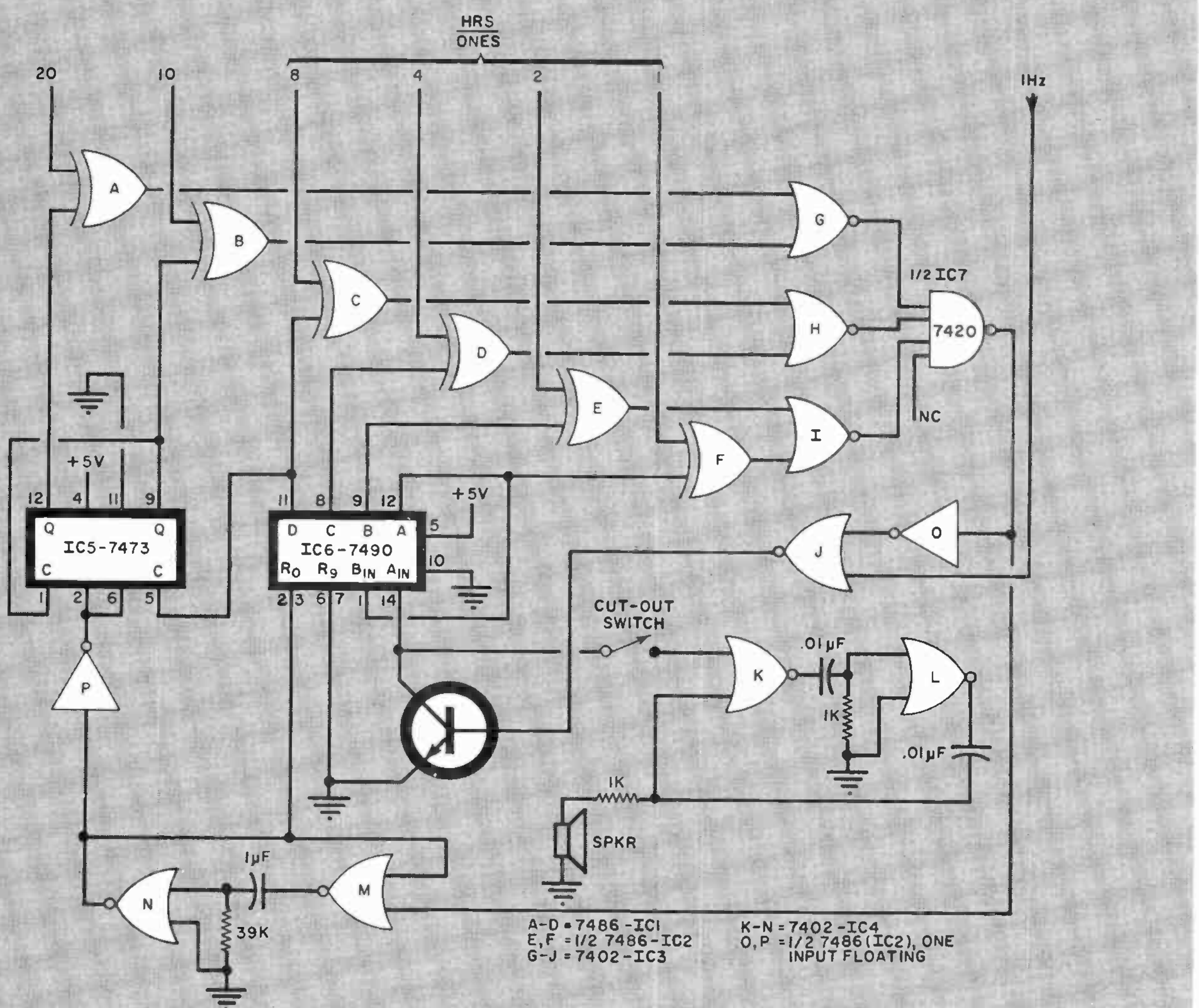
UPDATE YOUR DIGITAL CLOCK WITH ADD-ONS

AN HOURLY CHIMER

BY JEFFREY GLICK

The proliferation of digital electronic clocks in the last few years has been phenomenal. Particularly popular was the "Low-Cost Digital Clock" project published in these pages in March 1973. Never satisfied with the status quo, electronic experimenters have come up with all kinds of add-ons for their clocks—alarms, power supplies, etc. Now, we have a circuit that provides hourly chimes (at least, an audible tone) for your clock.

The circuit for the chimer uses the 1-Hz counting frequency from a digital clock, the 1-2-4-8 outputs of the ones-of-hours counter and the 10 and 20 outputs of the tens-of-hours counter. The latter must be high when the tens-of-hours readout indicates a

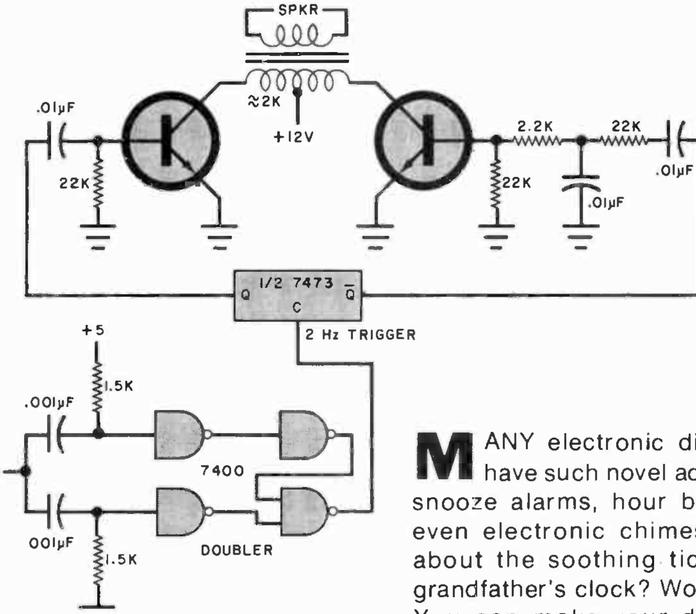


10 or 20, but low otherwise. The operating power can also be taken from the digital clock.

The exclusive-OR gates (*A-F*) normally have low signals on their inputs but when the clock changes the hour, the signal to one of the gates changes. This produces a high output from the NAND gate (½*IC7*). The latter triggers a one-shot multivibrator (*M,N*) to reset the counter (*IC5,IC6*) to zero. Simultaneously the 1-Hz clock signal is gated through gates *O* and *J* to start the count on *IC5* and *IC6*.

The 1-Hz clock signal also turns on a tone generator (*K,L*) which provides a beep once per second. Audio output is through a small (1″), low-impedance speaker.

When the counter reaches the state that disables the functioning exclusive-OR gate, the NAND gate is inhibited stopping the 1-Hz toggle, which stops the counter and the beep. Thus, the beep occurs once per second until it has indicated the number of hours. ◈



A GRANDFATHER'S TICK-TOCK

BY WILBUR MARKY

MANY electronic digital clocks have such novel accessories as snooze alarms, hour beepers, and even electronic chimes. But what about the soothing tick-tock of a grandfather's clock? Worry no more! You can make your digital clock sound like a grandfather's clock very easily with the aid of the logic circuit shown here. It can be assembled on perforated board or a pc board, and the power can be obtained from your existing clock.

If you have a clock that indicates seconds, then the 1-Hz timing signal can be found at the toggle input of the first decade counter. If the smallest indication you have is minutes, you will have to locate the 1-Hz signal in the countdown that feeds the units of minutes counter. If you have a single-chip clock, and there is no access to a 1-Hz signal, you can build a divide-by-60 from a couple of 7490's to produce the synchronized 1-Hz signal from the ac side of the transformer.

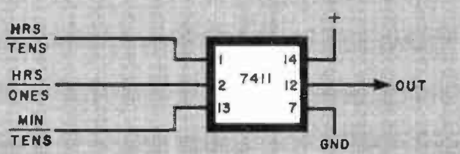
The 1-Hz signal (square wave) is coupled to a 7400 TTL chip arranged as a digital frequency doubler. The 2-Hz signal is then passed to a conventional divide-by-2 flip-flop (which can be any TTL chip having a single flip-flop available). The output of this flip-flop is then passed to a two-transistor sound generator, with one transistor having a simple capacitor coupling to generate the "tick," and the other having a filter to remove the high-frequency components and generate the "tock." Any type of npn switching transistor can be used. The transformer can be a standard unit for push-pull output transistors with a 2000-ohm center-tapped primary and a secondary impedance to match the speaker.

Connect the circuit as shown, install the board in the present clock case and attach the speaker to the wall of the case. ◈

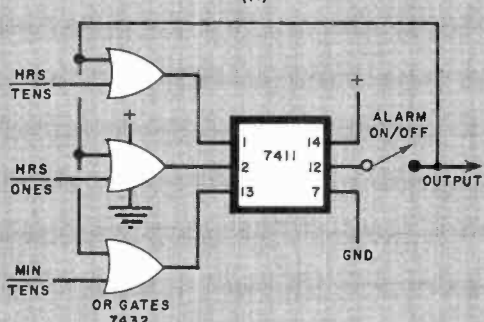
AN ALARM FOR HEAVY SLEEPERS

BY JERRY McELWEE

IN THE December 1973 issue of POPULAR ELECTRONICS (p. 61), a 10-minute alarm add-on for digital clocks was described. Unfortunately, a lot of people can drift back to sleep after the alarm first goes off and completely miss the 10 minutes. To prevent this, the circuit shown here can be added to keep the alarm going beyond 10 minutes.



(A)



(B)

Circuit (A) was used in the original alarm. The 7411 IC operated off of the tens-of-hours, ones-of-hours and tens-of-minutes signals from the clock. When the signals agreed with the set time, the output of the 7411 was used to drive some type of external alarm. However, as soon as the tens-of-minutes signal stopped, the output signal stopped.

Circuit (B) shows how to extend the length of time that the alarm is on, no matter what happens on the selected input signals. It uses three OR gates (in a 7432) and a switch wired as shown. When the switch is closed, and at the selected time, the OR gates are turned on and the 7411 delivers the alarm signal. However, the output signal is fed back to the second input of the OR gates which keeps them on until the switch is opened. If the switch is located far enough from the bed, the sleeper will have to get up to turn off the alarm. ◈

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BUILD THE ALTAIR 8800 MINICOMPUTER

PART TWO

Practical use of the computer, including programming

BY H. EDWARD ROBERTS AND WILLIAM YATES

LAST MONTH, we discussed the various subassemblies used in the basic Altair 8800 computer, went into details on how it is assembled, and listed a few applications. Here, we will describe a test program to be used in checking operation and then focus on practical uses and go through a software example to familiarize you with some operating procedures.

Test Program. The following simple program is used for initial testing of the computer's operation. It also illustrates how a program is loaded and run. The selected program will add two numbers stored at address locations 128 and 129 and store the result at address location 130. The procedure is as follows:

1 Set the power switch to ON and momentarily toggle the RESET switch. (Note: Excluding the power switch, all bottom-row switches on the front panel are spring-loaded, momentary-action types. The switches automatically return to their center-off positions when released from either of their operate positions. When instructed to operate any of the bottom row switches, momentarily throw it to the position indicated and release it.)

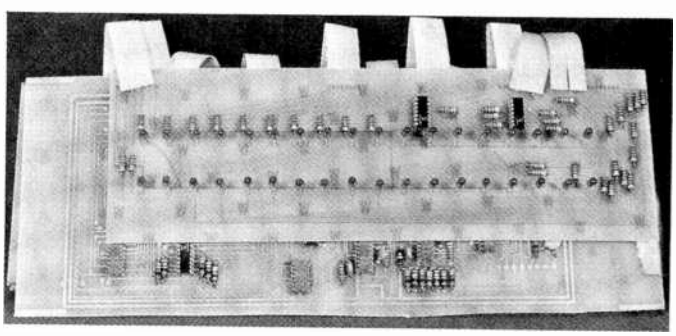
2 Set address switches *A0* through *A15* all to the 0 positions (down). Operate the EXAMINE switch, which should cause address LED's *A0* through *A15* to extinguish to indicate that location 0 is ready. (Some of the data LED's, *D0* through *D7*, might be illuminated, indicating the current contents at location 0.)

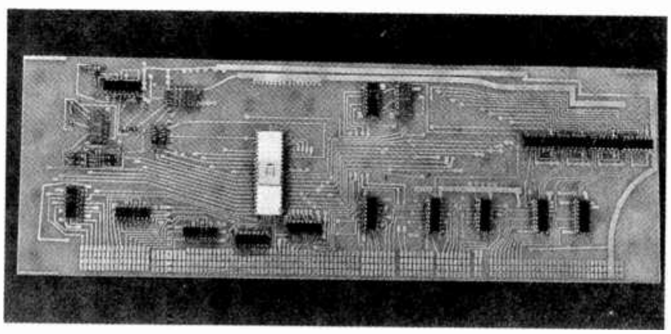
3 Next, store the load accumulator instruction at location 0 by using the binary number for 58 (00111010). Set this binary input up by using switches *D0* through *D7*, with a 1 represented by the switch in the up position and a 0 with the switch in the down position. Hence the switch sequence for 00111010 would be: *D7* down, *D6* down, *D5* up, *D4* up, *D3* up, *D2* down, *D1* up, *D0* down. Store this number at location 0 by operating the DEPOSIT switch. The *D0* through *D7* LED's should now match these settings, with a lighted LED indicating a 1 and a darkened LED indicating a 0. None of the *A0-A15* LED's should be on indicating location 0. The load accumulator instruction now tells the computer that the next two entries will be an address number (16 bits). Upon program execution, the data stored at that address number will be transferred to the accumulator.

4 Address numbers, such as address 128, are expressed in 16-bit binary format. The least-significant bits (last eight) are stored in the first memory location following the load accumulator instruction, while the most-significant bits are stored in the second memory location. Set *D0* through *D7* for 10000000 (128) and operate the DEPOSIT NEXT switch. This number is now stored, in binary form, at memory location 1. (*A0* LED should be lit indicating location 1.) Set *D0* through *D7* all to 0 and operate the DEPOSIT NEXT switch. The all-zero binary number is now stored at memory location 2 (*A1* LED is lit) and the computer has been instructed to put the contents of address 128 into the accumulator.

5 To add a second number to the current number stored in the accumulator, the computer must be instructed to transfer the current number to one of the general-purpose registers. In this example, we will use register B. The instruction used is "move A to B," where A is the accumulator. The code for this instruction is 01000111, set up with switches *D0* through *D7*. Operate the DEPOSIT NEXT switch. The instruction "move A to B" is now stored at memory location 3. (*A1* and *A0* lit.)

6 Now, instruct the computer to load the data from address 129 into the accumulator. This procedure is identical to that outlined in steps 3 and 4 above. Set switches *D0* through *D7* for 00111010 and operate the DEPOSIT NEXT switch. The load accumulator instruction is now stored at memory location 4. (*A2* lit.) Set *D0* through *D7* for





10000001 (129) and operate the DEPOSIT NEXT switch to store this number at memory location 5. (*A2, A0* lit) Then set *D0* through *D7* all to 0 and operate the DEPOSIT NEXT switch to store the all-zero number at memory location 6 (*A2, A1* lit).

7 Store the add instruction at memory location 7 by setting *D0* through *D7* for 10000000 (128) and operating the DEPOSIT NEXT switch. When executed, this instruction adds the number in the accumulator to the number stored in register B and places the result in the accumulator (*A2, A1, A0* lit).

8 To store the result at address 130, first store the instruction at memory location 8 by setting *D0* through *D7* for 00110010 and operating the DEPOSIT NEXT switch (*A3* lit). Set *D0* through *D7* for 10000010 and operate the DEPOSIT NEXT switch. The least-significant eight bits of address 129 are now stored at memory location 9 (*A3, A0* lit) Set *D0* through *D7* to 0 and operate the DEPOSIT NEXT switch. The most-significant eight bits of address 129 are now stored at memory location 10 (*A3, A1* lit).

9 A program that adds the contents of address 128 to the contents of address 129 and stores the result in address 130 has now been loaded into the computer. With the use of a "jump" instruction, you can now create a program loop that will direct the computer back to memory location 0 and allow repeating this addition procedure continuously for as long as desired. Store the jump instruction at memory location 11 by setting *D0* through *D7* for 11000011 and operating the DEPOSIT NEXT switch (*A3, A1, A0* lit). Set *D0* through *D7* to 0 and operate the DEPOSIT NEXT switch *twice*. The 16-bit address 0 is now stored at memory locations 12 and 13 (*A3, A2, A0* lit).

Before we can run this program, we have to load the two numbers we want added into addresses 128 and 129. For example, if we wanted to add 12 to 8, the procedure would be as follows:

Set address switches *A0* through *A15* for 0000000010000000 (128) and operate the EXAMINE switch (*A7* lit). Set *D0* through *D7* for binary 12 (00001100) and operate the DEPOSIT switch (*A7* still lit). Set *D0* through *D7* for binary 8 (00001000) and operate the DEPOSIT NEXT switch. The binary numbers for 12 and 8 are now stored at address locations 128 and 129, respectively (*A7, A0* lit).

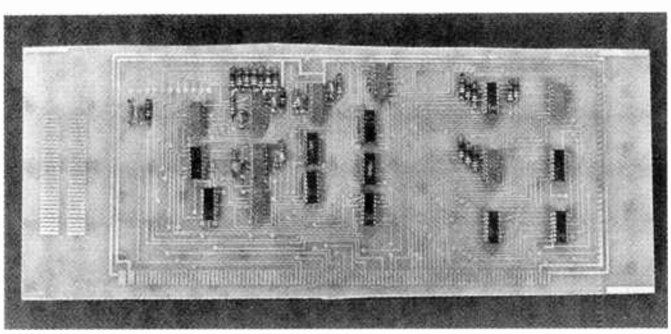
Set address switches *A0* through *A15* to 0 and operate the EXAMINE switch (all A LED's are off). Operate the RUN switch, and the program will execute at a rate of about 30,000 times per second. Operate the STOP switch. Set the address switches to address 130 (10000010) and operate the EXAMINE switch. LED's *D0* through *D7* will display the sum of the two numbers added, which is 20, in binary format (00010100).

Basics of Programming. If you have never done any programming, it may seem a little mysterious at first, but the basic ideas of programming

GLOSSARY OF COMPUTER JARGON

Access time — Time interval between the instant at which information is called for storage and the instant at which delivery is complete.
Accumulator — Part of the logical-arithmetic unit of a computer used for intermediate storage, to form algebraic sums, or other intermediate operations.
Address — Label, name, or number identifying a register, location, or unit where information is stored.
Assembler — Translates input symbolic codes into machine instructions.
Bit — Abbreviation of binary digit; a single character in a binary number.
Buffer — Isolating circuit used to avoid reaction of a driven circuit upon its driving circuit.
Byte — Group of binary digits usually operated upon as a unit. Usually shorter than a word.
Clock — Time-keeping device used to synchronize the computer.
Data — Basic elements of information which can be processed or produced by a computer.
Hold — Function of retaining information in one storage device after transferring it to another device, in contrast to clear.
Instruction — Coded program step that tells the computer what to do for a single operation in a program.
Interrupt — Break in the normal flow of a system or routine such that the flow can be resumed from that point at a later time.
Jump — Depart from the normal sequence of executing instruction in a computer (synonymous with branch).
Memory — Storage. A device that holds information that can be extracted at a later time.
Processor — Device capable of receiving data, manipulating it, supplying results usually of an internally stored program.
Programming — Art of reducing the plan for the solution of a problem to machine-sensible instructions.
Register — Device for the temporary storage of one or more words to facilitate arithmetical, logical, or transferral operations.
Stack — Portion of a computer memory and/or registers used to temporarily hold information.
Subroutine — Set of instructions in machine code to direct the computer to carry out a well-defined mathematical or logical operation; a part of a routine.
Word — Set of characters that occupies one storage location and is treated by the computer as a unit and is transported as such. Word lengths are fixed or variable, depending on the particular computer being used.

Definitions were extracted from "Computer Dictionary" by Charles J. Sippl and Charles P. Sippl, published by Howard W. Sams & Co., Inc., The Bobbs-Merrill Co. Inc., Number 20943, 484 pages, $8.95 (in Canada $11.95).



Shown at far left is the display board atop the control board, with cables that connect to other boards. The central processor unit is shown in the center, and the control board at near left. Not shown is memory board, which holds 17 IC's.

MACHINE INSTRUCTIONS

Instruction	Binary Code (for instruction)	Octal	Comment
IN 6	11011011 (IN)	333,006	Bring data from input 6 and store in register A (accumulator).
MOV B,A	01 (MOVE) 000 (B) 111 (A)	107	Take A and move its contents to B.
IN 30	11011011 (IN) 00011110 (30)	323,036	Bring input 30 into accumulator
ADD B	10000 (ADD) 000 (B)	200	Add contents of A to B. Put results in A.
OUT 128	11010011 (OUT) 10000000 (128)	323,200	Transmit contents of accumulator to output 128.

are really very straightforward and easy to master. The procedures that are always used consist of the following:

Defining the Problem. This is by far the hardest part of the programming. Don't worry about the computer or the computer language when doing this part of the preparation. Simply decide what is required to do the job you want to accomplish.

Establishing an Approach. The computer and computer language have nothing to do with this step, either. It involves outlining a step-by-step procedure to achieve the desired results and getting it down on paper.

Writing the Program. Once you are familiar with programming, you will find that this step is the simplest. It is merely a matter of translating step 2 into the appropriate language.

There are many books available on programming. Some of them are quite good and are particularly useful for learning techniques such as flow programming, looping, etc. However, in essence, they can all be boiled down to the three steps above.

Software Example. To get a feel for what programming the Altair 8800 is like, let's go through a sample program, which is similar to the test program that we first went through to check out the computer operation. Assume that we want to take the data available from input channel 6 and input channel 30 and add them, placing the result in output channel 128. The machine instructions are shown in the box.

The first instruction simply stores the data from channel 6 in register A (the accumulator). The next instruction moves this data from register A to register B. This clears A for the next input. The third instruction brings the data from input channel 30 into the A register. The fourth instruction adds the contents of register A (data from channel 30) to register B (data from channel 6) and puts the results back into register A. The final instruction transmits the answer from A to output channel 128. Total computer time used to perform this operation with the Altair 8800 is 18 microseconds. To put it another way, the computer could perform 56,000 of these operations in one second.

The instructions could be entered into the processor in one of three ways. The first and easiest would be with the use of an assembler. This is essentially a piece of software that converts alphanumeric symbols to machine language (binary code). For example, the assembler would convert our first instruction (IN 6) to the correct binary code. The problem with using an assembler is that you need a computer terminal for an input device and the assembler itself requires about 6000 words of memory storage. If extensive program development is to take place, the assembler is a good tool to have.

The next easiest method of entering the instructions is with the use of the Very Low Cost Terminal featured in the December 1974 issue of POPULAR ELECTRONICS. With this terminal, the instructions could be entered by using the octal code. The procedure would be to write the program in assembly language and then enter the corresponding code for each instruction. This system, while not being as fast as the use of an assembler is less expensive.

The third method, using front panel entry, is of course inexpensive but time consuming.

This has been only a brief summary of the programming procedures for the computer. Complete programming information is provided with the Intel 8080 integrated circuit and with the Altair 8800 computer kit. ◈

EXPANDING THE COMPUTER

In describing the assembly of the Altair 8800 Minicomputer in last month's article, it was noted that the interior of the cabinet provides plenty of room for expansion. The room can be used to add many functions to the basic computer. For example, the present memory board in the Altair 8800 can be expanded with the addition of three 256-word memories (Kit 8802-MS available from the manufacturer, MITS at $34 per 256-word memory). Further additions require an expansion mother board having four connectors that can accommodate any four memory or input-output (I-O) cards. This expansion board (Kit 8800-EB) is available for $44, while a 4K dynamic memory card (Kit 8840-MC) costs $198. Various other kits—a vectored interrupt card and a real-time clock, among them—are also available.

Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

The three components covered in this month's hi-fi equipment reports could easily form the heart of a very fine stereo or quadraphonic system. The general performance qualities of the Marantz 4270 receiver are more comparable to those of the better separate components than those of a receiver. Not only is it equally at home in a two-channel or four-channel system, it has built-in Dolby circuits for either FM decoding or tape recording and playback.

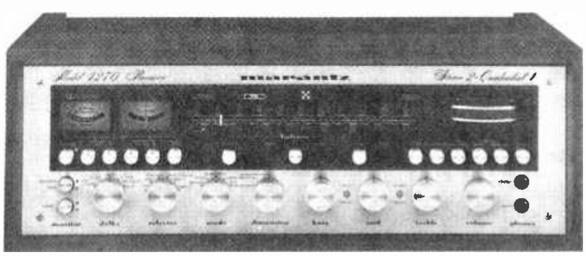
As for the Garrard Zero 100SB, this fine single-play record player combines the "zero tracking error" tonearm made famous by that company's Zero 100 record changer, with a new belt-driven turntable whose performance rivals more expensive units.

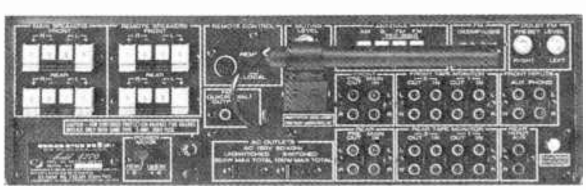
Finally, the new Ortofon VMS-20E cartridge is almost a twin of the highly regarded Ortofon M15E Super, with essentially the same performance (and sound) at a much lower price.

—Julian D. Hirsch

MARANTZ MODEL 4270 AM/FM STEREO 2—QUADRADIAL 4 RECEIVER

70 W/ch stereo, 25 W/ch 4-channel with built-in decoding matrix and Dolby NRS.





HIRSCH-HOUCK LABS REPORT

The Marantz Model 4270 shares many features of the other receivers in the company's "Stereo 2—Quadradial 4" line. It's a medium power quadraphonic receiver (25 W rms/channel) that preserves a user's ability to opt for one or more of the four-channel systems through plug-in matrix decoders and/or connection of an external CD-4 demodulator. In the stereo mode, the 4270 is transformed into a powerful 70 W rms/channel receiver.

Furthermore, the 4270 features a host of refinements, such as Dolby noise-reduction circuitry for tapes and FM broadcasts; a built-in quadraphonic synthesizer for stereo software; and an optical remote control, among others.

The receiver is approximately 17⅜ in. wide by 5⅜ in. high by 14⅜ in. deep (44.1x13.7x36.5 cm) and weighs 40.2 lb. (18.2 kg). Price is $699.95. SQ and QS decoders (ranging from basic SQ to full-logic SQ and SQ/QS models) are $49.95 to $79.95; CD-400 adapter, $99.95 (when purchased with receiver); remote control, $39.95.

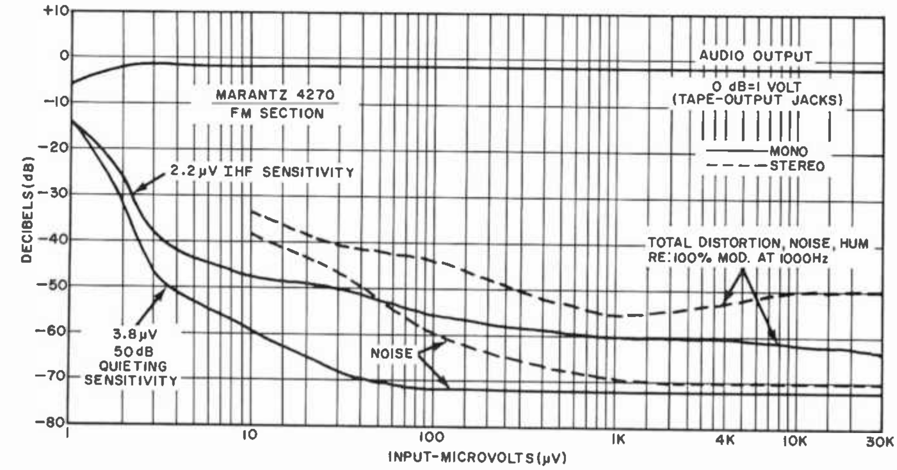
General Description. In addition to the conventional complement of controls and switches, the 4270 features separate tone controls—bass, midrange, and treble—for the front and rear channels. Further, complete Dolby noise-reduction facilities are available, controlled by a DOLBY switch.

When this switch is placed in one of the RECORD positions, program material is encoded or decoded for input to a tape recorder, depending on the noise-reduction capabilities of the particular tape deck. When FM DOLBY is selected, a decoder processes the FM signal for proper reception, with the added advantages of higher S/N ratio and dynamic range. Unusually complete Dolby system calibration facilities are incorporated into the receiver, including a level generator and calibrating meter that doubles as the signal-strength monitor.

Two sets of inputs and outputs for tape monitoring are included, selectable from the front panel. If only one set is used for a recorder, the other provides a convenient circuit interruption point for patching in a graphic equalizer or signal monitor.

A "flywheel" tuning control, protruding through the front panel selects the operating frequency of the tuner. Two meters, an AM/FM signal strength indicator and an FM zero-center monitor make precise tuning adjustments possible. Three slide-type controls adjust balance between the front, rear, and front/rear channels.

Among the rear-panel inputs and outputs is an FM UADRADIAL output. This jack supplies the composite detector output for possible use with a discrete four-channel adapter, should an FCC-approved FM system be developed. Also included are screwdriver adjustments for FM Dolby level, muting, and a socket for an optional remote control unit for volume, loudness, and balance adjustments. The PREAMP OUT and AMP IN jacks, normally bridged by jumpers, provide another circuit-interruption point for signal processors, or for using the 4270 with a super-powered amp. A slide switch changes the normal 75-µs de-emphasis characteristic to 25 µs, for proper reception of FM Dolby broadcasts. A power mode switch selects



either "strapped" stereo (70 W/channel) or four-channel (25 W/channel amplifiers. Two ac outlets, one switched, are included.

Laboratory Measurements. In virtually every respect, the Marantz 4270 met or exceeded the manufacturer's published specifications. In the four-channel mode, the amplifiers, rated at 25 W/channel, delivered 35.7 W at the clipping level with all channels driven into 8-ohm loads at 1000 Hz. Into 4 ohms, the amplifiers clipped at 52 W/channel. The clipping level of the two-channel "bridged" mode was 100 W/channel, 30 W/channel higher than the rated figure. Amplifier distortion at rated output was under 0.03% from 20 Hz to 10 kHz, and 0.04% at 20 kHz. At lower output the figure rose, but at no time exceeded 0.07%. THD at 0.1 W, 1 kHz, was 0.1%, falling to about 0.02% between 10 and 30 W, and reaching 0.1% at 35 W. (Below 1 W, distortion was less than figures imply, since it was masked by circuit noise.) IM distortion behaved similarly, declining from 0.15% at 0.1 W to 0.06% between 10 and 30 W.

Input sensitivity for a reference 10-W output was 80 mV at the AUX inputs, and 1.0 mV at the PHONO inputs. S/N ratios were very good: 78 dB and 68 dB, respectively (at 10 W output). Phono overload occurred at 115 mV, an output rarely, if ever, reached with today's pickups. Tone controls offered a wide variety of response curves, so that almost any tonal coloration could be obtained. The HI Filter response, which had a gradual −6 dB/octave slope, was down 3 dB at 5500 Hz.

RIAA phono equalization was within ±0.5 dB from 30 Hz to 20 kHz. Though phono cartridge inductance affected the equalization appreciably above 15 kHz, it had little or no effect below 10 kHz.

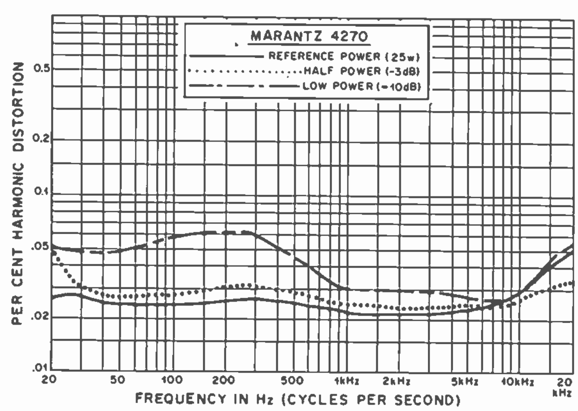
The FM tuner section displayed an IHF usable sensitivity of 2.2 µV, with a steep limiting curve that reached 50 dB of quieting at 3.8 µV in mono and 43 µV in stereo. Mono FM distortion at 1000 µV was very low, less than 0.1%, and in stereo was an excellent 0.17% to 0.33%. The ultimate quieting of the tuner was 72 dB in mono and 70 dB in stereo. These figures are close to the residual noise level of the signal generator used.

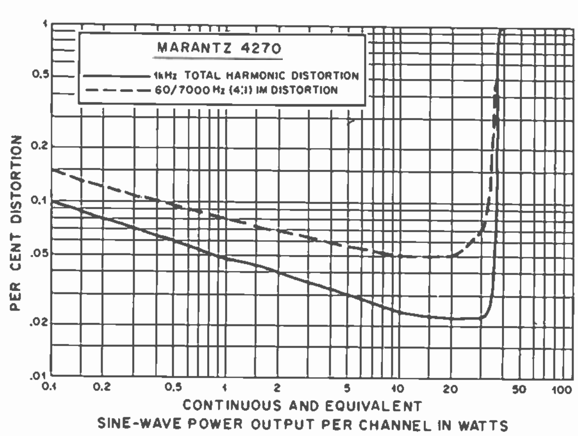
Stereo FM frequency response was flat within ±0.5 dB from 30 Hz to 15 kHz. The 19-kHz pilot carrier leakage was 67 dB below the 100% modulation level. Channel separation was 35 dB from 30 Hz to 8 kHz, peaking to 55 dB in the midrange, and 30 dB at 15 kHz. Capture ratio was 1.1 dB at 1000 µV, and AM rejection was a good 60 dB. The signal threshold for muting and automatic stereo switching was 10 µV. Image rejection was 76 dB, and alternate-channel selectivity was measured to be a very good 78 dB. The response of the AM tuner was better than average. It was flat over most of its range, down 3 dB at 33 Hz and 6000 Hz.

User Comment. The operation of the Marantz 4270 was flawless in every respect. Its many functions may prove overwhelming to a new owner, so a careful study of the instruction manual is recommended for most enjoyable use of the receiver.

Although no measurements were made on the Dolby circuitry, we did cross-check its performance with that of an accurately adjusted Dolby unit and found it to be subjectively identical and completely compatible. The FM Dolby function worked properly with the one Dolbyized station in our area. Interestingly, we found that it is possible to leave the de-emphasis switch in the 25-µsec position at all times, obtaining correct frequency response with all FM stations. This is possible because of the relationship between the switching functions of the DOLBY and de-emphasis switches. The FM muting operated with pleasing smoothness, free of thumps and noise bursts.

Our test receiver was not fitted with one of the plug-in SQ decoders, so its four-channel performance was judged using its Vari-Matrix. This proved to be effective in supplying four-channel ambience enhancement to stereo material and matrixed records, but as expected, did not provide the inherent directional response of a

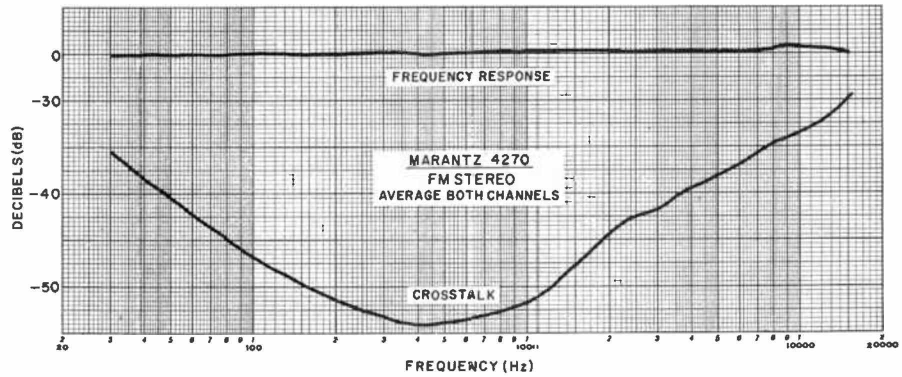




logic-assisted decoder, which is a moderately priced option.

In view of its versatility and features, not to mention its outstandingly fine performance, it is clear that the Marantz 4270 can serve as a first-class stereo receiver. Its price is not at all inconsistent with its overall quality and flexibility. It can be upgraded in stages to quasi-four-channel operation by merely adding rear speakers and to full four-channel with one or more decoders, depending on the owner's desires.

CIRCLE NO. 65 ON READER SERVICE CARD



GARRARD ZERO 100SB TURNTABLE

Automatic single-play machine with belt drive.

HIRSCH-HOUCK LABS REPORT

Manual record players were once the popular choice of hi-fi buffs. Interest in this type of machine died out, however, when record changers were introduced to combine high-quality, single-play provisions with automatic features. Turnabout is fair play, so more recently, a new breed of record player—the *automatic* single-play machine—has again captured the imagination of hi-fi music listeners. The Garrard Zero 100SB is one of a host of automatic single-play entries this year.

It's supplied as a complete turntable and arm, with wood base (black with teak side panels), removable hinged dust cover and all connecting leads attached. Adding a cartridge turns it into a functioning record player. Price is $209.95.

General Description. The Garrard Zero 100SB utilizes a belt-drive system instead of the idler-wheel drive used in the manufacturer's older Zero 100 model. With two speeds—33 1/3 and 45 rpm—a combined speed selector and record diameter indexing control shifts the belt on a stepped synchronous motor shaft for "automatic" single-play operation. (Records of any size can be played manually at any speed.) The 100SB employs a cast non-ferrous turntable platter that is 11½ inches in diameter and weighs 5½ pounds. Overall dimensions are 18 in. wide by 16 in. deep by 7½ in. high (with cover in place).

Operating controls are three levers. The AUTO lever starts the turntable and indexes the arm automatically while the MAN lever merely turns on the platter drive. Each has an OFF setting, which in the case of the AUTO lever, also returns the arm to its rest. In either mode, after a record is played, the arm returns to the rest and the motor shuts off. The third lever, CUE, raises and lowers the arm with damped control in both directions. Unlike most other cuing devices, it can lift the arm by any amount up to the maximum, and hold it at that point, which can reduce the lowering time considerably.

A clear plastic tonearm pivot housing contains the magnetic repulsion system used to supply anti-skating bias. A magnetic shield is moved between two magnets (one on the fixed section and one on the movable arm body) to vary the torque. Separate scales are provided for conical and elliptical styli.

The adjustable counterweight is elastically mounted to damp the low-frequency arm resonance. A unique feature of the Zero 100SB arm is the automatic record play counter built into the transparent pivot support. A red pointer moves up slightly every time the arm returns to its rest after playing a record, and the index marks on the plastic correspond to various numbers of plays from 400 to 1600. A knurled knob below the scales resets the pointer to zero.

Tracking force is set by a sliding weight on the arm body, calibrated at 0.25-gram intervals from 0 to 3 grams.

Laboratory Measurements. When the test cartridge (in this instance an Ortofon VMS-20E) was installed using the jig supplied with the Zero 100SB, tracking error was unmeasurably low (under 0.5 degree) over the entire record surface. The stylus force indications were very accurate, with less than 0.05 gram error at 1- and 2-gram settings, and only 0.1 at 3 grams. The anti-skating calibration was correct for equal playback distortion in both channels (a very unusual occurrance among the many arms we have tested).

To obtain visible waveform clipping on the 30 cm/s test tones we use for setting anti-skating, it was necessary to operate the Ortofon VMS-20E cartridge at 0.5 gram, and the corresponding anti-skating setting proved to be exact. This test, incidentally, established that the Zero 100SB arm, in spite of its multiple pivots, had negligible friction. As we see it, any cartridge made today can be operated in this arm at the lowest tracking force consistent with the design of the cartridge, without encountering difficulties of excessive arm friction.

The turntable wow and flutter were 0.06% and 0.04% at 33 1/3 rpm, and 0.04% and 0.035% at 45 rpm. The unweighted rumble was ±38 dB; with relative audibility weighting, it was a very low ±61 dB. Operating speeds were within 0.2% of the correct values, and did not vary measurably over a line voltage shift from 95 to 135 volts. The operating cycle in the AUTO mode required 14 seconds, from the time the lever was moved until the stylus set-

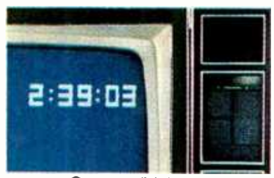
The whole neighborhood wondered what Frank Mallon was up to in his workshop.

Word had it he was up to something mighty peculiar. And when he didn't show up for bowling practice one Wednesday night, the Wabash Cannonballs (that was the name of his neighborhood team) began to wonder, too.

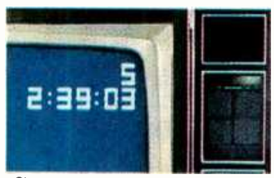
So it was that a bunch of the boys decided to pay their "star" a visit, and talk him out of his workshop and back into action.

It didn't happen that way, though.

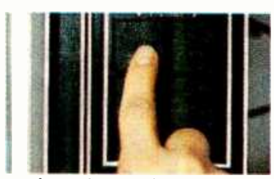
Matter of fact, it was Frank Mallon who talked the Wabash Cannonballs out of their bowling night and down into his workshop. What was it... what could be exciting enough to keep a bunch of ten-pin tigers from their favorite pastime? One of the most fascinating learn-at-home programs in the world, that's what!



On-screen digital clock



Channel numbers that flash on the screen


Automatic pre-set channel selector

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In fact, as part of the program, you'll actually build and experiment with a 25" diagonal color TV incorporating digital features.

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No electronics background necessary.

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696 R2

Simulated TV picture/test pattern.

tled into the lead-in groove. There was no lateral drift during descent when using the CUE control. The low frequency arm/cartridge resonance was at 5 Hz (indicating a moderately high arm mass), and an amplitude of about 10 dB.

User Comment. The Garrard Zero 100SB combines a number of useful operating conveniences. It boasts high performance in its basic characteristics at a price that matches or betters other record players of comparable quality. For example, only a few of the most expensive direct-drive turntables we have tested have shown lower rumble than the Zero 100SB.

However, we were surprised to find that the arm-wiring and signal-lead capacitance was too high for optimum performance with most magnetic CD-4 cartridges, which ideally should not be more than 100 pF of total circuit capacitances. Capacitance from the output connector of the integral signal cable to the cartridge shell measured 165 pF.

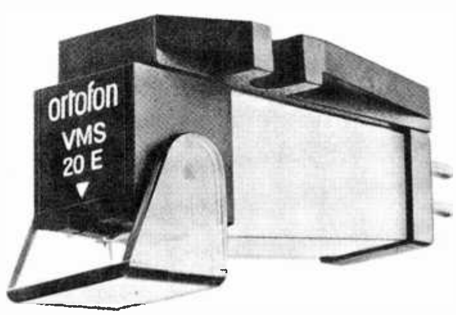
Though the operation of the record player itself could not be faulted, the same cannot be said of the dust cover design. Unless it was carefully lifted by the left front corner, it showed a strong tendency to come out of its hinging slot. Equal care was required when pushing the unit's spring-loaded armrest-lock support out of the way before lowering it.

Minor criticisms aside, we found the Garrard Zero 100SB to be one of the smoothest, easiest-to-use record players we have seen. All its basic operating controls and their functions behaved exactly as intended, with none of the "bugs" that so often afflict mechanical systems. For example, when the cartridge is installed and the arm balanced according to instructions, the unit is actually set up *correctly*, without additional adjustments with a stylus gage and tracking error protractor to achieve optimum performance capability.

CIRCLE NO. 66 ON READER SERVICE CARD

ORTOFON MODEL VMS-20E PHONO CARTRIDGE

Moderately priced variable-magnetic-shunt design offers neutral sound quality.



HIRSCH-HOUCK LABS REPORT

Ortofon first introduced its variable magnetic shunt (VMS) principle a couple of years ago in its still top-of-the-line Model M-15E Super stereo cartridge. In this cartridge, a magnetic armature is moved in the field of a light ring magnet. It varies the flux distribution through the internal pole pieces and coils, while reducing the flux through the pole pieces to zero when the stylus is in its neutral position. This design is claimed to greatly reduce nonlinearities in the magnetic system, resulting in lower distortion than was previously possible in magnetic cartridges of conventional design.

Now, Ortofon has brought the M-15E Super's essential qualities within reach of the many users of good-quality automatic turntables with the introduction of the Model VSM-20E cartridge. It also uses the variable magnetic shunt principle and has an 8- × 18-micron (0.3- × 0.7-mil) user-replaceable elliptical diamond stylus.

When the M-15E Super was introduced, a 15° vertical tracking angle was in general use. The standard has since been changed to 20°, and the design of the VMS-20E reflects that change.

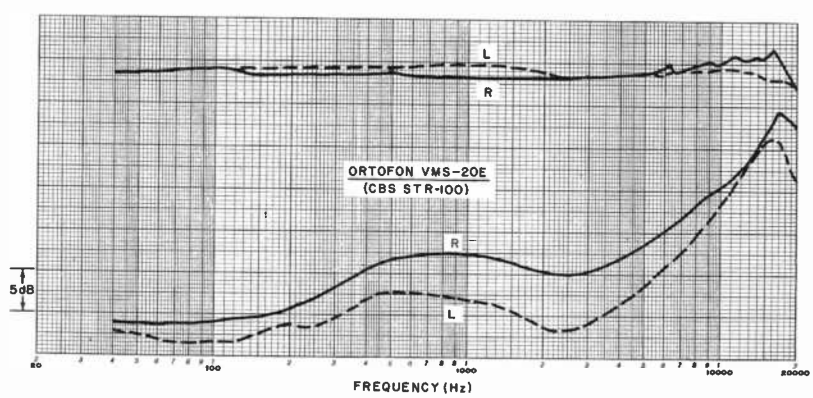
Physically, and in most of its other characteristics, the VMS-20E appears to be identical to the M-15E Super cartridge. It is a lightweight 5 grams and is rated to track at between 0.75 and 1.5 grams. (One gram is the recommended tracking force.) Ortofon specifies the loading of the cartridge at the standard 47,000 ohms and recommends a 400-pF shunt capacitance.

Aside from its vertical tracking angles, the VMS-20E appears to differ from the M-15E Super in only three specifications: It has about 25% greater output voltage; its tracking ability at 300 Hz is 70 microns, as opposed to 80 microns for the M-15E Super; and its lateral compliance is reduced from the M-15E Super's 50 × 10^{-6} cm/dyne to 40 × 10^{-6} cm/dyne.

Another very important feature is the VMS-20E's relatively inexpensive cost—$65. This sharply contrasts with the $90 figure asked for the M-15E Super cartridge.

Laboratory Measurements. We tested the VMS-20E in a Pioneer Model PL-71 record player/tonearm combination, using a 47,000-ohm load shunted by 340 pF. The low-frequency tracking ability of the cartridge was tested with a Cook Series 60 record at a 0.75-gram tracking force. The 1000-Hz, 30-cm/s test tones of a Fairchild 101 record revealed symmetrical clipping at 0.5 gram, with no improvement from the use of a higher force. This suggests that the amplitude limits of the stylus system rather than its dynamic tracking abilities were being exceeded in this very severe test. A 1-gram force was used throughout subsequent tests.

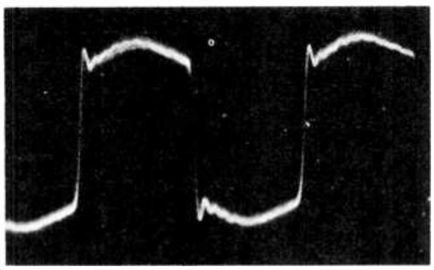
Ortofon's 300-Hz tracking specification for the VMS-20E is based on the use of a German hi-fi test record we also use in our test program. The cartridge easily tracked the 80-micron band of this record at 1 gram. By careful adjustment of the tonearm's anti-



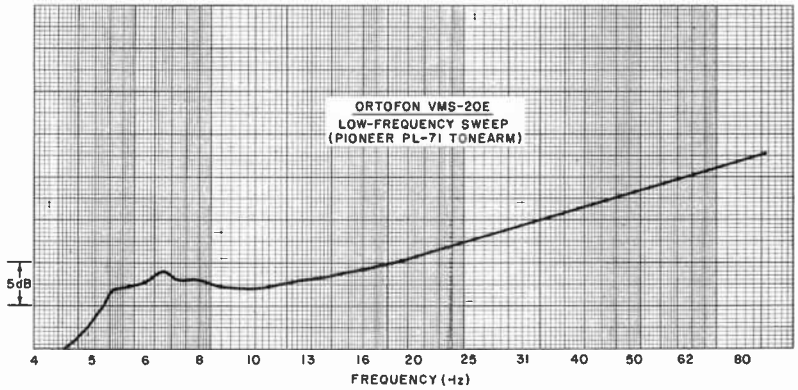
skating compensation, the 100-micron (highest-level) band could be played without significant distortion. It should be noted that very few cartridges can even approach this performance at any tracking force.

The output of the cartridge was 3.2 mV at a 3.54-cm/s velocity. A 1000-Hz square wave from the CBS STR-111 record was played with only a single small overshoot and no sign of ringing. As with the M-15E Super, the VMS-20E had an exceptionally flat response, varying only ±1.5 dB from 500 to 20,000 Hz on one channel and ±1 dB over the same range on the other channel when tested with the CBS STR-100 record.

The channel separation was typically 25 to 30 dB up to about 4000 Hz. It reduced smoothly to 15 dB at 10,000 Hz and 5 to 10 dB at 20,000 Hz. Both channels had very similar characteristics with respect to frequency re-



1000-Hz square wave.



sponse and channel separation. The low-frequency resonance when the cartridge was used in Pioneer's tonearm occurred at about 6 Hz.

User Comment. We used the Shure "Audio Obstacle Course—Era III" record to evaluate the tracking ability of the VMS-20E on actual musical material. Most portions of the record were successfully tracked at 1 gram at their highest levels. A slight mistracking of the highest levels of the musical bells and sibilance tests was noted at 1 gram. Increasing the force to the rated 1.5-gram maximum enabled the cartridge to track the bells at maximum level, but there was still a trace of mistracking at the highest level of the sibilance material.

The VMS-20E has a totally neutral quality, with no audio peaking or coloration in any part of the audio range. As Ortofon implies, the VMS-20E and M-15E Super cartridges have virtually identical performance in all respects. We could hear no differences between the two in side-by-side comparisons.

The major difference between the two cartridges appears to be that the M-15E Super will play anything we have seen on record without difficulty at 1 gram, while the VMS-20E might have to be operated at 1.5 grams in the most severe cases. We would still opt for 1-gram operation, assuming the tonearm is capable of it. (The VMS-20E should not be used in tonearms incapable of tracking at 1 gram.) At that force, it can still outperform most cartridges on the market.

CIRCLE NO. 67 ON READER SERVICE CARD

LAFAYETTE COM-PHONE 23 MOBILE CB TRANSCEIVER

Handset receiver provides mounting versatility and communication privacy.

LAFAYETTE's Com-Phone 23 is a 23-channel mobile AM transceiver using a telephone-type handset instead of a conventional grip mike. Adaptable to a variety of mounting positions, it can be installed horizontally above a transmission hump, mounted vertically on the wall of a van or camper, or similar to a wall phone in the home (with an ac adapter).

The use of a handset reduces interference from background noise. Additionally, the Com-Phone 23 retains "talk" flexibility with a PTT switch incorporated into the handset, and a panel-mounted switch to allow operation of a built-in speaker or a handset earphone.

Circuitry is all-solid-state, including a crystal-governed frequency synthesizer. Using only 14 crystals, the Com-phone 23 produces 23 transmitting and receiving channels. A 12-volt, negative- or positive-ground power source can be used, and an optional ac supply allows the radiotelephone to be used as a base-station rig. Other features of the transceiver include adjustable squelch, always-on noise limiter, "range boost" circuitry, adjustable TVI trap, and an external speaker jack for receiving or PA work. The Com-Phone 23 draws only 100 mA on receive (no signal) and 1 A on transmit (modulated).

The transceiver measures 4 in. by 5 in. by 9½ in. (10 cm x 12.6 cm x 23.8 cm) and weighs 3.25 lb (1.47 kg). Price is $189.95.

The Receiver. Dual-conversion circuitry is used, with i-f's at 10.6 MHz and 455 kHz. Two uncommon circuit configurations are employed—the r-f amplifier is a grounded-base stage, instead of the usual grounded-emitter mode, and a crystal diode is used as the second mixer, rather than a transistor. A ceramic filter in the second i-f stage affords good selectivity. The noise limiter is a series-gate type, and the squelch is agc-activated. Audio output is obtained from a class-B, push-pull stage which doubles as the transmitter modulator. The frequency synthesizer employs six 37-MHz and four 10-MHz crystals for all-channel operations.

Sensitivity measured 0.3 μV for a 10-dB S+N/N ratio, three times better than the 1.0 μV claimed by the manufacturer! Two watts of audio output was obtained from a 1-μV input signal. Image rejection was 80 dB, i-f signal rejection measured 60 dB at the first i-f frequency and 100 dB at 455 kHz. Spurious-signal and adjacent-channel rejection were 50 dB and 40 dB, respectively. The overall a-f bandpass was 350-2900 Hz at the 6-dB points, while threshold range for squelching action was 0.3 μV to 30 mV.

The agc held the audio output to within 14 dB for a 20-dB r-f input range (1 to 10 μV). However, input levels above 10 μV tended to drop 4 to 6 dB, apparently due to overload somewhere before the volume control. Any distortion generated at these levels was not audibly significant. In the absence of any input signal, the receiver was exceptionally quiet. In the PA mode, 3.25 watts of output power into 8 ohms was delivered, with 10 percent distortion at 1000 Hz at the start of limiting.

The Transmitter. To enhance performance, the transmitter features a two-section matching network, an adjustable series-tuned TVI trap, and a "range boost" automatic modulation control with a-f compression. Antenna changeover is accomplished by a diode. Other switching functions are handled by a relay.

A standard 13.8-V power supply provided 4 watts of carrier output. Distortion at full modulation was 4 percent using a 1000-Hz signal. With further mic-input level increases of 6 and 10 dB, distortion rose to 9 and 14 percent, respectively.

Unlike some other compressors, Lafayette's "range boost" circuitry prevented overmodulation on both positive *and* negative peaks. Adjacent-channel splatter was under 50 dB using a 2500-Hz tone at a level 10 dB higher than that required for full modulation. Audio response of the transmitter was 450 to 4800 Hz at the 6-dB points, and frequency tolerance for any one channel was within 275 Hz.

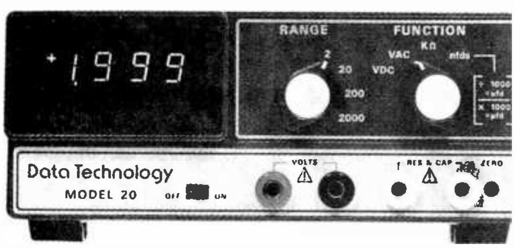
General. Audio output will appear at the handset or internal or external speaker, depending on the position of the panel-mounted switch. In the SPEAKER position, both the handset and the speaker receive audio; in the HANDSET position, the speaker is silenced when the handset is lifted from its cradle. Another switch selects CB or PA operation. When the latter mode is selected, both the internal speaker and the handset earphone are silenced, and output appears only at the external speaker jack. The connecting cables plug in at the top edge of the enclosure, which is convenient. In some mounting positions, however, special wiring may be necessary.

Summing up the attributes of the Lafayette Com-Phone 23 CB transceiver, its telephone-style design offers communications privacy, as well as mounting flexibility. Equally important, users will appreciate its good signal punch, made possible by the "Range Boost" circuit, and clean talk power without spurious products spilling over into nearby channels.

CIRCLE NO. 68 ON READER SERVICE CARD

DATA TECHNOLOGY MODEL 20 BENCH-TYPE AND MODEL 21 PORTABLE DIGITAL MULTIMETERS

Bench and portable units have 3½ digits and can measure capacitance.



MOST digital multimeters offer a broad range of measurement and function features coupled with an easy-to-read numeric display. The most popular display is one of the various types of seven-segment character formats, usually consisting of 3½ decades (digits).

Ever since the DMM first began to appear in the market in quantity, we have been anticipating new functions to appear as competition grew. Hence, it did not overly surprise us when Data Technology Corp. announced no less than two "extra-feature" DMM's. One is the Model 20 bench-type DMM and the other is the Model 21 battery-powered portable DMM that is about the size of a pocket calculator. (Each one is $269.) Both instruments feature capacitance-measuring functions in addition to the usual ac and dc voltage and resistance functions.

The capacitance function covers a range of from 0.002 μF to 2 μF full-scale in four decade-step ranges. Resolution is 1 pF on the 0.002-μF, 10 pF on the 0.02-μF, 100 pF on the 0.2-μF, and 0.001 μF on the 2-μF ranges. Consequently, you can now measure unknown capacitances with a high degree of accuracy.

Model 20. In the Model 20, there are four dc-voltage ranges that go from 0 to 2, 20, 200, and 1000 V full-scale. Input resistance is 10 megohms, and polarity indication is automatic. The ac-voltage ranges are the same as on dc, except for the highest range, which goes to 800 volts. The input impedance is 10 megohms shunted by 40 pF, while the frequency range is 50 to 500 Hz.

Resistance can be measured in decade steps in four ranges from 2000 ohms to 2 megohms full-scale. Test currents on the ranges are 5, 0.5, 0.05, and 0.005 mA respectively from the lowest to the highest range.

Any time the measurement capability of the DMM is exceeded, the overrange condition is indicated by the display blinking on and off.

The numeric readouts in the Model 20 are 1/3 in. (8.47 mm) high. They form a bright orange gas-discharge seven-segment display that is easy to read over a very wide range of viewing angles and from quite a number of feet away. The plus and minus signs used to display the polarity of the dc voltage being measured are also gas-discharge devices.

Aside from the RANGE and FUNCTION control knobs and display window, the only other things on the front panel of the DMM are the power switch and four banana jacks. Two jacks, color-coded red and black, are for the ac and dc voltage inputs. The remaining two jacks, coded white, are for the resistance and capacitance functions. A pair of banana plugs equipped with spring clips are provided with the instrument. These are convenient to use for measuring discrete, out-of-circuit resistors and capacitors. For in-circuit tests, the usual test leads can be plugged into the jacks.

Unlike most DMM's, the Model 20 can be disassembled in just a few minutes by pulling back on two plastic knobs located on the rear apron. This allows the DMM to be disassembled for access to all parts in the event service or repairs must be performed or when calibration is required. (Calibration is a snap when performed according to the instructions printed on the inside of the instrument case lid.)

We put the Model 20 through our usual tests, checking accuracy with a voltage standard and precision-tolerance resistors. It performed well within its published specifications. After a few weeks of use, we again checked accuracy and found no deviations.

Model 21. Next, we turned our attention to the Model 21 hand-held DMM. This instrument is identical in performance to the Model 20 (including the capacitance-measuring function) except that it is battery powered, much

more compact, and uses 6.86-mm seven-segment LED readouts. The battery pack is rechargeable, providing more than 1000 measurements before recharging is required. (The charger is provided with the instrument.)

Operation of the Model 21 is initiated by a fingertip switch located on the left side of the instrument case. The switch has three positions: off, momentary-on, and full-on. For momentary-on operation, the switch is depressed for as long as desired. For full-on, it is slid forward, where it locks in place until slid back to off.

The Model 21 comes with a soft carrying case, which is equipped with a belt clip. It also has a built-in pocket in which the test leads are stored when the instrument is not in use. As far as actual performance is concerned, we could find no difference between the Model 21 and the Model 20 in accuracy and flexibility, and the Model 21 is built to take the rough-and-tumble life of a tool-box/service-vehicle environment.

The Model 20 bench DMM measures 9 in. by 6¼ in. by 2½ in. (22.7 × 15.9 × 6.4 cm) and weighs slightly more than 2 lb (1 kg). Its total power consumption is 3.5 watts. The compact Model 21 measures 6¾ in. by 3¼ in. by 1¾ in. (17.1 × 8.3 × 4.4 cm).

CIRCLE NO. 69 ON READER SERVICE CARD

ZERO-TO-30V EXPERIMENTER'S SUPPLY

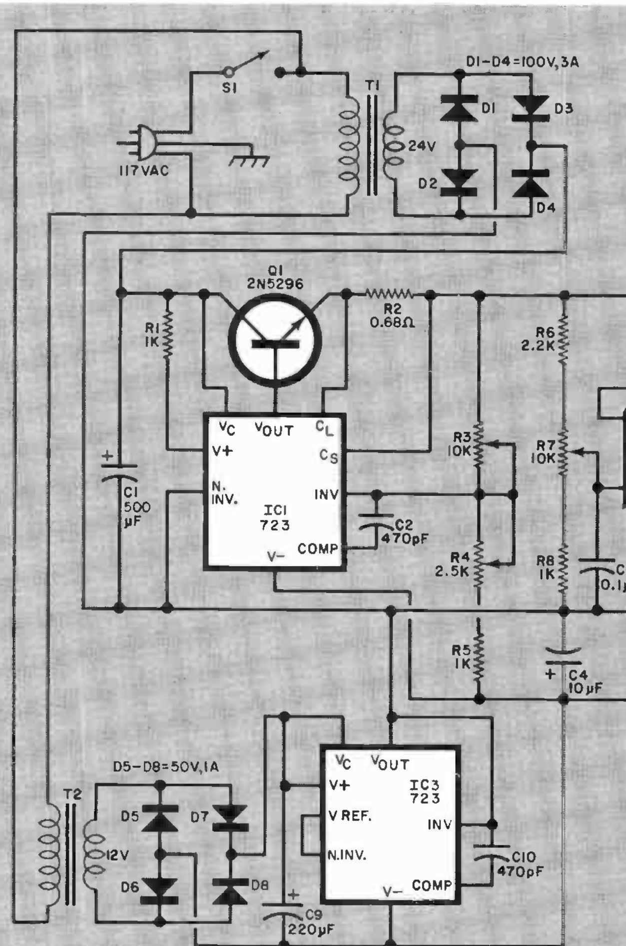
BY THOMAS McGAHEE

MOST power supplies that employ the popular 723 precision voltage regulator IC do not permit the output voltage to go down to zero. By using a bias supply (*IC3* in the schematic) to reference the main regulator *(IC1)*, the power supply described here is able to use a full 7 volts for its reference supply, while maintaining the ability to go to a 0-volt output. Top output is 30 volts.

The power supply employs a split output, providing both positive and negative output voltages referenced to a common point. The voltage splitter circuit is composed of *IC2, Q2, Q3,* and *R6* through *R8*. With the values given for *R6* and *R8*, the positive output voltage swing at *BP1* can be varied from 10 to 85 percent of the total available voltage, leaving a negative voltage swing at *BP3* of 15 to 90 percent.

Transistors *Q2* and *Q3* change their dynamic resistance to keep the output voltage properly split for loads of up to 1 ampere. Accurate tracking occurs for all output voltages where the total adds up to at least 3 volts. Below the 3-volt output level, operational amplifier *IC2* does not track exactly. For single-ended outputs, *BP1* is used as the positive and *BP3* the negative output connector; *Q2* and *Q3* then draw only a few milliamperes of quiescent current.

Because of the circuit's unique design, potentiometer *R3* permits a linear adjustment in the output from 0 to 30 volts. The voltage splitter circuit is also designed to perform in a linear fashion. The output current is limited by *R2* to 1 ampere at all outputs up to



Power supply has a split output to provide both positive and negative supplies. Voltage regulation is 0.05% in worst-case conditions.

PARTS LIST

BP1-BP3—Color-coded binding post
C1—500-μF, 50-volt electrolytic capacitor
C2, C10—470-pF ceramic capacitor
C3, C7, C8—0.1-μF ceramic capacitor
C4—10-μF, 15-volt electrolytic capacitor
C5, C6, C9—220-μF, 35-volt electrolytic capacitor
D1-D4—100-volt, 3-ampere silicon diode
D5-D8—50-volt, 1-ampere silicon diode
IC1, IC3—723 precision voltage regulator integrated circuit
IC2—741 operational-amplifier integrated circuit.
Q1, Q2—2N5296 transistor
Q3—2N6109 transistor
R1, R5, R8—1000-ohm, ½-watt resistor
R2—0.68-ohm, 5-watt resistor
R3, R7—10,000-ohm, linear-taper potentiometer.
R4—2500-ohm, linear-taper trimmer or standard potentiometer (see text)
R6—2200-ohm, ½-watt resistor
S1—Spst power switch
T1—24-volt, 1.5-ampere filament transformer
T2—12-volt, ½-ampere filament transformer
Misc.—Suitable chassis box; three-conductor line cord; heat sinks and insulators for transistors; line-cord strain relief; pc or perforated phenolic board with solder clips; spacers for mounting board; machine hardware; hook-up wire; solder; etc.

25 volts and 800 mA between 25 and 30 volts. The entire available current is delivered between *BP1* and *BP3* in single-ended applications, or it can be spit as needed between the *BP1/BP2* positive and *PB3/PB2* negative outputs.

Voltage regulation under the worst-case conditions in the power supply measured 0.05 percent in both the single-ended and split modes. The power supply can withstand short circuits across its outputs indefinitely if the three transistor heat sinks are large and mounted on the outside of the supply's case. With the power supply delivering 1 ampere at 24 volts, the ripple measured slightly less than 10 mV. Delivering 950 mA at 28 volts, the ripple was 30 mV—its worst-case condition. (The exact values for regulation and ripple appear to be due mainly to the particular 723 IC used. With some 723 IC's, the regulation can be as bad as 0.7 percent.)

The power supply is best assembled using a printed circuit board, owing to the fact that it utilizes three IC's. However, if you prefer, you can use perforated phenolic board and push-in solder clips—in which case, use sockets for *IC1* through *IC3*. The three transistors *must* be mounted on heat sinks, preferably on the outside of the case in which you build the power supply. (Note that, in the schematic, no pin numbers are given for the IC's. Each IC is available in a variety of package configurations with different pin-designation formats. Hence, pin functions are given so that you can design your pc board for the package configuration used.)

The power supply can be built into a 5⅞-in. × 5¼-in. × 3-in. (14.9-cm × 13.3-cm × 7.6-cm) metal utility box. The transistors, with their heat sinks, go on the rear outside wall of the box, while the front accommodates voltage control potentiometer *R3*, voltage split control *R7*, and power switch *S1*. Zero-set potentiometer *R4* can also be mounted on the front panel, or it can be located inside the supply's case, with access provided to it through a hole in the front panel.

In use, *R4* must be adjusted until the minimum output from the power supply is exactly zero. Then, potentiometer *R3* controls the output over the 0- to 30-volt range. Potentiometer *R7* permits the power supply to be operated in the split mode with both sides balanced or with different positive and negative voltages. ◈

IF YOU ARE READY FOR SERIOUS CAREER

Learn College-Level

Solid State

By Lou Garner

USING THERMOELECTRIC DEVICES

MOST electronics buffs find great delight in demonstrating their latest hobby project to friends and neighbors, be it a newly constructed audio amplifier, a special-purpose receiver, or whatever. Now you can flabbergast your friends and astonish your acquaintances just by demonstrating the operation of a single, relatively simple solid-state device. And you won't need a bench full of extra equipment to accomplish this marvelous feat. All you'll need is a standard *thermoelectric* (TE) module and a suitable dc power source.

Call in the friend you wish to impress. Place an aluminum cookie sheet on the kitchen table to "protect the surface" (you don't have to mention that its real purpose is to serve as a heat sink). Produce the TE module with a suitable flourish and a few well-chosen comments. Place the module on the cookie sheet and ask your friend to hold it flat in place while you connect the power leads to a dc power supply (in some cases, an ordinary lantern battery). Then ask your friend to continue to hold the module down until it starts to "warm up."

Within seconds, the module's top surface will start to get cold (unless you goofed and placed it on the cookie sheet upside down). Chances are your friend will move his (her?) hand away from the device with some degree of astonishment. Continue watching and, within minutes, a thin film of frost will start to form on the module's top surface. At this point, you can: (a) tell your friend about the device; (b) tell him it's a subminiature air conditioner for pygmy space capsules; or (c) tell him it's a defective heater that gets cold instead of hot.

After you've had your fun demonstrating the device to all your friends, you can use it in a variety of practical applications, from cooling the output devices in a power amplifier to keeping potables at a reasonable drinking temperature. If you're a high school student, you can incorporate the TE device in any of a number of exciting Science Fair projects or, if in college, use it in scientific research work.

Interestingly, TE devices, in themselves, are not new. Scientists have been working with these units in one form or another for over a century and a half, dating back to 1821, when a German, Thomas Seebeck, discovered that an electric current will flow in a closed circuit made up of two dissimilar metals as long as the junction between the two is maintained at different temperature levels. Named, appropriately, the *Seebeck effect*, this discovery has been utilized for decades in the manufacture of meter and temperature sensing *thermocouples*.

The next major breakthrough was made in 1834, when a French scientist, Jean Peltier, observed that heat energy could be transferred across a junction of dissimilar metals when an electric current was passed through the junction. The junction became, in effect, an electrical "heat pump." This is known as the *Peltier effect*.

Today, TE modules are manufactured using semiconductors and are classified as solid-state devices. The modern Peltier TE cell (Fig. 1A) consists of short sections of p-type and n-type semiconductor materials bonded together with a heavy metallic strap on one side, with electrical connections made to the free ends of the semiconductor elements. Most commercial units are multi-element modules made up by connecting a number of individual cells in series electrically, but in parallel as far as heat transfer characteristics are concerned, as shown in Fig. 1B.

In operation, a dc voltage is applied to the module (or cell), with the positive supply terminal connected to the n-type element, the negative to the p-type. Heat transfer from one side of the module to the other occurs as a result of the continuous formation of new current carriers and their migration through the semiconductor elements to the power terminals. Within limits, the greater the current flow, the greater the heat transfer, provided the transferred heat is dissipated by a suitable heat sink. Unfortunately, internal heating occurs as a result of the current flow, just as in a resistor.

At some point, therefore, the heat generated internally

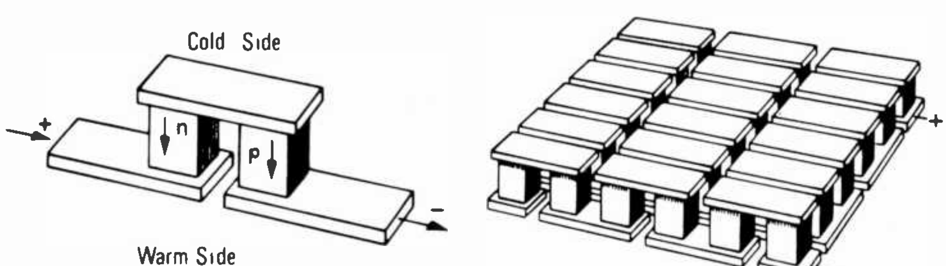


Fig. 1. Thermoelectric devices: single junction (left) and multi-element (right).

offsets the heat transfer and the unit will no longer operate efficiently as a heat pump. In practice, then, each module, depending on its size and construction, has an optimum current rating and maximum heat transfer capability. The direction of heat transfer can be reversed simply by reversing the applied voltage polarity. Thus, a single device can serve *either* as a cooling or a heating element.

As the legendary two-faced god, Janus, a TE device has two facets to its operation. It can "pump" heat *or* it can serve as a low-power electrical generator when heat is "pumped" through it. This can be accomplished by heating one side of the module while cooling the other. This technique has been used in commercial and military applications to generate electrical power in remoter areas.

Peltier-type TE modules are available from a number of major manufacturers, with some models carried as stock items by industrial electronics distributors and the larger mail-order supply houses. Prices vary, of course, depending on type and capacity; but in general they are comparable to the prices of medium-power uhf transistors. In addition to the modules themselves, several manufacturers also offer detailed application notes and handbooks.

The Jermyn type A1357 is typical of the medium-power units. It has a maximum cooling capacity of 20 watts and a maximum current rating of 9 A at 2 V dc. It can be powered by line-operated dc supplies provided the ac ripple does not exceed 15% and can develop a maximum temperature gradient of 60° C when the warm face is no hotter than +45° C. The A1357 sells for $40 each in quantities of up to four units.

Space limitations prohibit our listing all of the firms now manufacturing thermo-electric devices, but the following offer a number of types which should be of particular interest to experimenters and hobbyists:

Borg-Warner Thermoelectrics
Wolf & Algonquin Roads
Des Plaines, IL 60018

Cambridge Thermionic Corporation
445 Concord Avenue
Cambridge, MA 02138

Jermyn
712 Montgomery Street
San Francisco, CA 94111.

Reader's Circuits. Apparently, my discussion of LED's and their applications in last October's column struck a responsive chord among our readers. A number have suggested modifications of the basic circuits I discussed, several have written of their own experiences with these intriguing devices, and others have submitted original designs for new applications. The LED flasher circuit given in Fig. 2, for example, was submitted by Michael E. Lindsey (2625 Fairgreen Drive, Pittsburgh, PA 15241).

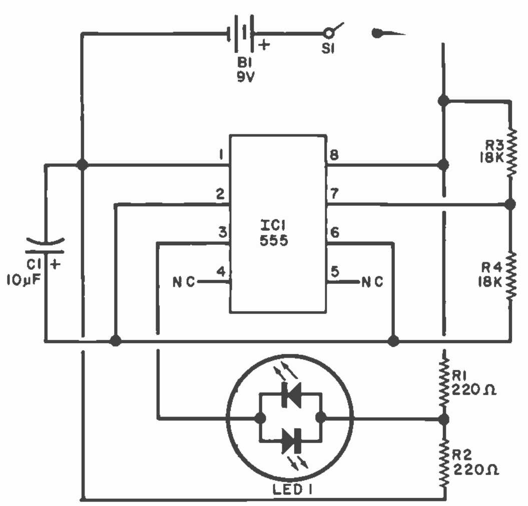


Fig. 2. Reader's flasher circuit uses a 555 tuner and a dual-element LED.

Featuring a single IC timer, a minimum of additional components, and a dual (red/green) LED, Lindsey's design alternately flashes red and green at a rate determined by the timing capacitor's (*C1*) value. The circuit can be used in toys, displays, and models or, if preferred, as a unique type of visual alarm for a control system or intrusion detector.

With neither layout nor lead dress critical and readily available components specified, Lindsey's design can be duplicated quite easily in the home workshop. A standard 555 is used for *IC1*; the resistors are ¼ or ½-watt types, *C1* is a 10 µF, 10-to-15-volt electrolytic capacitor, and *LED1* is a MV5491 red/green dual LED. Operating power is supplied by a 9-volt transistor battery, controlled by a spst toggle, slide or rotary switch, *S1*. A pair of individual LED's may be substituted for the MV5491, if preferred, provided they are connected with reverse polarity, as shown, while the circuit's flashing rate can be changed by using different values for *C1*.

"How simple can you get?" was my initial reaction to the circuit illustrated in Fig. 3. Submitted by reader James C. Graves, Jr. (11A Lin Drive, Eglin AFB, Valparaiso, FL 32542), this square-wave oscillator requires a hex inverter IC, a feedback capacitor, a dc power source, and . . . that's all!!! The basic design may be used as part of a function generator, in a test square-wave generator, as a tone source for electronic musical instruments, in a signal injector for radio-TV servicing, as a simple clock source for digital applications, or even as a code-practice oscillator if a hand key is used in series with the power supply.

James suggests a 7404 for *IC1* and a 30-µF, 6-to-12-volt electrolytic capacitor for *C1*, with the power supply furnishing 4.5 to 5.5 V dc. However, I suspect that other

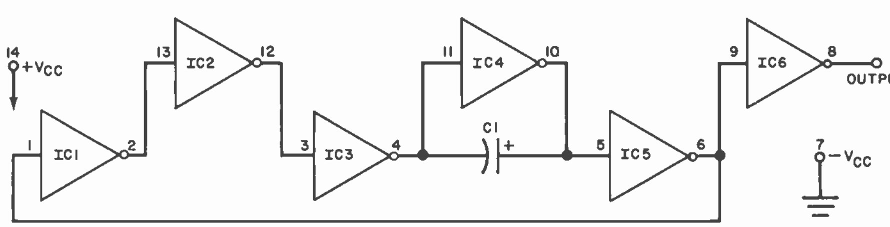


Fig. 3. Square-wave generator uses only a hex inverter IC, a feedback capacitor and a dc power source.

standard hex inverters will work equally well in the basic design, although the supply voltage may have to be changed to match device specifications. When duplicating the circuit, some builders may wish to modify the original design by adding a two-pole, multi-position switch to provide a choice of feedback capacitor values and, thus, a selection of different output frequencies.

The Lit Bit. Aside from your favorite technical magazines, the best sources of up-to-date literature on semiconductor devices and their applications are the reams of material published each year by the major semiconductor manufacturers. While a good deal of this material is directed primarily toward the advanced design engineer or to specialists in specific fields, many of the publications are of general interest and can be particularly valuable to the student as well as to the serious hobbyist and experimenter.

A fair amount of the material will be found on the literature shelves of local distributors. Some is available through area manufacturer representatives, while other items must be requested directly from the manufacturer. Although much of the literature is available without charge, there may be a nominal price for larger items, such as bound handbooks. Among the recent publications which, I feel, should be of special interest to our readers (some of which have been called to your attention in PE's *New Literature* section) are the following:

From RCA's Solid State Division
(Box 3200, Somerville, NJ 08876):

Understanding CMOS, publication CPI-279. An 80-page programmed text structured as a self-teaching aid to familiarize engineers and technicians with CMOS technology. Sells for $2.00/copy.

Thyristors/Rectifiers Pocket Directory, publication TRP-440A. A 68-page pocket-size directory describing over 500 RCA devices, including SCR's, ITR's, triacs, diacs, and rectifiers.

RCA Solid State IR Emitters, Isolators, and Laser Diodes, publication OPT-113A. An interesting 6-page brochure designed so that it can be inserted in a loose-leaf note-book or opened for use as a wall-chart, this publication provides basic information on RCA's line of subject devices.

Linear IC Wall Chart, form LIC-247A. Printed on heavy paper stock, this large wall chart features condensed technical data and functional diagrams for RCA's line of linear IC's.

From Siliconix, Inc.
(2201 Laurelwood Road, Santa Clara, CA 95054):

Designing Junction FET Input Op Amps, application note AN74-3. This 18-page application note deals with the design criteria for FET input op amps.

From Motorola Semiconductor Products Division
(Box 20912, Phoenix, AZ 85036):

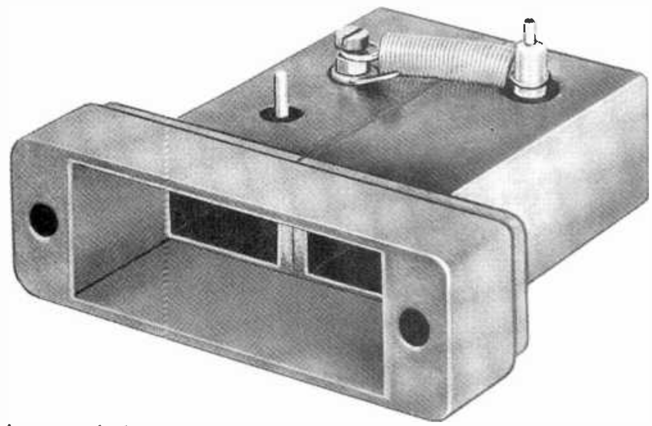
Generate Custom Waveforms Digitally, application note AN-589. Prepared by Karl Huehne, this 6-page publication discusses a method for generating custom waveforms using IC counters, a read-only memory (ROM), and a monolithic digital/analog converter, and a review of possible applications.

Battery-Powered 5-MHz Frequency Counter, application note AN-717. By Don Aldridge, this 10-page application note describes a battery-powered 5-MHz frequency counter featuring McMOS logic circuitry to achieve low-power operation. Designed for use on a 12-volt power source, the basic counter can be used with any of several readouts.

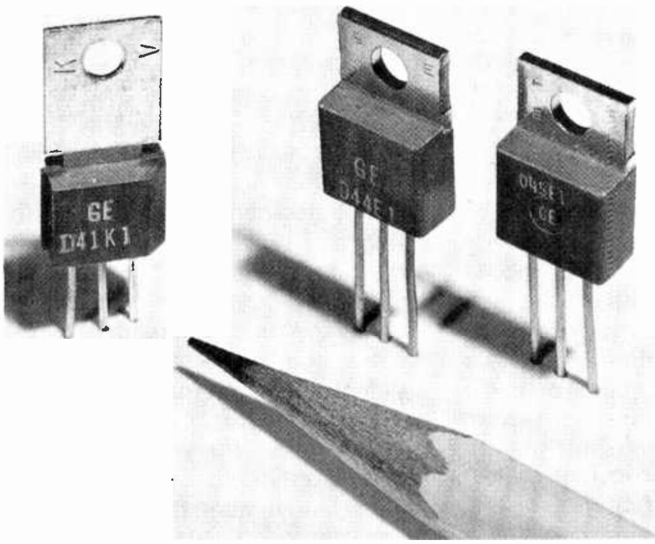
From Hamlin, Inc.
(Lake and Grove Streets, Lake Mills, WI 53551):

Liquid Crystal Display Application Manual—Written as an introduction to liquid crystal displays and their application, this 12-page, 8½ x 11 booklet covers such topics as: "What are liquid crystal displays?" "What is liquid crystal?" "How do LCD's work?" "How many types are there?" "Applications," and "Other displays." It includes one of the best explanations we've seen on the difference between dynamic scattering and field-effect liquid crystals.

Device/Product News.
The Amperex Electronic Corp. (230 Duffy Ave., Hicksville, NY 11802) has introduced a moderately priced solid-state product which should offer interesting possibilities in the hands of an imaginative hobbyist—a self-contained microwave module designed for X-band doppler radar proximity and motion detector systems. Priced at only $47.50 F.O.B. Hicksville in single quantities, the module includes an integral antenna, Gunn oscillator transmitter and low noise Schottky diode detector. Identified as the DX-489 Microwave Module, the new Amperex device is capable of detecting a moving man at a distance of 100 feet, and is suitable for a variety of applications, including intrusion alarm systems and "back-up" safety alarms for trucks, buses and cars. The DX-489 requires a 7-volt dc power source and consumes less than 1 watt while radiating approximately 8 mW at 10.525 GHz. Because of the low-gain antenna, extremely wide angle coverage is possible. The unit can be flush-mounted in a ceiling or wall and still effectively monitor an entire room for "intrusion alarm" applications. External deflectors can be used to shape the radiated pattern; and the vertical beam width can be reduced without reducing horizontal width.


Amperex's low-cost solid-state doppler radar proximity and motion detector.

Three new plastic encapsulated devices have been added to General Electric's (Semiconductor Products Dept., Bldg 7, MD49, Electronics Park, Syracuse, NY 13201) growing line of power Darlington transistors. Designated types D41K, D44E and D45E, the new units feature high current gains and low saturation voltages, and may be used as drivers, regulators and amplifiers. The D41K has a current rating of 2 amperes, with a minimum beta of 10,000 at 200 mA, and is the pnp complement to the earlier D40K. Types D44E and D45E, npn and pnp units, respectively, are complementary pairs in the 10-ampere range, and have minimum betas of 1,000 at 5 amperes. Each type is color-coded for easy pnp-npn identification.



GE's new series of complementary power Darlingtons have high current gains.

As a complement to the MPC1000 positive voltage regulator, Motorola's Semiconductor Products Division (P.O. Box 20294, Phoenix, AZ 85036) has introduced the MPC900 negative voltage regulator. Requiring a minimum of external components for operation, as illustrated in Fig. 4, the new device has a maximum input voltage rating of

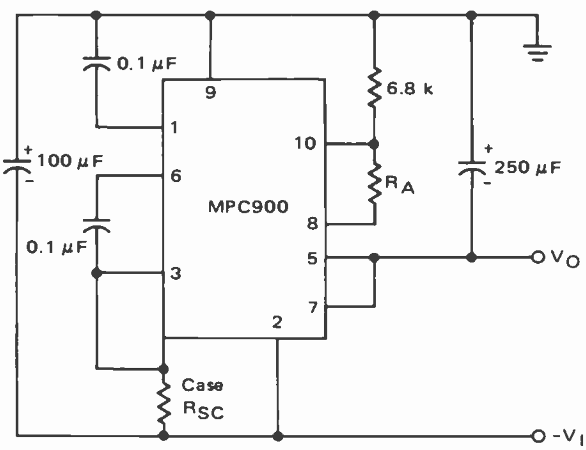
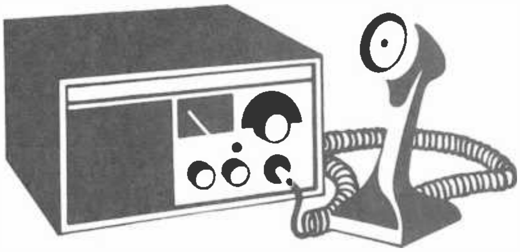


Fig. 4. Typical circuit connections for Motorola's MPC900 negative voltage regulator.

−35 V dc, and can supply an adjustable output voltage from −4 to −30 volts. Housed in a TO-3 style package, the MPC900 can deliver load currents of up to 10 A without an external current-boost transistor and has an internal power dissipation capability of 100 W. Device protection is provided by an adjustable overload circuit. The MPC900 and the MPC1000 can be used together in applications that require complementary regulated supply voltages with a common ground. ◈



CB Scene

By Len Buckwalter

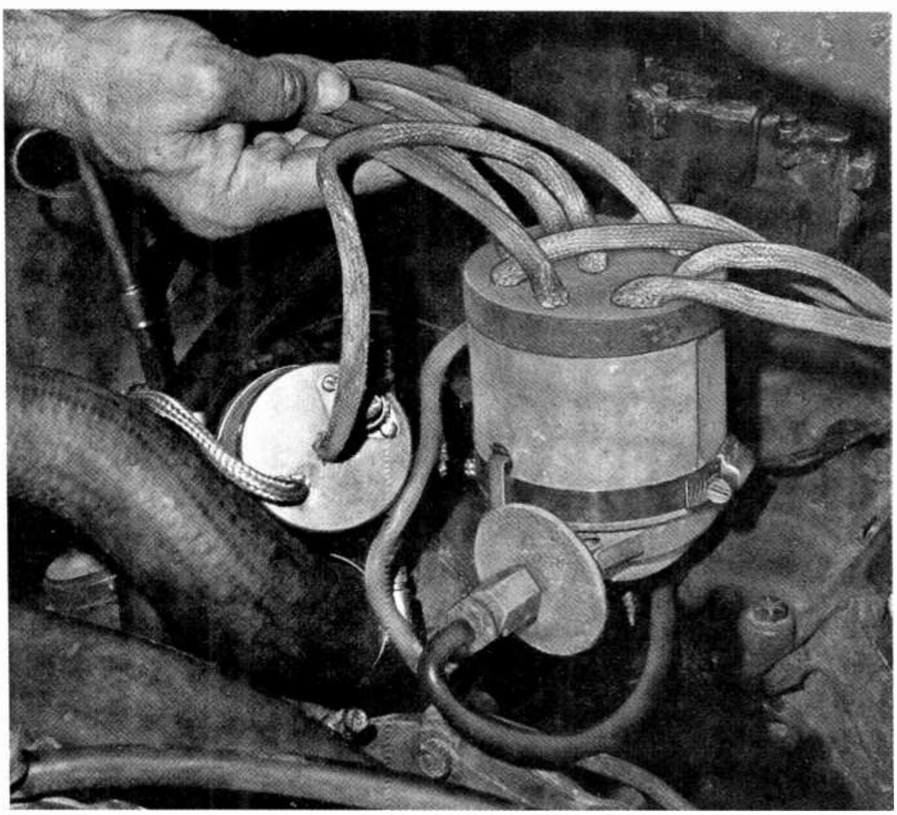
TAKING THE BARK OUT OF SPARK

I THOUGHT I knew something about ignition noise until I met Harry Bichsel. He probably knows more about the snaps, crackles and pops that tear up our mobile rigs than any other CB'er around today. Harry's a retired electrical engineer (from Westinghouse) and he's spent 25 years tracking down the nasty noises that disable the communications of a mobile rig. As I drove up to his home, he was puttering with a huge contraption that looked like a barn door painted black and covered with plumbing pipes. I soon found out it was designed to capture energy from the sun. But I was more interested in the two vehicles parked next to Harry's infernal solar machine—a 1971 Ford LTD and a perky Mustang. They looked like ordinary cars, but something beneath their bonnets made them the most interference-free mobiles for miles around. They had *shielded* ignition systems.

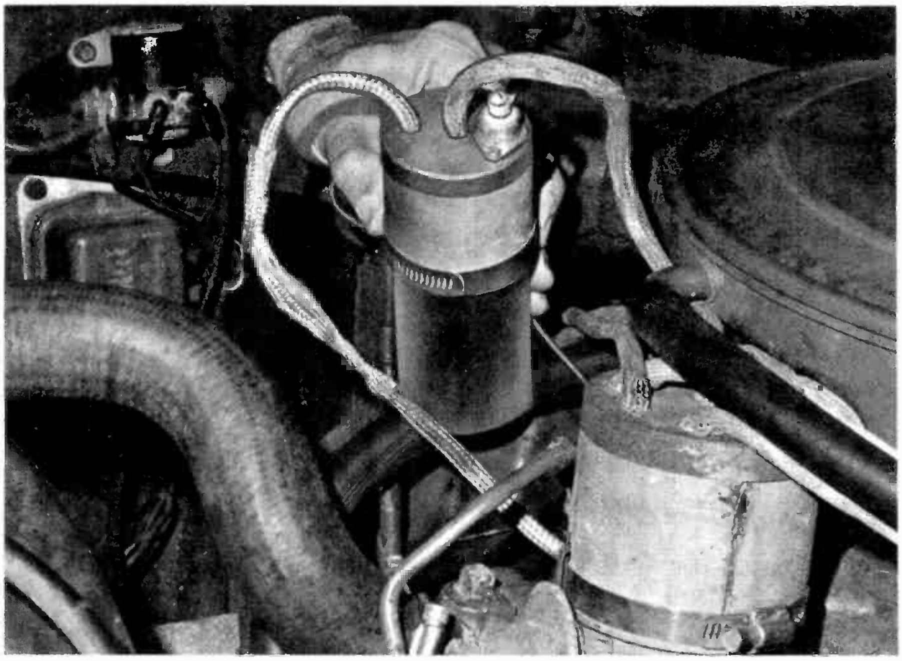
CB manufacturers have already done their part in trying to lick mobile radio's greatest problem. Noise limiters on today's sets are a far cry from the simple diode clippers of an earlier time. The diode simply clips the sharp spike created by a noise pulse just before it passes into the receiver's audio circuits. Since the pulse is almost always stronger than the voice modulation, the desired audio goes through unaffected. Well, almost, because clippers aren't perfect and they can reduce the set's intelligibility. If you get one of the newer r-f noise-silencer circuits, chances are it does a better job by attacking noise much earlier in the receiver, before those spikes slop up the i-f circuits. But noise limiters aside, it's generally agreed that in mobile rigs it's best to suppress the noise where it begins—in the car's electrical system. Let the noise limiters in the receiver deal with noise from the *other* fellow's car.

Harry had tried the usual suppression measures years ago. He had installed filters, bypass capacitors and other items to short-circuit offending r-f hash to ground before it rides into the receiver through antenna or power leads. If ignition noise causes an S-meter reading of S7, he explains, that's about 42 dB, considering that each S-unit might be equivalent to 6 dB. It means an incoming signal must rise to considerable strength to override the noise. The weak ones are never heard. As he demonstrated the point, I recalled a friend of mine who runs a vending-machine route and calls his office on CB to get messages. It's a great moneysaver in his business. But he has to stop and turn off his truck engine to hear anything! Harry found he could reduce an S7 noise reading to about S5, mostly by treating the voltage regulator and instruments (such as the gas gauge). But a whopping difference happened when he went all the way and shielded the ignition system.

The big culprit is the spark plug, and it's easy to see why. If you could somehow bring back Heinrich Hertz and show him the diagram of a car's ignition, he'd likely say, "Looks like the radio transmitter I built around 1890." There's a high-voltage generator and spark-discharge gap reminiscent of turn-of-the-century radio apparatus. A steeply peaked electrical discharge across an air gap creates a wave rich in harmonics that easily extends to 27 MHz. To make matters worse, the wires from each spark plug to the car's distributor act as a multi-element transmitting antenna. You can't bypass high-tension wires because it would warp the clean waveform needed for good ignition, and cost a fortune anyway. In a high-compression engine, spark-plug voltages occasionally reach 30 to 40 kilovolts. Thus, the practical answer is to shield the ignition wires.



At center is the distributor with a shield can clamped over it. In the technician's hand are high-tension wires encased in shield braid.



The ingnition coil is shielded where the wires connect to it. Shield braids are pulled over the primary wires going to the coil.

How to Shield. Harry has some good pointers on how the job is done. The first is to draw your own diagram that shows where each spark plug and coil wire are connected in your car. Also find the indexing mark on the distributor that orients the wires with respect to the ignition timing. (If you reverse a spark plug wire, it'll mess up the firing order.) All the old spark plug wires should be removed and replaced because these leads must be in excellent condition in a shielded system. Any cracks in the insulation will surely cause an engine miss, since the spark is attracted to the easy ground afforded by the copper braid pulled over each wire. One end of the braid is soldered to a metal shield that covers the spark plug. The other end of the braid is soldered to a can fitted over the distributor cap. (That cap is plastic and radiates considerable noise.) Another metal cap is fitted over the plastic end of the ignition coil to contain noise emitted from that area. Shielded braid is also pulled over the primary wires to the coil, and a 0.1-μF bypass capacitor is fastened to a coil lead.

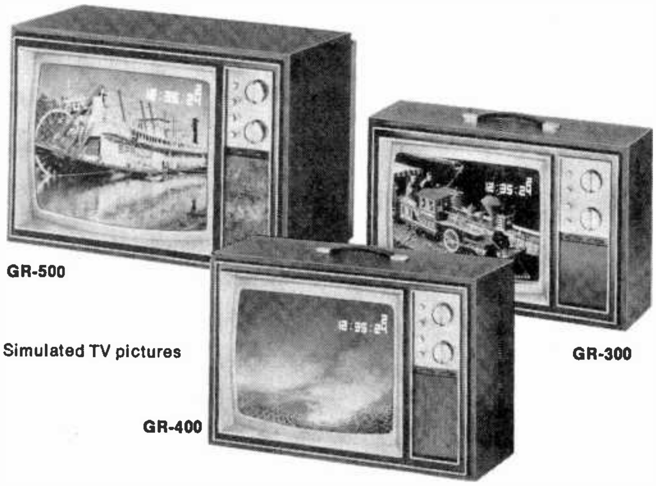
That's the basic routine for shielding an ignition system. Good insulation around the plugs inside the shield is important to avoid any possibility of arcing. The bypass capacitor on the ignition coil is needed to establish a good r-f short for noise currents circulating in the shield braids. Since Harry does his own ignition tuneups, he overlaps some braid on one lead to the ignition coil so he can slide back the braid and attach a tach or dwell meter. He's found no difference in engine performance or distributor point life after shielding the ignition system.

Is it worth all the trouble? I'd always thought shielding an ignition system was something done only in airplanes and text books. Much too exotic for us civilians. The answer came as Harry fired up the big V-8 and turned on a CB transceiver that had a *plastic* case, no less. The little radio hardly protested.

Of course, some cars are quiet, while another of the same make can create the sound of hail on a tin roof. I challenged Harry to remove some of the shielding. All he did was slide back the shield braid from a coil wire and the radio made noises like Baron Frankenstein's laboratory. The receiver's S-meter, which had been idling at a gentle reading of 1 or 2 units swung to S7.

Maybe the time and trouble to shield the ignition are worth it after all. I recall only one mobile rig I operated in the past that wasn't troubled in some way by ignition interference. It was aboard a boat a couple of years ago. Boats, like cars, are prolific noise generators. But come to think of it, that boat was powered by a *diesel* engine. It had no spark plugs! ◈

15 exciting new projects for '75



GR-500

Simulated TV pictures

GR-300

GR-400

15, 17 & 19" (diagonal) Color TVs with On-Screen Digital Readout

Advanced Heath engineering and outstanding picture quality. All feature on-screen channel readout & optional plug-in clock modules. In-line picture tubes with slotted shadow masks provide exceptionally bright, sharp pictures. In the GR-400 and 500, black matrix tubes improve contrast. And here's something new—static toroid yoke & magnet assemblies never require convergence & fixed LC filters eliminate instrument IF alignment. GR-300 & 400 come with walnut veneer cabinets; cabinets for the GR-500 start at $39.95.*

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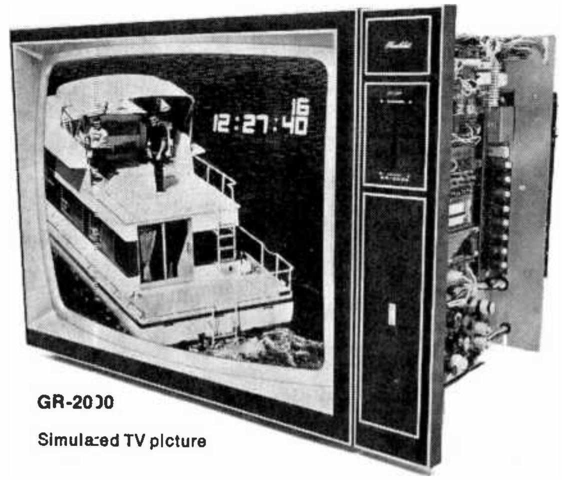
Kit GR-500 (19" diag.), less cabinet 499.95*
Kit GRA-2000-1, Digital Clock Module 29.95*



GR-2000

Simulated TV picture

Highly Acclaimed GR-2000 Digital-Design Color TV

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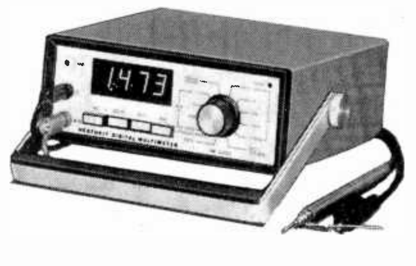

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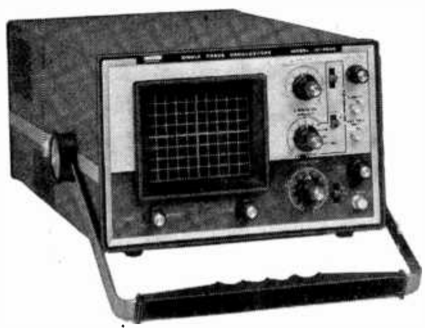

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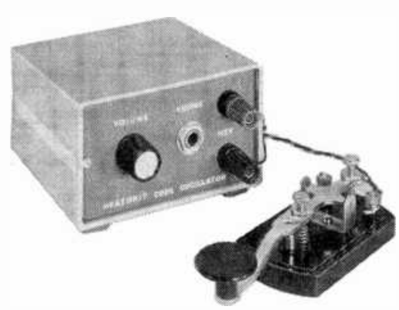

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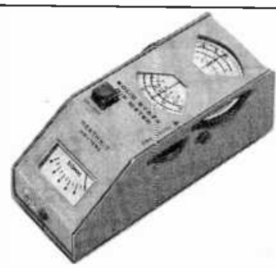

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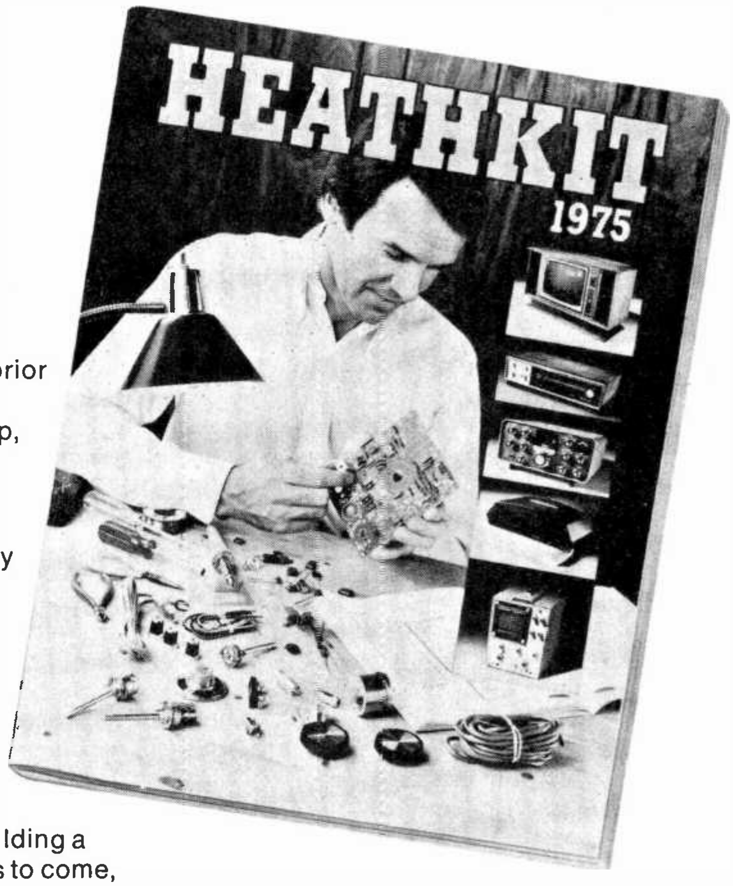

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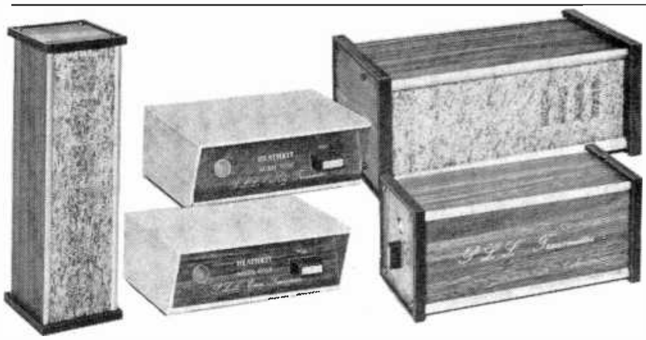

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CIRCLE NO. 5 ON READER SERVICE CARD

Art's TV Shop

By Art Margolis

MYSTERY OF THE POCKET POWER SUPPLY

AS I OPENED the door of my shop one morning, I was startled by the barking of a white toy poodle. A little old lady, obviously the tiny dog's owner, said sternly, "Quiet Killer." She then picked up Killer, put him in her large pocket book, and followed me into the store.

Strolling up to the counter, she pulled a 4-inch (measured diagonally) black-and-white Sony TV out of the same large pocket book. I shrugged, wrote up a service ticket and placed it in line for the bench.

I didn't get to it until late afternoon. Plugging it in and turning it on, the sound snapped on instantly. Some light struggled to appear on the screen, and finally pushed its way out. At the same time, I heard a buzz in the sound. Examining the raster, it was shrunk in on all four sides and badly bowed. The bowing then moved slowly through the picture and, as the bend reached the bottom of the screen some flopover occurred.

I slid the chassis out of the tiny cabinet and frowned at the tightly packed conglomeration of tuner, three printed boards and a CRT assembly. There were no tubes except the CRT and high-voltage quintupler. The classical symptoms. There was visible hum in the picture, audible hum in the sound and four-sided shrink. This indicated that a filter in the power supply had failed. The line voltage pulsations, if they weren't filtered, would raise the dickens in the picture and sound, while lowering B+ voltages enough to cause vertical and horizontal shrinking of the picture.

The filters in the power supply are needed to smooth out pulsations after the rectifier changes the input to pulsating output. As the rectifier conducts, the filter charges near the peak voltage of the rectifier's output. Then as the cycle approaches the zero base line, the filter discharges a bit of electron storage to keep the output near the peak. If the filter is large enough, it keeps on discharging, with little lowering of voltage until the next peak.

A glance at the schematic of the Sony showed that, while the ac input was 117V, the power supply B+ output was supposed to be way down at 10 volts. For receivers having a high B+ input (in the hundreds), a filter size like 20, 50, or 100 μF is ample. In small transistor sets where the B+ is so low, a large storage device is needed (1,000 μF or higher is common).

The Sony had two 1000-μF filters at the dc output and a 1900-μF at the ac input. These were the prime suspects. I located them quickly on the power supply board and decided to test them by direct replacement.

About ten minutes later, I had them out, new ones in and then the old ones back in place. They were all good. Unhappily, the test didn't work!

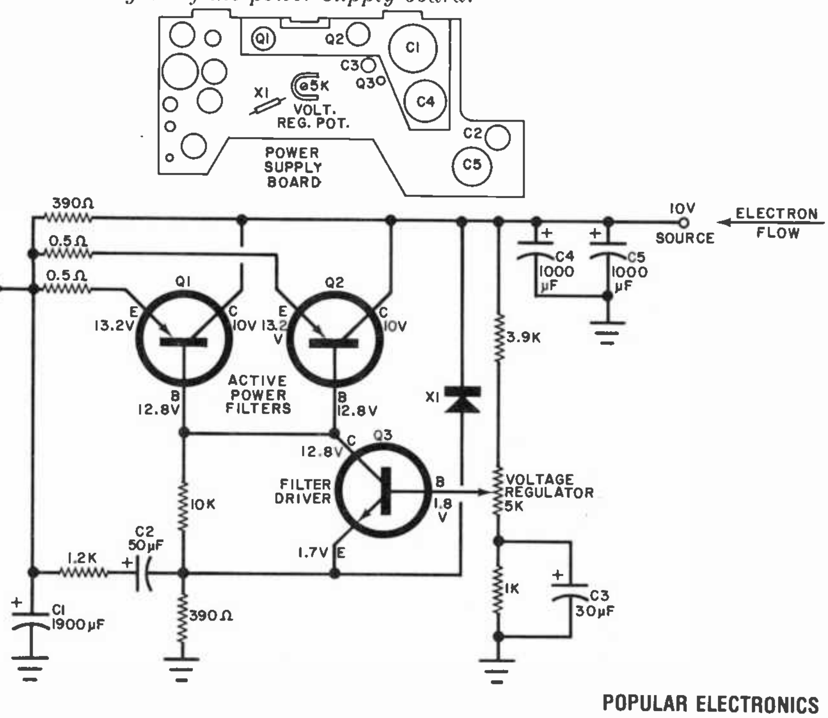
A closer look at the schematic, which I fortunately had, showed that there were three transistors in the power supply for further filtering. Operating as filters and voltage regulators, they noise-cancel the ripple and keep voltage at the prescribed level. In addition, they clean out any 60 Hz or 15,750 Hz from the vertical and horizontal sweep circuits that might be coupled into the supply and redistributed throughout the TV.

How They Operate. As electrons are drawn from the TV circuits to the B+ source in the supply, the electrons encounter the collectors of an active power filter system and the emitter of a filter driver, two pnp's and an npn.

The active power filters have their emitters connected to the rectifier. Electrons can thus flow easily through the collector to the emitter and on to the rectifier. Ripple, of course, pulses the electron flow.

Meanwhile, the filter driver has its collector attached to the bases of the active power filters. The base of the driver, however, is connected to a network between the +10 volt line and ground. It takes a steady sample of the rectifier ripple. The ripple enters the base of the driver and is amplified and inverted 180 degrees. Since its collector is attached directly to the bases of the active filter, the inverted ripple modulates the B+ passing through the active filter. The inverted ripple, 180 degrees out of phase with the active filter's ripple, cancels all ripple.

Schematic and layout of the power supply board.



In the base circuit of the driver is a potentiometer used to adjust the size of the amplified ripple. The adjustment is a screwdriver type, accessible through a hole on the center of the power supply board. I took my miniature screwdriver and tried the pot. No effect. Symptoms were unchanged.

I then read the dc voltage at source. Instead of 10 V there was about eight. I turned the control again, noting that the eight volts did not vary. Aha! The trouble was apparently in this pocket power supply.

Turning off the TV, I began resistance readings. When I tested the resistance across the 390-ohm resistor in the +10 volt line, the meter read almost zero. The resistor looked clean and shiny however, which meant it was probably good. The short circuit appeared to be across the resistor, but two active power filters paralleled it!

I had to unsolder them for the final test. But it was worth it! They were *both* shorted. Zero ohms from E to C.

In a few minutes I had new ones installed. The picture spread out both vertically and horizontally, the visible hum was gone and the buzz in the sound was eliminated. Also, flop-over disappeared and the vertical hold locked the picture tightly.

It was closing time now and I could hear Harry Harris whistling as he swept the front of the store.

I called the number on the little old lady's ticket. "Ma'am, your TV is completed," I told her. "we're closing in a few minutes."

"Killer and I would be so pleased if we could have it for tonight. Could you deliver it?"

Since it was on my way home, and it was probably her only TV, I said yes.

I knocked on her door. She came to the window, and waved me to the garage. When the overhead door squeaked open, Killer was there and started his high-pitched bark. Walking in, I saw a four-foot high doll house with its roof lying on the floor. On the second story was a tiny dog's bedroom and a miniscule TV table that was perfectly sized for the Sony I had in my hand.

I placed the TV on the table, as directed by the woman, plugged it in an actual electric outlet on the doll house wall and attached an antenna wire that came through the wall near the outlet. Video and sound came on, and Killer quickly snuggled down in front of it. Guess a dog's life isn't so bad nowadays. ◈

Test Equipment Scene

By Leslie Solomon

LEARNING TO LIVE WITH DIGITAL

IF I had to make a guess, I would say that most electronics service technicians are afraid to tackle jobs involving digital circuits. More than likely, this fear comes from a feeling that the technician knows almost nothing about digital electronics and is preconditioned by the "science fiction" surrounding it. Yet, these same technicians think nothing of tackling a complex color-TV problem, armed with nothing more than some basic test equipment and a service manual that may or may not be correct for the particular receiver.

However, the most important tool that the service technician has—problem solving "savvy" gleaned from many years of experience—is an attribute that can make any digital circuit just as easy to service as a five-tube radio.

Let's consider a few facts. During all the years that most service technicians were ignoring digital circuits—leaving them to the computer experts and the "wild-eyed" electronics hobbyists who build strange digital projects—designers of all kinds of consumer devices were putting digital circuits to use in their products. Last year, the Heath Co. introduced a color TV receiver that uses digital logic for tuning and displaying channel number and time on the CRT. This receiver also uses quite a bit of digital logic in its remote control. Magnavox has now introduced the "Star" system in its latest color TV receivers, with heavy use of digital circuits. Soon, we will see FM tuners with 100% digital front ends and numeric channel readout using LED's or liquid crystal displays. A digital power amplifier will soon find its way to the market; and frequency synthesizers using digital logic are already an important part of CB rigs. Lastly, we have recently been inundated by all types of digital calculators, clocks, and even wristwatches—some of which are going to need servicing one of these days.

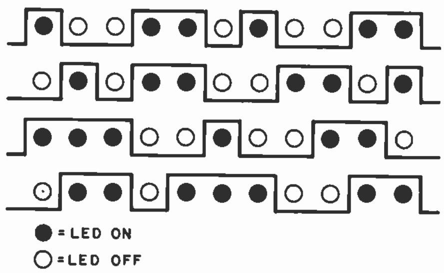
The Altair 8800 Minicomputer introduced in this magazine last month shows promise of wide use in many areas—schools, homes, garages, shops, etc.,etc.—presenting a challenge that the service technician must accept for the sake of his future livelihood.

Furthermore, audio equipment can not be expected to remain a bastion of linear equipment for long. Digital recording of music is a reality. Using analog-to-digital and digital-to-analog techniques, tapes have been produced that rival present-day analog recorded versions.

Where to Start. How does one learn the principles of digital logic? One way is through reading the articles on the subject in this or other magazines. Another is to take a course through one of the schools advertised here. The latter approach will give you a long-term knowledge that can be applied to any digital service job you might encounter in the future.

What does the service technician do when faced with a repair job on a digital circuit? The first thing is to arm yourself with a simple digital probe. There are several commercial models available, or plans for building your own have been published in this magazine (for example: "IC Digital Logic Memory Probe," March 1974 and "Digiviewer," March 1971). With a probe and the timing diagram of the equipment to be serviced, the technician can use his savvy to take on most any job. Actually, a digital probe is easier to use than either a scope or a VTVM. For example, the sketch shows a typical digital waveform as seen on a MITS MitScope Model 416 (a four-channel digital probe with memory). Like most other digital probes, the Model 416 has a lit LED for a logic 1 and a dark LED for logic 0.

At first, the waveforms may appear confusing but they are far easier to interpret than a scope waveform. The four lines represent the logic 1's and 0's that are present at four different points in the particular circuit. The circles within the waveforms represent the LED's in the probe display. There are only two states—on and off. If you were using a digital probe with a single LED, it would blink on and off depending on whether the probe tip was at a point that was 0 or 1 at that instant. Clean decisions are being made at all times. There are no questions of linearity, biasing, harmonic distortion, trap adjustments, etc. There are no scope sweep rates to adjust, no vertical gain to be set, no triggering point to be found, and no time-consuming alignments to be made.



When it comes to digital IC's, we have all learned by now to ignore their internal circuits and deal with them on a black-box level. Some pins are inputs, and some are outputs. All you need is some way to indicate the input and output relationships (logic states), all of which are available from the circuit schematic or the supplier of the device. Add to this a basic knowledge of some simple logic (AND, NAND, OR,NOR, etc.) and the mysterious circuit starts to yield its secrets.

All that remains is to follow the 1's and 0's down the line (just as you would follow a signal through the circuit of a TV receiver), looking for the correct signal. When an improper logic state is found, the defective stage is pinpointed. When you consider the numerous voltages and waveforms encountered in troubleshooting a TV receiver, digital logic circuits become almost elementary.

Essentially, what we are saying is that we must learn to live with digital electronics or prepare to live with the servicing standards (and income) of the five-tube radio days. ◈

Electronics Library

PRACTICAL TRIAC/SCR PROJECTS FOR THE EXPERIMENTER

by Richard W. Fox

There are many works with "Practical Projects" titles that are no more than compilations of schematics, with little or no explanation of circuit operation. This book is a notable exception. Starting with basic pn junction theory, the author progresses through BJT and UJT theory to three-junction devices—SCR's and Triacs. Practical projects are incorporated, utilizing the developed theory. These range from flip-flops to light organs. Also included are switching and voltage control circuits for a variety of ac and dc loads. The book is written for the technician and advanced hobbyist.

Published by Tab Books, Blue Ridge Summit, PA. 17214, 192 pages. $7.95 hard cover; $4.95 paper back.

RESISTIVE AND REACTIVE CIRCUITS

by Albert P. Malvino

This textbook is equally suited to formal classroom and home study As its title implies, it is presented in two parts. Part 1 deals with resistive circuits, covering both series and parallel configurations, theorems and laws, basic measurements, and time. Part 2 is devoted to reactive circuits, includingcapacitance, inductance, transients, reactance, phasor analysis, resonance, instantaneous ac analysis, switching circuits, etc. The student should have some familiarity with algebra and trigometry, although reviews of math are given where needed. Each section finishes with a series of questions related to the subject covered, and answers to odd-numbered questions are provided in the back of the book.

Published by McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, NJ 10020. Hard cover. 592 pages. $12.95.

HANDBOOK OF MODERN SOLID-STATE AMPLIFIERS

by John D. Lenk

This handbook covers the theory, proven design practices, test procedures, and troubleshooting techniques of modern solid-state amplifiers. The first chapter deals with basic amplifier theory. The next five chapters are devoted to the theory and simplified design for a-f, r-f, dc, and operational amplifiers, while the final chapter details amplifier testing and troubleshooting procedures and techniques. The text and diagram coverage takes in both discrete-transistor and selected integrated-circuit amplifier designs. The text assumes specific design goals and conditions, then presents simple, practical approaches to designing circuits that meet the assumed requirements.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hard cover. 414 pages. $15.00.

POLICE CALL

by Gene C. Hughes, Editor

Here is a series of handbooks which list police, fire, ambulance, paramedic, rescue squad, and government radios by frequencies and call letters and by city, county, and state.

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Available from Police Call, Lebanon, NJ 08833. 88 pages. $3.95 each volume plus 50 cents First Class postage and 20 cents sales tax for New Jersey residents (specify geographical location).

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Published by Howard W. Sams and Co., 4300 W 62nd Street, Indianapolis, Ind. 46206, 264 pages. $6.95, hardbound.

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by William D. Cooper

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by Alan Douglas

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by Richard Blitzer

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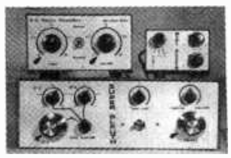

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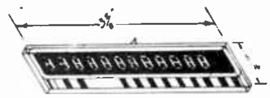

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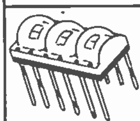

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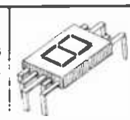

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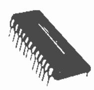

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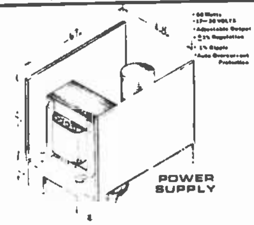

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7408— .24	7493— .75
7410— .18	7495— .99
7411— .30	7496— .95
7412— .45	8220—1.50
7413— .75	74107— .50
7416— .37	74121— .60
7417— .37	74123—1.00
7420— .18	74125—1.40
7426— .30	74126—1.40
7427— .33	74150—1.15
7430— .18	74151— .95
7432— .30	74153—1.10
7437— .44	74154—1.65
7438— .37	74157—1.25
7440— .21	74163—1.60
7441—1.05	74164—2.05
7442—1.00	74165—2.05
7445—1.10	74173—1.80
7446—1.15	74175—1.95
7447—1.15	74177—1.80
7448—1.20	74181—3.60
7450— .18	74192—1.50
7472— .40	74193—1.45
7473— .43	74195—1.00
7474— .43	75324—1.75
7475— .75	75491—1.10

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4012AE	.54	.53
4013AE	1.15	1.05
4014AE	3.70	3.25
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4016AE	1.15	1.05
4017AE	2.90	2.70
4018AE	3.20	3.05
4019AE	1.30	1.20
4020AE	3.90	3.30
4021AE	3.80	3.60
4022AE	2.75	2.55
4023AE	.54	.53
4024AE	2.30	2.00
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4029AE	5.40	4.60
4030AE	1.25	1.05
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4040AE	4.60	4.40
4041AE	3.30	3.20
4042AE	2.95	2.85
4043AE	2.95	2.85
4044AE	2.95	2.85
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4048AE	1.50	1.40
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74H08N	.44
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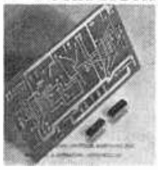

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I_{io} = 1000nA
I_b = 2000nA
Noise = 1.5dB
$2.20

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2N3375	5.50
2N3442	2.20
2N3730	1.70
2N3731	2.00
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2N3771	2.20
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2N4348	2.00
2N4395	1.30
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2N5109	2.10
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MCT2 1.45

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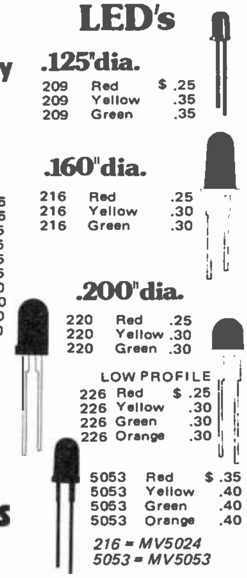

.125"dia.

209	Red	$ .25
209	Yellow	.35
209	Green	.35

.160"dia.

216	Red	.25
216	Yellow	.30
216	Green	.30

.200"dia.

220	Red	.25
220	Yellow	.30
220	Green	.30

LOW PROFILE

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226	Green	.30
226	Orange	.30

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5053	Yellow	.40
5053	Green	.40
5053	Orange	.40

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LM209K	3.70
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LM300N	1.40
LM304H	1.40
LM305H	1.10
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LM305N	1.20
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LM340-06K	2.60
LM340-08K	2.60
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LM302N	Dip	1.40
LM306H	TO-5	2.80
LM307H	TO-5	.90
LM307M	Mini-dip	.90
LM308H	TO-5	1.20
LM308AH	TO-5	5.00
LM310H	TO-5	1.40
LM311H	TO-5	1.70
LM318H	TO-5	2.50
LM555CM	Mini-dip	.90
LM709CH	TO-5	.45
LM709CN	Dip	.45
LM710CH	TO-5	.60
LM710CN	Dip	.75
LM715CH	TO-5	4.30
LM725CH	TO-5	5.00
LM733CH	TO-5	1.50
LM733CN	Dip	1.50
LM741CH	TO-5	.45
LM741CM	Mini-dip	.44
LM747CH	TO-5	1.90
LM747CN	Dip	.90
LM748CN	Dip	.40
LM3046CN	Dip	.95
LM3054CN	Dip	1.50

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40 pin DIL	1.90

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6 pin	TO-5	.90
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7552-1CPE	25.00

7400N TTL

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7401N	.23			74151N	.75
7402N	.22	7474N	.38	74152N	2.25
7403N	.22	7475N	$ .68	74153N	1.12
7404N	.25	7476N	.59	74154N	1.63
7405N	.29	7480N	.66	74155N	1.49
7406N	.38	7481N	1.21	74156N	1.49
7407N	.48	7482N	1.01	74157N	1.19
7408N	.24	7483N	1.01	74158N	1.54
7409N	.54	7484N	3.01	74160N	1.50
7410N	.24	7485N	2.49	74161N	1.35
7411N	.29	7486N	.49	74162N	1.50
7412N	.51	7489N	2.99	74163N	1.50
7413N	.78	7490N	.75	74164N	1.89
7414N	2.81	7491N	1.40	74165N	1.89
7416N	.46	7492N	.84	74166N	1.98
7417N	.64	7493N	.84	74170N	2.55
7420N	.19	7494N	1.29	74173N	1.79
7421N	.51	7495N	.88	74174N	1.52
7423N	.49	7496N	.88	74175N	1.50
7425N	.39	7497N	2.50	74176N	1.69
7426N	.29	74100N	1.45	74177N	1.69
7427N	.35	74105N	.54	74180N	2.49
7428N	.51	74107N	.48	74181N	3.85
7430N	.22	74108N	.91	74182N	1.19
7432N	.28	74109N	.91	74184N	2.89
7433N	.61	74110N	.71	74185N	2.29
7437N	.44	74111N	.91	74190N	2.89
7438N	.44	74114N	.91	74191N	2.89
7439N	1.01	74115N	.91	74192N	1.49
7440N	.19	74118N	1.50	74193N	1.39
7441AN	1.16	74119N	.81	74194N	1.35
7442N	.98	74121N	.54	74195N	.99
7445N	.98	74122N	.89	74196N	2.39
7447N	1.50	74123N	.95	74197N	2.39
7448N	1.29	74125N	1.39	74198N	2.59
7450N	.23	74126N	1.39	74199N	4.48
7451N	.28	74128N	1.21	74200N	5.05
7453N	.25	74132N	2.05	74122N	1.75
7454N	.26	74136N	.91	74251N	1.75
7460N	.24	74141N	1.89	74278N	2.95
7470N	.30	74145N	1.79	74293N	.92
7472N	.39	74147N	2.95	74293N	.92
7473N	.46	74148N	3.55	74298N	2.55

LOW POWER TTL

74L00N	$ .34
74L02N	.34
74L03N	.39
74L04N	.39
74L10N	.34
74L20N	.39
74L42N	1.62
74L47N	2.60
74L51N	.34
74L73N	.74
74L74N	.89
74L90N	1.62
74L93N	1.74
74L95N	1.62

93L00	1.50
93L01	1.60
93L08	3.20
93L09	1.80
93L10	2.80
93L11	4.20
93L12	1.80
93L14	1.70
93L16	3.20
93L18	3.50
93L21	1.50
93L22	1.80
93L24	2.80
93L28	3.70
93L34	4.00
93L38	4.20
93L40	6.50
93L41	6.50
93L60	3.00
93L66	2.70

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DM8820N	4.00
DM8820AN	6.50
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DM8831N	5.00
DM8832N	5.00
9600	1.30
9601	1.30
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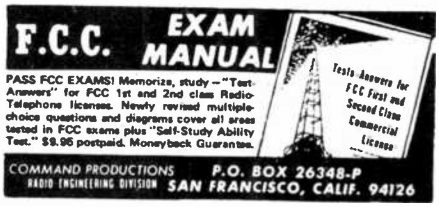

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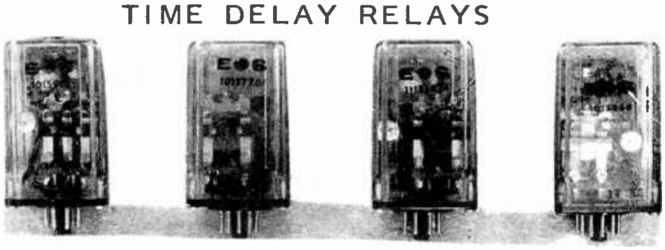

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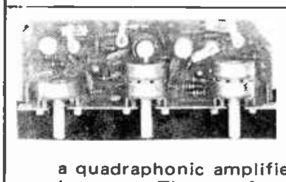

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7411	Triple 3-Input Pos. AND Gate	34
7413	Dual NAND Schmitt Trigger	.75
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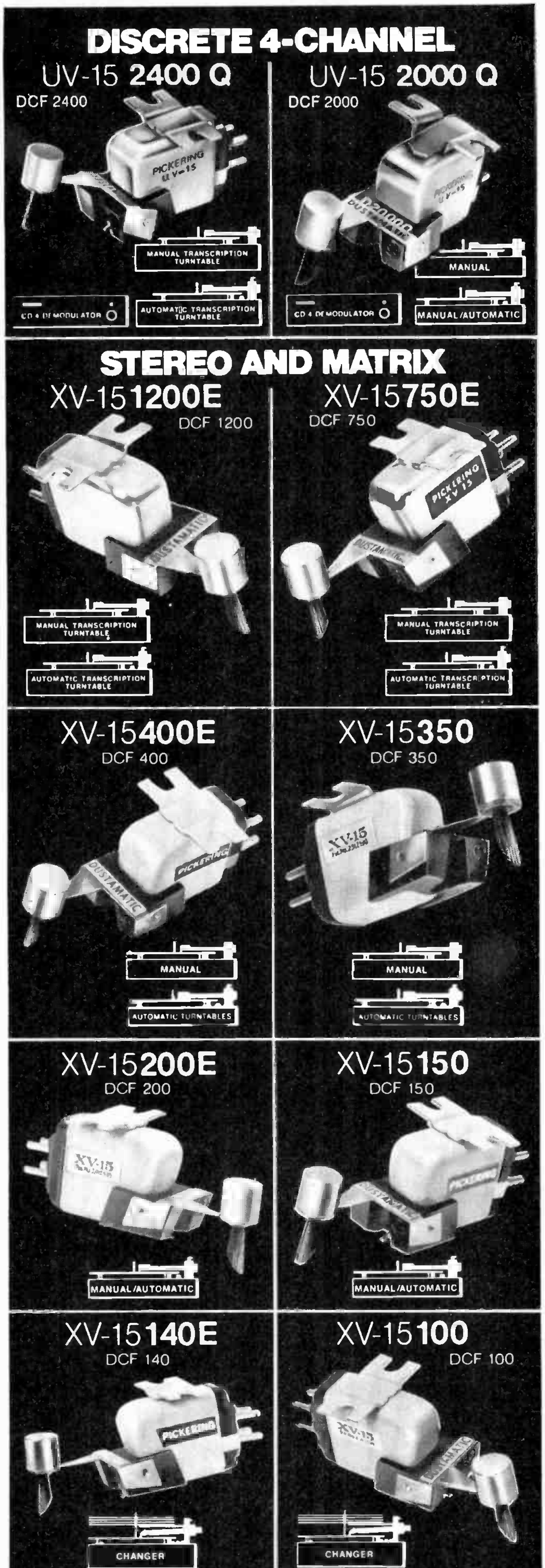

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