

REPORT ON SURFACE-WAVE AMPLIFIERS

Popular Electronics

FIFTY CENTS / MARCH 1971

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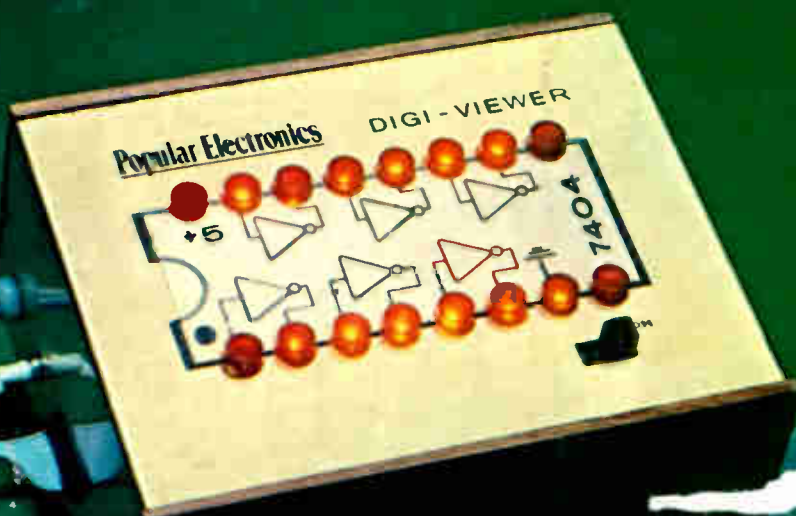
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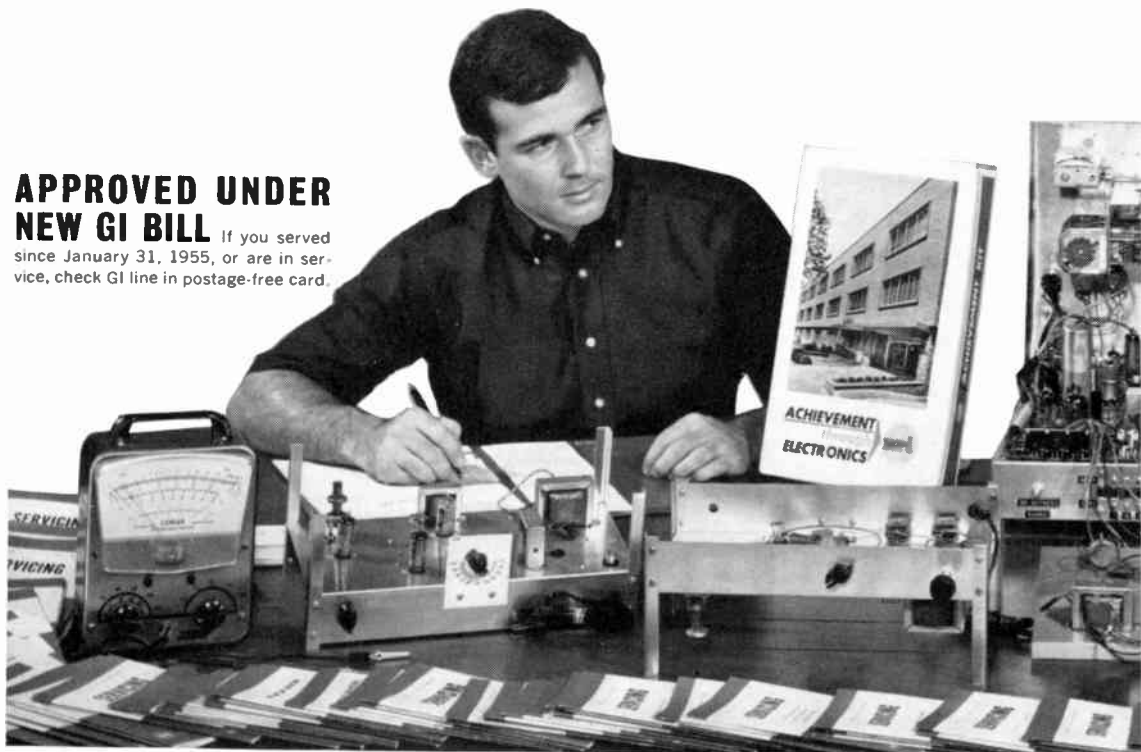
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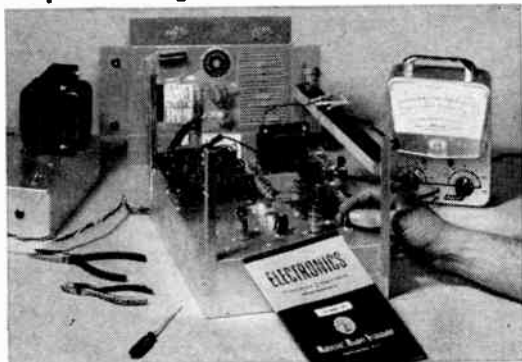
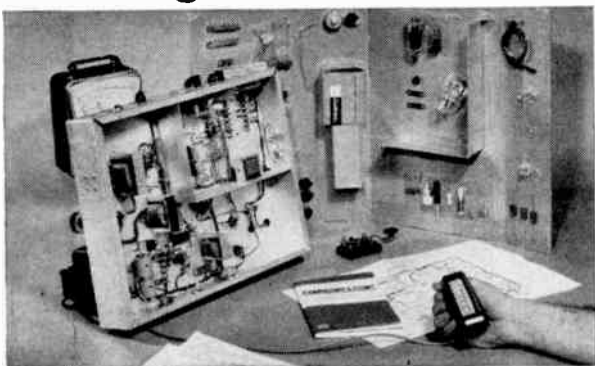
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POPULAR ELECTRONICS is Indexed
in the Reader's Guide
to Periodical Literature

This month's cover photo by
Justin Ker

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POPULAR ELECTRONICS



Seventh in a Monthly Series by Oliver P. Ferrell, Editor

TWILIGHT OF THE SHORTWAVE LISTENER

One aspect of the spectrum of hobby electronics that defies analysis is shortwave listening (SWL'ing). Statisticians can tag the number of cigarette smokers or boat owners, but no one can hazard a guess as to the "depth" of SWL'ing. Is SWL'ing of interest to only 5000 of the 200,000,000 people in the U.S., or do 750,000 or even 1,000,000 take to their shortwave receivers at some time each day?

Manufacturers have been deserting SWL's for the past decade. Drake, Galaxy, Heath, Hallicrafters, and Mosley maintain a minor interest in the hobby, but gone are Gonset, Hammarlund, National, RME, etc. Although some of the slack has been filled in by the Japanese—primarily through the mail order houses of Allied Radio Shack and Lafayette—there is an obvious dearth of equipment for the seriously interested SWL.

The novelty of long distance (DX) radio reception virtually insured prestige and occasionally even fame for the listener during the very early days of electronics—cum radio. At the close of World War II, shortwave radio broadcasting lost most of its hit-or-miss nature. Encouraged by the psychological effects of propaganda, several dozen countries spent hundreds of millions of dollars for broadcasting facilities to tell the rest of the world how good they were and how bad others were. Delighted by this avalanche of new stations and new countries to be heard, the technically proficient SWL went into a frenzy of activity. The number of SWL's probably peaked in the late 50's and early 60's.

There is—and always has been—substantial attraction in SWL'ing to teenagers, though the vast majority drop it in 9 to 12 months. Serious SWL'ing holds little appeal to those in the 19 to 35 age bracket, but the oldsters (like yours truly) drift back to SWL'ing in their 50's just to see how things have changed.

Perhaps—and only perhaps—the outlook for SWL'ing need not be as dark as it appears. To begin with, there is evidence that SWL'ing is a hobby that has never made a strong case for its own activities. Equipment manufacturers know neither the "size of the market" nor the exact type of equipment the SWL is willing to buy. International broadcasters are phasing out programs aimed at North America simply because listeners appear to be more interested in QSL's and frequency changes than program content. SWL's could dramatically improve their lot if they found a strong unifying force with perceptive leadership.

A lack of positive direction, along with pettiness, fragmentation, and a variety of minor annoyances plague this worthwhile hobby. It's not surprising that more and more teenagers are flocking to CB where the fellowship compensates for the lost excitement of SWL'ing. There could be a turnaround, but it can only be accomplished by all SWL's working together and not fighting over who will or will not preside at the wake.



INTERFACE

THE "OLD LOOK"

It never fails! Whenever someone has something good going, they try to make it better and end up ruining it. Whenever I received POPULAR ELECTRONICS, I immediately looked for, "Just When I Forgot My (Soldering) Gun," "Satellites On The Air," "Carl & Jerry," etc. You're forgetting the beginner and if this keeps up, I'm going to switch to one of your competitors.

J. CACCIATORE
Frankfort, N.Y.

Reader Cacciatore has a long memory—some of the "missing" items haven't appeared in POPULAR ELECTRONICS for six or seven years! We'll bet that three out of four of our readers don't know what that soldering gun business was all about.

ABOUT OMNIDIRECTIONALITY

I certainly enjoyed the "Stereo Scene" about loudspeaker concepts (October 1970). I agree with Mr. Holt's position on the Bose 901 and reflecting speaker systems as a whole. Certainly much of the sound we hear is reflected. To recreate the original sound image, these reflections must be reproduced in their original intensity and phase relations—the reflecting speaker systems produce random reflections.

In college, I wrote a paper that included a section on auditory localization. Some of the references might be of interest to your readers:

London, S. J., "The Origins of Psychoacoustics," *High Fidelity*, April 1963, p 44.

Helmholtz, H. L. F., *On the Sensations of Tone*, (1877), transl. A. J. Ellis, Dover Pubs., Inc., 1954.

Bell Telephone System Monograph B-1327, "Stereophonic Sound-film System," chapter by Harvey Fletcher on General Theory, 1941.

A. D. KELLER
Endicott, N.Y.

TEN-YEAR INDEXING

Recently my associates and I have compiled a complete index to all of the articles which have appeared in POPULAR ELECTRONICS over the last 10 years. It lists over 1200 articles, including such information as the nature and length of each article, plus any later corrections. Since we feel this index would be ex-

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INTERFACE

(Continued from page 8)

remely useful to anyone having access to back issues of PE, we are making copies available at \$2 each from Periodical Indexes, P. O. Box 178, San Luis Obispo, CA 93401. Indexes to other electronics hobbyists magazines will be available soon.

S. SULA
Periodical Indexes
San Luis Obispo, CA

A STEP TO PROGRESS

I have watched your "New Look" and although I was very sorry to see your SWL and amateur columns go, I think that congratulations and best wishes for your continued success in the future are now in order. In this era of widening interests and rising prices, you have taken a courageous step.

J. IRVING
Milwaukee, Wis.

WEST COAST GPO

West Coast residents interested in speeding up delivery of the manuals mentioned in the Kenneth J. Englert story, "Electronics Self-Study Course," will find most of the manuals available (at the same cost) from the Government Printing Office Book Store, 450 Golden Gate Ave., San Francisco, CA 94102.

TOM ADAMS, WA6KSS
Fair Oaks, Calif.

ABOUT READER MAIL

Obviously, the author of every construction project cannot "debug" it to every reader's satisfaction. How about the possibility of: (a) publishing a follow-up article several months after initial publication; (b) having the author prepare modification sheets and making them available at 50¢ a throw; or (c) having the author prepare a list of interested parties so that constructors with mutual problems can then correspond among themselves.

E. MORRIS, JR.
Dearborn Heights, Mich.

SUCCESSFUL PROJECTS

I wish to thank you for the "Automatic Vehicle Burglar Alarm" construction project by George Meyerle that appeared in your April 1970 issue. This alarm system was hooked up to a siren in my automobile and last week thwarted a burglary attempt in the early morning hours. It not only awakened me, but I had the opportunity to see the obviously very shook-up thieves making a hasty retreat. As my car contains a rather large investment in tape and radio equipment, this alarm has paid for its reasonable construction cost many times over with just this one incident.

H. F. GARRISON, WBØCMJ
Englewood, Colo.

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INTERFACE

(Continued from page 10)

Although I realize I am about six months late in completing this project, I constructed a stereo version of Don Wherry's "Build An Audio Multicoupler" that appeared in your July 1970 issue. I was able to compress it to only 4 cubic inches more than the mono coupler described in the article. I used plastic electrician's tape as resist to prepare the printed circuit foil pattern. The case was homemade and covered with wood grain vinyl.

Best of all—it works fine!

L. J. HARR
Shell Lake, Wis.

TECHNICAL MANUALS

The Kenneth Englert article "Electronics Self-Study Course" brings to mind the various Technical Manuals on electronic equipment that were—some years ago—available from the Government Printing Office. I have several pieces of equipment where the manual is missing. How do I obtain these GPO or TM manuals?

Many equipment manuals are available

from either S. Consalvo, 4905 Roanne Drive, Washington, DC 20021 or Slep Electronics, 2412 Highway 301 N., Ellenton, FL 33523.

OUT OF TUNE

"Electronics Self-Study Course," Dec. 1970. Since publication of this story, we have learned that "Cathode Ray Tubes and Their Associated Circuits," TM-11-671, is no longer available. We suggest that you substitute "Radior Electronics Fundamentals" (GPO Cat. No. N 29.2:R 11/3; \$1.50) and make the appropriate adjustments in the master course outline.

"Electronic Clinical Thermometer," Jan. 1971. In Parts List on page 76, R8 should be 3000-ohm at 25°C.

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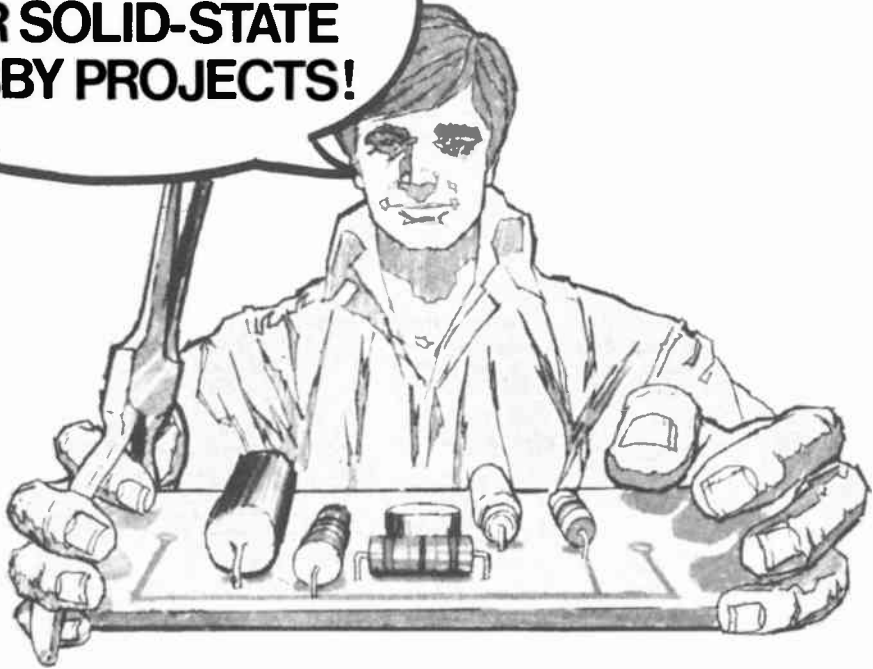
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Complete construction information on 62 circuits is given, including detailed descriptions of circuit operation, construction layouts, photographs, schematic diagrams, and parts lists. Full-size drilling or printed-circuit-board templates are included for most circuits.

There are sections of theory and operation of solid-state devices, testing and troubleshooting, basic circuits, mechanical considerations, and suggested circuit uses.

We've included suggestions for hams, motorists, photographers, music and hi-fi buffs, and others.

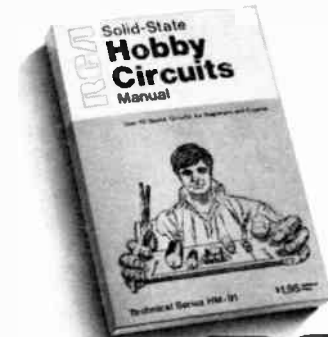
Build circuits for: Power Supplies... Shift Registers... Counting Circuits... Electronic Clocks... Audio Oscillators... Microphone Pre-amplifiers... Mixers and Line Amplifiers... Phonograph Preamplifier... Photoelectric Audio Attenuator... IC Wireless Microphone... Amplifiers... Telegraph Keyers... AF Operated Switch... Dip/Wave Meter... Variable-Frequency Oscillator... Calibrators... Metronome... Fuzz Box... Six-Octave Organ... Flasher... Enlarger Exposure Meter... Universal Timer... Lamp Dimmer... Temperature Alarm... Positive-Action Light-Operated Switch... Automobile Tachometer... Battery Chargers... Automobile Light Minder... Siren... Slot Machine... Dice

... Metal Detector... Motor-Speed Control... Model Train and Race-Car Speed Control... Time Delay.

In addition, RCA has Integrated Circuit Project Kits that contain a complete package of parts for many of these circuits.

The Hobby Circuits Manual is available for only \$1.95* from your RCA Distributor; or send check or money order (payable in U.S. dollars to RCA Corporation) to RCA Commercial Engineering I Harrison, N.J. 07029.

*Optional Price



RCA

CIRCLE NO. 24 ON READER SERVICE PAGE



To obtain a copy of any of the catalogs or leaflets described below, fill in and mail the Reader Service blank on page 15 or 95.

A new catalog (No. BI-2166-2) issued by *Telex Communications Division* covers 30 general communication and dictation headphones and other private listening devices and accessories. The eight-page, two-color catalog includes complete product information, photos, and prices.

Circle No. 75 on Reader Service Page 15 or 95

Hundreds of titles are listed in the 1971 Technical/Scientific Books Catalog recently issued by *Howard W. Sams & Co., Inc.* The 76-page catalog lists each book according to the science or technology and subdivision it applies to, giving a brief description about

its contents, number of pages, size, binding, and price.

Circle No. 76 on Reader Service Page 15 or 95

Hundreds of unusual and hard-to-find tools are listed in a new expanded 32-page catalog available from *Brookstone Co.* Listed are such tools as glass pliers, carbide sabre saw blades, plumb and level inclinometers, hand vises, magnetic work lamps, etc. Among the accessories listed are glass drills, step blocks, carbide-faced wire cutters, jewelers' screwdrivers, watchmakers' loupes, and an optical comparator.

Circle No. 77 on Reader Service Page 15 or 95

An illustrated primer on shortwave listening is being offered to the interested reader, DX'er, beginner and advanced SWL, ham, or hobbyist by *The Hallicrafters Co.* Titled "Short-Wave Puts You Where It's At," the primer takes the reader through the nuances of SWL'ing, explaining graphically just what the hobby is all about, what can be heard on the various bands (including public service), and points out what to look for when choosing a quality communications receiver. Also included in the primer is Hallicrafters' complete line of AM and FM general-coverage shortwave receivers, special frequency monitors, and amateur transceivers and accessories.

Circle No. 78 on Reader Service Page 15 or 95

HOW-TO for do-it-yourselfers



The Electronic Experimenter Circuit Manual, ETRM-3960A, takes 50 pages to describe the function and operation of various components... then, in more than 200 pages, supplies the diagrams and information needed for 44 projects geared for audio, automotive, marine, game, hobby, home, farm, camp and workshop applications.

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Popular Electronics

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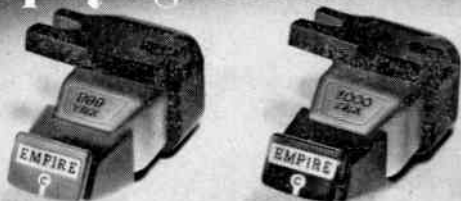
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50 IC PROJECTS YOU CAN BUILD

by Ronald M. Benrey

Even neophyte hobbyists and experimenters are expressing an early interest in the applications and uses of the unusual and versatile integrated circuit. For those readers who wish to familiarize themselves with IC's, this book will undoubtedly prove very useful. Starting off with a non-technical explanation of what the IC is, it goes on to explain how to work with IC's and what types of power supplies to use. Then are presented 50 author-built and tested IC projects that run the range of interest from automotive and photography devices to audio and communications gadgets to home alarms. Each project is presented with schematic diagram, parts list, circuit description, and construction hints. And care has been taken in selecting IC's to assure easy availability.

Published by Hayden Book Co., Inc., 116 West 14 St., New York, NY 10010. Soft cover. 120 pages. \$3.75.

ELECTRONIC COMPUTER TECHNOLOGY

by Norman R. Scott

Previously published under the title "Analog and Digital Computer Technology," this edition treats hybrid computers as well as analog computer design and usage, and digital computer structure and organization. In each case, the viewpoint used is that of the engineer who needs to know how to design a computer rather than how to use it. In addition, the analog material presents applications to various types of problems, since analog computer application and design are so closely related that it is of value to treat them together. Suitable for use in an introductory electronics computer course at the senior and beginning graduate levels, this book requires a knowledge of differential equations and a basic understanding of electronics theory.

Published by McGraw-Hill Book Co., 330 West 42 St., New York, NY 10036. Hard cover. 618 pages. \$17.95.

CIRCUIT CONSULTANT'S CASEBOOK

by T. K. Hemingway

Although they feel they have grasped the principles of design, many engineers find (Continued on page 99)

THE WORKHORSE

The industry's top replacement tube, 6GH8A, is used in so many makes of TV and in so many different applications that it will be a high volume replacement type for years to come.

RCA's versatile 6GH8A is designed to satisfy the demands of all these applications:

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The best way to get electronics into your head

No book ever written can give you the "feel" of electronics.

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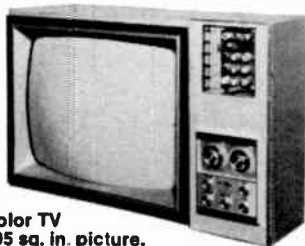
Putting equipment together, kit by kit, can teach you more about electronics than a whole library of bone-dry theory.

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You receive a big screen color TV with many unique features, including self-servicing equipment so you can make all normal test operations. You also get an AM-SW radio, solid-state radio, field-effect transistor, Volt-Ohmmeter and electronic tube tester. You learn about electronic principles, trouble-shooting, hi-fi, multiplex systems, stereo and color TV servicing.

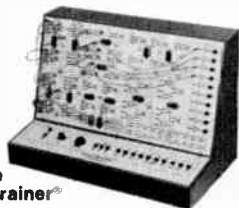


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The B&W TV receiver features the latest in *solid-state circuitry*, making your TV training the most modern, most advanced available.

NTS COMPUTER ELECTRONICS

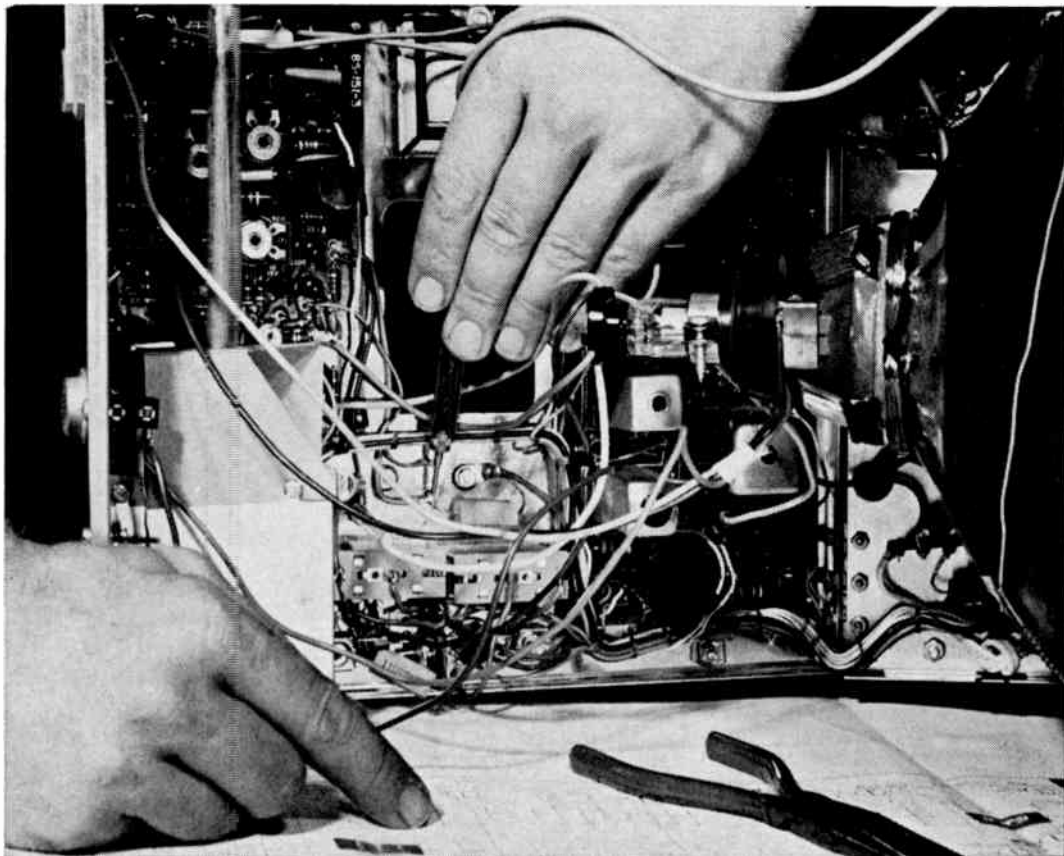
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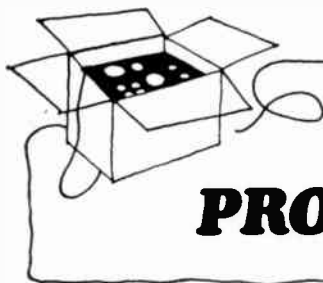
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NEW PRODUCTS

Additional information on products described in this section is available from the manufacturers. Each new product is identified by a corresponding number on the Reader Service Page. To obtain additional information on any of them, circle the number on the Reader Service Page, fill in your name and address, and mail it in accordance with the instructions.

B&K TRIGGERED SWEEP OSCILLOSCOPE—Identical to the instrument described in last month's "Product Gallery" (from another manufacturer) is B&K's (*Dynascan Corp.*) Model 1460 triggered sweep scope. Completely solid state except for the CRT (5" screen) the unit has 1650 volts on the accelerating anode to insure sharp patterns at fast writing speeds (0.1 microseconds per cm). The vertical amplifier goes out to 10 MHz; horizontal bandwidth is dc to 800 kHz (3 dB). There is a FET input stage and the triggering circuit is the active filter type.

Circle No. 79 on Reader Service Page 15 or 95



SCOTT AUTOMATED STEREO TUNER—A developmental prototype now in the works at *Scott* may take all the pain out of tuning an FM stereo receiver. There are four methods by which a station can be selected. One is by the insertion of a card into a slot on the front panel. The other three, all pushbutton activated, provide automatic station scanning, automatic stereo station scanning, and manual channel selection. Visual frequency indication is provided by a digital readout with cold cathode indicators. A quartz crystal standard is used to provide scanning steps between the 100 channels on the 88.1-to-107.9 MHz band.

Circle No. 80 on Reader Service Page 15 or 95



SAE STEREO POWER AMPLIFIER—Three new models of power amplifiers from *Scientific Audio Electronics* provide output power per channel of 60, 90, or 120 watts, both channels driven 20 Hz to 20 kHz. Harmonic distortion is less than 0.1% from 20 Hz to 20 kHz and S/N level is 100 dB below rated output. Twelve output transistors are used with no driver or output transformer. Each channel has its own power supply and gain control.

Circle No. 81 on Reader Service Page 15 or 95



KENWOOD TAPE DECK FOR FUN TOO—Whether you want a tape recorder primarily for its reproduction of good music or you simply enjoy the fun of creative recording techniques, *Kenwood Electronics, Inc.* has a new Model KW-5066 that may satisfy both needs. A built-in test signal oscillator generates a reference signal to enable control of recording bias for optimum quality. Sound-on-sound and echo controls permit a variety of special recording effects.

Circle No. 82 on Reader Service Page 15 or 95



SHAKESPEARE FIBERGLASS BEAM—Possibly the only all-fiberglass beam antenna for CB, *Shakespeare's* "Big Blazer" 4-element Yagi is said to give up to 14 dB gain. Since it has no metal parts, "boom sag" will not set in with age. The antenna is factory pretuned, has a boom length of 16', weighs 9 lb 4 oz, and has side rejection of 22 dB and front-to-back ratio of 26 dB.

Circle No. 83 on Reader Service Page 15 or 95

(Continued on page 24)

Instant inventory.

Keep electronic components handy with Mallobin® Benchtop Organizers. Each Mallobin contains a popular assortment of electronic components in a stackable, interlocking plastic case. Fifteen partitioned drawers keep parts neat. And each drawer is color coded and labeled for quick location of the part you want. Mallobins come

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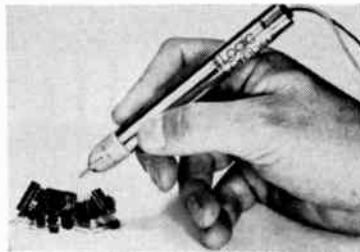


CIRCLE NO. 18 ON READER SERVICE PAGE

NEW PRODUCTS (Continued from page 22)

KURZ-KASCH LOGIC PROBE—Similar to POPULAR ELECTRONICS' "IC Tell-Tale" probe (April 1969)—but with several improvements is a new logic probe available from Kurz-Kasch. The simple readout system on the probe indicates "true", "zero", or "pulse" through two color-coded lamps. Absence of logic levels is indicated by both readouts remaining off. Applicable to DTL, TTL, or RTL IC systems, the probe can be obtained with a third readout to display high-speed pulse trains or a single-cycle pulse of less than 50 nanoseconds. Five models for various voltage ranges are available.

Circle No. 83 on Reader Service Page 15 or 95



DYNASCAN 23-CHANNEL BASE STATION—For day-in/day-out use, CB'ers will welcome the *Dynascan* Cobra 25 with crystal controlled transmit and receive on all 23 channels. A FET mixer stage eliminates cross talk, and the circuits include ceramic filters, IC amplifiers, delta tuning to reduce off-channel interference, "Dyna-Boost" speech compression. A PWR/S meter indicates relative strength of received signal and relative power output; and a SWR/Modulation meter is also included.

Circle No. 84 on Reader Service Page 15 or 95

COURIER CB WALKIE-TALKIE—At the top of a new line of hand-held CB transceivers from *Courier Communications* is the "Champion" Model CCT-4, a heavy duty unit that offers full 23-channel operation with all crystals supplied and full 5 watts with 100% modulation. The "Cheyenne" Model CCT-3 operates on 6 channels at 5 watts with 100% modulation. Both have detachable battery packs. Other models offer 6 channels at 1 watt and 3 channels at 100 milliwatts.

Circle No. 85 on Reader Service Page 15 or 95



VEXILAR DEPTH FINDER—Sonar technology is now an everyday, commonplace thing for small boat owners with the introduction by *Vexilar, Inc.*, of the Audi-Alert depth finder. Weighing slightly more than a pound, the unit has a solid-state circuit with precision meter and/or audio signal for indicators. The meter will indicate depths up to 75 ft. The transducer is 2½" long and has 15 feet of cable. Principal uses are monitoring depths to detect shoals or drop-offs while cruising and to warn of anchordrag overnight.

Circle No. 86 on Reader Service Page 15 or 95



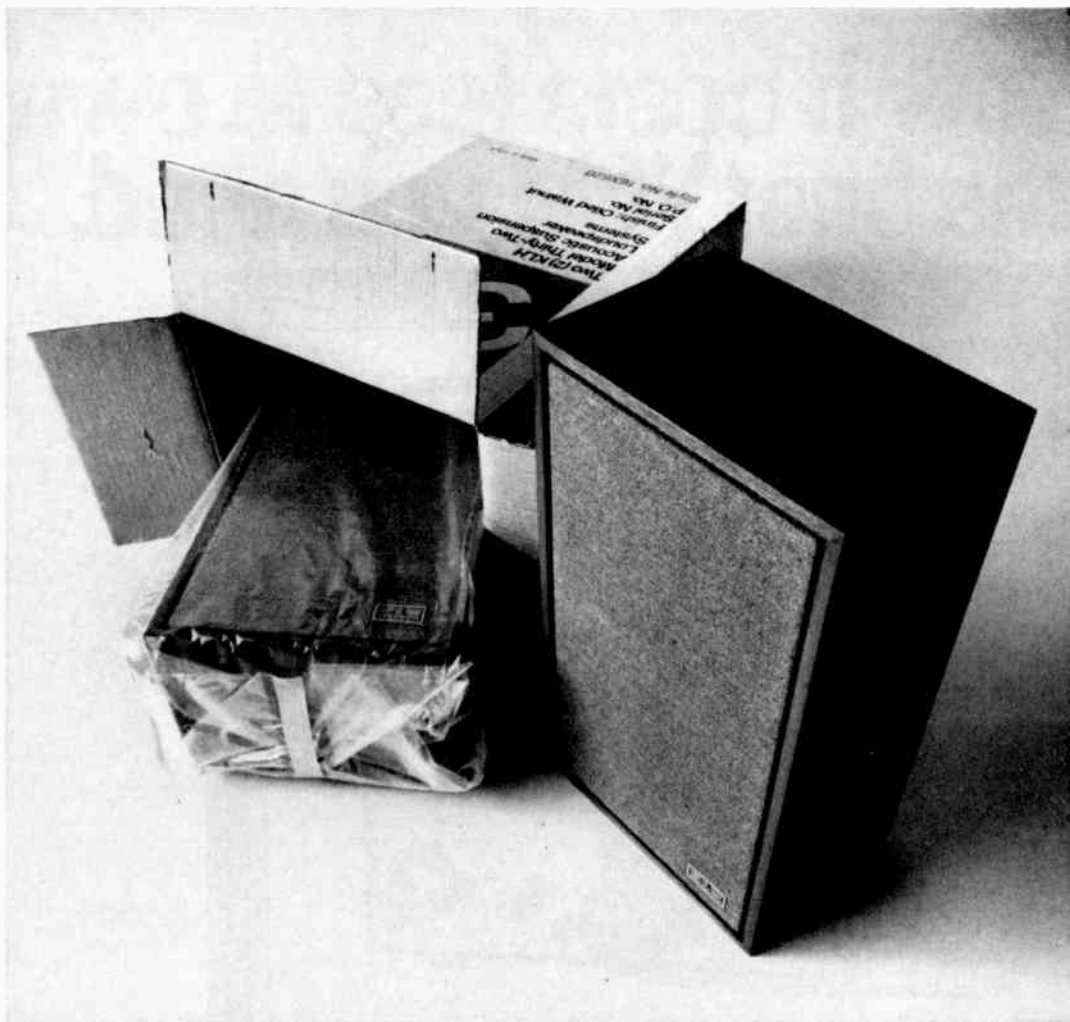
JMD HOME-MOBILE MONITOR RECEIVER—The Model RTX-MR receiver from *JMD Electronics* monitors police, fire, public safety, etc. without background noise. The solid-state monitor with squelch has provisions for 11 crystals. A model is also available to receive both high and low band, using two crystals at the same time. Units can also be ordered with a tone-activated squelch. Operates on either 117 volts or 12 volts dc with a sensitivity of 0.5 microvolts.

Circle No. 87 on Reader Service Page 15 or 95

TEAC CASSETTE DECK—Elimination of unnecessary frills has enabled *Teac Corp.* to provide a quality cassette deck (Model A-23) in the moderate price field (\$139.50). The deck has an outer-rotor hysteresis synchronous motor and all silicon transistor record and playback pre-amplifiers, plus all the other things necessary to providing low-noise performance.

Circle No. 88 on Reader Service Page 15 or 95





The new KLH Thirty-Two is the best speaker you can buy for the money.

Brovodo has never been our bog. But after carefully comparing the new model Thirty-Two with our competitor's best-selling loudspeaker, we're going to break our rule.

Our product is superior.

You see, the Thirty-Two sounds like a very close relative of our now famous Model Six.

With good reason.

It's designed like a Six. It's built like a Six. And it shares many of the Six's finest listening qualities. Bass response that curls your toes. A mid-range that seduces you with its smoothness. And an overall sound quality that finally puts an end to listening fatigue.

But the Thirty-Two not only sounds like an expensive speaker, it looks like one, too. It is unquestionably the

†suggested retail price. Slightly higher in the west.

best looking loudspeaker in its price range.

The price?

Almost as amazing as the sound. Just \$47.50 (\$95 the pair).†

Make sure you hear—and see—the new KLH Thirty-Two soon. And compare it with the best-known speaker in its price range. We are sure you will agree that there's never been anything like it for the money.

Anybody's money.

For more information on the Model Thirty-Two, write to KLH Research and Development Corporation, 30 Cross St., Cambridge, Mass. 02139. Or visit your KLH dealer.



*A trademark of KLH Research and Development Corporation

CIRCLE NO. 14 ON READER SERVICE PAGE

Now it costs less to own the best VOM you need.



The New RCA WV-510A Solid-State Master VoltOhmyst®

I.Q.*

*Inexpensive Quality
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RCA

The best you need is the new solid-state RCA WV-510A Master VoltOhmyst®. The most functional VOM we've ever produced, the 510A has all the features you'll ever need no matter what your requirements may be.

And we've added some extra features you won't find in any competitive VOM, at any price... features designed to make your work easier, help you get the job done faster.

For example: RCA WV-510A operates from batteries or AC. Remove the detachable AC line cord while you're taking a measurement and the batteries take over immediately without a flicker of the pointer. And you'll get maximum life from the batteries because they're always on trickle charge during AC operation. Stability? Switch from range to range and watch a whole series of measurements without constantly zero-adjusting the meter.

Some statistics:

Current:

0.01 milliampere to 1.5 amperes in 8 ranges.

Resistance:

0.02 ohm to 1000 megohms in 7 ranges.

DC Volts:

0.01 volt to 500 volts in 8 ranges.

AC Volts:

0.2 to 1500 rms AC volts in 7 ranges plus peak-to-peak voltages of complex waveforms.
21 megohm resistance on all DC ranges.

And it's only \$128,† complete with DC/AC ohms probe and flexible shielded input cable with BNC connector, and removable AC line cord.

Some statistics! For complete details, contact your local RCA Distributor.

RCA Electronic Components | Harrison, N. J. 07029

CIRCLE NO. 26 ON READER SERVICE PAGE

ACOUSTIC



SURFACE-WAVE DEVICES

NEW ACOUSTOELECTRONIC COMPONENTS
REPLACE CONVENTIONAL TUNED CIRCUITS

BY JAMES R. FISK, W1DTY

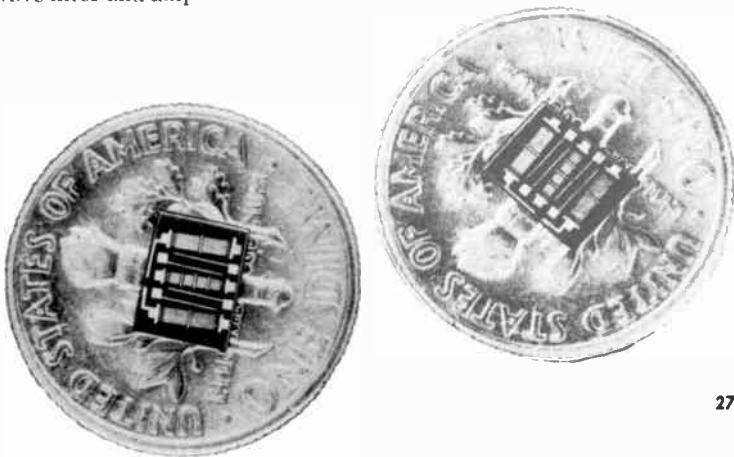
Within 3 years a wholly new technology has been quietly developed that may lead to the perfection of flat-screen TV, faster computers, better i-f strips, improved radar filters, etc. This is a report on what has been referred to as the "most significant development" since the transistor. The devices involve acoustic waves traveling on the surface of piezoelectric substrates.

THERE IS a broad interface between the sciences of acoustics and electronics. While most people think this mingling is in the area of voice radio communications and stereo sound reproduction, laboratories are quietly developing a brand-new acoustoelectronic component—the surface-wave filter and ampli-

fier. Recent advances promise that the impact on the design of electronic equipment will be equivalent to that of solid-state components.

The new technology goes by a variety of names: praetersonics (meaning beyond sonics), acoustoelectronics, surface waves, etc.; but it involves nothing more complex than honest-to-goodness acoustic waves travelling on the surface of miniature chips of piezoelectric substrates.

One company—Zenith Radio Corp.—has already developed acoustic-wave 40-MHz i-f filters for color TV. They are only 0.15 in. square and can be cascaded to synthesize the proper i-f response for color TV signals. Aside from small size, the filters have the ad-



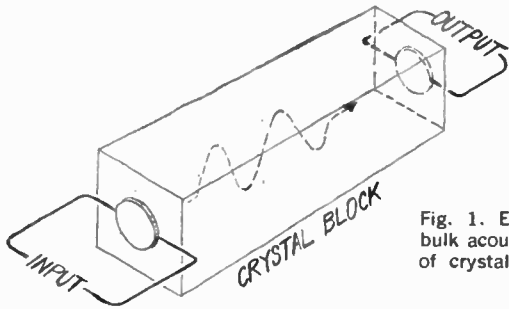


Fig. 1. Early acoustic-wave delay lines employed bulk acoustic waves which traveled through interior of crystal block from input to output transducer.

vantage of being permanently tuned. Once set, they cannot drift off frequency.

In other laboratory experiments with praeterasonics, high-gain r-f amplifiers, oscillators, resonators, signal couplers, waveguides and delay lines are being developed.

Electronic navigation and communications systems employ complex signals that must be rapidly processed and analyzed. Delay lines are essential to this process since they can store the signals and compress, expand, or decode their waveforms. These functions are usually handled by lengths of stripline or coaxial cable which add bulk, are inefficient, and often introduce losses. However, praeterasonic delay lines—the first practical application of acoustic-wave technology—offer a compact way of obtaining lossless, undistorted delays up to many microseconds duration, with easy access to the signal for processing anywhere along its travel.

Actually, the first acoustic-wave delay lines employed bulk acoustic waves traveling through the interior of a piezoelectric crystal.

In its simplest form (see Fig. 1), the bulk system has a pair of transducers mounted on opposite ends of a crystal. The input transducer, excited by an r-f signal, beams acoustic energy through the crystal. The output transducer picks up the energy and converts it into a usable electrical signal. The delay is simply the time the signal remains in the block.

Bulk delay lines have one major disadvantage: it is almost impossible to tap or otherwise manipulate the signal while it is in the crystal block. Surface acoustic waves, signals that travel on the surface of the crystal instead of through the crystal block, do not suffer from this shortcoming. The signal can be sampled anywhere along its travel, after any duration, and the delayed waveform will be identical to the input waveform.

The basic surface-wave device is the delay line shown in Fig. 2. It consists of a piezoelectric substrate (such as quartz) and input and output transducers. The input transducer is an "antenna" which converts the electrical signal into an acoustic wave which travels on the surface of the substrate. At the

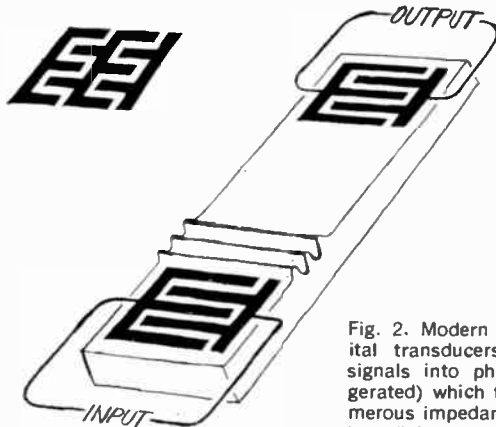


Fig. 2. Modern praeterasonic devices have interdigital transducers which translate electrical input signals into physical waves (shown greatly exaggerated) which travel along surface of crystals. Numerous impedances can be obtained by subdividing interdigital electrodes as shown at upper left.

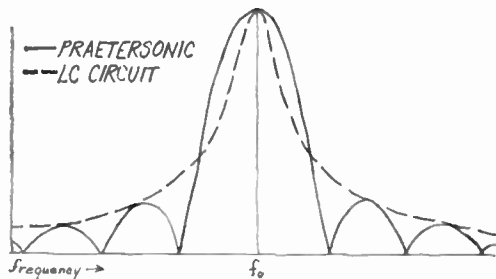


Fig. 3. Curves of conventional LC tuned circuits and praeter-sonics devices are basically similar.

other end of the crystal, the wave is converted back into an electrical signal by the output transducer.

The wave propagates rather slowly across the surface of the substrate, the delay being determined by the spacing between the transducers. A 1-inch spacing corresponds to a delay of about 8 microseconds.*

The design of the input and output transducers is extremely important since the mass and shape of the electrodes have loading effects which influence efficiency. The size of the transducer also affects bandwidth. The interdigital structure consists of two separate arrays of metal electrodes resembling interlaced fingers.

*Until recently, praeter-sonics was known as "microwave acoustics" due in part to the fact that early work in the field concentrated on devices for VHF and microwave applications. But the term "micro" is also associated with the micron wavelength of an acoustic wave on the surface of a piezoelectric crystal. At 30 MHz, for example, a 100 micron or 0.004" wavelength is possible because acoustic waves travel 100,000 times slower than do radio waves!

The r-f signal across the input transducer interacts with the piezoelectric substrate on the surface of the crystal, in opposite directions and at right angles to the electrodes. Since the acoustic wave receives an in-phase energy boost at each electrode, the wave generated by one finger pair builds up maximum acoustic power as it travels through succeeding finger pairs.

The interdigital transducer functions with relatively low loss over a wide dynamic range. By changing the number of fingers, the bandwidth can be tailored for nearly any application. Finger size and spacing determine the center frequency. So the basic acoustic-wave delay line becomes a resonator that can be substituted for LC tuned circuits. The re-

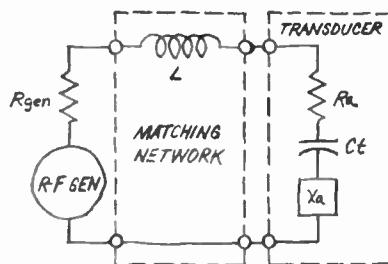


Fig. 4. Equivalent circuit of interdigital transducer is a series resistance-capacitance network.

sponse curves for a typical surface-wave resonator and a typical LC tuned circuit are shown in Fig. 3. The curves are basically similar.

The only significant difference between the simple delay line shown in Fig. 2 and a resonator is the spacing between the input and

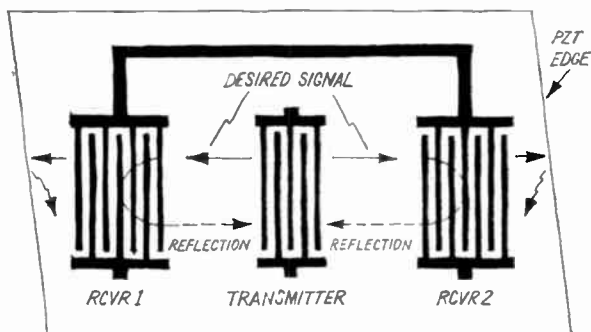


Fig. 5. To reduce losses and minimize echoes, two receiver transducers are used and substrate edges are cut at angles.

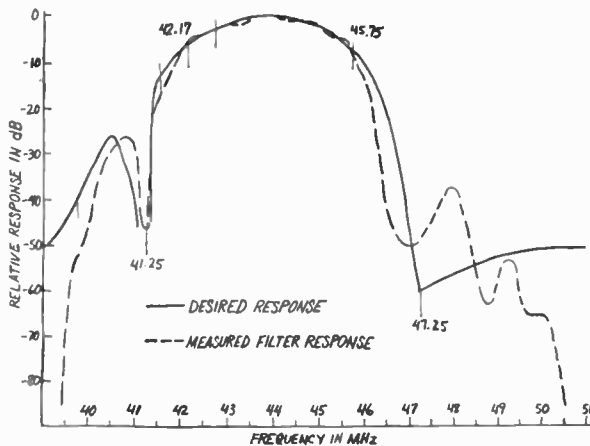
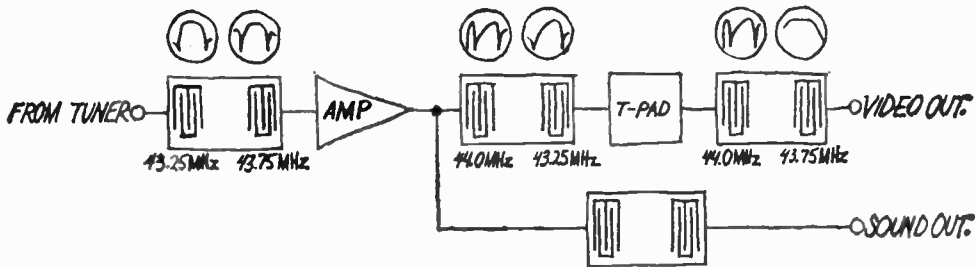


Fig. 6. Filter hookup for TV i-f strip and audio i-f take-off is shown at top. Directly above, waveform produced by filters (dashed line) is shown superimposed on desired wave shape. Both waveforms are basically similar.

output transducers. In the surface-wave resonator, the transducers are relatively close together (about 0.05" in the 40-MHz i-f filters made by Zenith).

The input impedance of the surface-wave device is determined by the number of electrode fingers and the length of the pattern. Also, a considerable impedance range is available by subdividing the electrode pattern (see Fig. 2 upper left). In practice, for the PZT material (lead zirconate titanate) used by Zenith, impedances between 20 and 1000 ohms are easily obtainable at 40 MHz.

The equivalent circuit of an interdigital transducer is a series resistance-capacitance-reactance network as shown in Fig. 4. In the diagram, R_a is the radiation resistance, X_a is the radiation reactance, and C_t is the transducer capacitance. Inductance L in the matching network compensates for C_t at the frequency of maximum response. This inductance reduces mismatch losses and has an influence on the shape of the passband.

In general, the tuning coil increases band-

width. Tuning it slightly off the frequency of maximum response skews the curve of the passband. This factor can be used to advantage when tailoring the passband to a specific requirement, such as the video i-f of a color TV receiver.

The interdigital transducer generates acoustic power that radiates in two directions. Hence, the transducers inherently have at least 6 dB insertion loss since half the power is radiated in the wrong direction. Also, if not properly terminated, this backwave can be reflected at the edge of the substrate into the delay line where it might show up as a spurious signal in the output.

To avoid the echo created by the backwave, wax is often deposited on the substrate edge to absorb the backwave energy or the surface is etched behind the transducer to scatter the backwave. Zenith cuts the substrate at an angle so that reflection of the backwave is away from the active surface of the resonator.

In addition to backwave losses, a sizable

portion of the signal arriving at the output transducer is reflected back to the input transducer, where it is again reflected. Each reflection results in a 6-dB drop in power level. This spurious echo, called the triple-transit signal, is seen at the output 12 dB below the original signal which made the trip only once. In the surface-wave i-f filter, this delayed and attenuated replica of the original signal manifests itself as a ghost on the TV screen.

Because the acoustic surface is not 100% efficient, there are transmission losses that must also be added to the losses created by the echo signals. Therefore, total losses can add up to 15 dB with tuning coils and 21 dB without the coils. A 3-dB reduction in these figures can be obtained by employing the double receiving pattern illustrated in Fig. 5, decreasing total insertion loss by lowering the directional loss of the backwave.

In Zenith's i-f filters, careful design, including the use of shield lines between transducers, has been successful in keeping reflections 30 dB below the desired signal. This appears adequate for color TV i-f strips.

Aside from passband shaping provided by the external tuning coil, the response can be broadened by increasing the terminating impedance. These two variables are used by the designer to shape the response curve to a given application.

Three cascaded surface-wave resonators

provide the required response curve for TV video in the Zenith filters. The connections between the resonators are shown in Fig. 6. Resonator A provides out-of-band rejection and moderate attenuation of the sound carrier. Resonators B and C provide a video notch at 41.25 MHz and, with resonator A, provide the proper passband, including a notch at 47.25 MHz. Resonators A and D work together to provide the proper level between the sound and picture carriers.

The measured video response obtained by cascading the three surface-wave resonators comes very close to fulfilling the desired color-TV i-f response as shown. It can be seen that the praeterasonic surface wave filter provides the required passband as well as the necessary traps at the desired locations.

When the praeterasonic i-f filter was substituted for a standard tuned-circuit i-f strip in a Zenith color TV receiver, it produced a picture of good quality with no noticeable ghosting. The amplifiers used with the experimental filter were of the wideband variety with at least a 60-MHz bandwidth.

Although the experimental Zenith filters used fairly conventional solid-state amplifiers, future designs will probably incorporate a surface-wave amplifier that is an integral part of the resonator. For useful praeterasonic amplification, the piezoelectric characteristics of the substrate should be separated from its

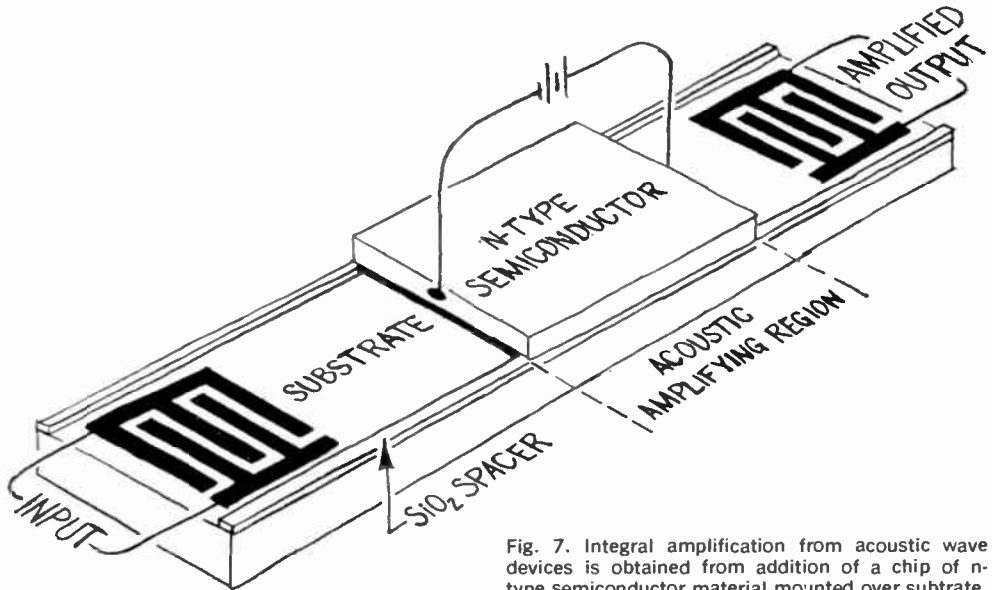
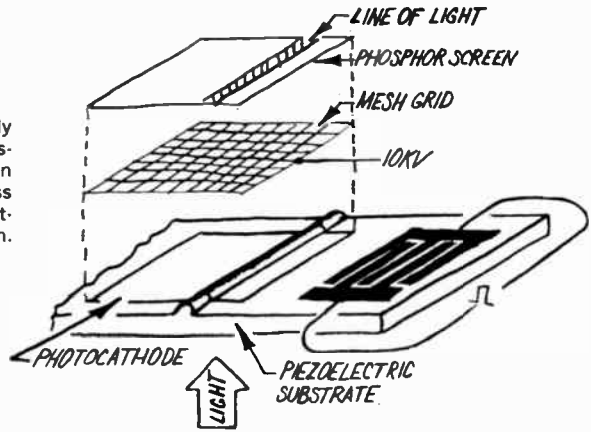


Fig. 7. Integral amplification from acoustic wave devices is obtained from addition of a chip of n-type semiconductor material mounted over substrate.

Fig. 8. Acoustic-wave devices may finally hold the key to flat-screen TV. In illustration, surface wave stimulates emission from photocathode. Emitted electrons pass through B+ boosted grid and are accelerated to produce light on a phosphor screen.



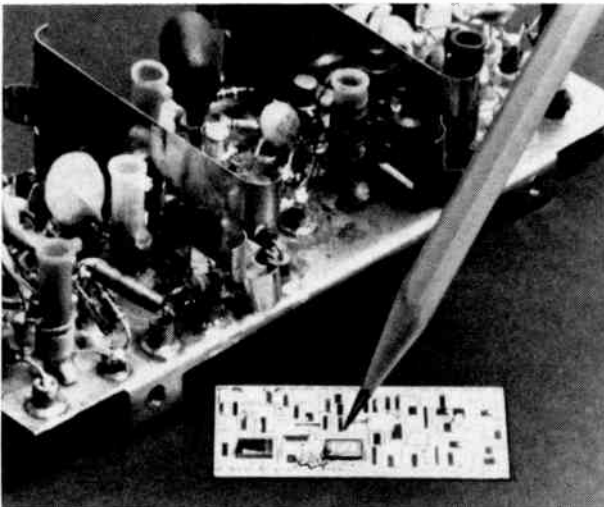
semiconductor properties. Since the electric field associated with an acoustic surface wave extends out of the surface of the crystal, it can interact with the electrons in a de-powered semiconductor placed a small distance above the crystal as shown in Fig. 7.

The basic items for the surface-wave amplifier are an optically flat piezoelectric crystal and an n-type silicon semiconductor. Amplification results from the interaction between drifting electrons in the n-type silicon and the piezoelectric field in the surface-wave device. For minimum signal distortion, the two crystals must be acoustically separated.

But for maximum field-electron interaction, the air gap must be a small fraction of the acoustic wavelength. In a typical 100-MHz praeterasonic amplifier, an air gap of about 200 millionths of an inch is used. This spacing can be obtained by a layer of silicon-dioxide that has been vacuum-deposited on the surface of the substrate.

Since the piece of n-type silicon is fairly large, it has high resistivity and requires a 2000-volt power supply for high gain. If the silicon is made very thin and broken into segments, however, 30 dB of gain is possible with a 180-volt supply.

By adjusting the supply voltage, this sys-



Zenith's thick-film circuit (foreground) is designed to replace modern bulky i-f strips (background). Ultrasonic filter at pencil tip will reject frequencies other than those desired.

tem can provide either gain or attenuation, allowing the output signal a range in excess of 100 dB. When the applied voltage is low, the surface wave is attenuated because energy flows from it to the slower moving electrons in the semiconductor. As the voltage increases beyond the point where electrons are moving faster than the surface wave, energy is imparted to the wave, resulting in gain.

The surface-wave amplifier has a built-in bonus. Reflections between the input and output transducers are attenuated so that the triple-transit signal is greater than 60 dB down from the desired signal. And the high-gain flexibility means that switches and modulators with greater than 90 dB of dynamic range are possible.

The acoustoelectronic amplifier can perform many other functions besides variable amplification. If the amplifier is operated in its nonlinear saturated region, it functions as an effective r-f mixer. Using external feedback, stable oscillation results. It is feasible to conceive a 500-MHz amplifier, mixer, and low-frequency i-f strip all operating on a single substrate.

With the arrival on the scene of the acoustoelectronic amplifier, it appears that conventional tuned LC systems have a serious competitor, at least in the frequency range from 30 to 500 MHz.

Looking into the future, praetersonics may hold the key to flat-screen TV picture tubes if current development work pans out. The basic principle for the flat screen is shown in Fig. 8. The electric field between crests of an acoustic surface wave is sufficient to control emission from a semiconductor photocathode. To use this voltage, a photoemissive material is deposited on the piezoelectric substrate. When suitably lighted, the photocathode emits electrons which are accelerated by a 10,000-volt field to produce visible light on a phosphor screen.

An input pulse produces a transverse line of light that moves across the phosphor screen, providing the horizontal scan. Vertical scan can be obtained with another acoustic beam applied simultaneously at right angles to the first beam.

Surface acoustic waves also have potential applications in high-speed data processing with bit rates in excess of 100 MHz. In this scheme, digital-logic bits in the form of acoustic pulses pass through an arrangement of transducers which perform the logic operations by providing outputs of zero or high-

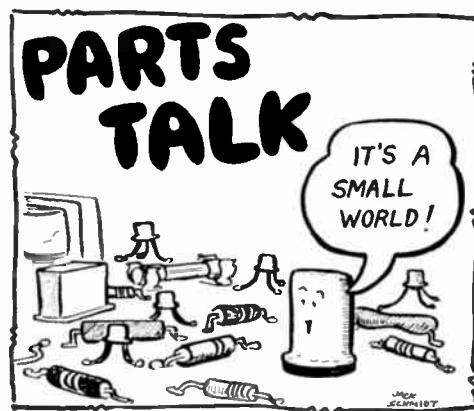
amplitude pulses. These acoustic wave pulses are then converted into pulsed r-f waveforms for further processing by an output gate circuit.

Logic inverters and NAND and OR gates have already been operated at 120 MHz with a 5-MHz bit rate. And 100-MHz bit rates are anticipated shortly.

Another important application of praeter-sonics is in the field of high-resolution radar. Current radar displays employ bandwidths of less than 10 MHz. But for high resolution, bandwidths should be on the order of 500 MHz. Broadband praeter-sonic delay lines can be used between the radar and the display to store and recirculate the signals so that they can be sampled and displayed at the lower frequency.

Since the acoustic wavelength is so much smaller than the free-space wavelength, many signal-processing techniques that have been previously confined to the microwave region can now be translated to the lower frequencies. Acoustic waveguides operating at 5 MHz are possible, as well as are strip-line-type directional couplers and other hardware familiar to the microwave technician. A lab-built directional coupler for 5 MHz, for example, provides up to 20 dB of isolation and its total length is only 6 inches.

Although praeter-sonics is a new technology, it has evolved from theory to practical hardware in less than three years. It is difficult to tell if we can expect the same rate of progress in the future, but praeter-sonics promises to have at least as much impact on electronic circuitry as did the introduction of the transistor. It is now only a matter of time before this prediction becomes reality. -50-



Building and Using The

2XY CALIBRATOR

DOUBLE-AXIS OSCILLOSCOPE CALIBRATOR

USES ZENER DIODES



This circuit involves the use of a pair of matched zener diodes to obtain true horizontal or vertical oscilloscope scale calibration. The author designed the circuit for a diode and transistor curve tracer, but its ease of construction and versatility make the calibrator useful for many functions. Details on matching zener diodes for the circuit are also given.

MANY TIMES in using an oscilloscope, it is advantageous to have the vertical and/or horizontal traces calibrated so that accurate values of the quantity being measured can be determined. There are several ways in which this calibration can be performed but you will find the simple double-axis calibrator described here to be an easy, accurate instrument that permits adjustment of either axis calibration voltage to almost any level.

The circuit of the calibrator is based on the simple phase-shift network shown in Fig. 1A. In this circuit, the voltages at the two ends of

the transformer secondary are 180° out of phase. With the addition of the resistor-capacitor circuit the voltages at V and H are made to have a phase difference of 90° . When connected to an oscilloscope (and with the gain controls properly adjusted), these V and H outputs produce a circle (or ellipse) on the scope. The vertical and horizontal diameters correspond to the respective peak-to-peak voltages. One shortcoming of this circuit is that the output cannot be varied in level since a potentiometer connected across the output would change the phase relationship.

If a pair of diodes is added as shown in Fig. 1B, the negative portions of both vertical and horizontal signals are cut off so that the scope pattern becomes a quarter circle. Finally, if the diodes are zeners, the cutoff voltage is higher and the transition from cutoff to conduction is sharper than with ordinary diodes. Thus a square pattern is obtained on the scope as shown in Fig. 1C.

The actual circuit of the double-axis calibrator is shown in Fig. 2. With the high-resistance potentiometers across the outputs,

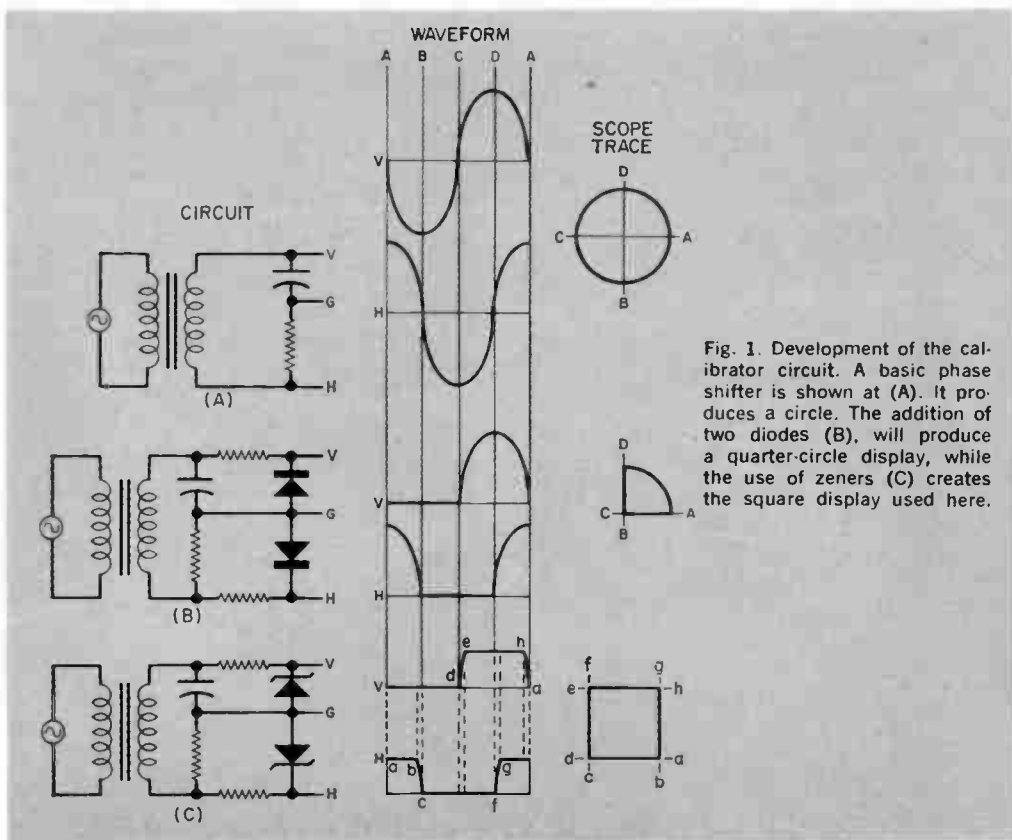


Fig. 1. Development of the calibrator circuit. A basic phase shifter is shown at (A). It produces a circle. The addition of two diodes (B), will produce a quarter-circle display, while the use of zeners (C) creates the square display used here.

the voltage can be preset from zero to the maximum determined by the zener diode.

Construction. The circuit can be built in any type of chassis or possibly within the cabinet of the oscilloscope—as long as the potentiometers and calibrated dials are available. Wiring can be point-to-point, using terminal strips to support the various components. Parts placement is not critical. If a

transformer with a higher voltage on the secondary is used, increase the wattage rating of $R1$. If the transformer secondary voltage is lower, the zener diodes and resistance values for $R2$ and $R3$ must be selected accordingly.

Any zener diodes with ratings of 25 volts or more may be used in the circuit as shown. If diodes rated above 25 volts are used, increase the transformer secondary or lower the value of $R2$ and $R3$. If the top right-hand

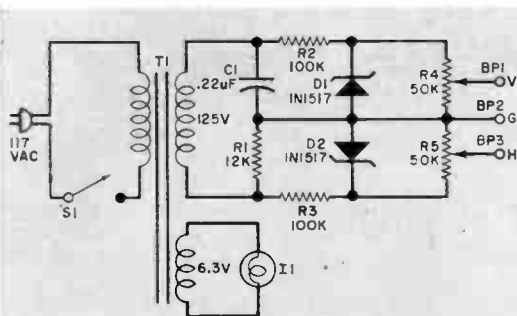


Fig. 2. The final circuit uses calibrated output potentiometers, and an optional power on-off lamp to indicate when the calibrator is in operation.

PARTS LIST

- $BP1, BP3$ —Five-way binding post
- $C1$ —0.22- μF , 200-volt capacitor
- $D1, D2$ —1N1517 zener diode (see text)
- $I1$ —6.3-volt pilot lamp
- $R1$ —12,000-ohm, 1-watt resistor
- $R2, R3$ —100,000-ohm, 1/2-watt resistor
- $R4, R5$ —50,000-ohm linear taper potentiometer
- $S1$ —Spst slide or toggle switch
- $T1$ —Transformer: secondaries: 125V at 15mA, 6.3V at 600 mA.
- Misc.—Pointer knob (2), dials (2), line cord, suitable chassis, pilot lamp holder and lens, terminal strips, mounting hardware, etc.



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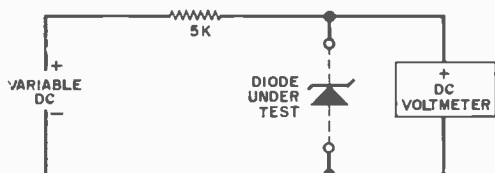
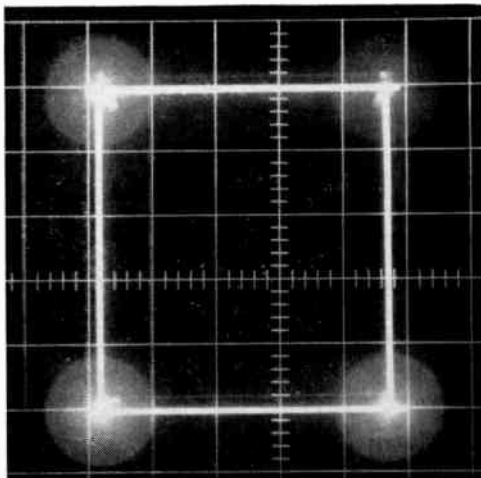


Fig. 3. This circuit can be used to check the operating voltage of any zener diode as long as the applied voltage is above actual diode requirement.

corner of the displayed pattern is rounded, it can be squared off by slightly decreasing the value of $R2$ and $R3$. Resistance of $R4$ and $R5$ is not critical, but it should not be lower than that specified.

Diode Calibration. The specified operating voltage of a zener diode is usually a nominal value. To determine the exact value for a specific diode, connect it in the circuit shown in Fig. 3. As the dc voltage is increased from zero, the voltmeter will indicate upscale until the zener goes into conduction. A further increase of the applied voltage will not change the meter reading. Note the point at which the meter just peaks. Reverse the diode and repeat the process, placing the voltmeter on a lower range. The indicated voltage will be very much less (approximately 0.5 volt) since the diode is now forward biased. Add the two voltages to obtain the voltage represented on one side of the square pattern at the maximum setting of the potentiometer. Repeat the calibration procedure for the other zener diode.

Diode Matching. Unless you are lucky, two zener diodes will have slightly different

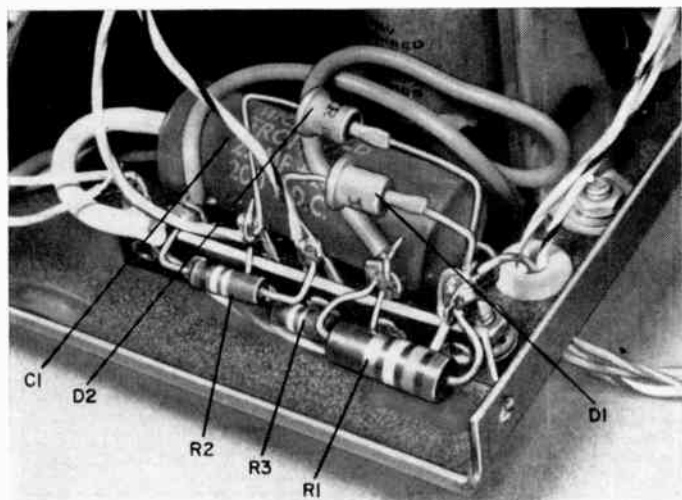


This is a typical calibration square as seen on a scope. The bright spot at each corner is due to the relatively long dwell period of the trace.

voltages. This can be tolerated since the two potentiometers will be calibrated independently. If you prefer to have the maximum indications of the potentiometers the same, or if you want to use a dual precision potentiometer, the diode circuits will have to be matched.

Connect the ground and either of the calibrator outputs to the scope horizontal input. Set both calibrator potentiometers to maximum; then adjust the scope horizontal gain until the trace occupies some given number of divisions on the horizontal axis. Now leave the horizontal gain control where it is and remove the calibrator output from the horizontal in-

(Continued on page 97)



The entire circuit can be built up on a single terminal strip with the circuit wired point-to-point. The three leads are optional scope input connectors.



Build a DIGI-VIEWER

AUTOMATIC
IN-OPERATION TESTING OF DIGITAL IC'S

Using simple Darlington pair transistor amplifiers, this handy digital IC tester can be built for under \$20 and will be a boon to the experimenter or technician who can't afford complex commercial equipment. At the same time, it is much more practical than simple one-circuit probes. By tying the IC's circuit in with the tester, a complete unit can be checked visually in a matter of seconds.

THAT OLD BUGABOO, testing in-circuit digital IC's, has finally been conquered for the experimenter/technician. (Assuming he's tired of one-lamp probes and can't afford a complex computer system.) The Digi-Viewer, which can be built for under \$20, is a simple visual display that indicates immediately the

state of every stage of an IC while it is operating in the circuit.

The Digi-Viewer consists of 16 indicator lamps driven by 16 Darlington pair transistor amplifiers. When these circuits are attached to the pins of an IC through a special clip-on connector, the lamps light or don't light depending on whether the potential on the respective pin is over or under 1.4 volts—thus indicating the "on" or "off" logic state. To identify which lights are which for specific IC's, a transparent overlay of the circuit arrangement is slipped between the rows of lights on the top of the Digi-Viewer and the faulty circuit can be located at once.

The Digi-Viewer can be used on any 14- or 16-pin dual in-line package, including RTL, DTL, TTL, and most of the newer MOS types. Due to the extremely low loading factor, there is no need to worry about overload-

BY DON LANCASTER

ing the IC. By substituting an IC in a circuit that is known to be good (using a socket), you can perform use tests and also find out whether or not the IC is good.

Construction. The schematic of the Digi-Viewer is shown in Fig. 1. The diodes, resistors, and transistors are mounted on a printed circuit board as shown in Fig. 2. As shown,

the Digi-Viewer is designed to handle 16-pin IC packages. If you have no need for the 16-pin version, two of the Darlington circuits (at one end) and their associated lamps may be omitted.

Any type of chassis may be used; the prototype was built in a 6" × 4½" × 2½" cabinet. The important thing is the placement of the lamps on the top surface. Space the lamps on

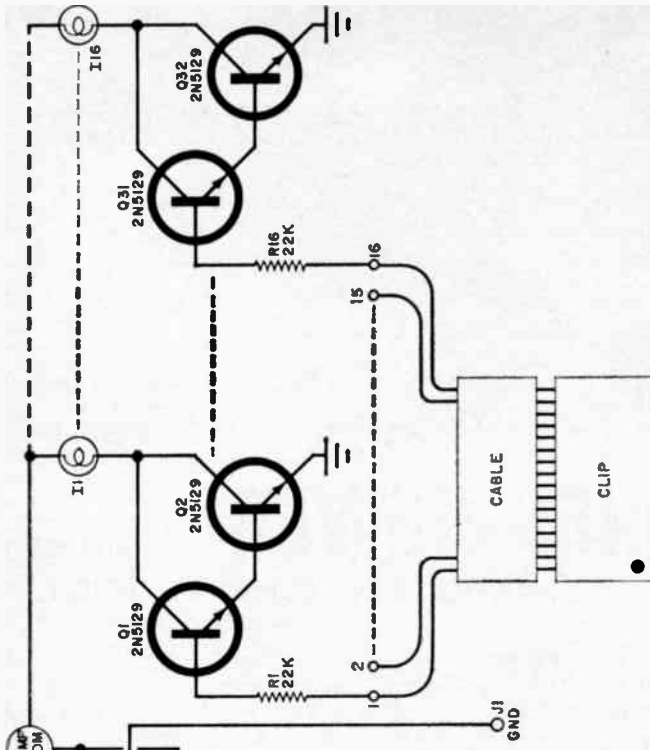


Fig. 1. A lamp goes on when the input exceeds 1.4 volts and goes off under that level. Input current is about 20- μ A before tested IC's are not loaded. Input capacitance is about 20-pF per line enabling use on all but highest speed circuits.

PARTS LIST

- C.A1—16-conductor flat cable, 2½ ft., #28 wire (3M 3365-16)
- C.LIP 1—16-pin integrated circuit test clip (API DIP)
- D1, D2—1A, 50V diode (1N4001 or similar)
- I1-I16—5-volt, 50-mA miniature lamp assembly with plastic cap (Southwest #57ASP-007)
- J1—Miniature uninsulated banana jack
- Q1-Q32—T transistor (National 2N5129)
- R1-R16—22,000-ohm, ¼-watt resistor
- S1—Spst slide or toggle switch
- T1—Filament transformer; secondary: 12.6V CT, 2.4

Misc.—2½ ft. insulated flexible wire, banana plug, miniature alligator clip, heat-shrinkable tubing, suitable chassis, dry-transfer marking, grommets, line cord, strain relief, spacers, mounting hardware, plastic and ink for slides, etc.

Note—The following are available from Southwest Technical Products, Box 16297, San Antonio, TX 78216: drilled and etched printed circuit board at \$2.65 postpaid; IC test clip at \$5.95 postpaid; complete kit of all parts including PC board, IC clip, and basic set of most-used circuit slides, chassis, etc. at \$19.85 plus postage and insurance for 4 lb. Slides for special types of IC's are also available.

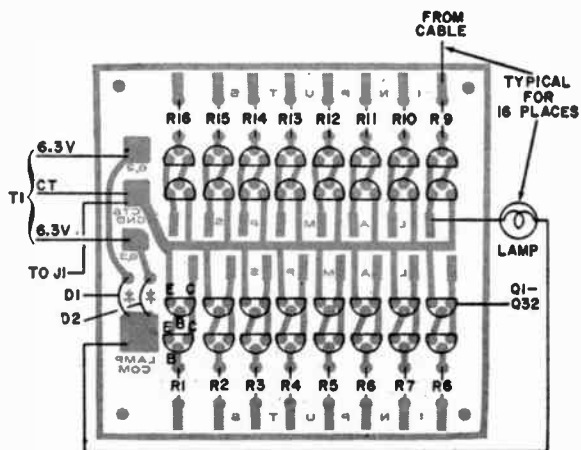
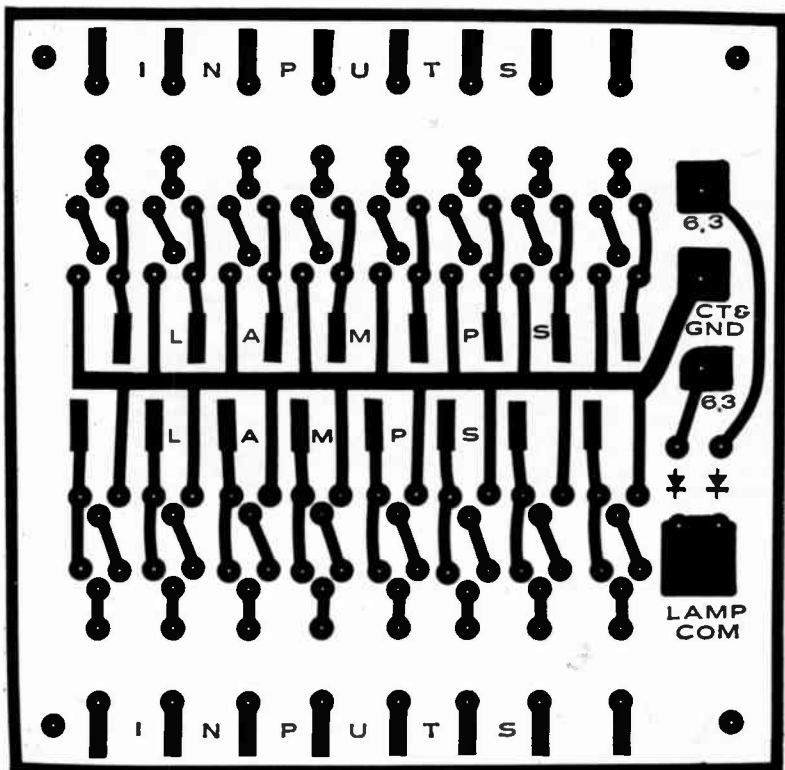
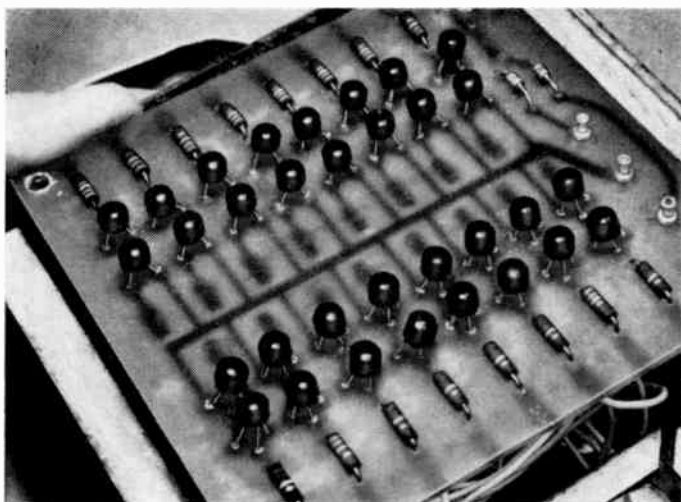


Fig. 2. Actual size foil pattern (above) and component installation (left) for a 16-terminal tester. If you need only 14 terminals, two end circuits are removed and two leads taken from 16-lead cable.

$\frac{1}{2}$ " centers with the two rows $1\frac{3}{4}$ " apart. Drill the lamp holes just large enough for a press fit with the lamp assembly. Determine which way the display is to be observed and make a conspicuously large dot at the number 1 lamp (pin). You can also outline the lamps with an IC layout, being sure to include the

notch between pin 1 and pin 14. Use permanent black ink.

With the lamps installed, solder one end of each lamp to the common ground solder pad on the foil pattern. Then, being very careful, solder the other leads to their respective solder pads that are connected to the transistors.



Connection to each lamp driver is made on the foil side of the board. The use of PC board terminals is optional as leads can be soldered directly to foil.

Looking down on the board, note that the transistor arrangement follows the pin arrangement of an in-line IC.

Mount the transformer on one wall of the chassis, and connect the three secondary leads to their appropriate pads on the board. Connect the primary to switch *S1* mounted on the top of the tester. Use a strain relief or rubber grommet where the line cord goes through the chassis. Mount the printed circuit board on four spacers.

Connect the 16-lead flat input cable to the input terminals on the circuit board, making sure that, when it comes to soldering the cable to the clip on the other end, you can identify and arrange the leads correctly. There must be a pin-for-pin correspondence between the lamps on the board and the clip. (If you are using only 14 pins, two leads may be removed from the cable.) Drill a hole and fit it with a grommet to hold the flat cable. Draw the cable through the hole in the chassis and connect it to the test clip. Identify pin 1 with a wear-proof mark. Use small lengths of heat-shrinkable tubing at the clip end to improve the looks, strengthen the cable termination, and remove the probability of short circuits.

For high-speed logic systems, including TTL, the multi-lead cable should be less than 2' long. Longer lengths are acceptable for RTL, DTL, and MOS circuits.

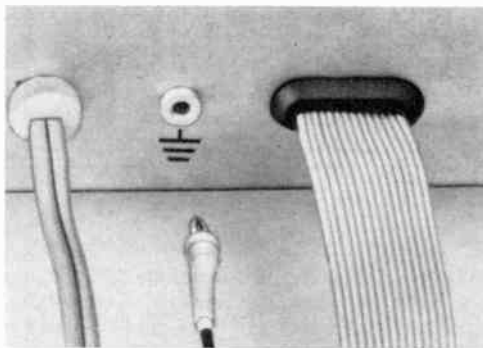
For the ground connection, use a conventional banana plug and jack with a piece of flexible wire 2 or 3 feet long. Terminate the other end in a miniature alligator clip. The ground jack (*J1*) is connected to both the metal case and the PC board ground.

Make up some plastic slides with cutouts

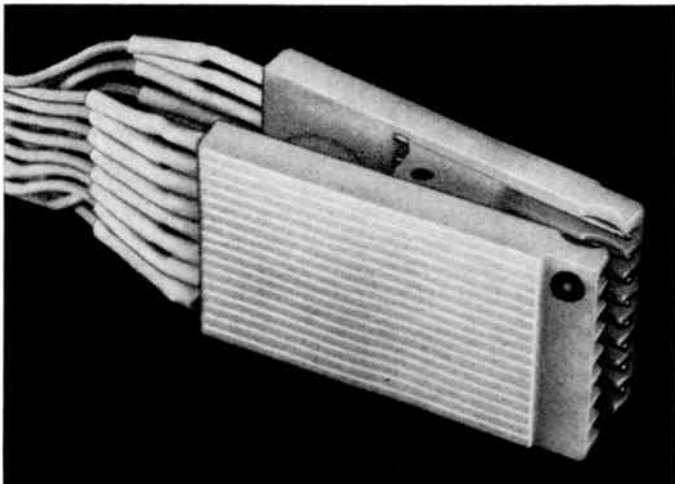
for the lamps so that they fit between the two rows of lamps. Mark the plastic (with permanent ink or temporary grease pencil) with the logic of the circuit to be tested.

Checkout and Use. With power supplied to the unit, connect the ground clip to the negative end of a 1.5-volt cell. As the positive end of the cell is connected to each pin of the test clip (via a test lead), the appropriate lamp should come on. The bulbs must correspond to the clip terminals.

To use, snap the correct slide into place and connect the ground clip to the ground terminal of the circuit under test. Connect the large test clip to the IC being tested, making sure that the locator dot at pin one is correctly positioned on pin 1 of the IC. Just open the test clip with a little pressure at the top end



Both the power line and 16-lead cable are passed through the metal chassis via rubber grommets. The ground jack (*J1*) is positioned at the center.



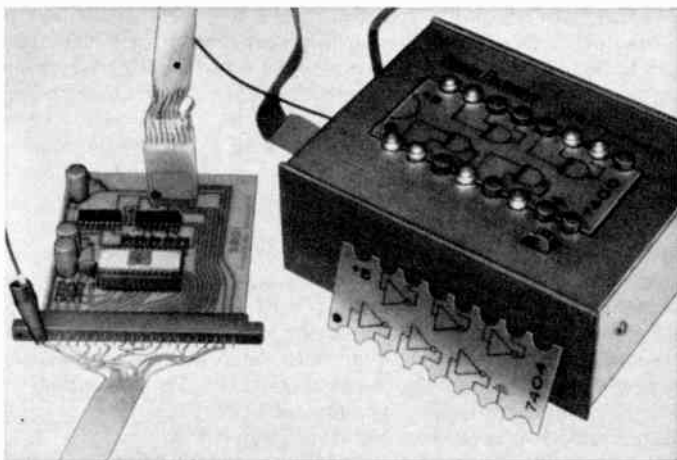
After wiring the 16-lead cable to the IC clamp, identify one end pin of the clamp with a dot to indicate pin 1. Make certain that each terminal of clamp corresponds with a similar terminal on PC board. Heat shrinkable tubing is used at cable-clamp interface for protection.

and fit it down over the IC. On a 14-pin inline IC, the two right-hand clip connectors will be off the right side of the IC away from the locator notch or dot code.

The first thing to note is that operating voltage is applied to the IC. This is indicated by the lighting of the lamp at the power supply pin. The ground lamp should not be lit. Now check that the input pins that could hold the IC at reset, zero or other state have the correct voltages on them to permit proper operation. Generally, RTL direct set, reset, and direct clear inputs are disabled by grounding, while their counterparts in TTL and DTL are made positive to disable. There

are enough exceptions to this rule however that the appropriate data sheets should always be on hand to check any IC to be tested.

After checking the various conditions that could cause difficulties, the logic rules for the IC should be verified. For example, on an inverter, when the input lamp is on (signifying a positive input), the output lamp should be off (signifying a grounded output), and vice versa. If both lamps are on, the IC is bad or there is an open ground. If both lamps are off, the IC is bad or the output is shorted. In the case of a flip-flop, the output lamps should turn on and off at half the rate of the input lamp. At high switching frequencies, the in-



To use, simply affix the IC clamp to the IC under test making sure that pin 1 of the clamp is contacting pin 1 of the IC. Also make sure that the tester ground lead is connected to the IC ground terminal lead.

put and output lamps will all be on but with partial illumination due to the high switching speed. Proportional brightness can also be used as a relative indicator of the duty cycle of other "too fast to see" signals. The logic can be cycled at a slower rate by using an external oscillator so that the indications become clear. A bounceless pushbutton may be used to "step" the logic manually, for a more detailed analysis. While you will not be able to see such things as a one-microsecond reset

pulse, the indicator lamps connected to the flip-flop outputs will show the effects of such a pulse.

A few digital IC's have open collector circuits (readout drivers for example). An unused open collector in a system may never get to a high state and thus may show an off condition on its lamp even when the IC is perfectly good. If there is no connection to these outputs, then a pullup resistor of about 2200 ohms to the circuit positive may be used. -30-

Leakage Current & Electrical Shock

BY PAUL B. JARRETT, MD

THE SENSITIVITY of man to electric shock and electric currents is well established. Until recently, physicians could discount the effects of minute currents and low voltages because of the insulating properties of the skin. When dry and calloused, the skin has an average resistance of about 100,000 ohms. Skin wet with perspiration, however, may have a resistance of less than 1000 ohms. Skin resistance varies with body area and vasomotor (flushing or capillary constriction) response.

A current flow of from 9 to 14 mA produces discomfort. With a current of 15 to 25 mA, the victim loses his ability to release the conductors due to muscle contraction in tetany. At 25 to 50 mA, respiratory paralysis can occur (depending on the current path) and the victim is in pain. If the current reaches 75 to 100 mA, ventricular fibrillation (heart irregularity) ensues and at 200 mA, or over, there is total cardiac standstill.

No Skin Insulation. A source of current acting on the body from under the skin is another matter. At 20 μ A this current, if applied directly to myocardium (heart muscle) for more than 3 milliseconds, will produce fatal ventricular fibrillation.¹ In medical circles particular emphasis is now being placed on external cardiac pacemakers with transverse bipolar electrodes inserted through the right jugular vein. An engineering analysis of the death of one such patient has recently been discussed in the literature.²

It was determined that the external pacemaker had not been grounded, but instead was being supplied ac power from a 2-prong, 10-foot extension cord. Measurement of the leakage current of the pacemaker including the 3-wire power cable of the instrument itself, plus the 10-foot extension cord, revealed a current of 54 μ A. Unfortunately, the patient with the pacemaker had been placed on an electrically operated bed that had been grounded to the hospital power system. The leakage current passed from the electrode into the patient's heart through his body and into the ground connection on the bed.

This accident has emphasized the growing interest in safety problems associated with medical electronic apparatus. Hospital personnel must be properly instructed about electrical safety.³ Patients with internally placed electrodes must not be placed in beds with ground connections that are accessible to the patient. The pacemakers should only be used with a current limitation device of 5 μ A under any condition. Untrained hospital personnel should also be taught the use of a new electrometer which permits safety monitoring of electronic equipment for leakage currents, static charges, and insulation resistance.⁴—Dr. Paul B. Jarrett

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1. J.M.R. Bruner, *Anesthesiology*, 28/2, 1967.
 2. Von Der Mosel, *Measurement & Data News*, Vol. 4 No. 4, July & August 1970.
 3. Von Der Mosel, *Medical-Surgical Review*, Oct.-Nov. 1970.
 4. Roveti Instruments (Mod EP-3), Annapolis, Md.



NON-DESTRUCTIVE TRANSISTOR TESTER

Check or Match Transistors and Diodes

BY JOHN L. KEITH

BUYING SURPLUS or bargain-package transistors is a little like buying a pig in a poke. Especially if you get one of those so-called "computer boards" to which several transistors, usually unmarked, are connected. You may get some real high-quality, expensive units—some others may be completely useless. For the most part, the transistors that are in operating condition can be put to good use by the experimenter, provided he can sort them out as to type and identify their parameters. This can be done of course with a good transistor checker but not everyone has one of those so the simple transistor tester described here comes in very handy and saves time and money.

The transistor tester can be used to check either npn or pnp transistors and will measure leakage down to 10 μ A and collector current to 10 mA. You can measure I_{CO} , I_C (with 20 or 100 μ A of base current), I_{CEO} , I_{CES} , and I_{EO}

(see sidebar for definitions). Diodes can also be checked by connecting them between the collector and emitter pins of the test socket. The tester is also useful for checking two transistors that must be matched for a specific application.

The tester has been designed so that it will check almost any type of transistor and cannot harm a unit regardless of the switch positions or the way the transistor is connected to the test socket.

Construction. As shown in the photographs, the prototype was built in a conventional plastic utility box with all components except the batteries mounted on the cover and with point-to-point wiring. The circuit is shown in Fig. 1.

The internal resistance of the meter movement is an integral part of the circuit. The combined resistance of the meter, R_5 , and R_1

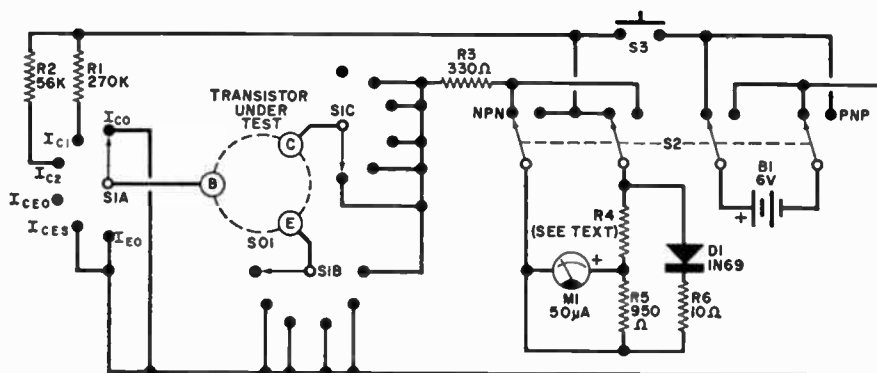


Fig. 1. All major transistor parameters can be checked using this tester since the novel circuit enables measurements from a low of 10 microamperes to high of 10 milliamperes.

PARTS LIST

- B1—6-volt battery (4 flashlight cells)
- D1—1N69 diode
- M1—50- μ A meter (Calectro D1-910 or similar)
- R1—270,000-ohm, $\frac{1}{2}$ -watt resistor
- R2—56,000-ohm, $\frac{1}{2}$ -watt resistor
- R3—330-ohm, $\frac{1}{2}$ -watt resistor
- R4—See text
- R5—950-ohm, $\frac{1}{2}$ -watt resistor

- R6—10-ohm, $\frac{1}{2}$ -watt resistor
- S1—Three-pole, six-position rotary switch
- S2—Four-pole, two-position rotary switch (Calectro E2-167 or similar)
- S3—Spst, normally open pushbutton switch (Calectro E2-140 or similar)
- SO1—Transistor socket
- Misc.—Suitable cabinet with cover (Calectro J4-726), knobs (2), battery holder, mounting hardware, wire, solder, etc.

must be 12,000 ohms. The value of $R4$ must be chosen to obtain this value as closely as possible. With the meter specified in the Parts List, $R4$ should be about 11,000 ohms. This insures full compression and, with the circuit of $D1$ and $R6$, provides a full-scale reading of 10 mA.

Operation. Insert the transistor to be tested in the test socket, place $S1$ on either I_{C1} or I_{C2} , and depress pushbutton switch $S3$. The meter should deflect upscale when $S2$ is in the

proper position. The position of the switch for upscale deflection determines whether the transistor is npn or pnp.

To check the dc gain (H_{FE}) of the transistor, place $S1$ on either I_{C1} or I_{C2} , depress $S3$, and note the meter indication. Then determine the gain from the conversion table. Note that position I_{C1} is for a base current of 20 μ A while position I_{C2} supplies a base current of 100 μ A. The gain is different for the different base currents.

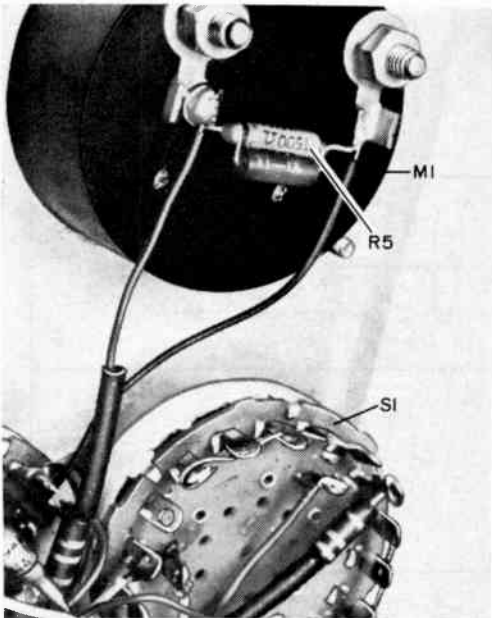
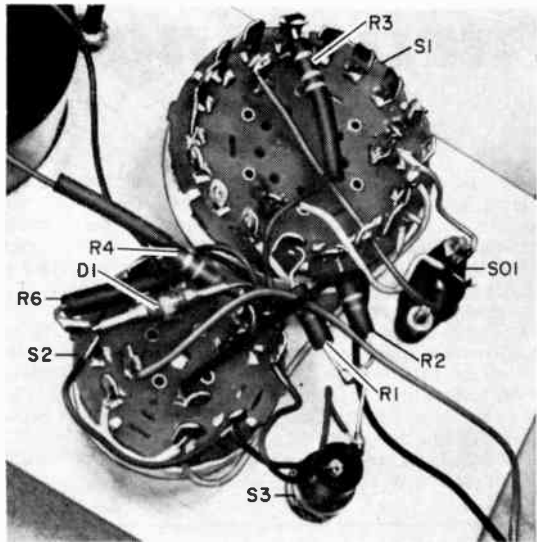
The other four positions of $S1$ are to test

PARAMETER DEFINITIONS

- I_{CEO} —Collector current with base open. The polarity of the applied voltage is such that the collector-base junction is biased in a reverse direction.
- I_{CEB} —Collector leakage current with base shorted to emitter. Equivalent to the leakage current of collector diode if emitter junction were not present. The polarity of the applied voltage is such that the collector-base junction is biased in a reverse direction.

- I_{EO} —Sometimes called I_{EBO} . Emitter-base current with collector open. The polarity of the applied voltage is such that the emitter-base junction is biased in the reverse direction.
- I_{CO} —Sometimes called I_{CBO} . Collector-base current with emitter open. The polarity of the applied voltage is such that the collector-base junction is biased in the reverse direction.
- I_C —Collector current—depends on the amount of base current supplied. A measure of dc gain (H_{FE}).

All the components except the battery are mounted on the front panel. The small parts such as resistors, capacitors and diodes are soldered directly to the two switches.

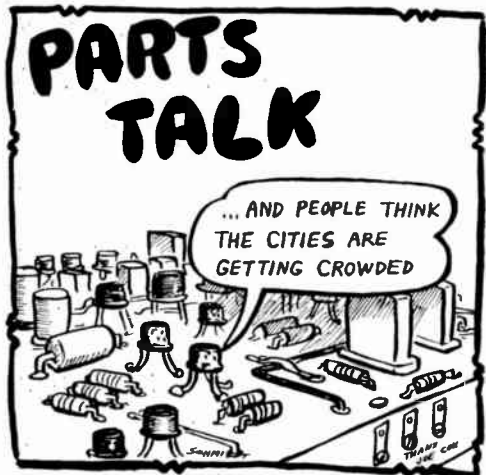


Two resistors in parallel are used to make up the meter shunt resistor (R5) in order to obtain the required resistance value. Here again the components are mounted directly on the meter terminals.

for leakage currents. Obviously, the less leakage in any case, the better. In these tests, the meter indicates directly in microamperes.

To check a diode, connect it between the emitter and collector pins of the test socket and place *S1* in either the I_{c1} or I_{c2} position. Depress *S3* and note the meter readings when *S2* is in the npn and pnp positions. Ideally, in one position, the meter should indicate full scale and it should give no indication in the other position—indicating that the diode conducts in one direction and not the other. The lower the ratio between the two readings, the poorer the diode.

—30—



Switching Logic Quiz

BY ROBERT P. BALIN

Switching circuits do only what they are logically designed to do. Understanding this logic is very important in designing electronic circuits. In the switching circuits below, the lamp symbols may represent lamps or some other device or decision. Switches which simply apply and remove power in a practical circuit are not shown. Match the statements (1-10) to the circuits (A-J).

1. Scientists must be in complete agreement before they can fire a missile.
2. A code is used to indicate whether the front, rear, or both doors are open.
3. When the darkroom light is on, the warning light outside is off, and vice versa.
4. Either one or both of the operators can start

the motor.

5. Since the pilot might get excited and push the wrong button, they are wired so that, regardless of which is pushed first, the canopy is blown off, and the second ejects him from the plane.

6. Only the fastest gun can hit his target.

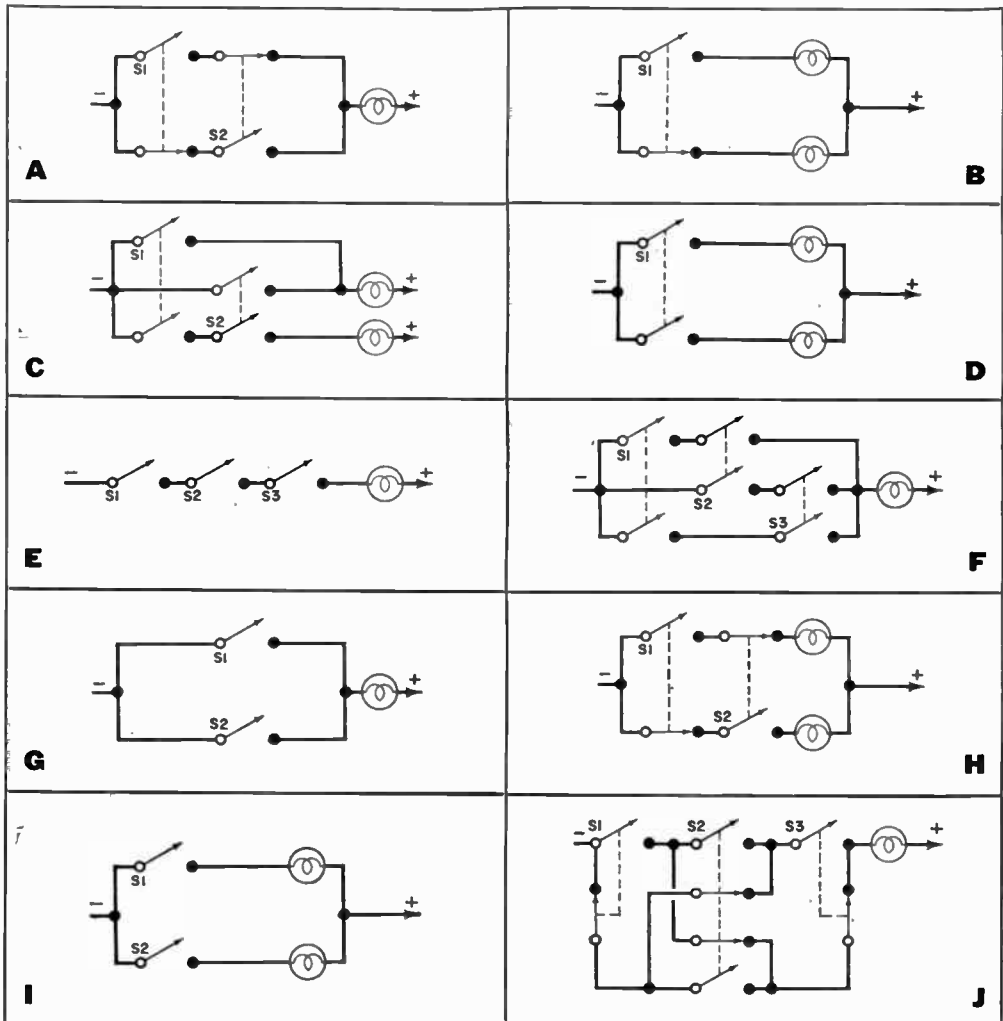
7. The decision will be made by a simple majority of the voters.

8. You can turn on the light before you climb the stairs and extinguish it from the top.

9. Let me know if an odd number of those present want to go ahead.

10. We want an indicator lamp to light when the amplifier is on.

(Answers on page 96)





LESLIE EFFECT SIMULATOR

*All-Electronic
Organ Accessory
That Sounds
Like A
Leslie*

The true Leslie speaker system is a cumbersome and costly organ accessory. The almost identical sound effect can be achieved by inserting the device described here between the keyed tone generators and the power amplifier in your electronic organ. Through use of a wobbled bandpass filter, the Leslie effect is reproduced by the main amplifier and speaker. Adjustments on the simulator permit the operator to duplicate roughly the acoustic effects of vibrato, tremolo, and Leslie.

THE SPECIAL EFFECTS Leslie speaker system is a popular addition to any organ—acoustic or electronic. Usually a “Leslie” system refers to a mechanical means of obtaining a vibrato-like sound effect—a gentle

undulation of intensity at a rate of 8 to 12 Hz. Even in modern electronic organs, the Leslie uses a massive rotating diffuser to disperse the sound from an extra speaker. It is effective, but also massive, noisy, and costly. Described here is a system which achieves nearly the same results with an adjustable all-electronic simulator.

While cost and size are definite advantages, perhaps the best part of the electronic Leslie Effect Simulator is its versatility. With the controls cranked back, the Simulator adds an interesting, subtle effect to conservative music. But if you're a wild man, you can really twiddle the knobs and wail! Control adjustments can produce anything from “super” bass or treble boost to sounds listeners describe as “shimmering, bubbly or out of sight!”

Theory of Circuit Design. While the frequency shift, or vibrato, effect of a Leslie

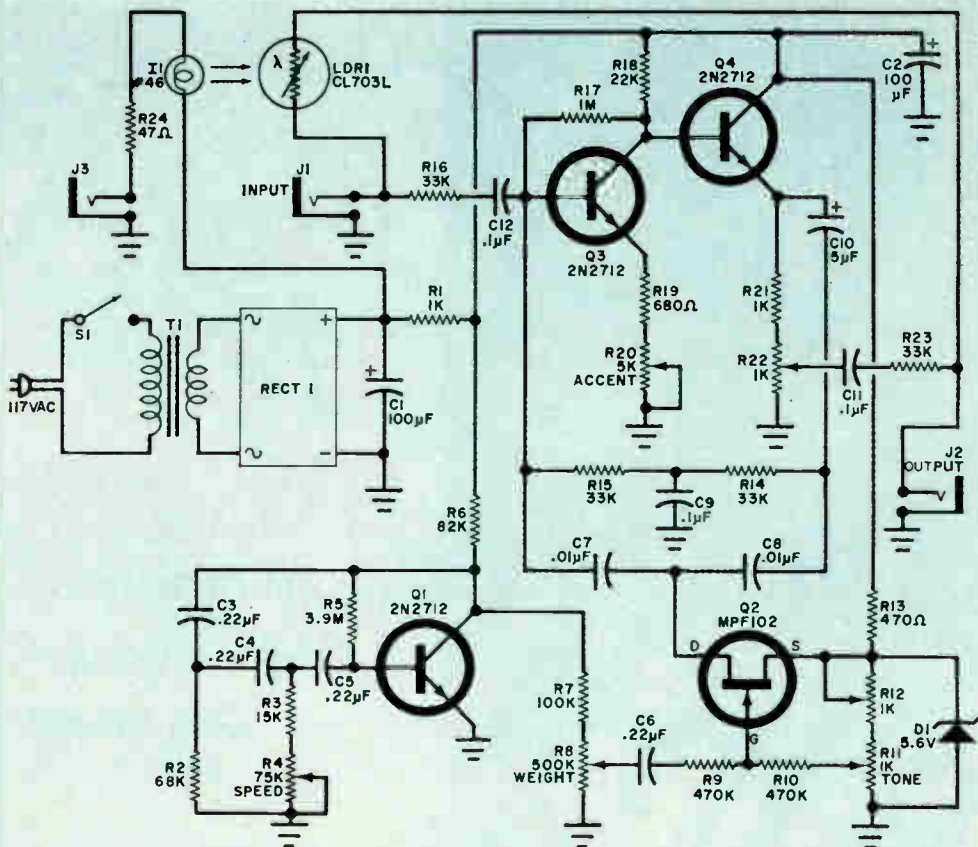


Fig. 1. Footswitch plugs into J3; when closed, footswitch powers I1 which illuminates LDR1. With LDR1 illuminated, input signal at J1 goes directly to J2.

PARTS LIST

- C1—100- μ F, 16-volt electrolytic capacitor
- C2—100- μ F, 10-volt electrolytic capacitor
- C3-C6—0.22- μ F Mylar capacitor
- C7, C8—0.01- μ F disc capacitor
- C9, C11, C12—0.1- μ F disc capacitor
- C10—5- μ F, 6-volt electrolytic capacitor
- D1—5.6-volt zener diode (Motorola HEP603 or similar)
- I1—#46 incandescent panel lamp
- J1-J3—Open-circuit phone jack
- LDR1—Light-dependent resistor (Clairex CL703L or similar)
- Q1, Q3, Q4—2N2712 bipolar transistor
- Q2—MPF102 or HEP802 field-effect transistor
- R1, R21—1000-ohm
- R2—68,000-ohm
- R3—15,000-ohm
- R5—3.9-megohm
- R6—82,000-ohm
- R7—100,000-ohm
- R9, R10—170,000-ohm
- R13—470-ohm
- R14, R16, R23—33,000-ohm
- R17—1-megohm
- R18—22,000-ohm
- R19—680-ohm

All transistors
1/2-watt, 10%
tolerance

- R24—47-ohm, 10% tolerance, 1-watt resistor
- R4—75,000-ohm, reverse audio-taper potentiometer
- R8—500,000-ohm linear-taper potentiometer with integral switch
- R11—1000-ohm linear-taper potentiometer
- R12, R22—1000-ohm trimmer potentiometer with printed circuit solder terminals
- R20—5000-ohm linear-taper potentiometer
- RECT1—1-ampere, 50 PIV, full-wave rectifier bridge module (Motorola MDA942A-1 or similar)
- S1—Spst switch (part of R8)
- T1—12.6-volt, 300-mA filament transformer
- Misc.—Circuit board; line cord with a strain relief; cabinet; 3-lug terminal strip; control knobs (4); spacers (4); rubber feet (4); 4-40 machine hardware; hookup wire; solder; etc.
- Note—The following items are available from PALA Electronics, Inc., P.O. Box 14359, Oklahoma City, OK 73114: etched and drilled printed circuit board (#5702pc) for \$3.50; complete kit of parts, including circuit board, case, and all parts (#5702K) for \$22.50. Plus postage 3 lb. Separate parts are also available; send itemized listing.

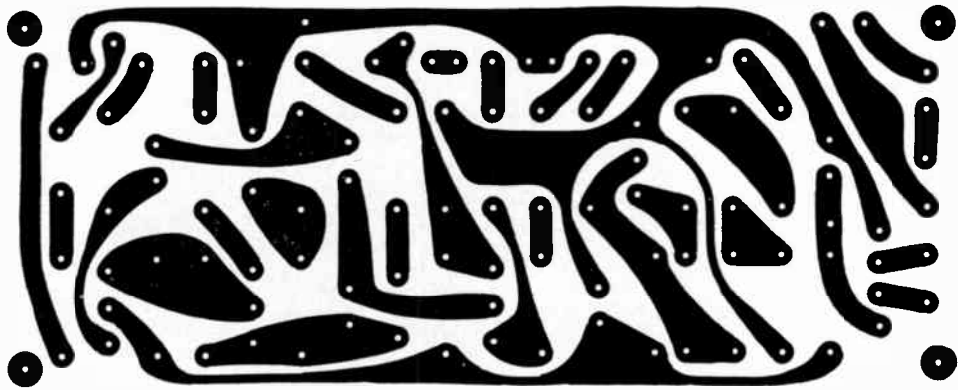
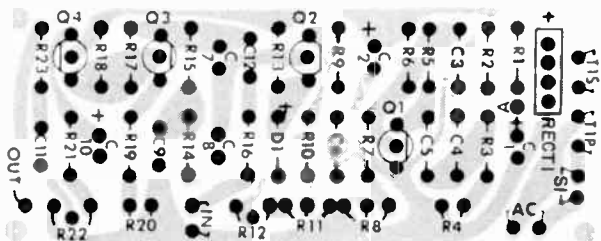


Fig. 2. Actual size printed circuit board etching and drilling guide is shown above. At right is components placement and orientation guide. Note orientations of flats on transistors and plus sign on rectifier assembly.



speaker system (see box) is expensive to generate electronically, the total effect can be convincingly simulated simply by placing a bandpass filter between the musical instrument and its amplifier and sweeping back and forth across the bandpass. This is the principle employed in the Leslie Effect Simulator circuit shown in Fig. 1.

At the heart of the Simulator is an active bandpass filter composed of *R11*, *R15*, *Q2*, and *C7* through *C9* in the feedback loop of the amplifier/buffer combination made up of *Q3* and *Q1*. Transistor *Q1* and its associated components form a low-frequency phase-shift oscillator, the output frequency of which can be set from between about 4 Hz to 12 Hz through the use of speed control *R1*. The signal from *Q1* is attenuated by weight control *R8* and applied to the gate of *Q2* to change the source-to-drain impedance of the FET and, consequently, the center frequency of the pass band.

Photoelectric system *I1/LDR1* is used to bypass the Simulator when the system is not in use. Closing a footswitch plugged into *J3* powers *I1* which, in turn, illuminates *LDR1*. Once illuminated, *LDR1*'s internal resistance drops and forms a signal bypass loop around the filter circuit.

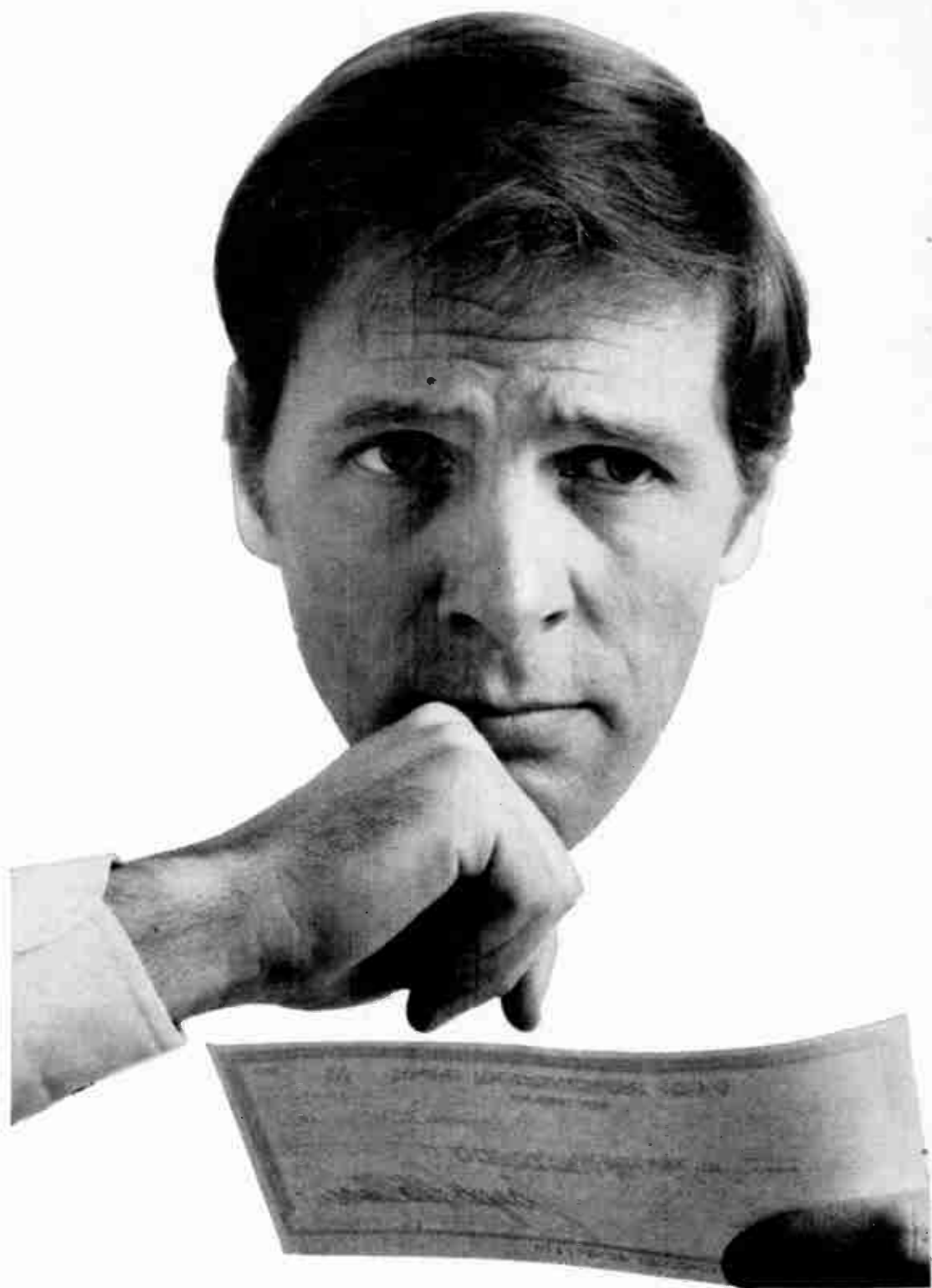
Construction. Since only low frequencies are involved in the operation of the Leslie

Effect Simulator, parts layout during assembly of the project is not critical. Just adhere to the general rules of neatness and good soldering. In particular, keep signal leads as short as possible.

Begin assembly by etching and drilling the printed circuit board, carefully following the actual size etching guide provided in Fig. 2. (If you prefer, you can obtain a ready-to-use

THE "LESLIE EFFECT"

In principle, the Leslie speaker system is nothing more than one or more loudspeakers mounted at the end of an arm which is rotated by means of a motor. (Other variations use a fixed speaker and employ a rotating "paddle" or baffle, but the principle is the same.) As the loudspeakers swing around in an arc, several things happen to the sound. First, a doppler shift in the apparent pitch of the sound is caused as the motion toward and away from the listener takes place. Next, a variation in sound level is produced as the speaker alternately faces toward and away from the listener. Finally, there occurs a great variety of effects which stem from changes in the acoustics of the system enclosure and the room in which the system is being used occur.



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circuit board from the source listed in the Parts List.) Once the board is prepared, mount the parts in their respective locations, paying particular attention to the orientations of diodes, transistors, and electrolytic capacitors. Use a low-wattage soldering iron to solder the component leads to the circuit board's foil pattern. It is also a good idea to heat sink the leads of the solid-state component to prevent heat damage.

After all components are mounted on the board, solder in place the primary and secondary leads of power transformer *T1* and pieces of hookup wire sufficiently long to reach the front panel controls when the project is fully assembled. Then carefully check the foil side of the board, particularly around the transformer connections, for solder bridges. If any exist, reheat and remove any excess solder to eliminate the bridge.

You can use just about any type of case that suits your fancy to house the circuit. If you wish to duplicate the case shown in the photos, all you need are some 22-gauge sheet aluminum, lumber, glue, and fasteners. No special tools are needed for forming and fabricating the metal parts.

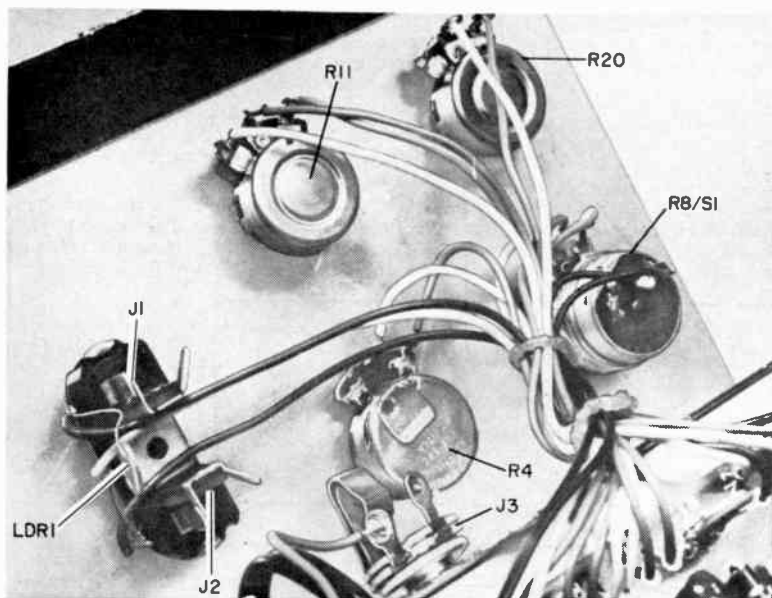
The top, front, and back of the case are made from a single sheet of aluminum, machined on the front and back panels to accommodate the controls, jacks, and entry for the

line cord. It is then bent to shape to form a friction fit over the side panels. While you're at it, you can also cut to size the bottom plate, using the same sheet aluminum.

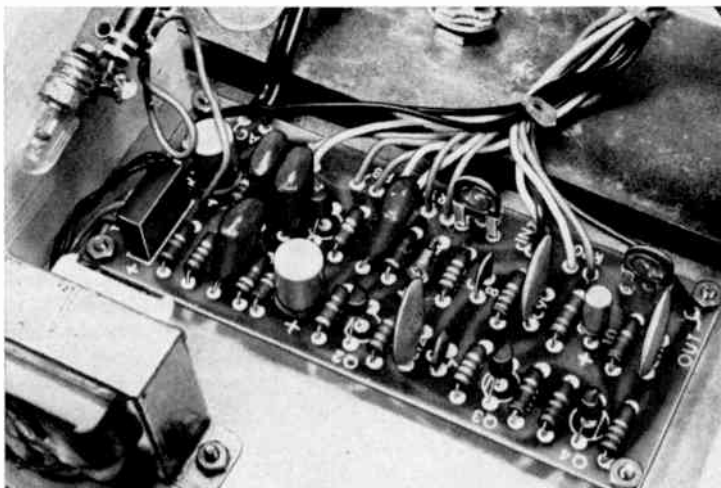
To make the side panels, you will need one walnut and one white pine panel for each. Cut the walnut pieces $\frac{1}{4}$ " longer in their length and width dimensions than the height and depth dimensions of the metal pieces. The pine pieces should be $\frac{3}{8}$ " shorter in both dimensions than the length and width of the walnut pieces. Now, make a "sandwich" of the pine and walnut pieces with white glue and wire brads, centering the former on the latter. This done, smoothly sand and hand rub paste wax on the outer face and edges of the walnut panels to bring out a dull sheen. Then use short wood screws to fasten the bottom plate to both side panels and temporarily set the assembly aside.

Next, paint the front, top, and back assembly with a color to contrast with the dark shade of the walnut panels. When the paint has thoroughly dried, use a dry-transfer lettering kit to label the controls and jacks. Mount the controls and jacks in their respective holes; then pass the free end of the line cord through its entry hole and secure it to the rear panel with a strain relief.

Referring back to Fig. 1, connect and solder the free ends of the wires coming from



Input and output jacks J1 and J2 should be located close to each other if separate jacks are used to allow LDRI to be mounted between them as shown here.



Neatly dress control and jack wiring to one side of circuit board and lace together with cable ties or lacing cord. Secure power transformer to chassis with 4-40 machine hardware; add $\frac{1}{4}$ " spacers when mounting board in place.

the circuit board to the lugs of the appropriate control and jack lugs. Tin the free ends of the line cord and solder them to the hole locations marked AC on the board. Now, interconnect with lengths of hookup wire the ground leads of *J1-J3* and connect and solder the leads of *LDR1* directly to the signal lugs of *J1* and *J2*. Neatly dress the leads along one edge of the circuit board.

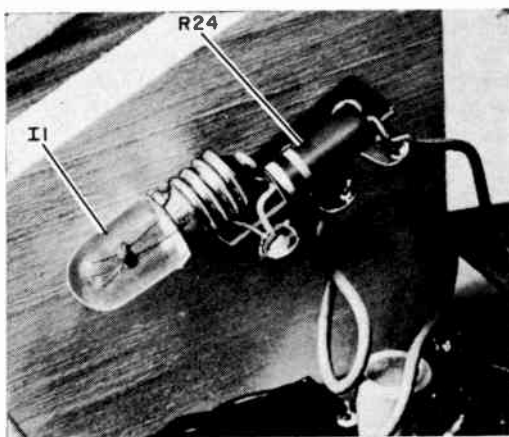
Now, mount *R24* and *I1* on a three-lug terminal strip (no lugs grounded). Position the assembly near *LDR1* so that when the lamp is lit it will illuminate effectively the LDR. Mount the assembly in place with 4-40 machine hardware. Connect this assembly via one wire to the positive side of the power supply on the circuit board.

Finally, mount the circuit board with 4-40 hardware and spacers, and power transformer *T1* with 4-40 hardware only. The project is now ready to be tested.

Setup and Use. Plug the line cord of the Leslie Effect Simulator into a 117-volt ac outlet. Connect an input and amplifier to *J1* and *J2*, respectively, and a footswitch to *J3*. Turn on the system by rotating *R8* clockwise just past the click. Close the footswitch to test the bypass circuit; *I1* should immediately come on.

Temporarily cover the sensitive face of *LDR1* with a piece of black electrical tape to keep ambient light from interfering with the adjustments to be made. Advance ACCENT con-

Current limiting resistor *R24* and *I1* are mounted on terminal strip fastened to side panel in line with *LDR1* when cabinet is assembled. If side panel is metal, use four-lug terminal strip and do not connect *R24* or *I1* to mounting lug.



trol *R20* to about two-thirds of its clockwise rotation and set weight control *R8* fully counterclockwise—but do not click the power off. The maximum effect of **TONE** control *R11* occurs over about one-quarter of its travel. The extra travel is useful in some effects when the weight control is fully advanced. Adjust *R12* so that the most sensitive area of the **TONE** control is at the center of the **TONE** control's travel. You can check out your settings by striking a chord and noting the action of the **TONE** control as it is rotated.

Trimmer potentiometer *R22* should be swept over its entire range to check the gain of the Simulator. It should then be set so that

clockwise. Set the **TONE** control to the center of its travel and adjust the **SPEED** control as desired.

Now, when the instrument plugged into *J1* is played, you should get an effect that is something like a tremolo, except that there will be a touch of sweeping pass band in the background. If the effect is not pronounced enough to suit you, advance the **ACCENT** control.

For super bass/treble boost, turn up the **WEIGHT** control as far as it will go without turning off the Simulator. Advance the **ACCENT** control all the way. Now the **TONE** control can be rotated clockwise for treble boost



In prototype, top of case slopes downward. Top, front, and rear panels are painted flat black to contrast with rich tones of walnut side panels. Controls and jacks are lettered in white, using dry-transfer lettering kit.

there is minimum change in volume level as the Simulator is switched in and out of the system (by operating the footswitch). While adjusting *R22*, be sure to remove the tape from over the LDR to permit switching out the Simulator.

To a certain extent, **ACCENT** control *R20* changes the overall gain of the Simulator. It should be adjusted for unity gain at the accent setting you intend to use most often or for whatever compromise suits your taste. When both internal adjustments (*R12* and *R22*) have been made, uncover *LDR1* and assemble the case.

In use, the best way to get the feel of the controls of the Simulator is simply to play with them. However, a few simple hints will get you started. First, to obtain the Leslie Effect, set the **ACCENT** control to approximately the center of its travel and rotate the **WEIGHT** control a small fraction of a turn

and counterclockwise for bass boost. Somewhere between the two extremes, the amplifier might break into oscillations, but this can be readily remedied simply by backing off on the **ACCENT** control slightly.

Advancing the **WEIGHT** control past its midpoint and setting the **TONE** slightly treble of center can produce an effect quite similar to reverberation if the **ACCENT** control is advanced to the point that just causes oscillation when a note is struck.

If, during the operation of the Simulator, you notice a loud ac hum level, try reversing the ac line cord plug. This should effectively curb the hum loop.

Beyond the very rough hints outlined above, familiarizing yourself with the Leslie Effect Simulator will depend on your experimental nature. You will certainly want to experiment to determine just what the Simulator is capable of doing. Go to it.

BY
ROBERT F. LEWIS,
K7YBF



Low-Cost 10.7-MHz Signal Generator

FOUR HUNDRED kHz BANDSPREAD TUNING

TO VERIFY FREQUENCY RESPONSE

IF YOU'VE EVER had occasion to check the frequency response of 10.7-MHz i-f stages, ratio detectors, and discriminators, you're aware of the inherent shortcomings of conventional signal generators employed for this kind of work. Most standard FM i-f transformers are designed to have a 3-dB bandwidth of about 200 kHz, while ratio detector and discriminator transformers usually have a peak-to-peak response of 300-600 kHz.

Since conventional signal generators are designed to cover a wide frequency range, the band required for FM i-f testing and alignment occupies a rather narrow segment of the generator's tuning dial. Consequently, frequency readings, in terms of 10 kHz or so, are next to impossible to obtain unless you can continually monitor the generator's output with a frequency meter. Even then, it is a tedious and touchy procedure.

However, for about \$12 you can build a simple 10.7-MHz signal generator that will spread out the 600 kHz of interest to cover a 180° segment of the tuning dial. Calibration is accurate enough to do the job for which the

instrument was designed, and the tuning can be continuously reset to within 1 or 2 kHz at the marked points on the dial or within 10 or 20 kHz in between the markings if your interpolation is good.

Theory of Circuit Design. The 10.7-MHz generator employs two field effect transistors; *Q1* is in a Colpitts oscillator configuration, while *Q2* operates as a source-follower output circuit (see Fig. 1). The frequency of oscillations is determined by the values of *L1* and the combination of *C1* through *C5*, with *C1* serving as the main tuning element in the circuit. The capacitive value specified in the Parts List for *C1* provides a frequency spread of slightly in excess of 600 kHz. This could easily be expanded or narrowed by changing the value of the tuning capacitor.

The drain of *Q1* is operated at +6 volts and is grounded for r-f through *C6*. Similarly, the drain of *Q2* is operated at +6 volts, with *C8* providing the r-f ground return. The output from *Q1* is coupled through *C7* to the gate of *Q2*. Capacitor *C9* provides signal

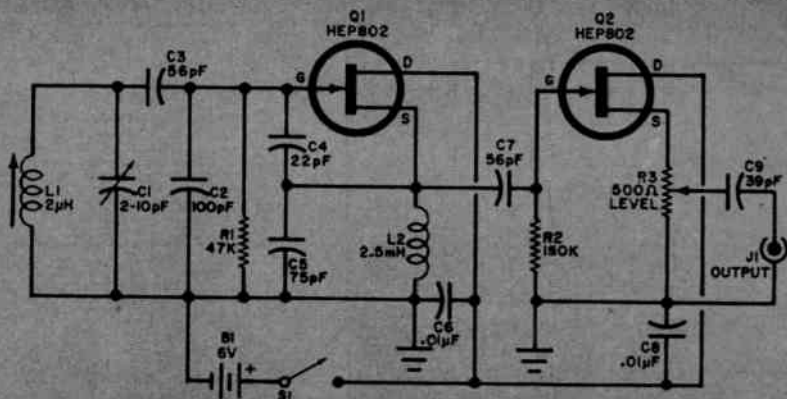


Fig. 1. Stage Q1 is wired up as a Colpitts oscillator, while source-follower stage Q2 serves as a buffer to prevent erratic oscillator operation under load.

PARTS LIST

B1—Four 1.5-volt AA cells in series
 C1—2-10-pF variable capacitor (Johnson No. 160-109A, or similar)
 C2—100-pF silver mica capacitor
 C3, C7—56-pF silver mica capacitor
 C4—22-pF silver mica capacitor
 C5—75-pF silver mica capacitor
 C6, C8—0.01- μ F disc capacitor
 C9—39-pF disc capacitor
 J1—UG-290A/U BNC-type coaxial connector
 L1—2- μ H inductor (15 turns \pm 24 enameled wire close-wound on $\frac{1}{4}$ " slug-tuned coil

form; use Miller No. 21A000 or similar form)
 L2—2.5-mH r-i choke (Miller No. 70F253A1, or similar)
 Q1, Q2—HEP802 or MPF102 field-effect transistor (Motorola)
 R1—47,000-ohm, $\frac{1}{2}$ -watt resistor
 R2—150,000-ohm, $\frac{1}{2}$ -watt resistor
 R3—500-ohm potentiometer
 S1—Spst switch (part of R3)
 Misc.—5" \times 4" \times 3" metal utility box; battery holders; circuit board material; hardware; spacers; control knob; hookup wire; solder; etc.

coupling to the external circuit connected to J1 and dc isolation between the signal generator and the external circuit.

Construction. With the exception of C2, all of the components that make up the 10.7-MHz signal generator mount on a printed circuit board, the actual-size etching guide for which is shown in Fig. 2. When mounting the components on the board, orient C1 so that its capacitance increases with clockwise rotation of the shaft and so that the flat on the shaft is parallel to the bottom edge of the front panel with C1 set for half capacitance. Then connect and solder C2 between the rotor and stator terminals of C1. Referring to Fig. 3, finish mounting all the remaining parts as shown.

Mount the circuit board to the front panel of a 5" \times 4" \times 3" aluminum utility box with 6-32 hardware and $\frac{1}{4}$ "-long spacers. Then fasten the battery holders to the rear panel of the utility box with 6-32 machine hardware.

Panel lettering must be done during the

calibration process. Although there are several methods you can choose from to mark the panel with the proper legends, the dry-transfer technique is by far the neatest and most professional looking. Also, if you wish to make the panel markings more permanent, wait several days after applying the lettering; then spray two or three light coats of clear acrylic finish on the front panel. Make these coats light, and wait until each is completely dry before applying the next coat or the lettering will lift off.

Calibration and Use. To accurately use the signal generator, it must first be calibrated. To do this, you need at least temporary access to an accurate frequency meter, such as a surplus BC-221. The calibration procedure is as follows:

First, turn on the signal generator and the frequency meter and allow both to warm up and stabilize. After a sufficient length of warm-up time has elapsed, set the tuning dial on the signal generator so that the index on

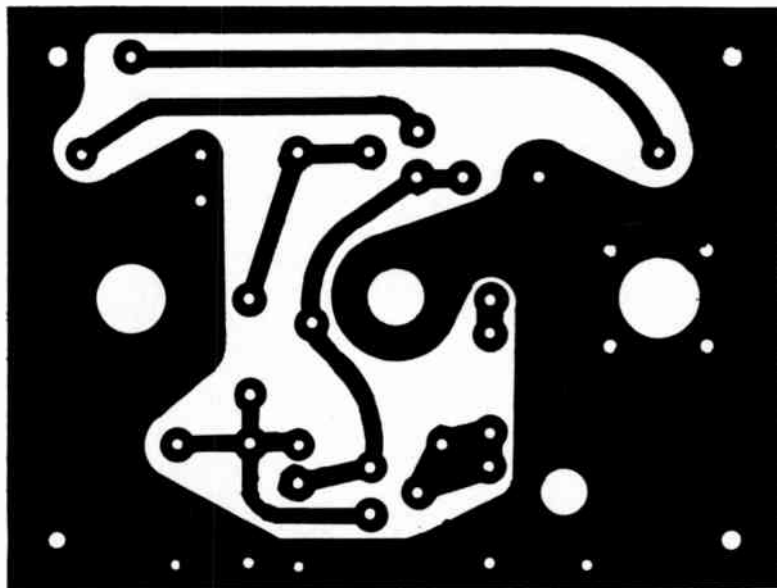


Fig. 2. To obtain proper operation from circuit, actual size etching guide must be carefully copied as resist pattern on copper foil side of circuit board.

the control knob is pointing straight up. Be sure that *C1* is at half capacitance at this point. Then connect the generator to the input of the frequency meter through a suitable length of coaxial cable. Set *R3* to its midpoint.

Adjust the setting on the frequency meter to exactly 10.7 MHz. Now, tune the slug in *L1* to produce a zero beat between the output signals of both instruments. Tighten *L1*'s locknut, and mark the 10.7-MHz calibration point on the front panel in line with the control knob's index or pointer. Repeat the process for the other calibration points desired.

You can roughly calibrate the level control (*R3*) with the aid of a low-voltage r-f voltmeter or other instrument capable of measuring low-level r-f voltages. An oscilloscope, properly calibrated, will do nicely.

When using the 10.7-MHz oscillator, here are some suggestions to enable you to obtain the maximum benefit from your instrument. Always use coaxial cable between the generator and the equipment under test to prevent stray coupling and false readings. When aligning FM i-f stages, or when running bandwidth measurements, keep the output level of the signal generator as low as possible so that limiting in the i-f strip will not give false indications. If a vacuum-tube receiver is involved, you can take de readings at a limiter grid with a VTVM. In solid-state circuits, one way is to use a VTVM with a rectifier-type

r-f probe and take readings at the base or collector of an i-f stage.

When checking peak-to-peak responses of discriminators, keep the generator's output level *high* so that heavy limiting occurs ahead of the discriminator. This maintains the discriminator's input level relatively constant
(Continued on page 97)

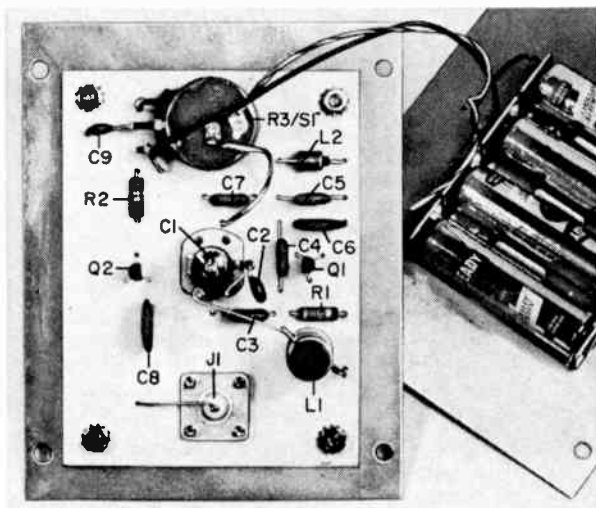


Fig. 3. Note that only one hole in board is used for C9; other lead of C9 goes to center lug of R3. A length of bare wire connects C1 directly to L1.



The Different

Resistance Decade

Unusual, economical switching arrangement

BY JAMES A. FRED

THERE ARE several different approaches that can be taken to the design of a resistance decade box. One simply switches increasing values of resistors, while others use tricky switching arrangements that add four values of resistance (1,2,3, and 4) to make 10 units per switch.

All of these schemes have their drawbacks—from either a cost, production, or use standpoint. Take the case where four resistors are used to add up to 10. There are bound to be switching irregularities in this process since it is impossible to switch out the one and two units and switch in the four unit at the same time. The total resistance jumps during switching either a value below three or above four. Such a condition may not be important

in many cases, but it may cause damage to a highly sensitive galvanometer or a delicate piece of electronic equipment.

Described here is a switching scheme for a resistance decade that solves many of the problems mentioned above and is simple and inexpensive to build. Six identical resistors are used in each decade to provide 10 smooth equal steps. A schematic of one decade switch is shown in Fig. 1. The secret of the scheme is in the values of the resistors and in the switch arrangement. The rotors on the two wafers of the switch are offset by one place to provide smooth operation. The resistors are twice the value that would ordinarily be used for a particular decade. That is, for the $\times 1$ decade the resistors are all 2 ohms; for the $\times 10$ dec-

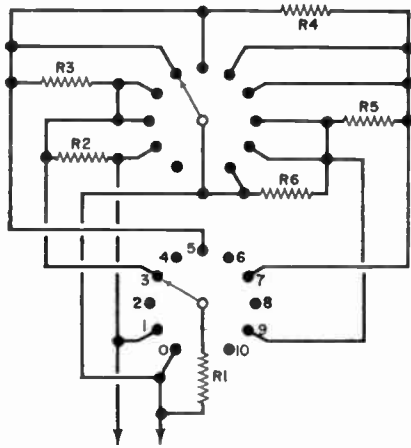


Fig. 1. Any number of decades can be made using this same circuit. Note that the two rotors are displaced one position apart.

PARTS LIST

For X1 decade:

R1-R6—2-ohm resistor (Mallory 3AE or Ohmite 995-3A)

For X10 decade:

R1-R6—20-ohm resistor (Mallory 3AE or Ohmite 995-3A)

For X100 decade:

R1-R6—200-ohm resistor (Mallory 3AE or Ohmite 995-3A)

For X1K decade:

R1-R6—2000-ohm resistor (Mallory 3AE or Ohmite 995-3A)

For X10K decade:

R1-R6—20,000-ohm resistor (Mallory 2MOL22k or Ohmite 995-5B)

For X100K decade:

R1-R6—200,000-ohm resistor (IRC RC2)

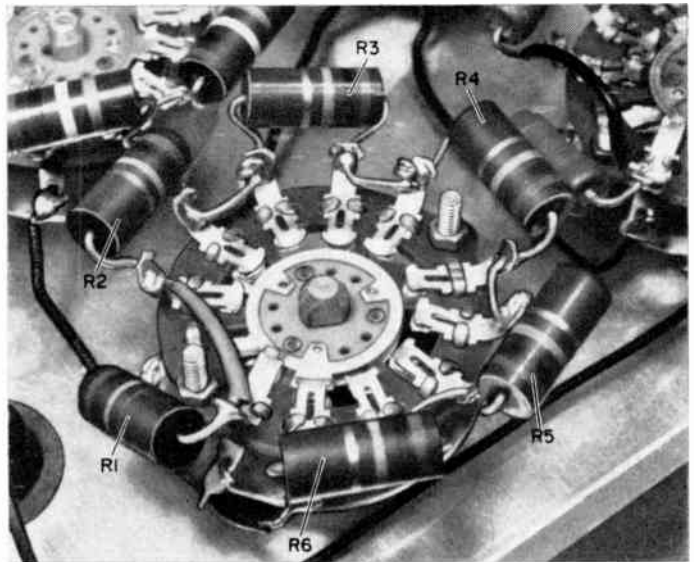
S1—Two-pole, 12-position rotary switch (one per decade)*

Misc.—Suitable chassis, knobs, five-way binding posts (2), wire, solder, etc.

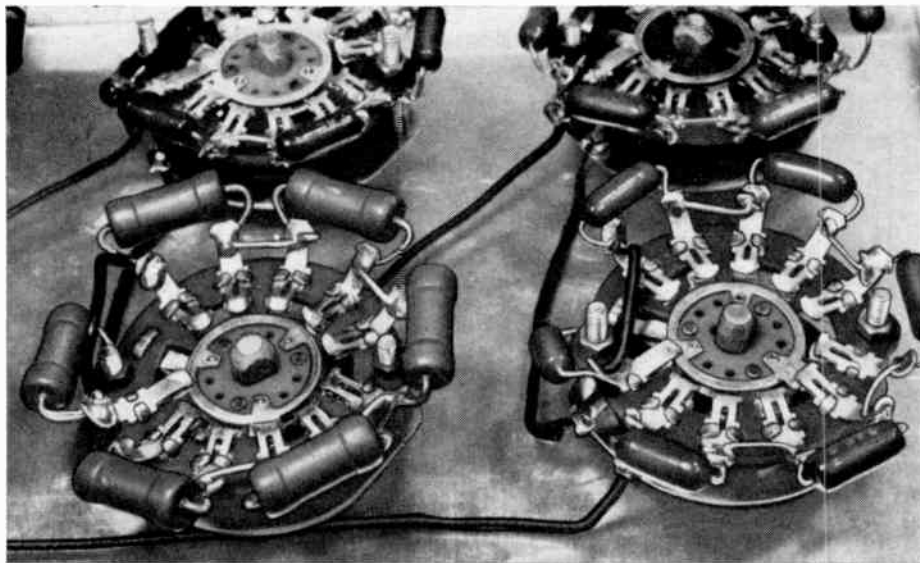
*Available as JMSW1 from J & M Electronics, Rte 1, Box 28, Cutler, IN 46920 at \$3 each, \$2.50 each in lots of 6, postpaid. Indiana residents add 2% state sales tax.

ade, they are 20 ohms; etc. To provide the even values (2, 4, 6, 8, and 10), the resistors are connected in series. To provide the odd values, the sixth resistor "floats" from one position to another so that it is in parallel with one of the other five, thus giving a resistance value equivalent to 1. Several factors

must be taken into consideration when planning the decade box. First, the wattage of the resistors must be decided. This, of course, depends on where you are going to use the instrument. Then, the overall range of resistance must be determined. Six switches will produce resistance values in one-ohm steps



Typical switch showing how the associated resistors are mounted directly to the contacts. Make sure that each resistor is isolated from each of the others and from the chassis to insure against accidental shorts.



When building up several decades, use resistors having the same tolerance and wattage. Certain terminals on two wafers of each switch are stapled together. Note decade interconnections.

from one ohm to one megohm. Eight switches will allow coverage from 0.1 ohm to 10 megohms.

The accuracy of the decade box must also be considered. Low-tolerance resistors cost more than higher tolerance types. However, 5% tolerance should prove adequate for general work.

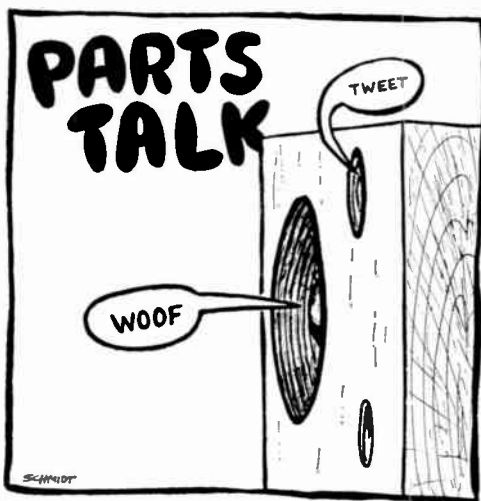
Construction. The six-switch decade box shown in the photographs was constructed in a 5" x 9½" x 2" aluminum chassis having a removable top. The chassis size is not important as long as it can comfortably support the selected number of switches and the output five-way binding posts. Construction and operation will be greatly improved by the use of the special switch specified in the Parts List. This switch has its two sections staggered as required and has the proper terminals on each wafer stapled together to make the necessary electrical contact.

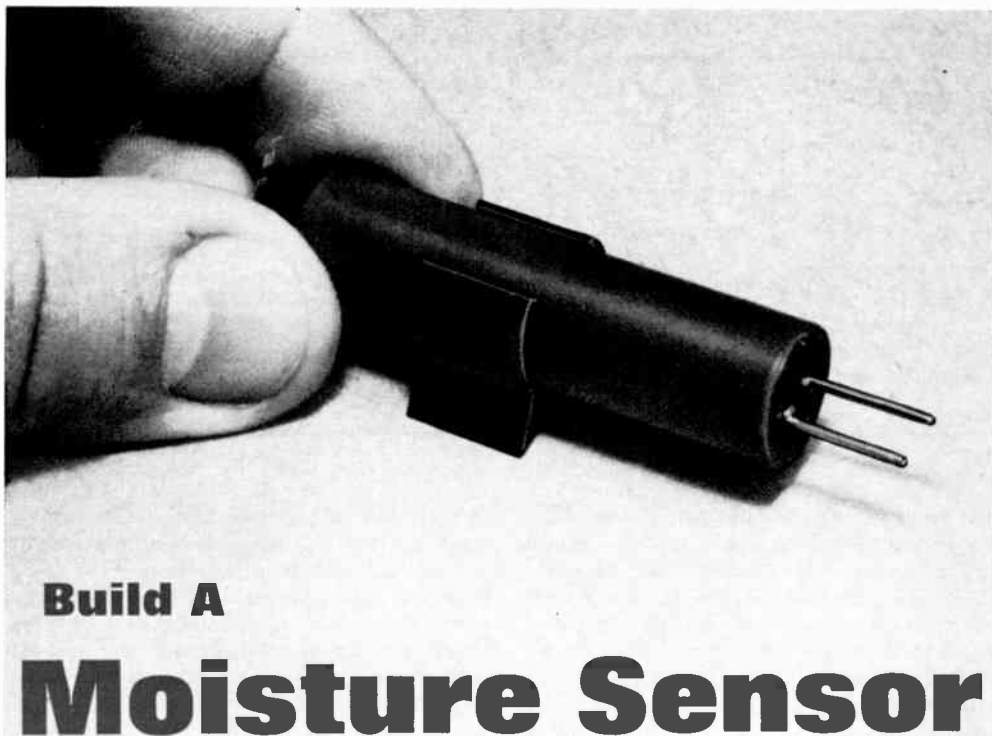
Wire the switches as shown in Fig. 1. Test each switch after completion with an ohmmeter. Connect the switch outputs in series. Make sure that resistors are not touching each other or the chassis. If high-wattage resistors are used, it is advisable to make several ventilation holes in the chassis. Mark the switch positions and the multiplication factor with press-on type. Once complete, use an

ohmmeter to check the overall operation of the box.

To use, connect the decade box binding posts to the required external circuit and position the switches to obtain the total value of resistance required. The zero position of each switch forms a short across that switch, thus effectively removing it from the circuit.

-30-





DETECT LIQUID OF ANY KIND IN ANY LOCATION

BY H. ST. LAURENT

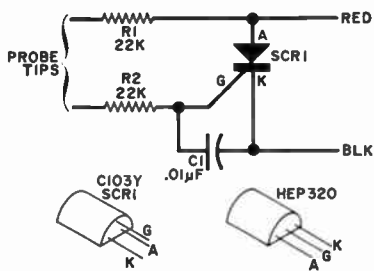
DETECTING leakage or overflow in any system involving liquid storage or transmission is not as easy as it sounds without spending a lot of money. Detection devices on the market range in price from \$40.00 to \$100.00 (or more) depending on the packaging. On the other hand, the sensor described here can be built for about \$3.00. The sensor itself is the heart of an efficient and accurate detection system. The cost of the external warning and power components will vary depending on how the sensor is applied.

Applications for the moisture sensor are myriad. It can detect water leaks in aquariums, basements, boats, freezers, humidifiers, sprinkler systems, boilers, etc. It will locate moisture in lumber, silos, or any stored material susceptible to moisture damage. Another important use is in the detection of condensation in fuel tanks since, in this sensor, no power is present at the probe tip

(even when activated) so that there is no danger of an explosion.

One of the best features of this sensor is that it uses no power when on standby. This makes it possible to use dry cells such as lantern batteries to monitor remote, hard-to-reach areas. The sensor is not voltage sensitive; operating voltage can be varied as much as 25% without adversely affecting the operation. A number of sensors can be coupled to a central control panel for covering wide areas.

Theory of Circuit Design. The circuit of the moisture sensor is shown in Fig. 1. When any moisture is present between the probe tips, a low-level positive voltage passes from the red lead, through the two resistors, to the gate of the SCR. This fires the SCR and causes it to appear as a very low resistance across the two power leads.



PARTS LIST

C1—0.01- μ F miniature capacitor
R1, R2—22,000-ohm, 1/2-watt resistor
SCR1—Silicon controlled rectifier (GE C103Y or Motorola HEP320)
Misc.—Plastic tube, perf board, non-corrosive wire, cable, potting compound, solder, etc.
Note—A complete set of parts including perf board, plastic tube and matching mounting clip, but excluding potting compound, is available for \$3.00 from Lectromek Co., Box 824, Warwick, RI 02888.

Fig. 1. The moisture sensor is a simple circuit that operates very readily. Color-coded leads indicate the applied dc voltage, red for positive, black for negative.

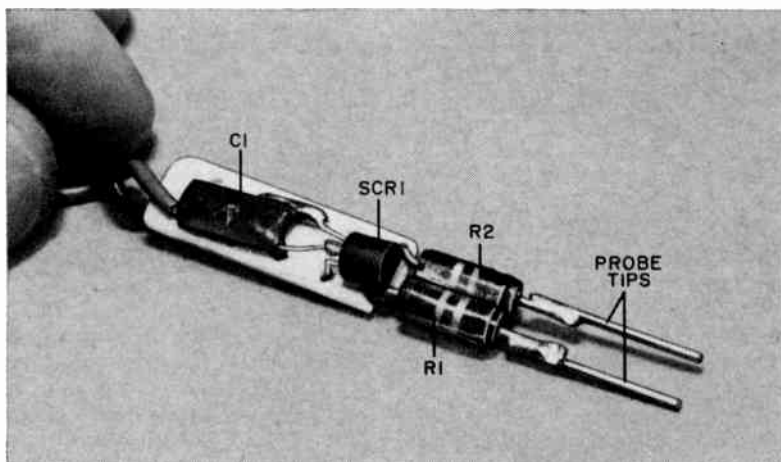
When a suitable power source and alarm are connected to the power leads as shown in Fig. 2A, the alarm is activated when the SCR fires. The particular SCR used in this sensor operates best with supplies between 6 and 18 volts. The maximum current drawn by the SCR when fired is about 800 mA.

Either dc or ac may be used for the power supply. If dc is used, once the SCR fires, it must be reset (with the probes in the clear) by disabling the power source momentarily. If ac is used, (a 6- or 12-volt filament transformer works well) then reset occurs automatically when the probes are in the clear and the ac waveform passes through zero.

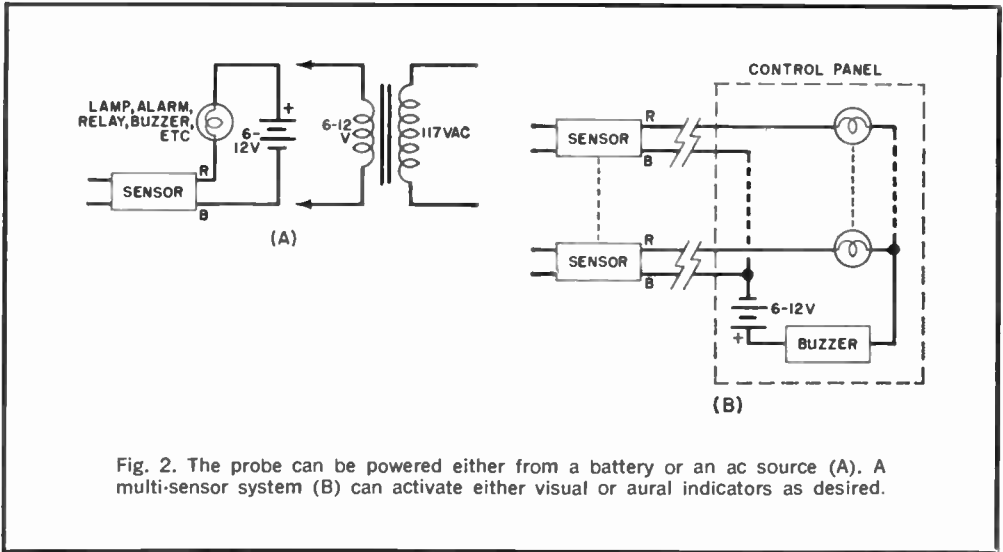
Construction. The sensor can be housed

in any type of narrow plastic tube—even a small pill bottle. Cut a piece of perf board shorter in length than the plastic tube to be used and just wide enough to fit within the tube. Mount the components on the perf board, making sure that only one end of each of the resistors is attached to the board (see photo). If the sensor is to be used in a corrosive atmosphere, cut the loose ends of *R1* and *R2* short and solder about 3/4 to 1" lengths of 0.040" Monel (or other type of non-corrosive wire) to the loose ends. For non-corrosive use, leave the loose ends of the resistors their natural lengths. These are the probe tips.

Connect lengths of red and black wires to the appropriate points on the board. A con-



The plastic circuit board should fit snugly within a plastic tube. The probe tips are either the resistor leads or small lengths of any type corrosion-proof wire.



necter can be used to join the sensor to a longer set of leads to run back to the power supply and control panel.

Slide the finished board into the plastic tube so that the two tips protrude about $\frac{3}{4}$ ". Connect the sensor to the test circuit shown in Fig. 2A and wet your fingertips and jumper the two probe tips. The alarm should operate when the contact is made.

Once you know the probe is operating, remove it from the test circuit and plug both ends of the tube using paraffin, sealing wax, or any commercially available non-conducting

potting compound which will harden to make a liquid-tight seal.

Operation. Mount the sensor using a suitable clip so that the probe tips are in the area of interest: bilge of a boat, slightly off of a basement floor, near the top of a storage tank, or any place where the presence of moisture or liquid is to be detected. The circuit shown in Fig. 2B shows how to couple a number of sensors to a control panel. You can use either visual or audio signaling, or both.

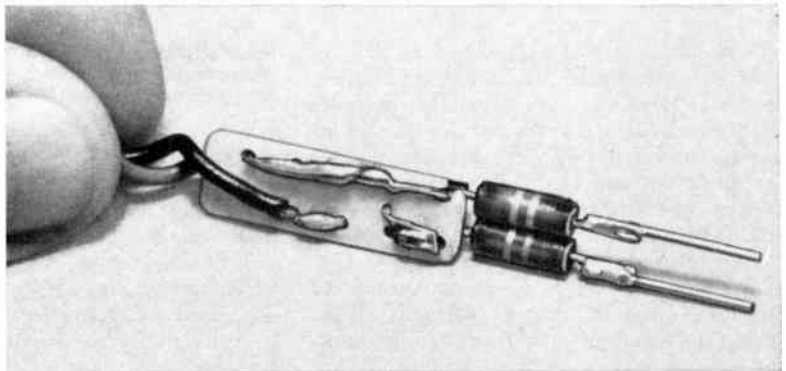


Photo of underside of the sensor plastic board shows how component leads are soldered together both to form the circuit and provide a solid physical mounting.

Light-Operated Bistable Switch

BY DAVID C. CONNER

A SWITCH that can be operated by a light beam from remote locations of up to 30 feet is a handy device to have around the house or in the workshop. Such a switch, especially if it can be operated under wide ambient light extremes, is used to turn appliances on and off, silence the audio on a TV receiver during commercials, and serve as a remote switch in a garage or basement. You can readily see how much of a work saver and safety provider a light-operated remote switch can be.

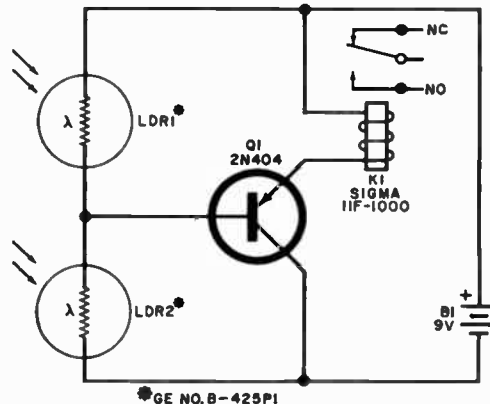
As shown in the schematic diagram, the remote switch described here is a simple device, employing a pair of light-dependent resistors (*LDR1* and *LDR2*) which provide on and off bias for a simple transistor amplifier (*Q1*). The amplifier load is a relay which is energized or de-energized depending on the conduction state of the transistor. The relay has a double-throw contact arrangement so that an appliance or device can be connected to either the normally open or normally closed contacts, depending on the operating condition desired. (These contacts will handle up to 1 ampere of current at 117 volts ac. If higher power is required for a particular de-

vice, *K1* can be used as a control relay to drive an appropriately rated power relay.)

In operation, illumination of *LDR2* causes *Q1* to conduct sufficient current to energize *K1*. Once *K1* is pulled in, it remains energized even after the light is removed from *LDR2* because the solenoid of the relay is normally biased near its pull-in point during its de-energized period. Hence, although the energizing current must exceed a certain level, the holding current is within the biasing current range.

Now, by illuminating *LDR1*, the bias condition at the base of *Q1* changes, causing the transistor to conduct less heavily—this time sufficiently below the holding current of *K1* to allow it to drop out. Again, the situation is such that the normal standby current through *Q1* and *K1* allows the relay to remain de-energized even after the light is removed from *LDR1*.

Background changes from total darkness to full brightness will not cause false operation of the remote switch since the resistance ratio between *LDR1* and *LDR2* will not change



Relay *K1* closes and opens when *LDR2* and *LDR1*, respectively, are illuminated. Sufficient current is normally available to latch *K1* in desired state.

and, as a result, the biasing scheme is unaltered. However, the amount of light reaching both *LDR*'s must be the same at any given time for this to be true.

When assembling the remote switch, bear in mind that the *LDR*'s must be physically separated so that they can be illuminated selectively (by a flashlight, for instance). Experimentally, a separation of about 7 inches provided reliable operation at distances up to 30 feet.



Seventh in a Monthly Series by J. Gordon Holt

"IT WAS A VERY GOOD YEAR"

THE YEAR 1970 saw more than the usual number of developments in what has become known as "the home entertainment field." For instance: four-channel "encoding" systems, the Dolby B tape-noise-reduction for home use, the first Dolbyized pre-recorded cassettes, and tantalizing announcements of video cassettes for the home. It's nice to see the industry advancing on all fronts; however, for the person who wants a piece of the action but can't afford to invest in every new device that comes along, the current home-entertainment scene is a picture of utter confusion. Where, indeed, are we going? Or, more succinctly, what can you buy today that won't be obsolete tomorrow?

Anyone who climbs out on a limb of prognostication runs the risk of having it sawed off from under him. This is merely embarrassing when the predictions have no significant consequences; but when readers go out and spend their hard-earned dollars on the basis of these predictions, it behooves the predictor to choose a solid limb and stay clear of the flimsy end branches. So, with an eye to the consequences of my educated guessing, I'll take a cautious stab at forecasting some things to come.

Cassettes Are Here. First of all, there is no longer any doubt but that the audio cassette is here to stay. The best cassette reproduction—that is, from a chromium dioxide (Crolyn) cassette through a good Dolbyized recorder—is very nearly as good as the best disc reproduction. This does not mean, however, that you will get this kind of sound from a commercially recorded, mass-produced cassette. Even with Dolbyizing (which we now have) and duplicating on Crolyn (which we don't), there is still no practical way of ensuring uniformity of sound from one cassette copy to another,

and the high-speed duplicating that is deemed necessary for economic reasons takes an additional toll in the loss of transparency and detail. At the level of mediocre-fi, to which the majority of people listen, a cassette will have cleaner crescendos than a disc but probably more wow and flutter. So take your pick!

I may be wrong, but I think the 33 $\frac{1}{3}$ -rpm disc will be around for a long time to come—if only because it has become such a habit. If you've built a substantial library of discs or demand the very finest reproduction, it is reasonably certain that you are safe in continuing to buy discs. Surface noise in discs will cease to be a major consideration when they are Dolbyized, which will probably start to happen some time this year. (I know, I know! Discs have been made with the Dolby for the last few years, but that's not what I'm talking about. I'm talking about leaving the Dolbyization on them when they are released so that the consumer can do the final Dolby deprocessing in his home.) Disc Dolbyization may significantly reduce mistracking problems also since the lower surface noise will allow them to be cut at somewhat less insane levels.

On the other hand, if you're just starting your music library and are willing to swap the disc's present superiority for the cassette's convenience and durability (you can't scratch a cassette), you can buy cassettes with the assurance that the industry won't make them obsolete with another "better" medium for many year to come.

Cartridges Are Out. What about the 8-track cartridges? I cannot drum up any enthusiasm for them—as readers of this column may have guessed—for two reasons. First, they are obviously made to provide musical noises for people who don't



...the new Heathkit® 25" ultra-rectangular TV color picture is that perfect.

"Picture postcard perfect"...an apt description for the quality of color reproduction in the new Heathkit GR-371MX 25" ultra-rectangular solid-state color TV. And the reasons are as clear as the expanded 315 sq. in. view:

New Heath MTX-5 ultra-rectangular matrix picture tube. Developed in conjunction with leading domestic tube manufacturers to produce a sharper picture, purer colors, more natural flesh tones. Specially formulated etched face plate cuts out unwanted glare, increases contrast without sacrificing brightness. Matrix screen around phosphor dots eliminates reflected light, allows use of higher transmission glass for greater light output. New square-corner rectangular design opens up the largest picture in the industry...25" diagonal measurement, a full 315 sq. in. of viewing enjoyment. New shape allows complete transmitted image to be seen for the first time. Pictures don't wrap around sides of tube as before. And 25,000 volt high voltage assembly assures optimum picture quality.

Unique solid-state design: 45 transistors, 55 diodes, 2 silicon controlled rectifiers; 4 advanced ICs containing another 46 transistors and 21 diodes; and just 2 tubes (picture and high voltage rectifier) combine to deliver performance and reliability unobtainable in conventional tube sets.

Other plus-performance features include: High resolution circuitry for improved picture clarity, plus new adjustable video peaking that lets you select the degree of sharpness and resolution you desire; an exclusive solid-state VHF tuner with MOS Field Effect Transistor for superior reception even under marginal conditions; Memory Fine Tuning; 3-stage solid-state IF, factory-assembled and aligned; Automatic Fine Tuning; VHF power tuning; "Instant-On"; Automatic Chroma Control; adjustable noise limiting and gated AGC; adjustable tone control; hi-fi sound output to your stereo or hi-fi system.

Exclusive owner-service capability...only Heath offers you this money-saving advantage: built-in dot generator and tilt-out convergence panel let you do periodic dynamic convergence adjustments required of all color TVs. Modular plug-in glass-epoxy circuit boards with transistor sockets permit fast, easy service

and adjustment. Volt-Ohm meter supplied for detailed troubleshooting right down to the smallest part.

Available in choice of factory-assembled, pre-finished cabinets: Mediterranean, Early American, Contemporary...or without cabinet for custom installation.

Kit GR-371MX, 125 lbs., (less cabinet)\$79.95*

Choose from the complete line of Heathkit solid-state Color TVs... for every size and budget requirement:

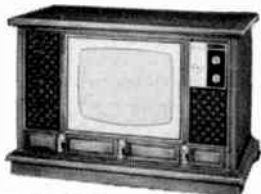


14" portable solid-state color TV

Kit GR-169, 69 lbs., including cabinet\$349.95*

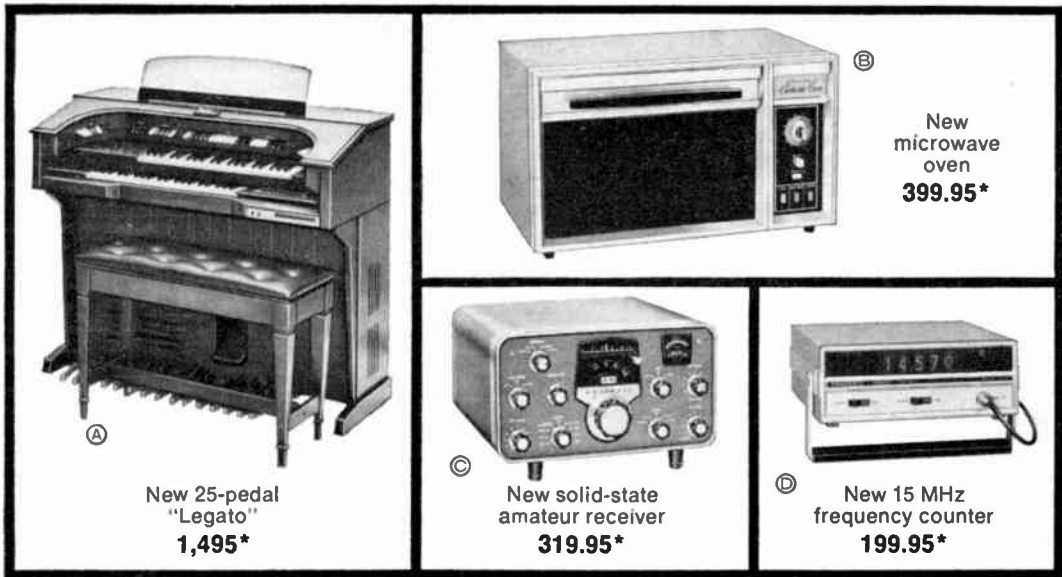
20" solid-state color TV

Kit GR-270, 109 lbs., less cabinet\$489.95*



23" solid-state color TV

Kit GR-370, 124 lbs., less cabinet\$539.95*



A New 25-pedal
"Legato"
1,495*

C New solid-state
amateur receiver
319.95*

B
New
microwave
oven
399.95*

D New 15 MHz
frequency counter
199.95*

And while you're at it, picture these Heathkit newsmakers in your den, kitchen, ham shack or shop.

A New Heathkit solid-state "Legato" 25-pedal Theater Organ

One of the world's most versatile musical instruments...now in money-saving kit form. Designed exclusively for Heath by Thomas Organ craftsmen. All solid-state. Features 15 manual voices, 4 pedal voices...any or all at the flip of a tab. 25-note heel & toe pedal board, range 16' & 8' C0 to C3. Color-Glo® key lights and comprehensive organ course supplied have you playing like a pro in minutes. Two 44-note keyboards; accompaniment range 8'...F1 to C5. Solo manual 16', 8', 4', 2'...F1 to C7. 200 watts peak power from two solid-state amplifiers...one for the 2-speed rotating Leslie speaker and one for the two 12" speakers. Tape record/playback jack on amplifier. Band Box & Playmate accessories available.

Kit TO-101, 299 lbs.1,495*

B New Heathkit microwave oven

The cooking revolution of tomorrow, here today in easy-to-build kit form...saving you hundreds of dollars over comparable electronic ovens. Exclusive patent-pending Heath double door interlock system provides absolute safety...oven cannot be turned on if door is open. Prepares meals in minutes, not hours. Cooks on china, glass, even paper plates in spacious, roast-size oven cav-

ity. Low-profile, countertop design fits unobtrusively into kitchen decor. Portable convenience, too...can be used on patio, at poolside, etc...wherever a 120 VAC grounded outlet is provided. Give your wife a break from kitchen drudgery...with this new miracle of microwave cooking.

Kit GD-29, 97 lbs.399.95*

C New Heathkit solid-state 80-10 meter amateur receiver

All the quality you'd expect in a new Heathkit receiver...and solid-state to boot. Tunes USB, LSB, AM, CW & RTTY, 80-10M. 15 MHz WWV coverage. 100 & 25 kHz calibration. Dual gate MOSFET front end for greater dynamic range. Solid-state factory-assembled & aligned linear master oscillator for rock-solid tuning with 1 kHz readout. ¼ µV sensitivity for 10 dB S+N/N. 2.1 kHz selectivity with built-in SSB crystal filter...optional AM & CW crystal filters available.

Kit SB-303, 21 lbs.319.95*

D New Heathkit solid-state 15 MHz frequency counter

Another Heathkit first...highly accurate frequency measurement at a price you can afford to pay. Delivers stable, accurate counting from 1 Hz to over 15 MHz. All integrated circuitry for top performance, high reliability. Automatic trigger level for wide range input without adjustment. Five digit cold-cathode readout with Hz/kHz ranges and overrange indicators give 8-digit capability. Input Z 1 megohm shunted by less than 20 pF for low circuit loading.

Kit IB-101, 7 lbs.199.95*

See these and 300 other Heathkit suggestions at one of the following Heathkit Electronic Centers:

CALIFORNIA: Anaheim, 92805, 330 E. Bail Road; El Cerrito, 94530, 6000 Potrero Avenue; La Mesa, 92041, 8363 Center Drive; Los Angeles, 90007, 2305 S. Flower St.; Redwood City, 94063, 2001 Middlefield Rd.; Woodland Hills, 91364, 22504 Ventura Blvd.; COLORADO: Denver, 80212, 5940 W. 38th Ave.; GEORGIA: Atlanta, 30305, 5285 Roswell Road; ILLINOIS: Chicago, 60645, 3462-66 W. Devon Ave.; Downers Grove, 60515, 224 Ogden Ave.; MARYLAND: Rockville, 20852, 5542 Nicholson Lane; MASSACHUSETTS: Wellesley, 02181, 165 Worcester St.; MICHIGAN: Detroit, 48219, 18645 W. Eight Mile Rd.; MINNESOTA: Nepkies, 55343, 101 Shady Oak Rd.; MISSOURI: St. Louis, 63123, 9296 Gravois Ave.; NEW JERSEY: Fair Lawn, 07410, 35-07 Broadway (Rte. 4); NEW YORK: Jericho, L.I., 11753, 15 Jericho Turnpike; New York, 10036, 35 W. 45th Street; OHIO: Cleveland, 44129, 5444 Pearl Rd.; Woodlawn, 45215, 10133 Springfield Pike; PENNSYLVANIA: Philadelphia, 19149, 6318 Roosevelt Blvd.; PITTSBURGH, 15235, 3482 William Penn Hwy.; TEXAS: Dallas, 75201, 2715 Ross Avenue; Houston, 77027, 3705 Westheimer; WASHINGTON: Seattle, 98121, 2221 Third Ave.; WISCONSIN: Milwaukee, 53216, 5215 W. Fond du Lac

Retail Heathkit Electronic Center prices slightly higher to cover shipping, local stock, consultation and demonstration facilities. Local Service also available whether you purchase locally or by factory mail order.

a Schlumberger Company

HEATH COMPANY, Dept. 10-3
Benton Harbor, Michigan 49022

Enclosed is \$ _____, plus shipping.

Please send model (s) _____.

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CIRCLE NO. 13 ON READER SERVICE PAGE

give two hoots in hell about high fidelity. Perhaps some cartridge buyers *are* sound-conscious, but the manufacturers don't seem to think so because all the recent attempts at sonic improvement—Dolbyization, Crolyn tape, electronic-drive capstans, and so on—have been applied to cassettes, while cartridges continue on their previous, merry, low-fi way. Second, the continuous-loop format of the cartridge, having no definite beginning or end, is not really suit-



Harman-Kardon's Model CAD5 tape cassette deck is one of the first to have built-in Dolby noise reduction circuits. It can play Dolbyized or not, and Dolby controls can be set for special tapes. Frequency response is improved to beyond 12,500 Hz.

able for recording things that have a start and a finish (like classical works or musical shows). The continuous loop is ideal for programming short selections that comprise the bulk of background-music listening—and that's about all. Nobody has come up with a way of high-speed reversing of a cartridge, although there has been an announcement of a continuous-loop cassette, which may or may not be a disaster when you try to reverse it.

Cartridges will be with us for some time to come, simply because there are so many cartridge players in use, but I don't think cartridges will ever be rated as a serious contender in the high-fidelity sweepstakes.

As long as cartridge manufacturers feel the way they do about their products, there will be a lot of musical material—the less popular classics, etc.—that will never be released on cartridges. Virtually every recording released in the U.S. since 1949 has been available on 33½-rpm discs, and this will probably continue for the foreseeable future. It is also very likely that practically every future release will come out on a cassette, too, which means that these are the only two media that will allow a listener to follow his developing musical tastes wherever they lead him. In other words, don't hold your breath waiting for Schoenberg on a cartridge!

Dolbyization, which seems to have become all-pervasive almost from the moment of its introduction, will undoubtedly go much farther than most people imagine. Pre-Dolbyized cassettes are here, and Dolbyized discs offer such obvious advantages that they too should be on the market within a matter of months. With tapes and discs Dolbyized, the next step seems obvious: total Dolbyizing from original master tape to home playback. If the Dolby deprocessor is in the listener's home, radio stations could transmit pre-Dolbyized recordings as is, without deprocessing so the final deprocessing in the home would reduce FM hiss as well as noises from other links in the reproducing chain. And if the listener wished to record something off the air at home, he could do so, leaving the final deprocessing for playback, when it would reduce the hiss from his own tape machine too. Listeners who didn't have home Dolbys would hear just what they hear today, but with a somewhat hotter high end which could be tamed with a simple treble tone control adjustment.

Total Dolbyization will, I strongly suspect, be adopted without any industry fanfare or foofaraw, simply because it will be the path of least resistance for the radio stations. Unlike stereo FM, which required the purchase of new broadcast equipment and thus came about gradually, Dolby transmissions of Dolbyized discs and tapes can be done just by playing them "as is" through the existing broadcast equipment. Thus Dolby broadcasts will start as soon as Dolby recordings are available.

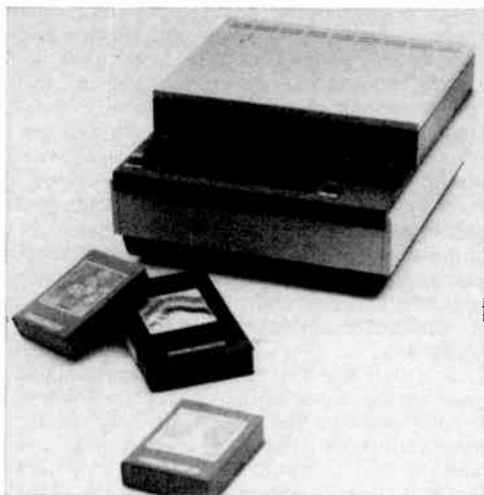
Fly in the Ointment. There is a potential fly in the Dolby ointment, though. The Dolby B system that is now in use for home tape equipment acts only on the high end of the audio spectrum—where most tape hiss is. The proposed Dolby C system for discs will apparently have a second controlled band at the low end for rumble suppression. This would seem to make sense, but it does mean that anyone wishing to deprocess both discs and tapes is going to have to do it either with two separate Dolby units or with a single unit equipped with a B/C throwover switch. Either solution will cost significantly more than a single B-type deprocessor, which means that fewer people will be able to afford them, and that many who *could* will just not bother because of the added complication.

Since nobody is yet manufacturing a Dolby C (to my knowledge), it should not be too late to reconsider the decision to do so, and I fervently hope the decision goes against the C. For listeners who worry about rumble, there are inexpensive, rumble-

free turntables available. And for home Dolbyization really to become big time, there must be one *standard* home Dolby. I see no reason why it can't be the B model, but I won't stick my neck out and predict anything about the ultimate outcome. I can only hope.

Should you buy a Dolby B now? Yes, if you're a tape user who's bothered by hiss. If a C comes along, you'll probably be able to buy an add-on that won't force you to throw out your B model.

The Video Scene. Are video cassettes really just around the corner? You might be expected to think so, after all those mouth-watering articles in the Sunday sup-



Sony's videocassette system will playback color and black and white, record black and white. It is not yet in production; will run around \$500.

plements about the wealth of programming that will be available "soon" on video cassettes: memorable football games, great prize fights, cartoons, plays, nature films, old TV shows, hard-core pornography, etc.—each for a small rental fee. Well, don't rush out and buy your videocassette player just yet; because, if you think the disc-versus-cartridge-versus-cassette scene in audio is a bit confused, you haven't seen anything yet!

The home video cassette scene is in a state of chaos. The thought of millions of Americans shelling out their money to watch things they've been seeing for free on TV has the entertainment business in a frenzy of avaricious hysteria which would seem to belie the inescapable fact that there is no home videocassette market—because there is no home videocassette player. What there is, at the present time, is some 16

manufacturers working hell-bent to develop what they hope will *become* the cassette player in every American home. And to make matters worse, it appears that not one of these marvels will reproduce material recorded for one of the others. There may be a brighter tomorrow, but the reality of today is that only one video cassette machine is available: the Motorola/CBS EVR unit. And at a shade under \$800, it is not exactly building a mass market that will have aspiring cassette distributors snapping like hounds at the kill.

Which Way to Go? If you can't interchange video cassettes, what is going to be used? If there were only three serious contenders for the title of "Mass-Market Player," a distributor might consider packaging in all three formats. But with more than 15 on the horizon and the possibility that some may be better than anything announced to date, it is not surprising that the cassette distributors are tied in knots of indecision. Clearly, the sensible thing for them to do is sit tight and see what develops. But since this might mean letting their competitors buy up the cream of the programming and build up an inventory of cassettes "ready to go," there is a consuming urge to get ever-more-deeply committed to a medium that seems to have nothing concrete to offer except the promise of a bonanza. (There are some in the business who have doubts about even this, citing the miserable failure of disc-rental services and the necessarily exorbitant prices that would have to be charged for the outright sale of videocassettes.)

In other words, nobody in his right mind would try to predict an outcome in the video cassette field. I have a hunch, though, that when the smoke clears and the losers have been buried, the one remaining video cassette machine, the one that will become America's "Home Standard," will fit the following description: It will take cassettes that can be rented for \$3 or less per hour of playing time and cannot be accidentally erased or relieved of their tape contents. (The copy-and-switch gimmick is a tape renter's worst headache.) And, it will provide a picture quality at least as good as the average TV viewer can get on his antenna-fed set—hopefully better.

To the prospective buyer, my advice would be to sit tight, let your neighbors field-test the first available video players, and use the new-release catalogs as a score sheet. As soon as one cassette format starts to show a steady growth in numbers of listings while others diminish accordingly, you'll know what format is likely to win out. That's the time to start shopping. —30—



OPPORTUNITY AWARENESS



Thoughtful Reflections On Your Future

Eleventh in a Monthly Series by David L. Heiserman

Getting Into Computer Servicing

Electronics has always been my favorite hobby and having just graduated from high school I am seriously considering training as a computer service technician. How do I go about preparing for a career in computer servicing?

● Getting started in computer servicing involves three distinct phases of preparation: 1. Completing a formal education in electronics; 2. Getting a job with a large computer firm; 3. Getting specialized computer training.

You can kick off the first phase by either taking a home study course or enrolling in a local technical college that has an appropriate electronics course. In either case, your objective must be to learn as much as possible about all phases of electronics. If you can get an "Associate's Degree" or a degree in Electronics Engineering Technology, so much the better.

This first phase is necessary since most computer companies say that they will only hire service technicians who have at least two years of electronics training or the rough "equivalent." These companies generally mean two years of formal classroom training in a technical school, but some companies will accept military electronics training, or home study schooling with, perhaps, some practical on-the-job experience.

One passing note. In selecting a program of study in electronics technology, stay away from data processing. Data processing schools and instruction courses teach you how to run a computer and not the electronics involved.

Some home study schools and technical colleges offer special programs that can lead to a diploma in computer technology. Before signing up for such a program, make sure you'll learn just about as much general electronics as you would if you were taking a regular electronics technology program. If there are elective courses in digital electronics and data processing and these will not

delay your graduation, take them by all means.

Also in the second phase, note that most schools operate a job placement service and many of the major computer firms have recruiting programs underway most of the time. It is very doubtful you'll have to wait a long time before some recruiters will get in touch with you. If they are impressed with your enthusiasm about computer servicing, you may only have to take a minor technical examination and an aptitude test. Since all computer service technicians represent their company, it is quite important that you show a confident and friendly attitude to all people. Computer servicing is definitely not a "bench job."

Accepting a job with a computer firm and reporting for work opens up the third phase of your career. Instead of starting to fix computers your first day on the job, the company will probably ship you off to school for a full-time, company-paid course in computer technology. These courses will assume that you have substantial electronics training and for 6-10 weeks you'll review more electronics and absorb more computer know-how than you ever suspected existed. When you graduate from the company school, you'll know their line of computers inside and out, and you'll have a first-class job and a bright, promotion-filled career waiting for you.

How Not to Ask for a Job

● Many readers have asked us for advice on how to make a good impression at employment interviews or for more information regarding professional-appearing resumes. The latter subject was covered in part in the May 1970 issue on p 77. Sometimes, however, a single example of "how-not" makes a more lasting impression than a whole feature article written as a "how-to."

Employers appreciate hearing from job applicants who are sincere, enthusiastic, competent, and talented. *Broadcasting Magazine* recently published a letter written by

Mr. Eliot Kohen, program director, KVOR (AM), Colorado Springs, Colorado. This letter was Mr. Kohen's response to a job applicant who had mailed his resume to the station. The comments apply equally well to job seekers in almost any technical profession.

"We haven't any openings, and even if we did, your letter and resume would immediately disqualify you. Perhaps that is the reason for this letter. I'm just flat tired of receiving letters like yours: poorly duplicated, addressed to 'Manager' or 'Program Director' (as if we didn't have any name or as if you were too lazy to look them up), full of spelling, punctuation and grammatical errors.

"Whether or not the school of broadcasting from which you say you will soon graduate told you, broadcasting is a profession. As a broadcaster, you should plan on being a professional. The crime is that there are 'schools' in virtually every city of any size that are happy to take your money, let you play with their tape recorder, pat you on the back, and call you an announcer. And what compounds the crime is that there is always a station somewhere looking for cheap help and willing to hire unqualified people at absolutely minimum wages."

Certainly, the above speaks for itself and change around a few words in the last paragraph and the letter states the case as to why some people are never hired.

Professional Engineering Exams

Your material on electronics consulting (June, 1970, p 69) was read here with great interest. How can I find out where and when the Professional Engineering exams are to be given in my state?

● Although the laws vary somewhat from state to state, an electrical engineer who is self-employed and who designs and specifies electronic and electrical systems must be certified by his state government to call himself a Professional Engineer. Professional Engineering certification is much the same as certification of medical doctors, lawyers, and other service-oriented professions.

To find out where and when your state has Professional Engineering examinations, write to:

National Society of Professional Engineers
209 K Street, N.W.
Washington, DC 20006

This Society can also answer specific questions about all matters relative to Professional Engineering certification.

Evaluating EDP Schools

I would like to start my career in electronic data processing by attending a local EDP school. I have heard some bad comments about EDP schools, though, and I would appreciate any suggestions you might have concerning ways of avoiding being duped.

● Electronic data processing is a relatively new and fast growing occupation. For many people, the prospect of working with the "giant brains" seems quite glamorous and a rewarding and exciting career in EDP has a lot of appeal. The EDP schools know this. There's nothing wrong with sales and advertising efforts that take advantage of this popular appeal as long as promises agree with the facts. Unfortunately, there are a few EDP schools that overplay the rewards and offer shoddy, inadequate training.

The American Federation of Information Processing Societies and the National Better Business Bureau have outlined a few precautionary measures for anyone who wants to enroll in an EDP school:

1. Be cautious with schools that flash extravagant or misleading advertising, employ high-pressure salesmen, or make glib promises of giant salaries immediately after graduation.

2. Avoid schools that offer "prizes" or special discounts for signing a contract immediately.

3. Be wary of schools that offer extremely simple or short entrance aptitude exams or, even worse, none at all.

4. Be skeptical of any school that runs down its competition or tries to sell itself by offering courses that are much shorter than corresponding courses at other schools or in industry.

5. Avoid a school that implies an affiliation with a leading EDP firm when such an affiliation does not exist.

For further information about EDP careers, salaries, and training, write for a booklet titled, "Careers, Computers, and You." Send your request and 25¢ to:

American Federation of Information
Processing Societies
201 Summit Avenue
Montvale, NJ 07645

QUESTIONS ANYONE?

Reader inquiries to this department should be addressed to the attention of Mr. David L. Heiserman, POPULAR ELECTRONICS, One Park Ave., New York, NY 10016. Questions considered to be of significant interest to a number of readers will be answered in print.



COMMUNICATIONS

AMATEUR RADIO

Final Report on Australis-Oscar 5—The 1970 annual report of AMSAT (Radio Amateur Satellite Corp.) contained some interesting notes on the accomplishments of satellite Australis-OSCAR 5. Launched in conjunction with a routine NASA satellite on January 23, 1970, AO-5's two-meter beacon operated for 23 days and the 10-meter transmitter operated for 46 days. Commands from ground were successfully received by AO-5 (a first for amateur radio equipment) and the satellite was heard by hundreds of observers in 27 countries—including the Soviet Union. The passive magnetic attitude stabilization system employed in AO-5 was successful and the spacecraft aligned itself with the earth's magnetic field within 1 week after launch. Work is in progress on the first long-term amateur communications satellite.

SHORTWAVE LISTENING

New Jamming Techniques—As if by mutual agreement, all of the major Communist countries (Soviet Union, People's Republic of China, etc.) introduced new jamming techniques in late 1970. The Soviets are either replacing or adding a new sound to their jammers. Heretofore, much of the Soviet jamming sounded as though the listener were standing 5 feet away from a diesel engine. Recently, a whiny, whirling sound has been introduced that does not appear to have excessive negative peak modulation or wide (30-50 kHz) bandwidth. On some frequencies, the Soviets continue to jam with an "inverted" voice/music signal that some listeners claim to be the Russian Home Service. Communist China has broadened its jamming signals through the use of what appears to be a white noise generator. The broader jamming signal is designed to prohibit the anti-Chairman Mao broadcaster from escaping through a carrier frequency shift of 5 to 7 kHz. (Submitted by Short Wave News Service)

SHORTWAVE LISTENING

Radio Nederland's Madagascar Relay—The new Radio Nederland's relay station in Madagascar will use two 300,000-watt transmitters and will be on the air in mid-1971. The relay operation will be similar to the Radio Nederland station at Bonaire, but will use antennas and transmission times to cover Asia, Africa, and Australia. The tentative schedule has been announced—although no actual date of operation or frequencies have been stated: To Western Australia in the 16-meter band between 0930-1050 and in the 19-meter band between 1100-1200 (all times are GMT). To Indonesia in the 16-meter band between 1100-1200 and in both the 19- and 16-meter bands between 1230-1350. There will be another broadcast to Indonesia between 2300 and 0020 in the 41- and 31-meter bands. The 25-meter band will be used between 1400 and 1520 for transmission to Indonesia and the Philippines and to Eastern Australia between 2130 and 2250. A 19-meter band outlet will also be used in the latter broadcast. Radio Nederland is planning an expansion of transmitters at Lopik in Holland with probably a boost in power and new antennas. (Submitted by Arthur Cushen, MBE)

CITIZENS RADIO (CB)

Channel 9 Looks Good—REACT National Headquarters has announced results of its survey on the effectiveness of the FCC Ruling reserving Channel 9 for emergency communications. Prior to the implementation of the Rule, only 5% of the REACT members felt that Channel 9 was free of non-emergency and illegal communications. After only 10 or 12 weeks of the new Rule, over 28% of the REACT teams indicated that Channel 9 was now clean and free of interference. In the same survey, 69% of the REACT teams said that prior to the Ruling, Channel 9 was unusable, but after implementing the Rule, only one-quarter of the REACT teams say that there is objectionable crowding and interference. The REACT survey also indicated that 55% of the team members felt that the FCC was reluctant to cite violations on Channel 9 and 36% of the REACT teams felt that there should be an increase in the monetary fines imposed on Channel 9 violators. In a separate survey, the swing in the condition of Channel 9 was more dramatic in Ohio and from a 17% rating of "good" and an 82% "bad" rating, the tables were turned a full 180° to 82% "good" and 17.5% "bad."

MEDIUM WAVES

FEBC Expansion Plans—*The Far East Broadcasting Company is the most diversified of the missionary broadcasters with transmissions in 36 languages and stations in the Philippines, Okinawa, California, and recently in Seychelles. The FEBC Vice President for Public Affairs, Mr. M. D. Atienza (right), gave me details not long ago of their expansion plans. Besides the regional stations now in operation—DXKI, Koronadal, South Cotabato, Philippines (1060 kHz, 1 kW); DXAS, Jolo, Sulu, Philippines (1300 kHz, 1 kW); and DYFL, Borongan, Eastern Samar (650 kHz, 1 kW)—new stations are to be opened in Dumoy, Davao City, Philippines some time this month with a 5-kW transmitter. Plans are also underway for a station at Legaspi (1-kW transmitter) and Cayan Isabela, both in the Philippines. Outside of the Philippines, the three medium-wave stations in Okinawa will probably close when the Ryukyus are handed back to Japan. South Korea is visualized as the most likely new home for these stations. It has also been reported to me by a missionary from Johannesburg that new antenna towers will be erected in Seychelles for transmitting gospel programs to Central and South Africa. (Submitted by Arthur Cusben, MBE)*



CIVIL DEFENSE

New LF Warning System—The Office of Civil Defense is requesting \$2,000,000 to install and test a prototype LF warning transmitter near Edgewood City in northeastern Maryland. The OCD has developed a rapid warning dissemination system predicated on a low-frequency network of "control" and "distribution stations." These stations would be scattered from coast to coast. The new system has been tentatively called Decision Information Distribution System (DIDS). The 10 distribution stations would be activated by two new control stations to be constructed, one near Alcova, Wyoming and the other in northwest Arkansas. The control stations will

(Continued on page 98)



THE PRODUCT GALLERY

Seventh in a Monthly Series by "The Reviewer"

THE DESIGN, manufacture and sale of TV antennas comprise one of the most competitive areas in consumer electronics. With little to distinguish one antenna from another, advertising claims have recently concentrated on ease of assembly, colors (anodizing), strength, etc. The need for something new has been present for several years and, to our way of thinking, has been fulfilled in the past few months.

WINEGARD "SENSAR" VHF/UHF TV ANTENNA

The "Sensar" is physically a "different" TV antenna. It appears to be a folded dipole with an unusually low length-to-element-width ratio (10:1). The Sensar measures 46 inches from tip to tip and the blade-shaped element is just under 5" wide. At the center of the dipole is a plastic housing containing a broadband VHF-UHF TV amplifier. No details on the amplifier circuit were received by your reviewer though certain assumptions can be made. The gain exceeds 40 dB and the passband virtually eliminates amplification of signals between 90 and 170 MHz.

There are six parts to the Sensar TV antenna system: the SR-20 antenna itself, the supporting mount, 75-ohm coaxial downlead or feedline, low-voltage power supply, connecting cable from the supply, and the VHF-UHF band separator or splitter. Winegard sells 3 mounting variations—one for the roof (Model SRM), one for wall, chimney or attic (Model WRM), and one for use on a boat or a house trailer (Model STM). Obviously, you can use any existing supporting mast as long as it has the necessary height and rigidity.

Tests. The Sensar was tested by comparison to the "Pyramidal" (POPULAR ELECTRONICS, July 1969, p 27) and the results given here are subjective. (No field strength measurements were made.) At a distance of 27 air miles from New York City's Empire State Building, the Sensar provided color signals of the same quality as the multi-

element Pyramidal on all VHF channels. There was slight ghosting on channels 2 and 4. In the UHF TV band, the Sensar outperformed the Pyramidal and produced notably better color pictures with less grain. This improvement was undoubtedly due to the amplification of the UHF signal at the antenna as opposed to feeding the signal down without amplification.

The broad horizontal pattern of the Sensar is not a true figure 8 but appears to consist of several major lobes on each side of the antenna. As expected, the lobe structure varies between the VHF and UHF channels.

The principal advantages of the Sensar are physical size (ease of mounting) and signal amplification at a low noise figure (good circuit design). Though extensive urban tests have not been made, the Sensar probably has the disadvantage of lack of discrimination between primary signals and ghost signals arriving at the back of the antenna from tall buildings, hillsides, water towers, etc. This effect can be curbed by careful mounting to take advantage of the screening of walls, chimneys, etc.

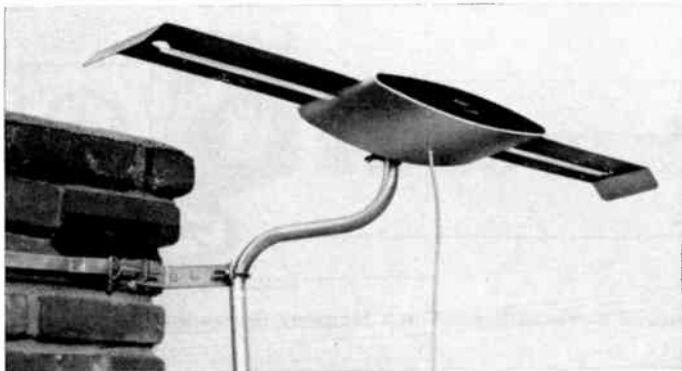
EDSYN SOLDAVAC

The need for a suction-type desoldering tool is keeping pace with the increasing use of printed circuits. Repair of PC's and replacement of components can be simplified by use of the proper tools. In April 1970, we described a solder sucking tool that worked like a charm, but was hazardous to the user because of the "throw" of the plunger. Some months later we received a more sensibly constructed tool that wins our unqualified recommendation. The Edsyn Soldavac is small, low-cost, one-handed, and very efficient. It is operated by cocking the spring-loaded plunger and then releasing it to create a sucking action through the Teflon tip held near the puddling solder. The solder is sucked into the barrel and can be shaken out or the Soldavac disassembled for easy cleaning.

—50—

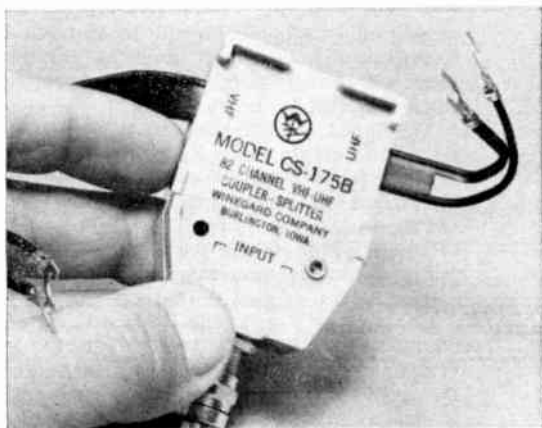
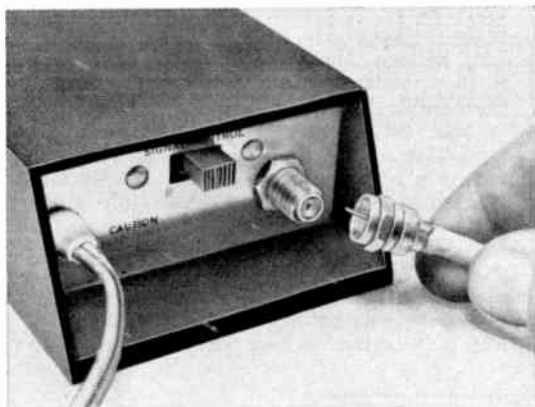
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Winegard Sensor—Circle No. 89 on Reader Service Page 15 or 95.
Edsyn Soldavac—Circle No. 90 on Reader Service Page 15 or 95.



**WINEGARD
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OUTER SPACE LOOK. Winegard's new "Sensar" TV antenna system features a solid-state broadband amplifier in a plastic housing with two metallic wings forming a sort of aperiodic tuned circuit. It looks like something out of the early movie version of "The War of the Worlds." This shows the preferred chimney mounting, but the downlead has not been looped and fed down through support.



SUPPLY AND ISOLATOR. Power for the amplifier in the antenna is rectified in small package (left) that must be located near the TV receiver. The voltage going up to antenna and signal coming down are isolated from one another. Slide switch introduces 20-dB cut in amplification. The signal separator (above) is attached to the amplifier/power supply output through a 5-foot length of coaxial cable.



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EASIEST TO USE. The Soldavac is a truly one-handed, sucker-type desoldering tool. Suction is created by plunger action inside the short barrel. User cocks the plunger by depressing tab with thumb until tab locks in place. Plunger release is actuated by the lever under the user's index finger. Tool is easily disassembled to remove dirt and flakes of cold solder that collect during use.

SOLID STATE

One Hundred Seventy-Eighth in a Monthly Series by Lou Garner

MANY READERS who have built the PLL SCA Adapter (December 1970), have requested a squelch circuit to remove the background noise when the SCA carrier is removed during portions of the program. Such a circuit is shown in Fig. 1.

The input is connected to the emitter of *Q1* of the original circuit, while the output is taken from the emitter of *Q3* (of the original circuit) and passed to the squelch circuit via diode *D1*. The output terminal and *C12* of the original circuit are not used, and the audio output is now taken from the same source as the original adapter.

Looking at Fig. 1, the SCA subcarrier is coupled to amplifier *Q1* whose collector load is a tuned circuit at 67 kHz. Emitter follower *Q2* provides the impedance change required to drive the squelch rectifier (*Q3*) without loading the tuned circuit. When the 67-kHz SCA carrier is present, the squelch rectifier collector voltage drops to near zero, thus making diode *D1* conductive, and allowing the audio signal to reach the audio output terminal.

When the 67-kHz subcarrier disappears, *Q3* does not turn on, thus its collector volt-

age goes up, reverse biasing diode *D1*. This does not permit the audio signal to reach the output terminal. The control potentiometer at the input to the squelch circuit should be set at the point where the SCA audio passes through the circuit. If this potentiometer is set too high, the background noise will turn on the squelch rectifier, nullifying the circuit.

A Fishy Project? Many fishermen feel that fish are inquisitive about strange noises underwater. It appears that sometimes the little (or hopefully, big) rascals come arunning when a strange noise suddenly appears in their midst. Over the years, many an experimenter has built a so-called "fish attractor" usually consisting of a simple audio generator and a small speaker, all mounted within a watertight case, and lowered into the depths. Some claim it works, while others just shake their heads. Anyway, if you want to try it this spring, Techniques Inc., 235 Jackson St., Englewood, NJ 07631 is making available their Pisces 1, a two-transistor tone generator whose schematic is shown in Fig. 2. Varying the two potentiometers pro-

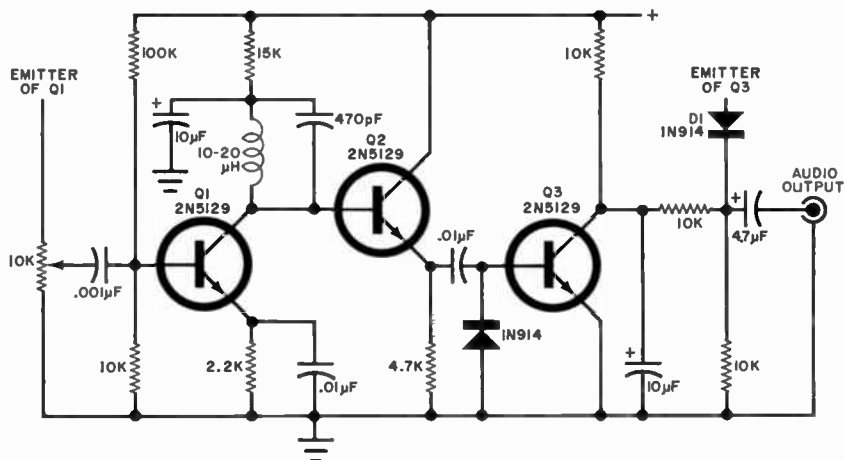


Fig. 1. This squelch circuit can be used with the PLL SCA Adapter to remove the background noise when the SCA carrier is removed during portions of the regular program.

duces a wide variety of sounds, hopefully including one that will attract the fish you are after. Pisces 1 is available at \$9.95 in kit form, and comes with a pair of waterproof plastic bags to protect the device underwater.

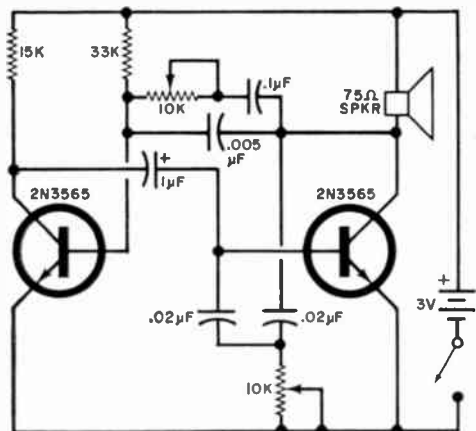


Fig. 2. Schematic of Pisces 1 two-transistor tone generator. Varying potentiometers changes sound.

Readers' Circuits. Submitted by Vincent X. Golden (736 North 4th St., Springfield, OR 97477), the UJT-controlled flasher circuit illustrated in Fig. 3 may be used for assembling an emergency flasher for autos, a signal lamp for small boat piers, and identification flasher for a driveway or turn-off road entrance, or an attention-getting device for store window displays. It may be modified, if desired, for use as a cyclic switch for

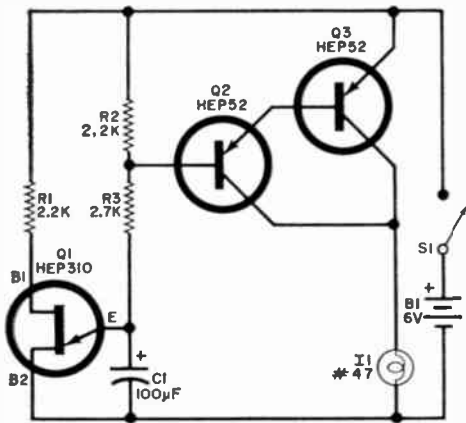


Fig. 3. This UJT-controlled circuit may be used for various applications including an emergency flasher for autos, boats, piers, and roadways.

March, 1971

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CIRCLE NO. 37 ON READER SERVICE PAGE

heaters or such electromechanical devices as motors and solenoids.

In operation, unijunction transistor $Q1$ is used as a conventional relaxation oscillator to provide base bias drive to Darlington pair $Q2$ - $Q3$ through its tapped charge resistor, $R2$ - $R3$. The Darlington amplifier ($Q2$ - $Q3$), in turn, drives an incandescent lamp load. The circuit's repetition rate (frequency) is determined by the UJT's characteristics, by the supply voltage, and by $Q1$'s emitter RC time constant. In practice, the circuit's flashing rate generally is changed by changing $C1$'s value—as it is increased, the cyclic rate is reduced and vice versa.

Neither parts arrangement nor wiring is critical and therefore, the circuit may be duplicated using any preferred construction method. Vincent writes that he assembled his model on a conventional terminal strip and mounted it in an empty shoe wax bottle fitted with a red plastic cap. If cyclic switching is preferred to a flashing lamp, replace the lamp with a moderately sensitive dc relay with a 6-volt coil, using the relay contacts to switch an external device, such as a

more powerful lamp, a solenoid, or a relay.

Noting that many commercial IC's require dual dc power sources, reader Eugene Richardson (Alexandria, VA) suggests that the transformerless dc-to-dc converter circuit in Fig. 4 might be of interest to readers assembling projects for mobile applications where single battery operation is preferred. He indicates that the design was adapted from a circuit described in a professional engineering journal.

A straightforward arrangement, the converter is basically a dc chopper combined with a conventional voltage-doubler rectifier. Referring to the schematic diagram, a square wave signal source, such as an IC multivibrator, is used to drive phase-splitter $Q1$ through coupling diode $D1$. Base bias for $Q1$ is furnished through $R1$, while $R2$ and $R3$ serve as its collector and emitter loads, respectively. Driven by $Q1$, $Q2$ and $Q3$, in conjunction with diode $D2$, serve as a simple high level switch, developing a square wave signal with a peak-to-peak amplitude essentially equal to the dc supply voltage. Coupled through $C1$ to remove its dc component, the

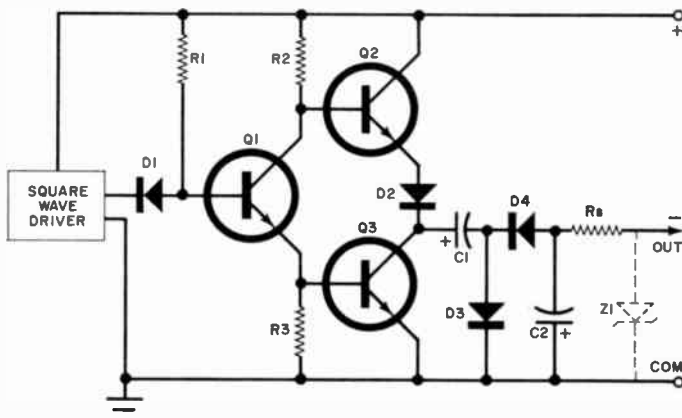


Fig. 4. This transformerless dc-to-dc converter circuit is good for any mobile application when single battery operation is desired. It is basically a dc chopper combined with a voltage-doubler rectifier circuit.

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square wave signal is converted into dc of reverse polarity by a voltage-doubling rectifier network made up of $D3$, $D4$ and $C2$ (in conjunction with $C1$). Capacitor $C2$ also serves as a ripple filter. The resulting dc may be used directly in other circuits or, if desired, stabilized by a voltage regulator consisting of series resistor $R3$ and zener diode $Z1$.

Requiring relatively few components, the dc-to-dc converter may be assembled on perf board or on a suitable etched circuit board, as a self-contained secondary dc power source. Neither device types nor component values are overly critical as long as the transistors and diodes are capable of handling required load currents at the voltage levels involved. For optimum performance and maximum efficiency, however, a symmetrical drive signal should be used, with component values chosen so that $Q2$ and $Q3$ are driven to saturation and cut-off on alternate half-cycles. The drive frequency is not critical, either, but signals in the kHz range (say, 2 to 6 kHz) are preferred for best ripple filtering. Capacitors $C1$ and $C2$ should be moderately large—100 to 400 μf .

Gyration, anyone? Dubbed a *gyrator* because its electrical action is analogous to that of a mechanical gyroscope, the circuit illustrated in Fig. 5 has the interesting characteristic of being able to transform a load impedance into its "dual" electrical equivalence. Thus, a load capacitor (ZL) connected across its output acts as a high- Q inductance at the circuit's nominal input terminals.

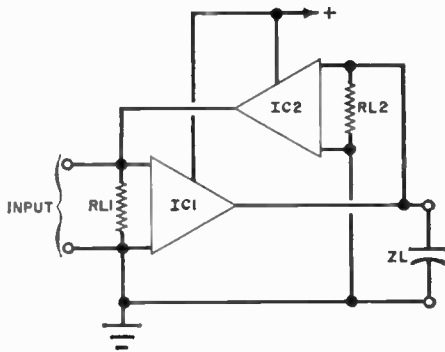


Fig. 5. The gyrator concept is used to transform a load impedance into its electrical equivalent. Back-to-back amplifiers form a two-port network.

As the phase-locked loop (or PLL) discussed in our January column, the gyrator concept has been known for some time but, in the past, has seen relatively little practical use due to its comparative complexity and the large number of discrete components re-

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quired for circuit operation. With the current availability of low-cost linear IC's, however, the circuit now can be used in such practical equipment projects as active filter systems, receivers, and tuned amplifiers.

Referring to the circuit diagram, the basic gyrator consists of back-to-back coupled amplifiers, forming a two-port network. One amplifier (*IC1*) is noninverting, while the other (*IC2*) is an inverting type, providing a 180° phase-shift between its input and output signals. In operation, the output signal derived from the first amplifier is applied to an output load impedance, *ZL*. If a capacitor is used here, the load current will lead the voltage by 90°. When this signal is applied to the inverting amplifier, *IC2*, and given an additional 180° phase-shift, the resulting output current *lags* the original input voltage by 90°, thus simulating the electrical action of an inductive element.

In practice, the amplifiers used in the cir-

cuit must be quite stable both at unity gain and with an active feedback factor equal to their forward gain. In addition, they should provide the option of both inverting and non-inverting outputs and have very high input and output impedances. A number of commercial IC's meet these requirements.

Slow That Kick! Another chapter—hopefully the last—in our continuing serial, *The Saga of the Slow-Kick Windshield Wiper*. As you may recall, our story opened on a note of finality with the publication of Donald K. Belcher's original feature article in our March 1968 issue. But the villain would not die, so readers Jonathan J. Albers and Charles A. Huber struck telling blows with "slow-kick" circuits of their own, published in our December 1968 and April 1970 columns, respectively. Huber's effort was particularly potent, for it was by far the simplest of the circuits, requiring but a single

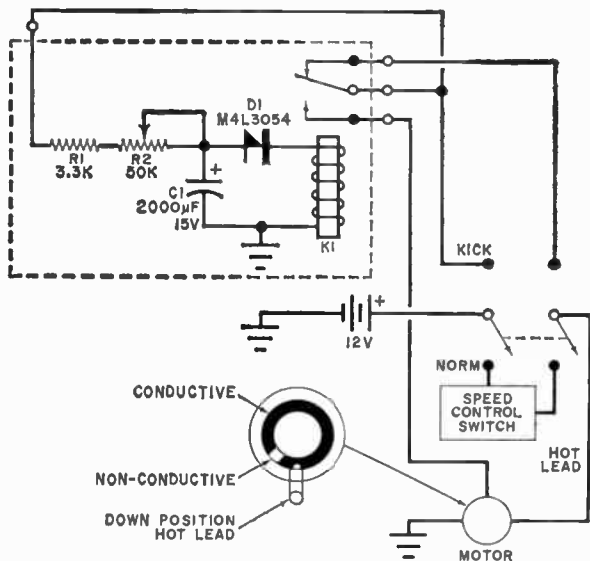


Fig. 6. Original slow-kick windshield wiper circuit of one reader is enclosed in dashed box. Another reader adds a dpdt switch and use of additional relay contact to make the whole circuit applicable to cars such as the Volkswagen.



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active device (a four-layer diode), two resistors, one capacitor, and a 12-volt relay. Everyone breathed a sigh of relief.

But lo—the villain still lurks in the shadows! It seems that Huber's circuit, while simple, inexpensive, efficient, and reliable, does not work too well on the ever-popular "bug," at least according to Volkswagen owner Richard C. Gabbey (2002 1/2 N. Wisconsin St., Racine, WI 53402). Dick writes that VW's, unlike American cars, use a unidirectional wiper motor controlled by a special conductive timing disk. As a result, Huber's circuit "kicked" the windshield wipers over a mere one-third of their normal travel distance.

Like most of our readers, Dick is inventive by nature. Instead of hanging his head in despair, he promptly modified Huber's design to achieve the arrangement shown in Fig. 6. Huber's original circuit is enclosed by the dotted line, with the only new component being a dpdt "Kick-Normal" switch. Except for the switch, the only other major change is the use of relay *K1*'s NC contact to furnish power to the wiper motor's "down position hot lead."

O.K., Beetle owners?

New Hobby Kits. Two new construction kits have been announced by Motorola HEP through its distributors. They are the HEK-3 Radio Amateur Kits retailing at \$5.95 that contain two r-f/i-f linears IC's and an RTL logic IC, and a project brochure showing how to make transmitters, amplifiers, etc. The other kit is the HEK-4 Home Handyman Hobby Kit at \$4.95 containing an SCR, a UJT, a silicon rectifier, and a silicon npn transistor. The brochure that comes with this kit illustrates 11 different and useful home applications for the semiconductors.

Manufacturers' Circuits. Designed for use as a variable-speed control for low-power universal motors of the type used in sewing machines, mixers, blenders and similar household appliances, the circuit shown in Fig. 7A was abstracted from the specifications brochure for GE's type C106 SCR. According to GE, the design may be used as a direct replacement for carbon-pile or rheostat type controllers and is suitable for any universal (ac/dc) motor requiring up to 1.5 amperes. Unlike many simple SCR control circuits, this version includes a speed-dependent feedback arrangement to insure adequate torque at all speed settings.

In operation, RC network *R1-C1-R2* provides an adjustable ramp-type reference voltage superimposed on the dc voltage developed by diode *D1*. The combined voltages are applied to the SCR's gate as a control signal through diode *D2*, but the reference voltage is balanced within the gate by the

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SOLID STATE

(Continued from page 89)

motor's residual counter-emf, coupled back through $C2$. If the motor slows down due to heavy loading, its counter-emf drops, permitting the reference ramp voltage to trigger the SCR earlier in the ac cycle, applying more power to compensate for the load and thus speeding the motor back up to its pre-set speed.

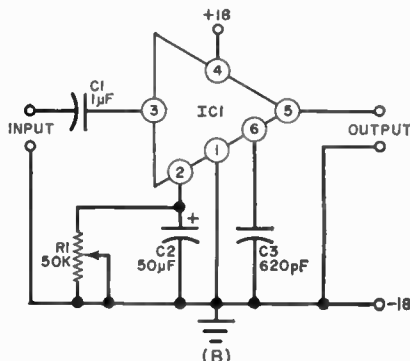
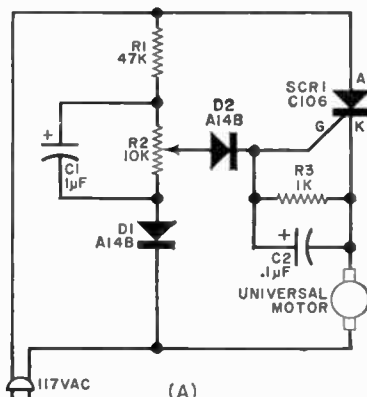


Fig. 7. Circuit at (A) uses SCR to control the speed of low-power universal motors used in appliances. Circuit (B) uses new electronic attenuator IC in remote volume control with 13 dB gain.

Featuring inexpensive components, the speed control circuit can be duplicated at modest cost. Except for linear potentiometer $R2$, the resistors are half-watt types, while both capacitors are 50-volt electrolytics.

With neither layout nor lead dress critical, the control circuit can be assembled on a perf board, small chassis, or etched circuit board. The SCR should be heat-sinked, of course, and all dc polarities must be observed. If adequate space is available within

the controlled appliance, the SCR circuit might be installed as a direct replacement for an older control—if not, the circuit could be assembled in a small plastic or insulated metal box as a separate accessory.

The "remote" volume control circuit illustrated in Fig. 7B is but one of several possible applications for a unique new component recently introduced by Motorola Semiconductor Products, Inc. (Box 20912, Phoenix, AZ 85036). Identified as the type MFC6040 electronic attenuator, the new device is a six-lead, plastic-encapsulated, monolithic silicon IC consisting of ten npn transistors, three diodes, eighteen resistors and an integral capacitor. It can supply a voltage gain as high as 13 dB while providing an attenuation range of up to 90 dB. The unit's maximum input signal voltage rating is 0.5 volt, rms, while its frequency response extends well into the lower MHz values.

Referring to the schematic diagram, the MFC6040 (IC1) is controlled by potentiometer R1, bypassed for ac signals by C2. Capacitor C1 serves as the dc blocking input capacitor, while C3 provides high-frequency roll-off. An 18-volt dc power source is used.

In practice, the circuit may be used as the gain/attenuator stage in a PA system or other audio amplifier. Since the control device (R1) handles only dc, it can be placed at any reasonable distance from the amplifier proper and connected to it with ordinary two-conductor cable.

Extremely versatile, the MFC6040 may be controlled by an externally developed dc signal voltage as well as by a resistive component. This permits the device to be used in compression and expansion amplifiers or in audio age systems. If combined with suitable frequency-shaping networks, the device also should be suitable for "remote" tone control applications.

Manufacturer's Circuit. Suitable for use in high-frequency oscilloscopes, video equipment, signal tracers, receivers, counters, and other types of test and communications equipment, the wideband amplifier circuit given in Fig. 8 was developed by RCA (Harrison, NJ 07029) to illustrate a typical application for their type CA3018 integrated circuit. Assembled in a 12-pin TO-5 style package, the CA3018 is a monolithic device consisting of four silicon npn transistors on a common substrate. While all four transistors are uncommitted, two are independent while the other two have a common base-to-emitter terminal.

According to RCA, the amplifier is flat within 3 dB from 800 Hz to 32 MHz and provides 49 dB gain at mid-frequency. Its gain characteristics remain essentially unchanged from -55° to 125° C. The amplifier's maximum output with a 6-volt dc power supply

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SOLID STATE

(Continued from page 91)

is between 2 and 3 volts, while its dynamic range permits it to accept input signals ranging from 20 μ V, pk-to-pk, to 4 mV rms.

The complete amplifier is basically a dc coupled two-stage arrangement, with each stage a common-collector/common-emitter pair. Referring to Fig. 8, the input signal is coupled through dc blocking capacitor *C1* to common-emitter stage *Q1* which, in turn, is direct-coupled to common-collector (or emitter-follower) stage *Q2*. Resistor *R2* serves as *Q1*'s collector load, *R5* as *Q2*'s emitter load. First stage stabilization is provided by feedback resistor *R4*, bypassed by *C2*. The output signal of *Q2* is direct-coupled to common-emitter stage *Q3* which drives the output emitter-follower *Q4*. Resistor *R6* acts as *Q3*'s collector load, with stabilized bias developed by emitter resistor *R7*, bypassed by *C3*. Both ac and dc feedback is provided by *R3*, trading gain for bandwidth. Finally, *R8* serves as *Q4*'s emitter load.

Conventional components are used in the design. All resistors are half-watt types, while the capacitors may be high-capacity ceramic or paper units or, if preferred, good quality electrolytics. Although neither layout nor lead dress is overly critical, good high-frequency wiring practice should be observed when duplicating the circuit.

Reasonably versatile, the circuit may be modified quite easily to meet specific performance requirements. Its low-frequency response, for example, is determined primarily by the values of *C1*, *C2* and *C3*, while its high-frequency and overall gain characteristics depend on the values of the load and feedback (*R3* and *R4*) resistors.

Device News. RCA's Solid State Division (Route 202, Somerville, NJ 08876) has introduced five new dual insulated-gate MOS-FET's containing integrated gate protection circuits to guard against damage from external transients. All five are depletion type n-channel devices designed for VHF amplifier and mixer applications. Type numbers are from 40819 through 40823.

A new series of six-ampere silicon rectifiers in plastic, axial-lead cases is now available from Motorola Semiconductor Products, Inc. (P.O. Box 20924, Phoenix, AZ 85036). Designated the MR751 series, the new devices are offered in four working peak reverse voltage ratings—100, 200, 400 and 600 volts. With forward voltage drops of 0.9 volts (max) and reverse current ratings of

only 0.25 mA (max) at their specified dc voltages, the new units feature an outstanding 400-ampere inrush surge current capacity.

Also from Motorola comes the announcement of a new group of four complex function TTL IC's. The new devices are the MC4038P and MC4040P gated decoders, the MC4041P Hamming code detector and generator, and the MC4039P seven segment character generator. All four devices are derived from Motorola's XC-170 128-bit

read-only memory (or ROM) and are electrically compatible with all other MTTL lines. Characteristics shared by the circuits are a total power dissipation of 200 to 240 mW per package, less than 7.0 pF output capacitance, and outputs capable of sinking 20 mA dc. All the devices are supplied in 16-pin, dual in-line plastic packages.

Fairchild Semiconductor (Box 880A, Mountain View, CA 94040) has published two new interesting booklets. One is a 12-page brochure describing the firm's TO-92

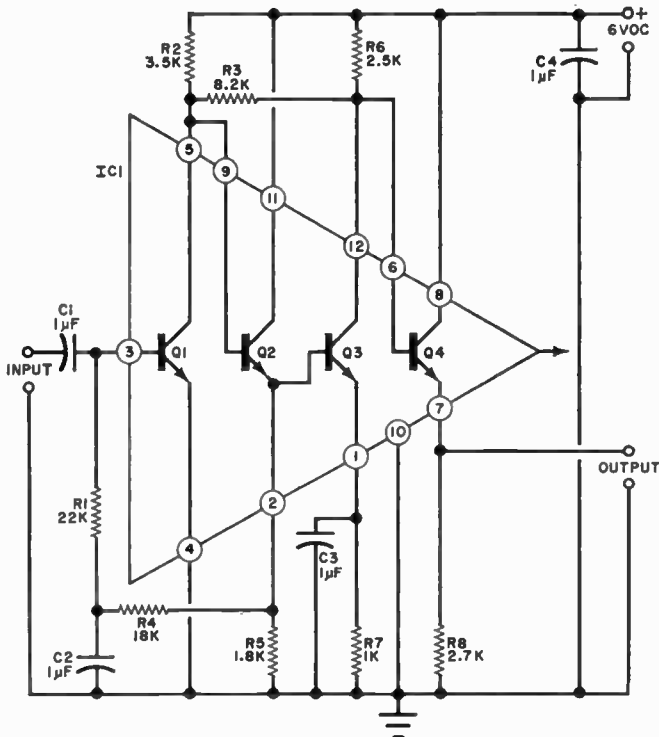


Fig. 8. Wideband amplifier circuit uses a new IC with four transistors to provide 49 dB gain. Response is within 3 dB from 800 Hz to 32 MHz.

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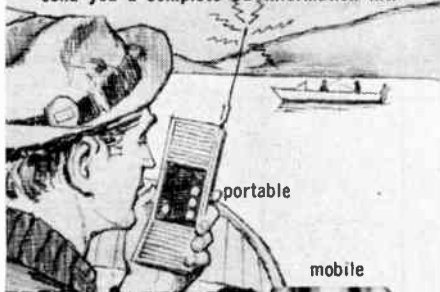
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CIRCLE NO. 19 ON READER SERVICE PAGE

SOLID STATE

(Continued from page 93)

plastic transistors. Providing device specifications and a selection guide for the 75 transistors available in the TO192 package, the brochure also describes construction and design features and includes photos of the company's highly automated assembly lines, illustrating production techniques from die attach and lead bonding to package molding and final testing.

The second booklet is a thick 112-page color brochure that contains specifications for the more than 150 circuit functions making up the firm's complete TTL line. Entitled "Fairchild TTL Family," the booklet includes design information about logic, memory and interface circuits in standard, low power and high-speed ranges, a section on custom devices, and loading charts and pin diagrams. An interesting "extra" included with the booklet is a color wall chart listing all Fairchild TTL devices.

A new series of 250-ampere average rated fast firing SCR's from 600 to 1200 volts has been announced by International Rectifier's Semiconductor Division (233 Kansas St., El Segundo, CA 90245). Available in three case styles in stud-mounted and flat base configurations, IR's new 250RM SCR series is intended for applications such as inverters, ac motor drives, inductive loads with free-wheeling diodes, incandescent lamp loads, induction heating and similar industrial and commercial use.

TRW Semiconductors (14520 Aviation Blvd., Lawndale, CA 90260) has introduced two new broadband r-f microcircuit amplifiers, types CA800 and CA600.

The CA800 amplifier has a 5-MHz to 500-MHz bandwidth, furnishing 25 dB gain across the band. A universal broadband gain block in thin film hybrid IC form, it is intended for use in 50-ohm instrumentation and radio systems. With a 28-volt dc supply, it can deliver a CW power output of 400 mW.

Designed specifically for 75-ohm CATV use, the companion amplifier, type CA600, can supply 28 dB gain over the 40- to 300-MHz band using a 24-volt dc source. This device also offers a 46 dbmv output at -57 dB cross modulation and -66 dB second order harmonic distortion.

Both amplifiers employ class A circuitry and are mounted on aluminum heat sinks which also serve as spacers for PC board assembly.

That closes our story for March . . . but watch those March winds!

—Lou.

Popular Electronics

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CIRCLE NO. 35 ON READER SERVICE PAGE

SWITCHING LOGIC QUIZ ANSWERS

(Quiz is on page 50)

- 1—E In this series AND circuit, all of the switches must be in the "yes" or closed positions before the missile can be fired (lamp lights).
- 2—I In this inclusive OR parallel circuit, each branch provides an indication of the condition of one or both of the doors (switches).
- 3—B In this exclusive OR parallel circuit, only one lamp or the other, but not both, can be on at any one time.
- 4—G In this inclusive OR parallel circuit, the operator of either switch, or both operators simultaneously, can turn on the motor.
- 5—C Closing either switch removes the canopy first (lights the same lamp), and closing the remaining switch then ejects the pilot (lights the other lamp).
- 6—H The first switch to be closed causes its corresponding lamp to be energized at least momentarily and prevents the remaining lamp from operating by opening its series switch. In a draw (simultaneous closing of both switches), neither lamp can operate.
- 7—F Any two of the three switches, or all three can operate the lamp, but any single switch cannot.
- 8—A Closing either switch can turn on the lamp, and the remaining switch can then turn it off. Control of the lamp can take place in any sequence from either direction.
- 9—J In this "odd parity" circuit, any one or all three of the switches can be used to operate the lamp, but no combination of two switches can.
- 10—D In identical parallel branches, one circuit contains the amplifier and the other the indicator lamp.

CALIBRATOR

(Continued from page 40)

put and connect it to the vertical input. Adjust the scope vertical gain until the trace occupies the same number of divisions on the vertical axis. Do not disturb the scope vertical gain control after this.

Connect the calibrator to the scope in the correct way; i.e., V to vertical and H to horizontal. The ground should still be connected. The display should be a square if the diodes are closely matched. If not, insert a trimmer potentiometer between the higher voltage potentiometer (the longer side of the oblong pattern) and the associated diode, and adjust the trimmer until a square is obtained. If the proper value can be found, you can now replace the trimmer with a fixed resistor.

Dial Calibration. Both potentiometers should have pointer knobs and matching blank dials. The maximum full position should be marked with the voltage value found in calibrating the diode (see above). Assume this is 27 volts; then the maximum clockwise mark should be 27. Adjust the scope horizontal and vertical gain controls until the square is 27 divisions on a side. This produces a one-volt-per-division condition on the scope. Now, without touching the scope controls, set both calibrator potentiometers to obtain a square that is 25 divisions on a side. Mark the dials accordingly. Work your way down the scale in 5-volt steps until zero is reached. Intermediate one-volt markings can be added if desired.

If you have zeners with odd voltage values, add equal-value resistors between each po-

tentiometer and its associated zener until a more convenient voltage is reached. For example, assume your zener voltage value is 19.5. You may prefer a more convenient maximum of 15 volts. Set both calibrator potentiometers at maximum and the scope gain controls so that the square trace is 19.5 divisions on each side. Insert resistance between each potentiometer and its associated zener until the trace drops to exactly 15 divisions (15 volts) on a side. This resistance is in addition to the matching resistor previously added. Calibrate the dials as previously described.

Using the Calibrator. The calibrator was originally designed for use with diode and transistor curve tracers and permits the calibration of both the horizontal and vertical scales of the scope. In this case, it is often desirable to have the horizontal scale compressed relative to the vertical scale. This can be done easily using the calibrator to provide one or two volts per division on the horizontal and 5 volts or more per division on vertical. Any type of calibrations can be obtained on the scope. -30-

GENERATOR

(Continued from page 63)

throughout its frequency range. Discriminator output readings should be taken at the dc output point, but prior to any audio coupling capacitor. A zero-center VTVM is handy for these measurements, although any VTVM or TVM can be used simply by switching the meter polarity as the pointer deflection passes through zero. -50-

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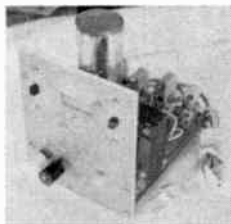
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COMMUNICATIONS

(Continued from page 81)

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CITIZENS RADIO (CB)

CB in Brazil—CB operation in Brazil is taking an enormous upswing and many CB'ers in the United States will be surprised to hear that all CB activity was illegal in Brazil prior to January 26, 1970. Brazilian CB regulations were issued by the Dentel and approved by the Communications Minister. Much equipment is being imported from the US.

LIBRARY

(Continued from page 16)

that their attempts to put design principles into practice are disappointing. This book has been written in an attempt to remedy this situation by the use of two approaches. The first part is devoted to overcoming typical design hazards. The second deals with techniques which enable unusual requirements to be met by simple means. It is assumed that the reader is familiar with the fundamentals of design. The treatment of the text is largely non-mathematical and the emphasis throughout is on design of practical circuits. Most of the illustrated examples include component values suitable for a typical application.

Published by TAB Books, Blue Ridge Summit, PA 17214. Hard cover. 224 pages. \$9.95.

SERVICING TRANSISTOR EQUIPMENT

by Gordon J. King

This book details a systematic approach to the servicing of solid-state radio and TV receivers, tape recording and playback, and high fidelity equipment. The emphasis is on the speedy diagnosis of the trouble one might encounter with such equipment. The early chapters in the book describe semiconductors, how they work, their operating characteristics, and basic circuit types. Subsequent chapters concentrate on fault diagnosis, and include a summary chart of fault diagnosis covering audio and video amplifiers, various generalized circuits, and oscillators. A separate chapter is devoted to the portable transistor radio receiver, including alignment instructions. A final chapter gives practical advice on making repairs and explains printed circuit boards.

Published by Hart Publishing Co., 510 Sixth Ave., New York, NY 10011. 151 pages. \$7.95 hard cover; \$3.95 soft cover.

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Published by The MIT Press, 50 Ames St., Cambridge, MA 02142. Hard cover. 143 pages. \$7.50.

INTRODUCTION TO ELECTRIC CIRCUITS

by H. Alex Romonowitz

Although this book was written for use in a one-year formal course of study, its format is well-suited to home-study techniques. This is not a book on electronics, per se. Rather, it deals exclusively with the characteristics of R, L, and C circuits and networks. Basic principles, theorems, circuit behavior, and problem-solving procedures are presented so that the average student can obtain a clear understanding through an adequate amount of private study. There are 200 worked-out numerical example problems, 600 review questions (about half of which have answers provided for them in a key at the back of the book), and items of historical interest concerning pioneers in science and electrical technology. The reader should have a working knowledge of algebra.

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MARCH 1971

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Ben Valerio, P. O. Box 21, Magna, Utah: "The Edu-Kits are wonderful. I am sending you the questions and also the answers for them. I have been in Radio for the last seven years, but like to work with Radio Kits, and like to build Radio Testing Equipment. I employed every minute I worked with the different kits; the Signal Tracer works fine. Also like to let you know that I feel proud to become a member of your Radio-TV Club."

Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va.: "Thought I would drop you a few lines to say that I received my Edu-Kit, and was really amazed that such a bargain can be had at such a low price. I have already started repairing radios and phonographs. My friends were really surprised to see me get into the swing of it so quickly. The Trouble-shooting Tester that comes with the Kit is real fun to use and find the trouble, if there is any to be found."

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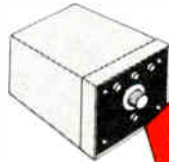
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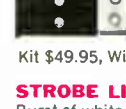
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