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Radio-Electronics

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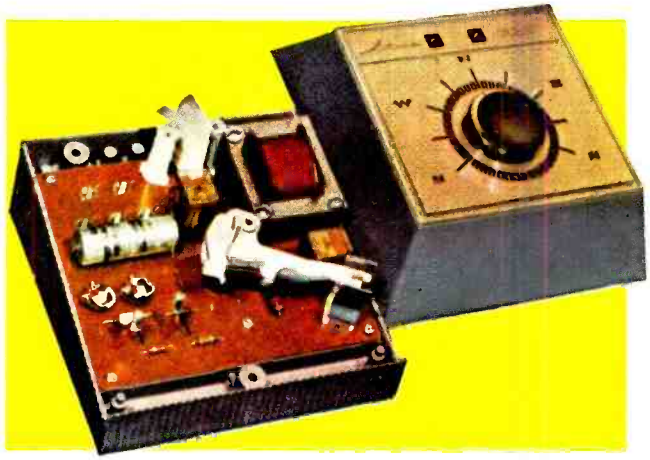
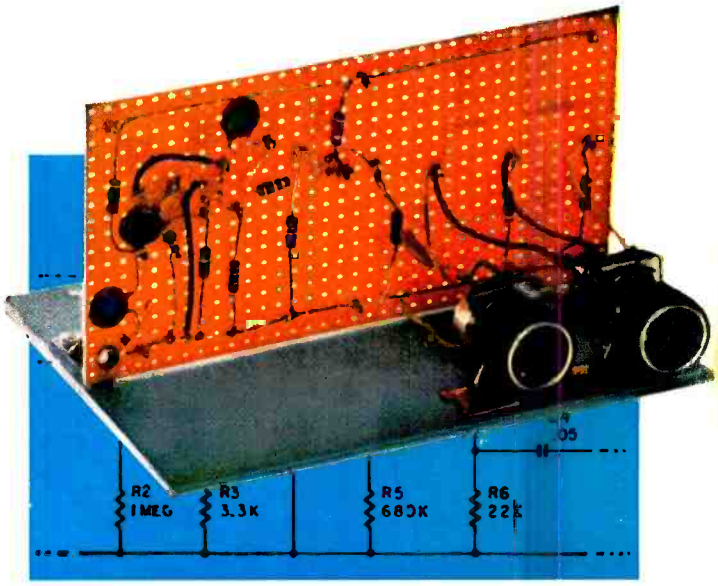
How they work—
New solid-state TV rotators



Experimenters
MOSFET circuits you can build



New in stereo Cassettes '70

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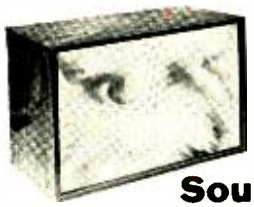

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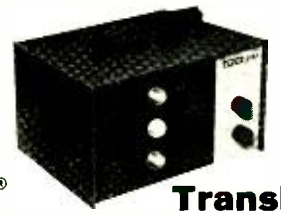

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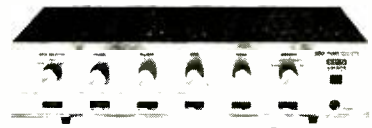

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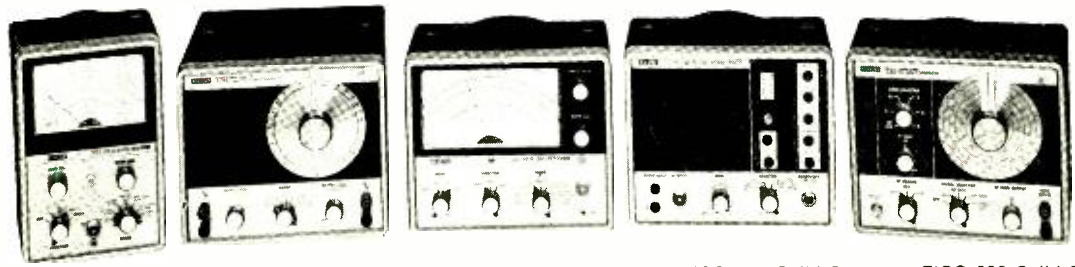

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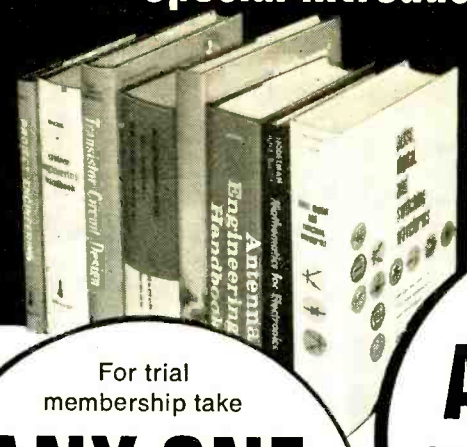

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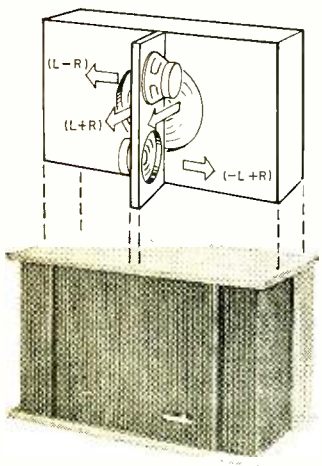
NEW & TIMELY

Volume 40 Number 12 RADIO-ELECTRONICS December 1969

TWO NEW SPEAKER SYSTEMS

NEW YORK—Two types of speaker systems were demonstrated by Jensen and Admiral here recently. Both are designed to reduce costs for stereo systems.

Jensen's approach is a single-speaker setup using "acoustic matrixing." A circuit within a bookshelf-type cabinet combines left- and right-channel signals to produce sum and difference outputs. These signals are directed to an 8-inch acoustic suspension speaker and two 5-inch speakers, one facing left and the other right.

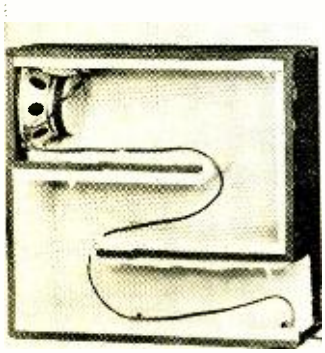


Jensen's Stereo 1

R-E editors, A-Bing the Jensen speaker with a two-speaker system, found that Jensen's new Stereo 1 produces a definite depth and spread in stereo, but concentrates all the instruments at the center.

Admiral presented more details of its "Bull Horn" speakers announced a year ago. Essentially, these are high-compliance speakers used in vented quarter-wavelength, tunnel-reflex enclosures. The idea is to improve bass without massive woofers and powerful amplifiers. The tunnel reflex tubes (see photo) are folded to fit compact enclosures. Various sizes of the system are being used by Admiral for portable stereo phonographs and consoles.

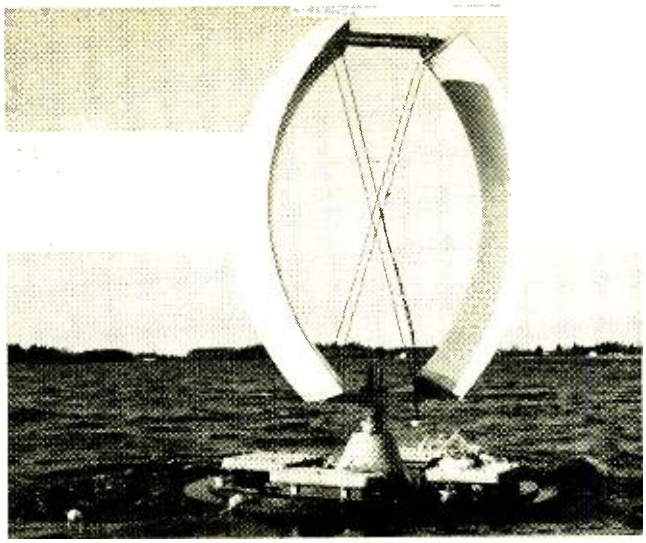
An R-E editor, listening to a "Bull Horn" demonstration, found the system had low bass response, but noticed a "boomy" quality to audio at the low end.



Admiral's Bull Horn

IN THIS ISSUE

TV rotators have turned to solid-state control circuits. Do you know what's inside the new ones? Story starts on page 42.



Robot sailboat afloat on the high seas. Has capability of traveling anywhere in the world, directed by radio.

16-FOOT ROBOT SAILBOAT

NEW YORK—An unmanned robot sailboat capable of moving to a fixed location at sea and "electronically tethering" itself there for a year was recently unveiled by RCA here.

The 16-foot-high vessel maintains its position by receiving signals from navigation satellites, computing where it is and where it should be, then navigating to its station. The sails are rigid, foam-filled plastic structures.

Its disc-shaped hull can carry instrumentation for oceanographic and weather research or defense operations. The SKAMP (station-keeping and mobile platform) can be recalled easily with a land-based radio signal. The Navy has expressed interest in SKAMP.

LOOKING AHEAD

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

SelectaVision and EVR

The two most influential companies in American communications-entertainment-electronics agree that the next major home electronic product will be the color video equivalent of the phonograph—the home video player. And each is pushing its own system, trying to line up allies among manufacturers first, the public later.

Shaping up is a fierce battle of the '70's between SelectaVision (SV) holographic recording and Electronic Video Recording (EVR) film system for home viewing library standards. The battle will be reminiscent, in more ways than one, of the post-World War II fight over phonograph record speeds and color TV systems. The protagonists are the veterans of those former wars—RCA Corp. and CBS Inc.

Despite the 100 per cent incompatibility of the two systems, they're both based on the same premise: That the public will want a simple-to-operate, cartridge-loading, playback-only system to play visual recordings through the antenna terminals of a color TV set—and that magnetic tape isn't the answer.

(continued on page 4)

NIGHT-VISION SCOPES FOR COMMERCIAL USE

NEW YORK — Commercial versions of the military night vision scopes used in Vietnam were introduced by Raytheon Co. at an electro-optical conference recently. Suitable for law enforcement, industrial security and nature study, the MS-101-10 (photo) makes it possible to view a man under starlight conditions from about 300 yards with 4X magnification.

Not shown at the conference was a new night vision tube made by Aereojet Delft Corp. that magnifies an image from a 25-mm lens and displays it on a integral 125-mm-diameter phosphor screen. The direct-vision display tube has a cathode, focusing electrode and

(continued on page 6)

Radio-Electronics

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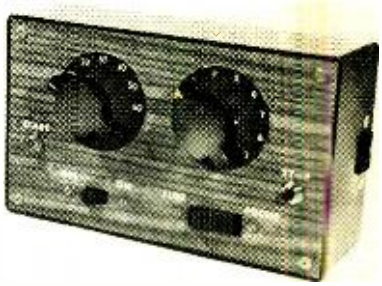
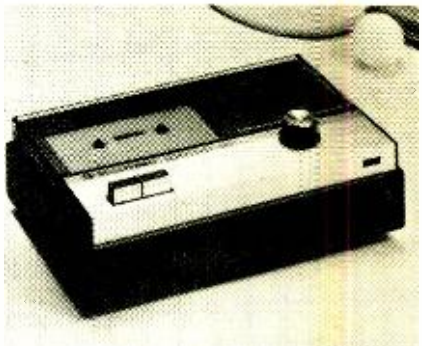


Photographers: put this solid-state, automatic-reset enlarger timer to work on your prints. For complete construction details . . . . . . see page 50



Cassette sounds are improving as new, high-quality tapes and features like this model's preamp-only output, autoload and stereo become available. see page 37

RADIO-ELECTRONICS, DECEMBER, 1969, Vol. 40, No. 12
Published monthly by Gernsback Publications, Inc., at Ferry St., Concord, N. H. 03302
Editorial, Advertising, and Executive offices: 200 Park Ave. S., New York, N.Y. 10003. Subscription Service: Boulder, Colo. 80302.
Second-class postage paid at Concord, N. H. Printed in U.S.A. One-year subscription rate: U.S. and possessions, Canada, $6, Pan-American countries, $7. Other countries, $7.50. Single copies, 60¢.
POSTMASTER: Notices of undelivered copies (Form 3579) to Boulder, Colo. 80302.

Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)

LOOKING AHEAD

(continued from page 2)

Electronic Video Recording

CBS's EVR system is now in the advanced stages of production engineering in an industrial-educational black-and-white version, with both instruments and program cartridges promised by mid-1970. The home color version is scheduled for production the following year. Motorola has the exclusive American rights to EVR until the 1971 color system comes along, when licensing will be available to all comers. Motorola's b-w version will sell for $795, and its color player is tentatively penciled in at 20% more, which would make it around $950 or so.

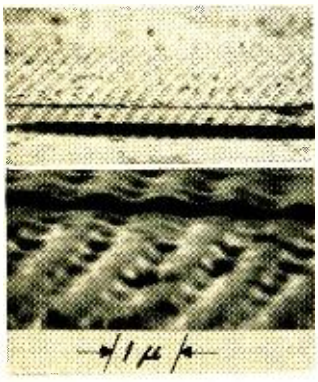
EVR uses a cartridge-encased, sprocketless motion-picture film whose masters are recorded electronically. Prints are made by a high-speed optical exposure process. In the color version, there are two sets of frames side-by-side on b-w film, one containing a conventional optical b-w picture, the other encoded gradations of grey which are electronically decoded into the color signal within the EVR player. (A detailed description of EVR was featured in Looking Ahead in February, 1969.)

SelectaVision . . .

RCA still has an "experimental" label on its SV system, but has given some preliminary demonstrations, presumably to line up allies who might otherwise drift toward EVR. RCA says SV players and cartridges could be on the market in 1972. SV's advantages, according to RCA, are simplicity, ruggedness and low cost. The price target for the color player is $400 at retail, with half-hour home programs to sell for less than $10. Unlike EVR, SV is designed exclusively for home use.

SelectaVision promises to be the first product to bring the laser into the home, and is based on the new science of holography, or the recording of light interference patterns. The tape used by the SV player is low-cost uncoated vinyl on which holographic information is embossed, in much the same manner as a phonograph disc is pressed. The transport will be comparable to a standard mass-produced audio tape unit, except that it probably will have stop-motion and reverse-action capability.

Among the major advantages claimed by RCA for its new system: The tapes are virtually impervious to wear. Scratches, dust, even holes in the tape result in no visible deterioration of the picture because any segment of the frame contains all the information necessary to reproduce the entire frame. No shutter mechanism is needed, mechanical or electronic.



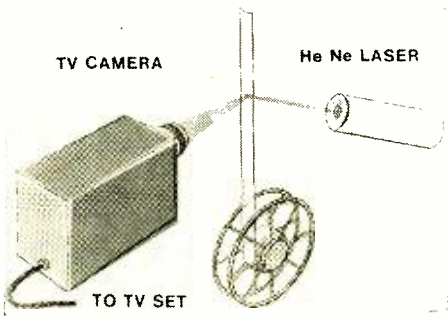
Microphoto of embossed vinyl tape with impressed holograms.

An even closer look at the hologram tape. Note size scale.

A color SV tape is produced from program material on film, video tape or live TV. The first step is to electronically print the material on b-w film, with the color information encoded as a series of vertical stripes. Then the film frames are recorded by a standard laser-beam process as holograms on a plastic tape coated with photoresist. After processing, the plastic tape, which then contains a holographic relief image, is used as a mold to make a metal tape master. Duplicate tapes are made by passing the metal tape at high speed through pressure rollers along with heated vinyl tapes, which become embossed with both the holographic and the color code information.

This printing process is considered a significant breakthrough, permitting the mass duplication of holograms and making the whole RCA system a potentially practical home viewing method. It is based on a patent recently issued to RCA, whose original application in 1964 (in England) envisioned a video disc, rather than tape.

In the home playback device, which probably will be the size of a small open-reel tape recorder, the tape is reeled past a low-powered, 2mW laser, which illuminates it and reconstructs a picture (as well as the coded color information) for a b-w vidicon camera. An electronic decoder converts the picture and the vertical color stripes into a standard NTSC color signal, which is fed through the set's antenna terminals for viewing on an unused channel.

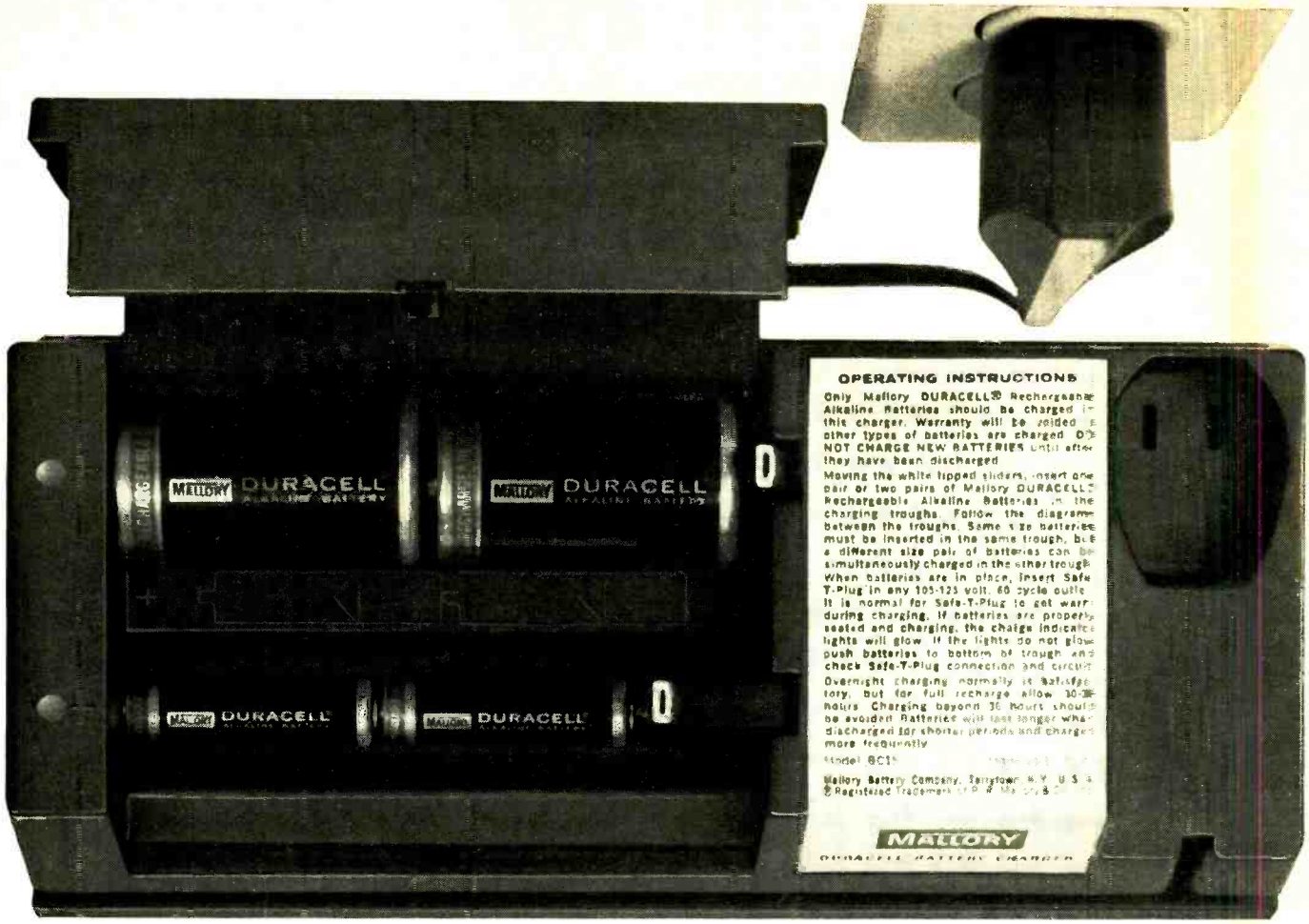


Tape speed and size have not been finally resolved, but in a preliminary demonstration, RCA used ½-inch tape, running at 7.5 ips for 30 minutes of playing time on a 6-inch reel of 2-mil tape. Resolution of a b-w picture shown on the system was about 400 lines, considered completely adequate for home viewing. The final version probably will use tape encased in a two-reel cartridge, somewhat similar to an audio cassette. The SV tape can be stopped at any individual frame for a steady still picture, or played backwards or in slow-motion without picture jitter or loss of sync. RCA's first demonstration was confined almost exclusively to b-w programming, with only a single rudimentary color picture. But engineers said perfection of the color signal was only a matter of time. No sound was on the tape; this probably will be added in the form of optical coding to be picked up by the vidicon camera, rather than a magnetic stripe.

. . . and VTR

Where does this leave the video tape recorder, previously regarded as an important future home electronic instrument? The many previous attempts to introduce magnetic-tape TV recorders for the home have failed, although the VTR has found wide acceptance in education and industry. But there's no question now that magnetic picture record-playback machines for the home have now received a major setback—at least temporarily. It may well turn out that playback-only devices will achieve popularity first, followed some years later by consumer acceptance of new, low-cost, record-and-playback TV machines—just as the phonograph came before the tape recorder in home audio systems.

(continued on page 12)



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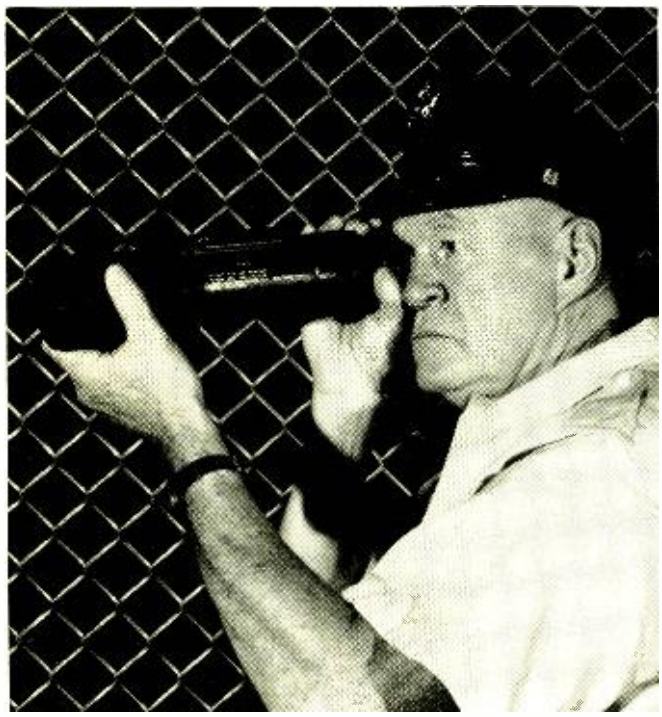
(continued from page 2)

anode. It takes the place of a man's eye behind a secondary-electron-conduction (SEC) scope, displaying a 5X image. Unlike CRT's, the tube does not have a raster-like scan. Developmental versions cost $6000 at this stage.



Also at the electro-optical conference, Amperex introduced a silicon-diode-array camera tube similar to those first developed at Bell Labs. Unlike conventional vidicons, the sensing mosaic consists of some 650,000 n-type islands on a quarter-size p-type silicon wafer. The light-sensitive wafer can easily provide a TV image of a smoker from the glow of a cigarette.

RCA presented a combination SEC and silicon-target vidicon with an image gain of 2500. The combination technique provides 600 TV line resolution at 2 X 10^{-5} foot candles. RCA's C21117B uses the silicon array for the photoelectron-sensing SEC target. It will be available in mid-1970.

X-RAY BURNS REPORTED AT NEA CONFERENCE

WATERBURY, CONN.—X-radiation from color TV sets under repair was blamed for burns and eye damage by technicians attending the annual National Electronic Association conference. According to two technicians, permanent damage to their right eyes had been caused by being too close to the CRT screen during convergence. Another technician, who habitually laid his left arm on top of sets while making adjustments, claimed he had developed a type of skin cancer on his forearm.

A G.E. representative pointed out that ordinary safety glasses can significantly reduce X-rays reaching eyes. G.E. and other set manufacturers indicated new chassis have been engineered for minimum radiation. Misadjusted or excessively high voltage is the prime cause of high X-ray levels in color TV.

IN THIS ISSUE

Experiment with MOSFETS. Complete details on a group of useful circuits you can build and use. Story starts on page 61.

SATELLITE TV

A stationary applications satellite will be beaming TV directly to millions of Indian villagers in 1972 if all goes according to plan. The joint U.S.-Indian plan calls for thousands of 10-foot dish antennas costing only $500 to be installed in villages.

These antennas will receive transmissions from a 30-foot antenna on a satellite capable of beaming a concentrated TV signal to earth from a 22,300-mile equatorial orbit. An 80-watt transmitter is planned for the satellite.

Programs planned by the Indian Government will be beamed to the satellite from a ground station.

SUPERPOWERFUL LASER TRIGGERS FUSION

PARIS—A superpowerful laser has been used by the French Atomic Energy Commission to create minute thermonuclear explosions. The laser, capable of delivering 50-billion-watt pulses for 5 nsec, was used to fuse deuterium nuclei held near absolute zero.

The fusion energy released in the form of neutrons is difficult to detect because of its low level. The

(continued on page 12)

Radio-Electronics

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RADIO-ELECTRONICS is published by Gernsback Publications, Inc.
200 Park Ave. South
New York, N.Y. 10003
(212) 777-6400

President: M. Harvey Gernsback
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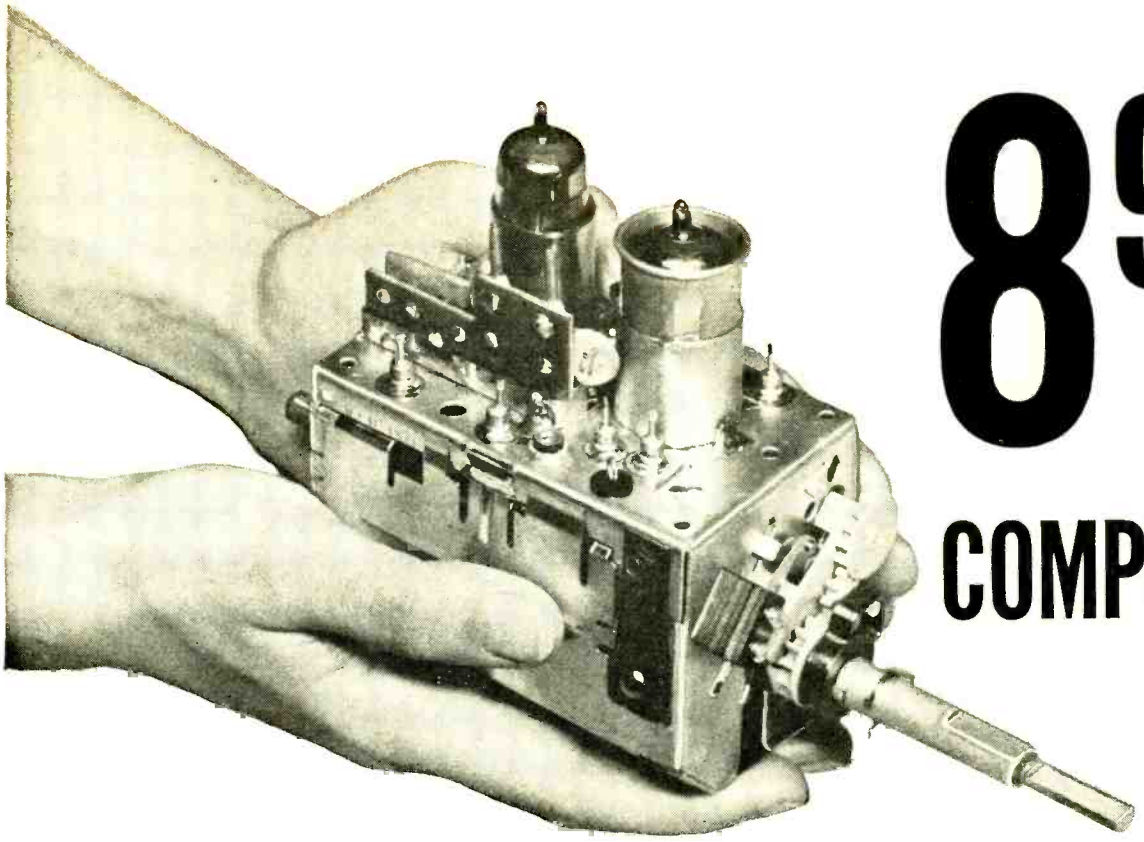

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CR6XL	Parallel 6.3v	2½″	12″	41.25	45.75	10.45
CR7XL	Series 600mA	2½″	12″	41.25	45.75	11.00
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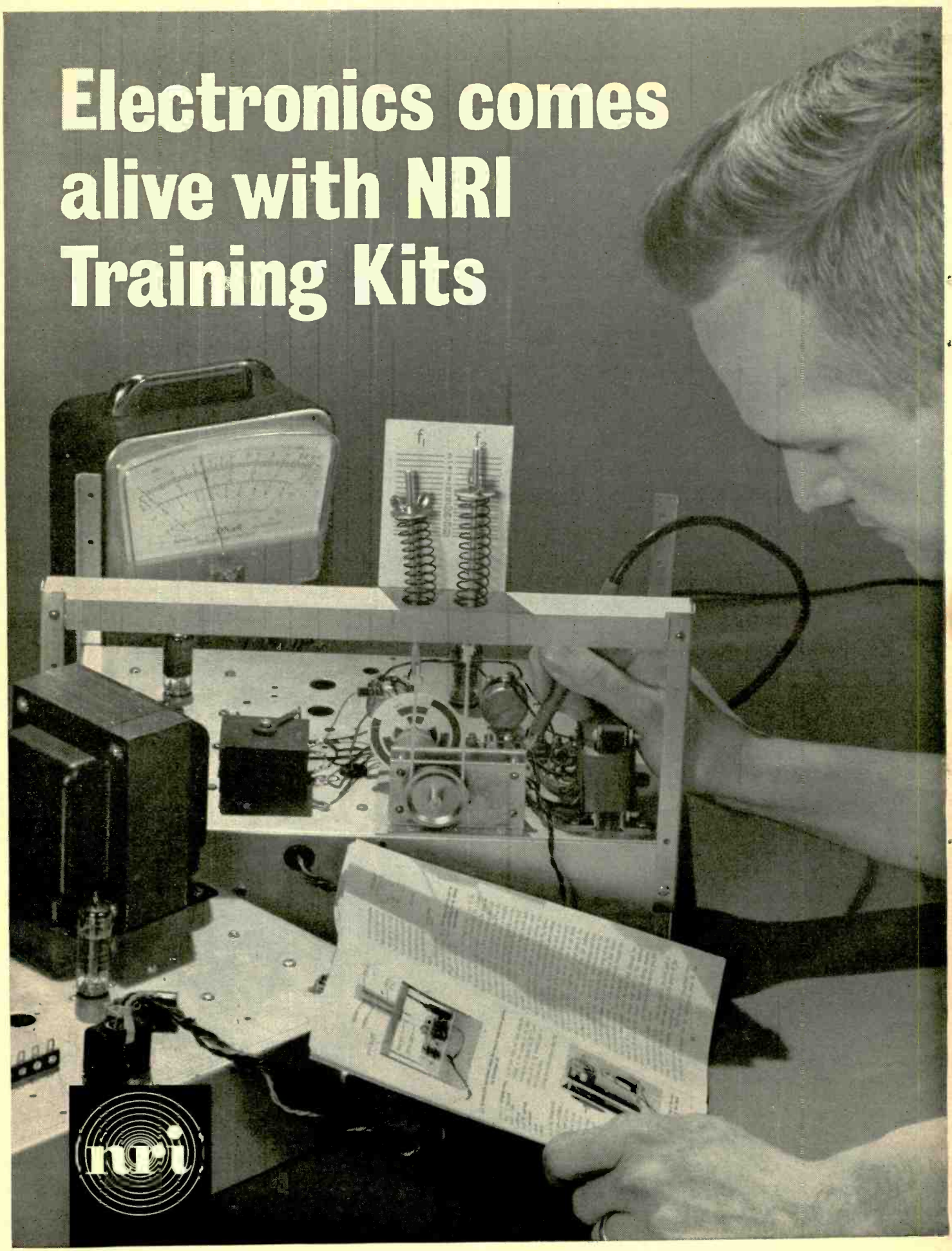

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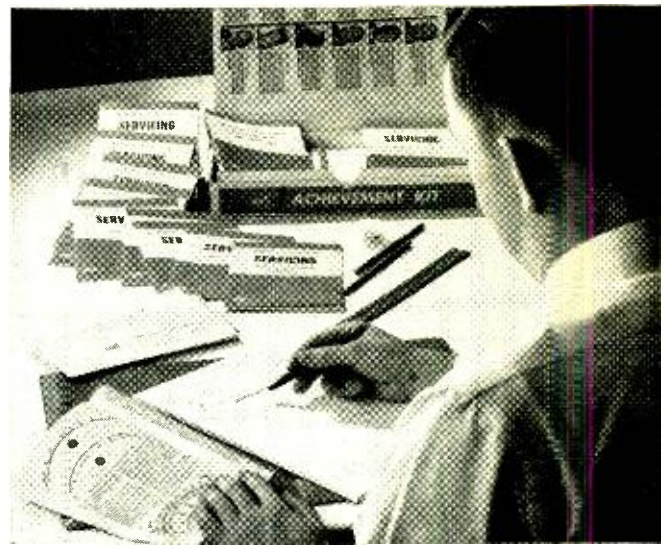

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*You must pass your FCC License exams (any Communications course) or NRI refunds in full the tuition you have paid.

New & Timely (continued from page 6)

laser blast raises the deuterium temperature to 15 million degrees Fahrenheit. Similar experiments have been conducted in the USSR and the U.S., according to a report in *The New York Times*.

ELECTRONIC TOOL SEES COLORS

Color blind? The Colormate 2000 might solve some of your problems, although the newly patented instrument was designed with the chemical and printing industries in mind.

The Colormate "sees" a sample of a material as a human eye would by comparing it with a standard and recording any color differences. A sample color is identified by alternately shining light on the sample and a standard through amber, green and blue filters. A photocell receiving the reflected light then moves up or down until it receives equal light from both sample and standard.

A printout or chart indicates color changes needed to achieve a match. The electronic colormeter is made by Neotec Corp., a Rockville, Md., firm.

VOICE-OPERATED TYPEWRITER FOR PHYSICALLY HANDICAPPED

Poor typists who blame their mistakes on the typewriter would feel comfortable with this model—it's voice operated .An experimental set-up developed by a British division of ITT, it is being studied as an aid to the physically handicapped. Up to 20 words per minute can be typed by "dit-dahing" Morse code sounds into the machine's microphone. It works, but there are no immediate plans for production.

(continued on page 14)

LOOKING AHEAD

(continued from page 4)

Mobile radio problems

The long-simmering problem of overcrowding in the mobile radio bands has taken a new turn. A special study made for the FCC by the Stanford Research Institute indirectly blamed the FCC for "inadequate frequency management." Mobile radio users and manufacturers have long insisted that insufficient spectrum space is available for land-mobile use and have requested the reassignment, or sharing, of a portion of the current uhf television band. The Commission now has pending proceedings for sharing of channels 14 through 20 between television and mobile radio and the reassignment of TV channels 70 through 83 to mobile radio use.

The Stanford report suggested that lack of FCC "management" of the mobile spectrum was largely responsible for overcrowding condition in some areas and under-utilization of fre-

(continued on page 14)

Circle 14 on reader service card ➔

The RCA rotator has many features your customers won't understand. It has one that everyone recognizes: the name, RCA.

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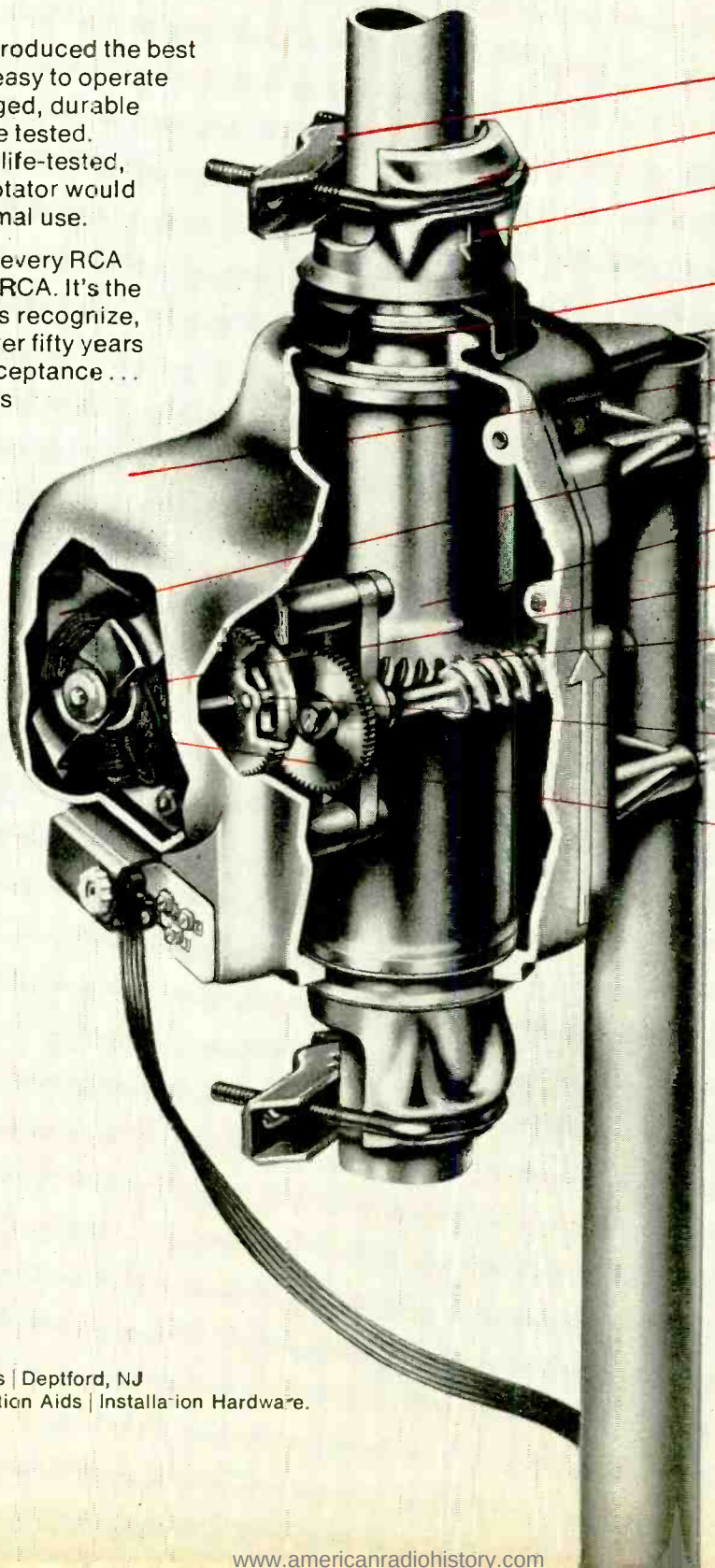

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New & Timely

(continued from page 12)

FOUR CHANNEL STEREO IS HERE ON TAPE AND AIRWAVES

NEW YORK—Four-channel or "surround" stereo went public in September with the conversion of Acoustic Research Inc.'s Grand Central Terminal listening room to a 4-channel setup.

The AR demonstration used a 4-channel Telex tape deck model and AR4x speakers for the two rear channels. Most people who have heard 4-channel demonstration have been impressed by the additional presence the rear speakers add.

Vanguard now has a number of 4-channel tapes on the market, and Telex demonstrated a tape deck for less than $300 at the Los Angeles Hi-Fi Show in October. Scott is already marketing a 4-channel amplifier.

The new sound is still experimental. FM stereo broadcasts using two stations (and requiring 2 tuners) have been tried in Boston and New York. According to a *Television Digest* report, a 4-channel broadcast using an FM subcarrier for the rear channels was planned for October 26 over New York's WNYC. This setup requires only modifications of SCA equipment, and does not alter the main stereo broadcast. Record discs have also been made by multiplexing the left and right stereo channels with the rear channels and decoding the output of a normal cartridge.

Microphone placement for most 4-channel tapes will be to pick up reflections from rear and side walls not reproduced in 2-channel stereo. But gimmick or rock recordings may place the mikes between or among the recording group to bring even more presence to the tape. **R-E**

LOOKING AHEAD

(continued from page 12)

quencies in others, and indicated the belief that proper use of the present spectrum might relieve most of the congestion problems.

Radiation and TV viewers

The Bureau of Radiological Health has released a rather reassuring study of the calculated effects of color TV radiation on television viewers, based on average annual viewing and average viewing distances, as observed in home tests in the Washington, D.C., area. The tests showed that the average color set radiated about 0.05 mR per hour at 5 cm, or approximately 1/10 the limits established by health authorities. At that rate, the average doses from viewing color TV to critical areas of the body would all be well below one-half of one percent of the suggested limit of radiation established by the National Council on Radiation Protection and Measurements. Even from sets emitting 0.5 mR per hour, the Bureau said, radiation would be below the recommended limit of 5% of the average dose from natural background sources (buildings, pavement, atmosphere, etc.).

How many 1969 models?

The 1970 model sets are here, and it's time to take stock of how the 1969's did. Not so bad, it turns out. American sales of 1969-model color TV totaled about 6,450,000 sets, including imports, an increase from 5,700,000 of the 1968 models. Some 6,100,000 black-and-white sets were sold during the 1969 model year, as compared to 5,963,000 in the preceding year.

Phonograph sales were up slightly, totaling 5,563,000 American-branded units. **R-E**

The New 1970 Improved Model 257 **A REVOLUTIONARY NEW**

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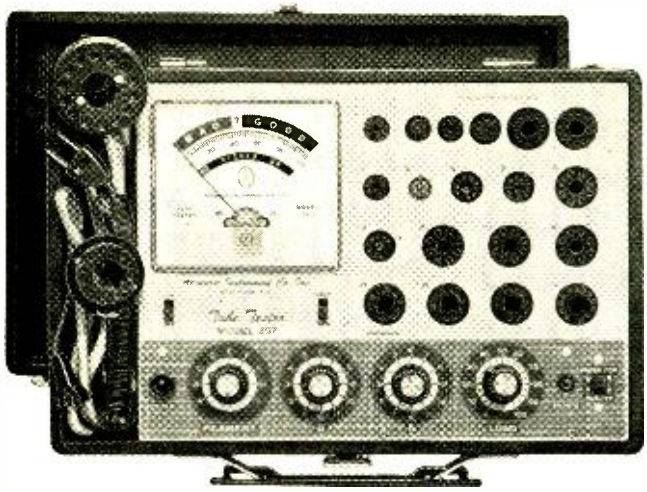

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Circle 16 on reader service card

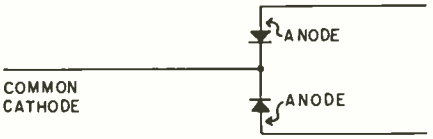
In the Shop . . . With Jack

By JACK DARR
SERVICE EDITOR

Sherlock And The Schematically Impossible

THERE ARE THINGS, HORATIO, WHICH are not explainable even in thy philosophy. Especially in the bewildering business of electronics repairing. We run into them every day. How well we get along depends on how flexible we can be. We simply have to keep an open mind at all times or we're dead. A lively imagination is a big help in this business.

Since we do detective work for a living, we need to remember what the greatest detective of them all said: "Consider all the evidence. Then, when you have eliminated all but one of the possibilities, the one which remains must be right." Sherlock Holmes wouldn't recognize that quotation in that form, but he did say it.



To illustrate this, take the Case Of The Tunerless TV. While fiddling around with it trying to find out what was wrong, I disconnected the tuner completely. Somehow I happened to feed the signal (from a cable system antenna) directly into the open i.f. input. I got a pretty fair picture on Ch. 4. sound and all!

Hmm. How-come? Trf video i.f. aligned on Ch. 4 or something? No! Normal i.f. signal goes through as it should. What's happening? Investigation disclosed that the 3rd i.f. stage was oscillating, and evidently at a frequency which beat with the Ch. 4 rf carriers to make a picture. The cure was obvious. Watson. Stop the oscillation. (Open screen bypass.)

The Case of the Schematically Impossible Horizontal Afc was another one and probably a better illustration of the point. This set had practically no horizontal stability, in a strictly stock horizontal afc circuit. So I went through all of the stock tests. Pulses, waveforms, p-p voltages, and everything checked out ok. Dc voltage on the "afc grid" wasn't, of course, since this was the root cause of the horizontal instability.

So take it apart. Open the coupling capacitors and check on the

(continued on page 22)

*Now... **everyone** in your family can watch the TV shows they want... **where** they want... **when** they want!*

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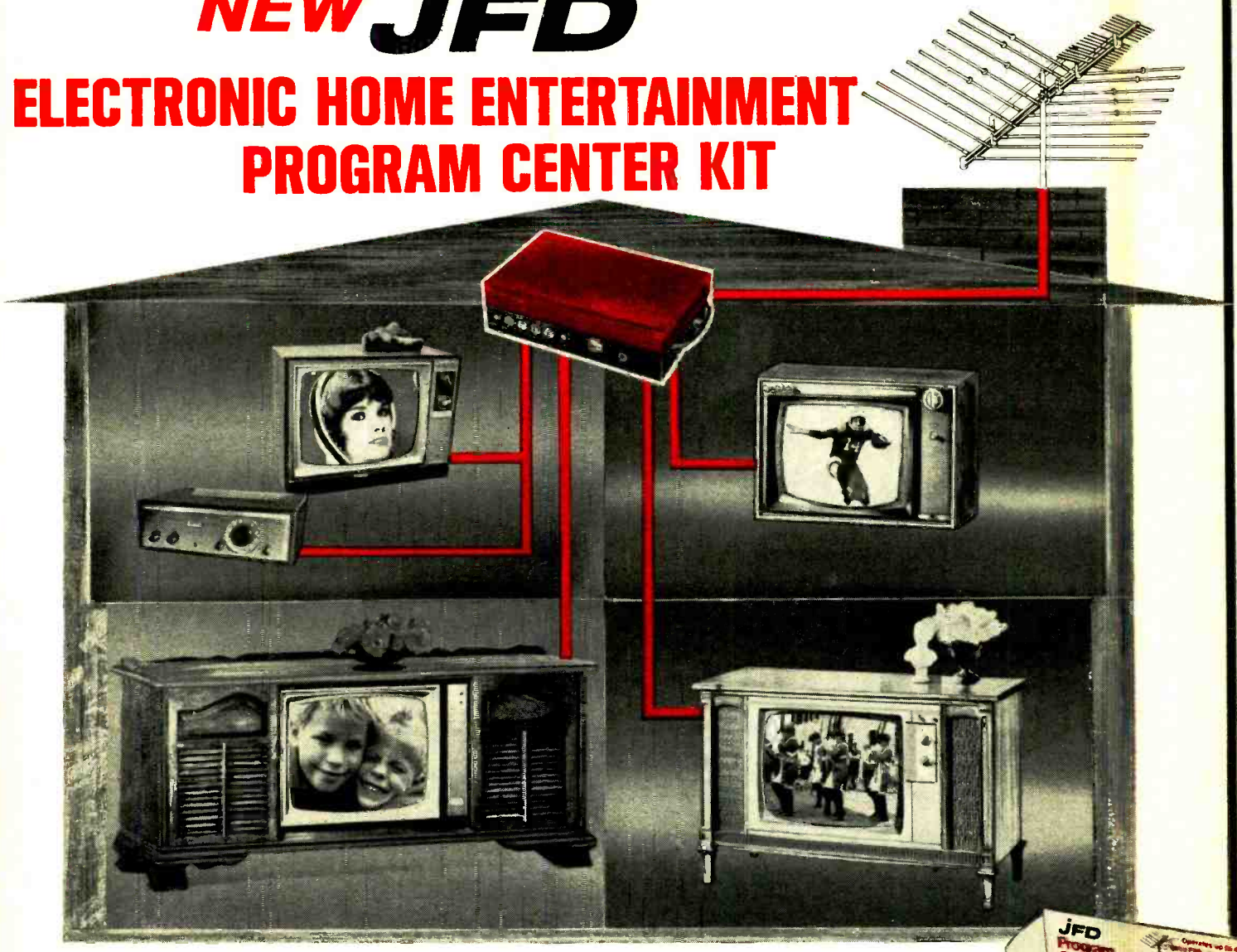

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IN THE SHOP

(continued from page 16)

open end for the sync and comparison pulses. Good. Nice clean waveforms, right p-p voltage, etc. One down. Take resistance readings around the circuit. Pretty good. No shorts to ground, etc, although they didn't look just right.

Check the diode with ohmmeter, in-circuit. Looks good. Diode-readings on the common-cathode unit showed that both diodes were ok. Well! Take the diode out and check it on the transistor-tester to make sure. Ok, fine. Both diodes show nice high reverse resistance, low forward resistance, and they match. Put it back in. Same as before. Very narrow horizontal hold range although the picture would hold fairly well once locked in, and it would hold without the afc, showing that the oscillator itself was running as it should, and not trying to pull out of range. This was an afc trouble, but where?

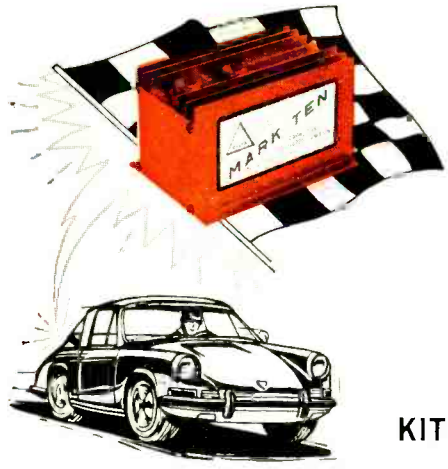
Well, do it over again. You've missed something. The resistances around the diode circuit looked odd. So out with the diode again. Check with ohmmeter. Hey! What's this? While checking, I'd left one ohmmeter clip on one of the anodes, then moved the cathode clip to the other anode. Hey! Short? Yes! Nice dead short. From ANODE TO ANODE? Yes sir. A new diode cleared up the trouble.

Now what happened? *Schematically*, this is impossible (Fig. 1). The anodes are the terminals *farthest apart*. They can't short to one another! But they did. The answer is, of course, that this is an optical illusion, caused by the way the diodes are *drawn* in a schematic. In the actual diode chip, it is quite possible for an anode to anode short to take place (Even I could see this for it just *did!*) The chip doesn't look anything like the schematic representation of the thing. So, this can give you a mental block as to considering such possibilities.

Keeping a really wide-open mind can be a big help when trying to diagnose such complaints. If you will freely admit the possibility that *anything* can happen, and probably will, you won't be apt to overlook things like this. For example, wires that are far apart on a schematic can actually be about 15 thousandths of an inch apart on the chassis itself, and easy to short together with a tiny bit of solder, etc., etc.

Keep the mind open: when you have eliminated all of the possible causes except one, that has to be it. Thanks, Sherlock! **R-E**

DELTA will tell you *everything!*—Complete Specs including schematics!



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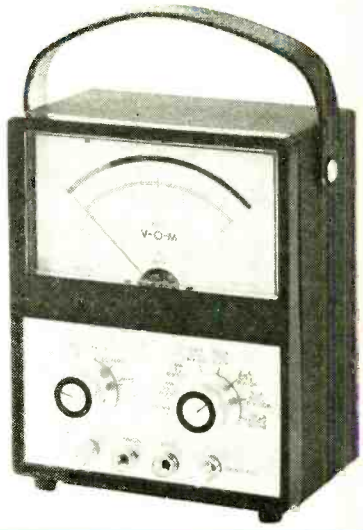

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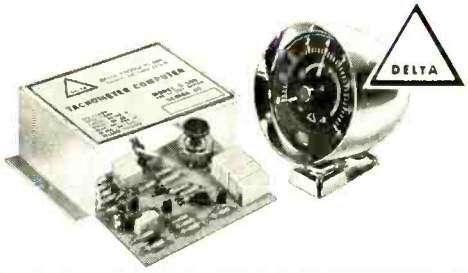

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Circle 22 on reader service card

Correspondence

IMPROVE SOUND RELAY

Mr. Wilson's sound-operated relay (September issue) was of special interest, since I have designed several of these in various forms over the past 10 years.

The circuit as shown is well-conceived. However, one suggestion may be of interest to your readers. I have found that an inexpensive magnetic earphone, of the type often supplied with miniature radios, makes a fine microphone for this application. Besides being cheaper and much smaller than a speaker, these tend to have a broad resonant peak in the frequency range of interest, which improves sensitivity. Further, their typical impedance of a few kilohms is ideal for matching most common transistor amplifiers.

For further miniaturization, the bistable relay may be replaced by a transistor flip-flop driving a standard miniature relay. I have built an entire circuit comfortably into a 2¾ x 2⅛ x 1⅝-inch Minibox. A chassis-mounting male ac plug on the Minibox makes the unit self-supporting when plugged into a wall outlet. Of course the case must be isolated from the circuit, and preferably connected to a third "ground" prong on the ac plug for hot chassis safety.

MAXWELL STRANGE
Fulton, Md.

VANISHING LETTERS

Some of the lettering for the PC pattern got trimmed from the margin in our "One-IC Radio" article last month (page 51).

R11-2 is the unlabeled lead between R11-3 and R11-1 on the left. On the right of the drawing, 1, 2 and 3 coming from S1/R11 are twisted leads going to respective points on the left, the left unlabeled wire is +6V to the PC pattern and the right unlabeled wire is +6V to B1.

If you're interested in obtaining Amperex parts for the project, write: One-IC Radio, RADIO ELECTRONICS, 200 Park Ave. S., N.Y., N.Y. 10003

7 arguments in favor of building your own speaker system from scratch.

The easiest way to buy high fidelity speakers may not always be the best. Because a complete pre-packaged system may be far from what you need. Consider some of the advantages of separate component loudspeakers:

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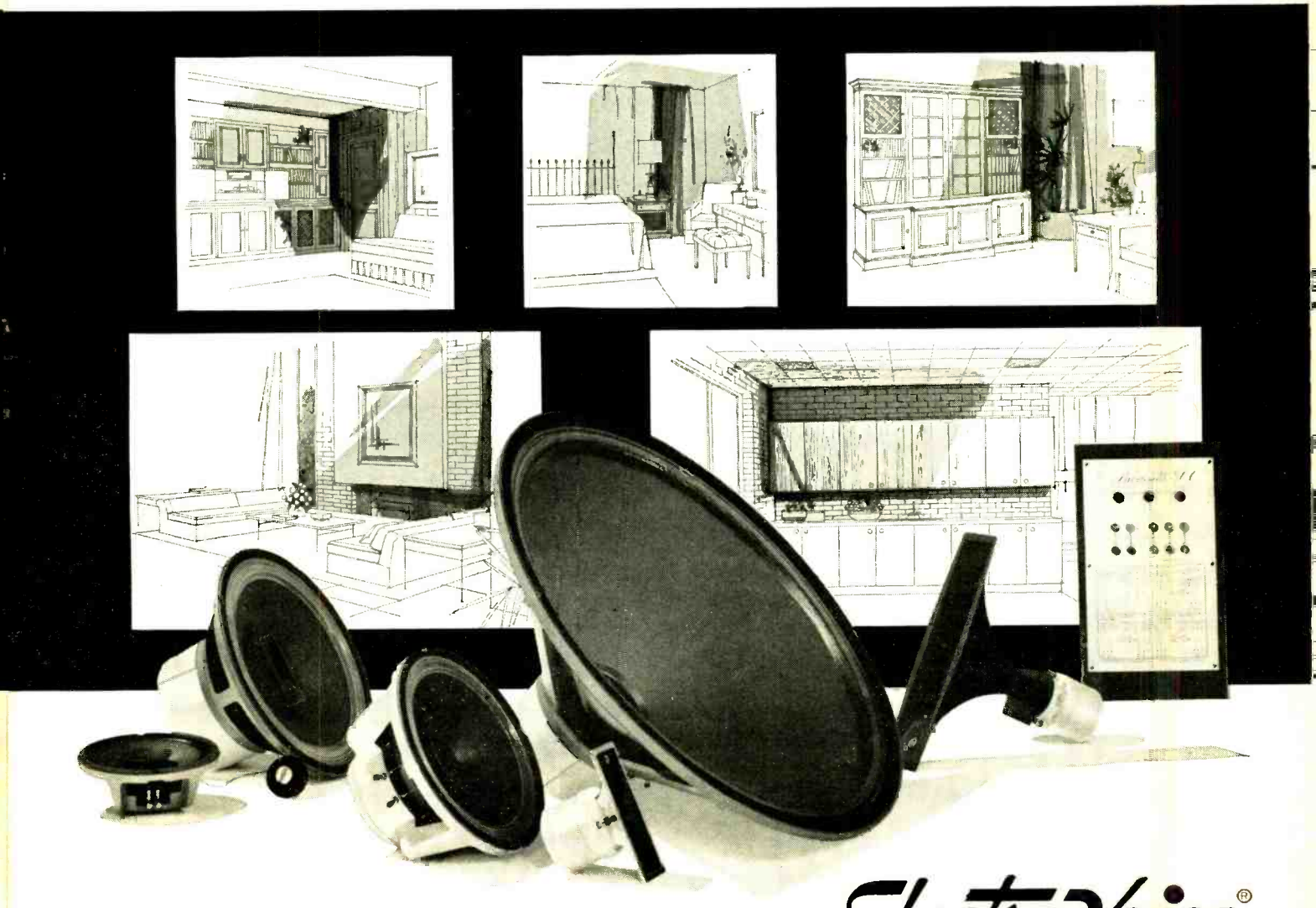

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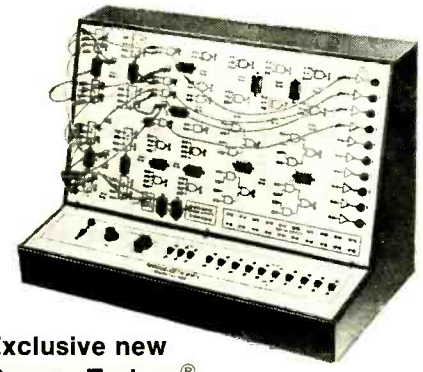

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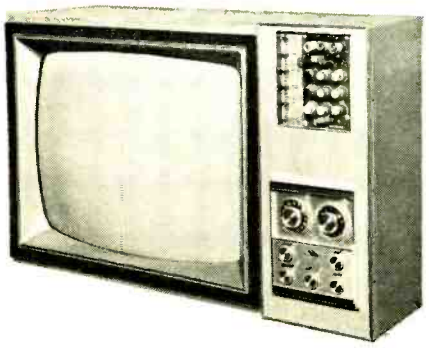

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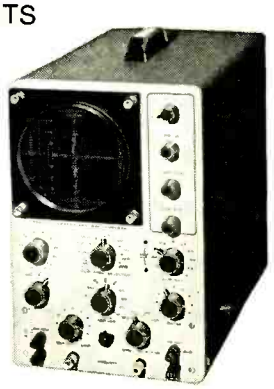

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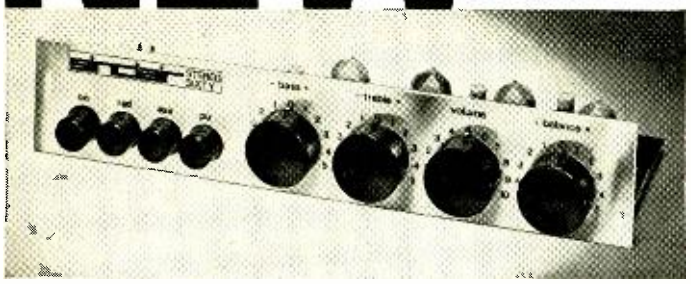
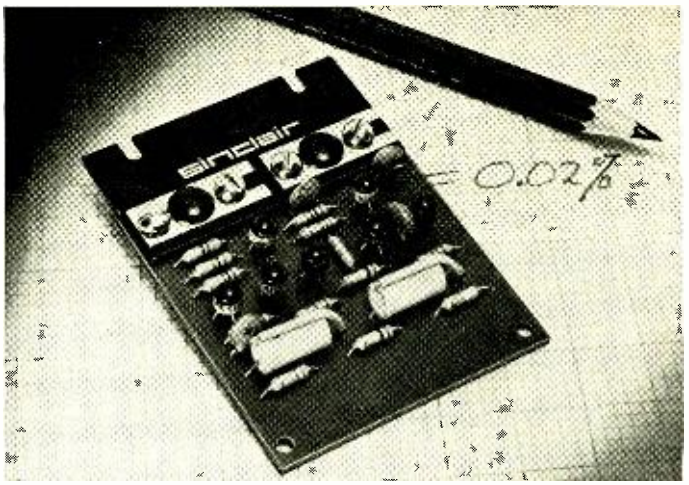




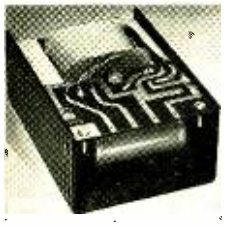
Stereo Sixty Control Center

The Sinclair Stereo 60 is a completely new unit for use with the new Z-30 amplifier module. Four push buttons are used for input selection and rotary controls are used for bass, treble, volume and balance. The on-off button also controls the power to the power amplifiers. The Stereo 60 may be used with two IC-10's or any other high performance amplifier. As with the Z-30, the Stereo 60 is unsurpassed in its price range.

STEREO 60 SPECIFICATIONS

Frequency response:	Radio and Aux. 20-25KHz plus or minus one db. RIAA equalization accurate within one db.
Inputs:	Radio, auxiliary and magnetic.
Overload factor:	Better than 20db on all inputs per channel.
Distortion:	.03%.
Signal-to-noise:	Better than −70db unweighted.
Size and finish:	8¼ x 1½ x 4 inches. Aluminum with black trim.

$36.95



The new PZ-6 power supply unit is suitable for driving a pair of Z-30's and the Stereo 60. The PZ-6 is fully filtered and stabilized and provides 1.4 amps at 35 volts DC.

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The Stereo 60, Z-30 and PZ-6 are recent additions to the expanding Sinclair-Audionics line of audio modules. The Z-12, IC-10, Stereo 25 and PZ-4 units are recommended where less power or ultimate performance is required.

To receive a brochure describing the entire Sinclair line ranging from the IC-10 silicon integrated circuit high fidelity amp and pre-amp to the teak-trimmed Q-16 speaker system, use the coupon below or a postcard and mail to Audionics, Inc., 9701 S.E. Mill, Portland, Oregon 97216.

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The introduction of the **Z-30 high fidelity amplifier module** by Sinclair now makes it possible to construct an amplifier with laboratory standards for less money than ever before. The Z-30 module boasts the lowest distortion level of ANY amplifier in the world. At the maximum rated output or any level lower than the maximum, the harmonic distortion never exceeds .02%. The Z-30 utilizes nine silicon epitaxial planar transistors in a unique circuit. Over 60 db of negative feedback, with a constant current load to the drive stage obtained by incorporating a two transistor circuit in place of the more usual bootstrapping technique, helps to achieve this remarkable performance. Besides home audio applications the Z-30 is ideal for many commercial and industrial uses where high performance, reliability and size are factors . . . not to mention low cost.

Z-30 SPECIFICATIONS

Power output:	15 watts continuous sine wave (30 watt peak) into 8 ohms from a 35 volt supply. 25 watts continuous sine wave (50 watt peak) into 4 ohms from a 35 volt supply.
Frequency response:	20 to over 30KHz plus or minus one db.
Distortion:	.02% or less up to and including full output into 8 ohms.
Size:	3 x 2.2 x 0.5 inches.
Sensitivity:	250mv into 100K ohms.
Signal-to-noise:	−70db unweighted, class AB output.
Power requirements	The Z-30 will perform perfectly down to voltages as low as 8vdc, with the exception that power output levels will be decreased.

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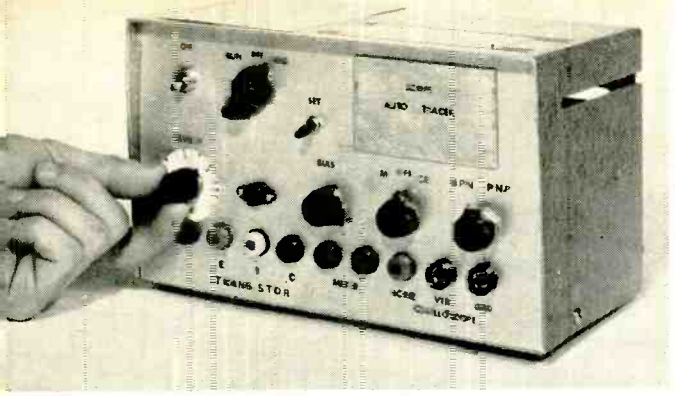


Automatic—
TRANSISTOR CURVE TRACER

by PHILLIP C. BRASSINE

SCOPE-TRACE DIAGRAMS OF TRANSISTOR characteristics are familiar to most people working with solid-state electronics. Manuals and data sheets show selected transistor curves from which you can establish circuit parameters.

Often though, it's desirable to make sets of curves for particular transistors and to supplement available information. Comparisons between two or more transistors of the same type are often required for matching or selection. Familiarity with a scope tracer makes it easy to identify unmarked units as to type and voltage. Zeners and other diodes may also be tested.

The scope tracer described here will provide the more common and desirable transistor parameters. It was designed to place npn and pnp types in the common-emitter configuration and permit six curves to be displayed individually or simultaneously on the scope screen. Audio, rf, switching and some low-power units can be tested within a range of up to 1 mA or so of base current.

A basic tracer circuit

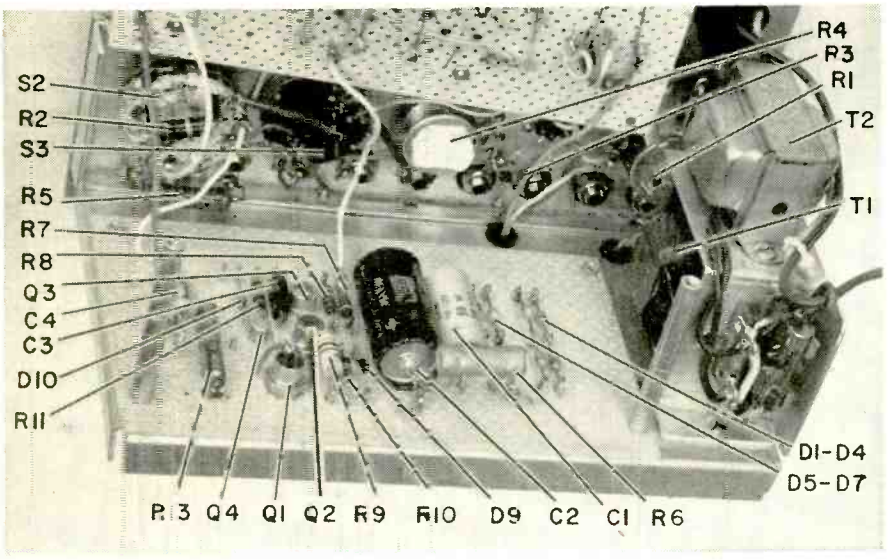
The basic circuit of a curve tracer is shown in Fig. 1. Rectified ac is applied across the collector and emitter of the test transistor. This voltage deflects the horizontal amplifiers of the scope. The voltage drop across the 100-ohm sensing resistor is proportional to the current flow through it and deflects the vertical amplifiers according to this ratio.

A battery and variable resistance form the base bias circuit. When R_B has infinite resistance, the collector and emitter can be considered an open circuit and the collector voltage will be maximum. When bias is applied to the base, current flows relative to the characteristics of the transistor, reducing V_{CE} accordingly.

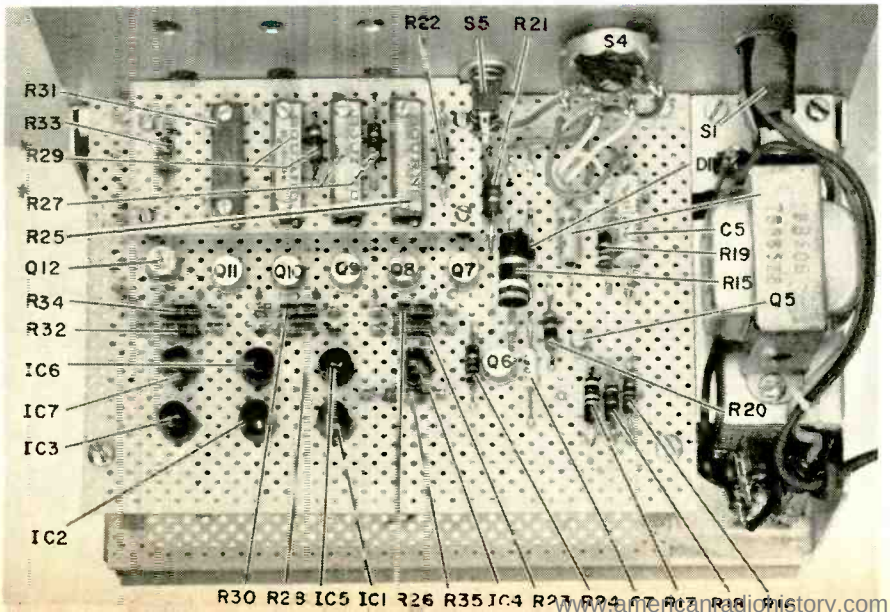
The amount of bias is shown on the CRT by the height of the sweep voltage above the base line. The length of the trace depends on the value of the sweep voltage relative to the applied bias. In light of transistor action: as base current increases, the collector-to-emitter voltage decreases until the transistor reaches saturation.

To obtain a satisfactory reference point (base line) for the curves, the dc input of the scope is used. The grid of the CRT is usually defined in peak-to-peak volts per major division. The vertical displacement is converted to mA according to the IR drop across the sensing resistor.

If a number of different biases are applied, a like number of curves are produced, and the total is considered a family of curves from which



Parts layout for the filter/regulator circuit is shown in the photo above. The text describes details of the chassis arrangement used by the author. The photo below shows the perfboard layout for the sync generator, counter and step bias circuits. *See text & parts list.



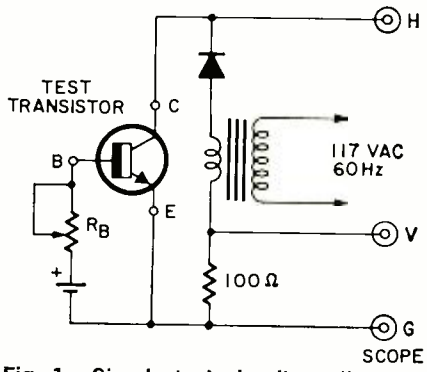


Fig. 1—Simple test circuit applies rectified ac across collector and emitter.

the characteristics of the transistor can be computed. Of necessity, each curve must be copied onto graph paper for evaluation. If all curves can be seen simultaneously, only the pertinent data need be recorded in most instances.

Auto tracer circuit

A combined block diagram and schematic of the scope tracer circuit is shown in Fig. 2. No chassis ground is used as both supplies must be reversed to accommodate the two types of transistors.

Transformer T2 supplies full-wave rectified voltage between the collector and emitter of the test transistor. This voltage is controlled by the 3000-ohm pot. Limiting resistor R2 restricts the current to about 100 mA to safeguard precision resistor R5. Transformer T1 feeds a full-wave supply that furnishes power for all units in the base circuit.

Six transistors shunt the bias line of the test transistor to obtain different voltage levels. The bias steps are controlled by the counter, which is driven by the sync generator. An external meter is connected into the bias line to set specific biases.

With pnp transistors, the curves are displayed conventionally: left to right for sweep voltages, and bottom to top for vertical deflection. Npn curves are reversed and upside down. Either presentation is satisfactory after you are accustomed to working with them.

The unijunction transistor sync generator in Fig. 3 is supplied from the positive side of the rectified output of T1. Bias of UJT Q5 is established by R18 and R20 relative to R16. Resistor R17 and a capacitor across the emitter of the UJT form the timing network for the sawtooth wave. The firing point of the UJT is synchronized to occur on the negative slope of the waveform seen at B2. The output pulses from B1 are inverted by Q6 and used to drive the counter flip-flops.

Although it is a simple matter to obtain synchronization with the source voltage, the bias steps must occur at the zero phase angle of the sweep voltage; otherwise, lines or breaks will appear on the horizontal section of the curves. Final selection of UJT circuit resistors should therefore be done only after the tracer can produce scope traces.

With S4 at RUN, the generator operates at a 120-Hz rate. In TRIG, this is slowed to about 1 sec by C6. The switch is turned from TRIG to OFF to retain any bias curve. A resistor in the OFF position reduces the emitter potential well below the firing point to introduce a time delay when the switch is returned to TRIG. This delay prevents premature triggering of the counter by switch contact.

The counter is a conventional divide-by-six circuit composed of three IC flip-flops (IC1–IC3). These are decoded by four dual 2-input gates (IC4–IC7) to give six outputs, each connected to a transistor that shunts the bias line through a variable resistance.

Decoding is accomplished by two or more lows from the flip-flop outputs to cause a high level at one of the gate outputs. These operate in a sequential manner in which only one is high at any time. Decoding operation is illustrated in the truth table. The high level biases the respective transistor to conduction, while the resistance of the pot determines the shunting action, setting the voltage to a specific level.

A 500-ohm resistor in the regulator supply line to the bias circuit limits the maximum current. The step-bias circuit is therefore equivalent to six combined shunt-voltage regulators, each on for 8.33 msec at a 20-Hz rate.

SET toggle switch S5 is used when S4 is at RUN only. This toggle switch permits setting and measuring the maximum bias applied to the test transistor without recourse to triggering. When S5 is closed, the counter will continue operating until IC7 (pin 6) goes high. The connection to the clear input (pin 3) of IC1 holds the NOT-A output in a high state, preventing further action. A and C of the divider are low at this time, so trace 6 is presented until S5 is opened.

The driver transistors should be tested for complete switch action. That is, that they turn on and off completely. This will insure minimum interaction between these elements. If necessary, the bias resistors can be adjusted to compensate for differences in gain.

If difficulties are encountered with the IC circuit, the driver collectors can be disconnected from the resistances and 10-volt 15-mA or similar lamps inserted to give a visual display of counter action. In this case the lamps are connected directly to the 10-volt line and the slow speed of the sync generator is used.

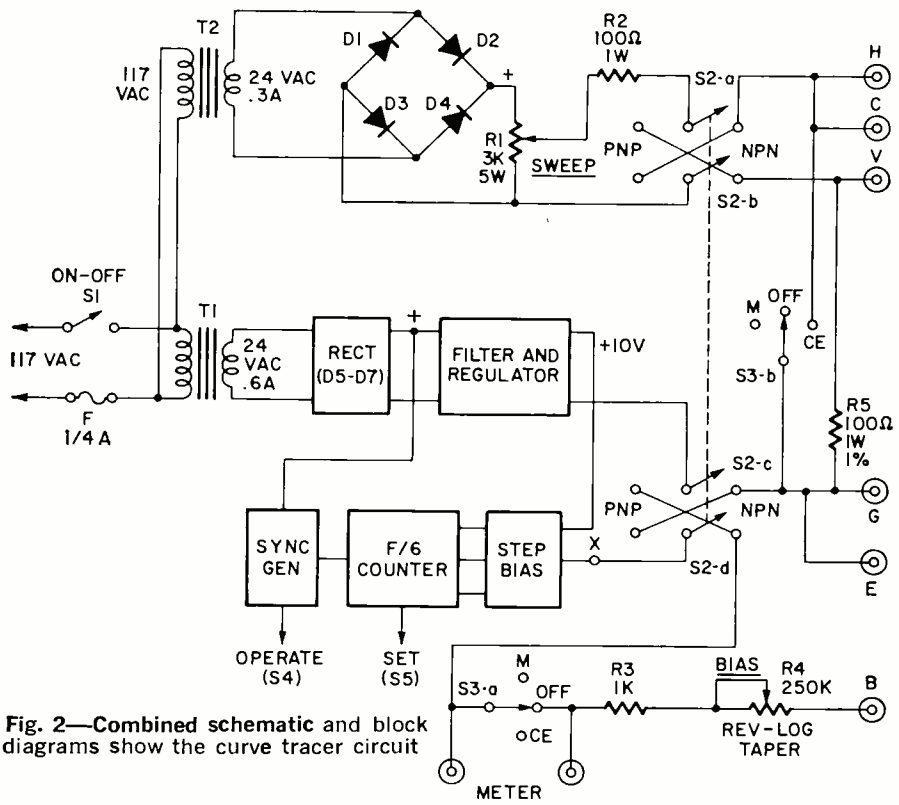


Fig. 2—Combined schematic and block diagrams show the curve tracer circuit

Regulated supply

A highly regulated supply is included in the tracer (Fig. 4). It will

hold a constant +10 volts from no load to the full load of 160 mA. Output ripple is less than 2 mV. The step bias is supplied directly from the 10-volt line while the IC circuit voltage is reduced to 3.6 volts by a current-limiting resistor and Zener diode.

The first filter capacitor from the rectifiers is small to provide a waveform with sufficient amplitude to which Q5 can be synchronized.

The resistance value from the emitter of Q3 to ground must be determined during tests covering no-load to full-load conditions. Too low a value can cause positive regulation (a slight *rise* in voltage with increased current), so R8 should be fixed just above this point.

A 5000-ohm trimmer can be substituted for the three-element divider network (R12, R13, R14) to the reference amplifier. Other transistors can be used in this circuit with equal results. A 2N1613 can directly replace the 40407 shown in the diagram.

In the step-bias circuit of Fig. 3 resistors R22 and R33 for curves 1 and 6 are fixed values, although they can be made adjustable if preferred. Resistor R22 places the lower curve near the base line for most transistors. Resistor R33 is set for about 3 mA through the driver when it is conducting. The resistances of R25, R27, R29 and R31 are approximate values and will vary somewhat according to operating conditions.

A preliminary adjustment of the pots is made by shorting the B–E terminals, triggering for curve 6 and setting R_B (BIAS pot R4) for 100 μA, using a microammeter in the jacks

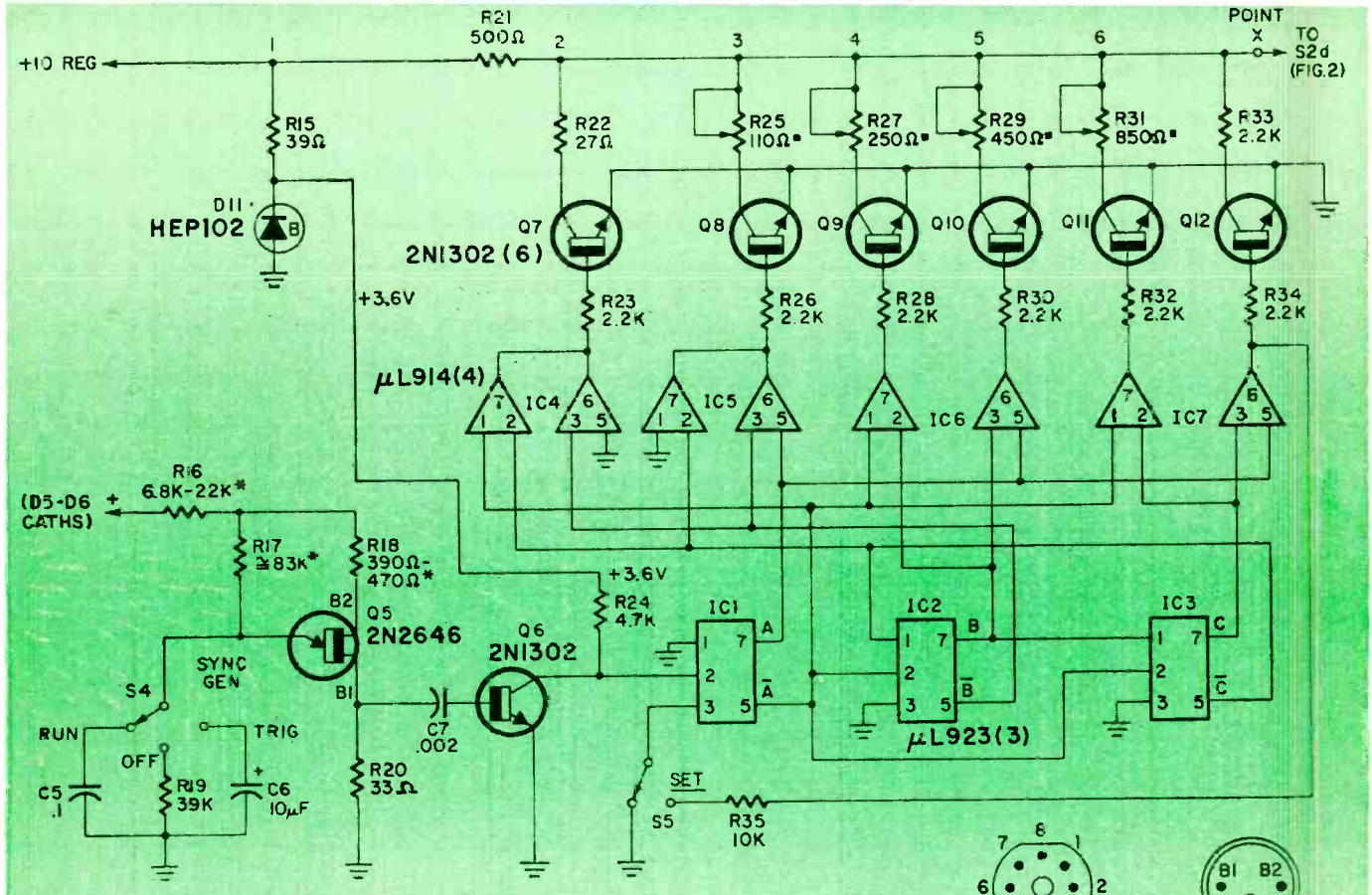


Fig. 3—Sync generator circuit includes (Q5), counter (IC-1 IC3) and decoders (IC4-IC7), which provide step bias through transistors Q7-Q12.

NOTE: GROUND TO REGULATOR ONLY
IC1-IC7: PIN 8 - +3.6
PIN 4 - GROUND
*SEE TEXT
▪ APPROX SETTING, SEE PARTS LIST, TEXT

PARTS LIST (Figs. 2, 3 and 4)

R1—3000-ohm, 5W, wirewound linear potentiometer
R2—100-ohm, 1W
R3—1000-ohm
R4—250,000-ohm, reverse-log (CCW)-taper potentiometer
R5—100-ohm, 1W, 1%
R6—65-ohm, 5W
R7, R24—4700-ohm
R8—680,000-ohm (see text)
R9—27-ohm, 1W
R10, R11, R35—10,000-ohm
R12—1500-ohm
R13—5000-ohm trimmer potentiometer
R14—2700-ohm
R15—39-ohm, 2W
R16—6800–22,000-ohm (see text)
R17—83,000 ohms
R18—390–470 ohms (see text)
R19—39,000 ohms
R20—33 ohms
R21—500 ohms (2 1,000-ohm, ½W in parallel)
R22—27 ohms
R23, R26, R28, R30, R32, R33, R34—2200 ohms
R25, R27—500-ohm trimmer potentiometer (150-ohm series resistor with R27)
R29—1000-ohm trimmer potentiometer (with 220-ohm series resistor)
R31—2000-ohm trimmer potentiometer
All resistors ½ watt, 10%, except base resistors for Q7–Q12, (5%).

Capacitors

C1—50μF, 50V, electrolytic
C2—250-μF, 50V, electrolytic
C3—0.01 μF
C4—10-μF, 15V, electrolytic
C5—0.1 μF, 100V
C6—10-μF, 15V, electrolytic

Semiconductors

D1-D8—1 amp, 100 PIV or more diode
D9, D10—6.2-volt, 1W Zener diode (HEP 103 or equal)
D11—3.6-volt, 1W Zener diode (HEP 102 or equal)
Q1—Any 500-mA, npn power transistor (see Radio Shack No. 276-587, '69 catalog). (2N1647 is stud mount to fit space)
Q2—40407 transistor (RCA)
Q3—2N1305 transistor (RCA)
Q4—2N40231 transistor (RCA)
Q5—2N2646 unijunction transistor (GE)
Q6–Q12—2N1302 transistor (RCA)
IC1–IC3—μL923 JK flip-flop integrated circuit
IC4–IC7—μL914 dual 2-input nand/nor gate integrated circuit

Other parts

S1—spst switch
S2—4-pole, 2-position switch
S3—4-pole, 3-position switch
S4—sp-3-position selector switch (Centralab 1461 or equal)
S5—spdt toggle switch
T1, T2—24-volt, 300-mA and 600-mA transformers [Lafayette No. 99 T6266 (1A) is suitable for both]
MISC—Chassis, case, ¼A fuse, fuse holder, knobs, jacks, IC sockets, perf board

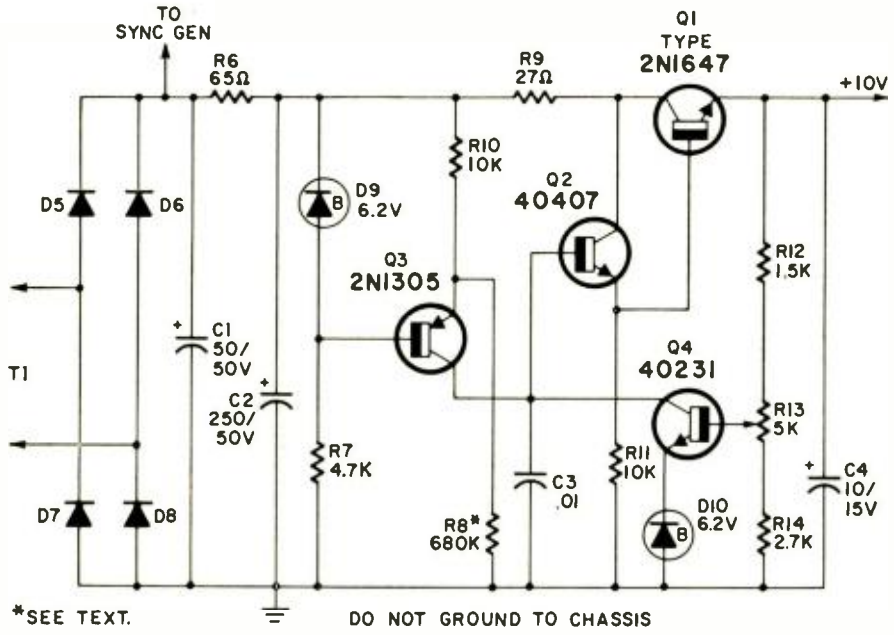


Fig. 4—Regulated supply circuit for the tracer keeps ripple to less than 2 mV. A Zener diode (D11 in Fig. 3) supplies the 3.6 volts for the integrated circuits.

provided. Biases of curves 2 through 5 are then set to 20, 40, 60 and 80 μA, respectively.

The B-E terminals are now opened, a transistor inserted in the socket and the above procedure repeated. Polarity must be observed in all cases.

Since these even ratios will hold to about 1 mA of base current, it is only necessary to obtain curve 6 and mentally calculate the others. Each bias step can be checked by utilizing the TRIG position of S1 and allowing the counter to cycle, presuming meter response is adequate. Manual triggering (switching S4 back and forth between OFF and TRIG) can, of course, be employed when precise bias values are desired.

These even multiple ratios will generally hold true for either silicon or germanium transistors, but not both. The difference in the spread of their base resistance is most apparent at the lowest bias level, the silicon giving the lowest reading.

This difference may amount to 12, 8 and 6 μA, for traces 1, 2 and 3, respectively, when trace 6 is set for 100 μA. Ordinarily trace 1 can be used as an indicator and left to fall as it will. The pots can be set to a mean value so the percentage of error will be within tolerable limits for most calculations. Therefore, quick evaluations can be made by merely utilizing S5 and setting R4 to some value.

Since interpretation of transistor characteristic curves is described in many books, only a few points will be discussed here. For detailed analysis, a photo or graph reproduction of the display may have to be made.

If you prefer, a 5000-ohm trimmer can be used in place of resistors R12, R13 and R14. Also, a number of other transistors may work in the filter-regulator.

Load lines can be derived directly from the curves. A diagonal is placed from a point on the I_C ordinate to a point on the V_{CE} axis. This gives $R_L = V_{CE}/I_C$.

Dc beta = I_C/I_B. A vertical line is drawn from V_{CE} to intercept a curve having a certain base current. From this point on the curve a line is projected to the I_C ordinate. Beta is then a ratio of the base current to the collector current at a specified collector voltage.

Transistor saturation is termed the region to the left of the knee of the curve and is defined as $V_{CE(sat)}$ at some stated I_C and I_B. The point at which the transistor reaches saturation can also be found by displaying curve 6 and increasing I_B until the end point of the curve becomes coincident with the vertical section. At this point any further increase of I_B will cause little increase in I_C.

Zener diode characteristics are found with these two operations: If the polarity is known, connect the cathode to the collector, and the anode to the emitter of the transistor socket (R_B is not used.) The tracer is hooked to the scope as when displaying curves. The scope horizontal gain is set to a convenient value such as 2V/cm. The tracer NPN mode places a positive voltage on the cathode, and increasing the tracer sweep displays the breakdown voltage. Changing to the PNP mode reverses the current through the zener, and the forward conduction curve will be seen. The scope horizontal gain can be changed to 1 V/cm for a more accurate reading.

Diodes and rectifiers are displayed in the latter manner. Minimum sweep is used to prevent overheating from excessive current.

Double lines can be caused by several factors and may not always be possible to eliminate. If the problem is serious, check the amplitude of the complementary half sine waves from the rectifier output. Transformer T2's secondary may be unbalanced; causing a difference in the two half cycles. They should be reasonably close. Keep all wiring capacitances to a minimum. Excessive tracer sweep voltage combined with high bias and high vertical scope sensitivity will aggravate the condition. Be sure to use the dc input to the scope.

Observation of the waveforms generated in the tracer will aid in adjusting and troubleshooting. The pertinent voltages are:

UJT sync	**UJT-B2**	**Lower half of negative slope**	
UJT sawtooth	**UJT-E**	**3–9V p–p**	**120 Hz**
UJT output	**UJT-B1**	**1–4V p–p**	**positive pulse**
Counter input	**Q6-C**	**0.8V p–p**	**negative pulse**
Gate outputs	**IC4–IC7**	**3V p–p**	**20 Hz**
Step biases	**Point X**	**5–6V p–p overall**	**Equal steps of minimum tilt**
VE curves	**Vertical jack**		**Six curves**

The VE curves are formed across the sensing resistor with a transistor in the tracer socket and step biases applied. (Use scope internal sync.) Place a pot across R16 or R17 of the UJT sync generator. Note the effect a decrease in resistance has on the curves. Both points of each curve should stop on the same horizontal level, without breaks or overshoots.

Scope calibration

An audio oscillator and vtvm are used to calibrate the scope. Since the vertical gain on some scopes is not calibrated, the complete procedure will be described.

A sine-wave signal with a frequency of 120 Hz and amplitude of 2 volts p–p as measured by the vtvm is fed to the vertical input of the scope. The vertical attenuator and gain control are adjusted for a 4-cm

(continued on page 77)

TRUTH TABLE

Sequence	A	B	C	$\overline{A}$	$\overline{B}$	$\overline{C}$
1				L	L	L
2	L				L	L
3		L		L		
4	L	L				
5			L	L		
6	L		L			

New in stereo Cassettes '70

The boom in the cassette field continues to grow as 'gimmics' and 'gadgets' make listening easy, and high-quality tapes improve the sound

by WALTER G. SALM

USE ANY YARDSTICK YOU WANT TO—THE CASSETTE IS ONE of the fastest growing branches of the home entertainment industry. These days the cassette has an undeniable identity—it's an all-purpose recording medium with almost universal public acceptance.

No one is afraid to buy a tape recorder now. The era of the all-thumbs-set being shut out of this market has passed. For the cassette is a tape medium that's human-engineered as no other recording system has been—right from the basic concept of a goof-proof plastic case enclosing a ¼-inch-wide ribbon of tape—to snap-out anti-erase tabs that make accidental erasures a thing of the past.

Cassette players are priced as low as $19.95 and four-song micro-cassettes are available at mini-prices (about 50¢ per song) making both the player and tapes competitive with both Playtape and records.

The cassette format is the only tape system that offers full compatibility and interchangeability between mono and stereo machines. Equipment includes mono players at $19.95, mono ½-track recorders at $29.95 up, stereo recorder/players for the living room starting at $99, under-the-dash automotive stereo systems with recording capability for $79.95, plus a new line of cassette plug-in AM and FM tuners. The cassette story is a bit much to absorb in just one gulp, so let's backtrack a little.

The first cassette—where it began

About six years ago, N. V. Philips Gloeilampenfabrieken, headquartered in Eindhoven, Netherlands, introduced the cassette recorder to the United States under its North American brand name, Norelco. The new machine was small, lightweight, and could be carried suspended from a shoulder strap. It used an enclosed plastic cassette-type cartridge that snapped in and out of the machine easily. The machine, dubbed the "Carry-Corder" had (and still has) a single-lever control for record/playback, fast forward and fast rewind. A small dynamic microphone and remote control switch fit easily into a small leather case on the shoulder strap. The whole rig sold for $150.

Then the idea took hold. Philips couldn't make Carry-Corders fast enough to keep up with the demand. A few copycat recorders showed up on the market very briefly—notable among these were machines from Grundig and Aiwa—both using different, non-compatible cassettes. The public started to get confused. Too many different types of 'ideal" cartridges around. Which one to buy? The smart money was on Philips, and in a brilliant move that's still the cause of some debate, the Dutchmen offered to license the cassette format to any and all comers. They had 39 major companies signed up within a couple of months, and over the intervening years have managed to add just about every major recorder manufacturer in the world to the roster.

Today, the minuscule cassette is a major force in the recording industry. To be sure, the slow speed (1⅞ ips) still limits upper frequency response, but this barrier too, is being pushed back. Right now, the lid seems to be between 10,000 and 12,000 Hertz.

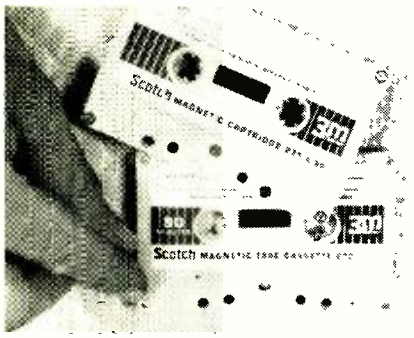
It's in the prerecorded tape area that cassettes are having their greatest impact right now. Since the format lends itself so well to the teenage market, tape manufacturers such as Ampex are slanting entire product lines toward this audience. Hard rock and Top-40 tunes appear regularly in the $1.98 micro-cassettes, and attractive sales promotion campaigns and deals are common.

Philips helped kick the bottom out of the market when it introduced a play-only machine last year for $29.95. This is the same machine that's sold for the same price by Ampex and by Bell & Howell. The bulk of the cassette equipment from these two companies comes from the Philips lightbulb factory, produced either in Holland or in Austria. Heavily tape-oriented 3M was also name-branding Philips cassette machines for quite a while, but finally came out with its own line last year.

The Japanese manufacturers are probably the hardest to track down. Aside from the super giants like Sony, Panasonic (Matsushita) and Toshiba, most Oriental pro-

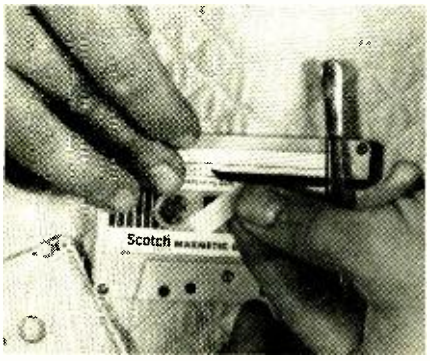
ducers gladly remain anonymous by private-labeling their products for as many retail outlets as want this service. Trade magazines abound with ads offering blank tape cassettes with "your company name here" on the paper label. Bargain hunters can find blank cassettes in dozen lots at incredibly low prices in the Sunday N. Y. *Times* sports section.

But such bargain hunting raises another potential problem—how good are the cheapie cassettes? The answer: pretty darn good—now. Twasn't always so. Couple of years ago, an inexpensive Japanese-made cassette could be expected to jam up or lose its trapped mylar leader after a couple of passes through the recorder. Even today, this can happen, and it does just as frequently with the expensive name-brand cassettes as it does with the cheap ones. It's possible to make repairs in most cases, provided you have the willingness, the patience, a steady hand and are loath to part with money needlessly.

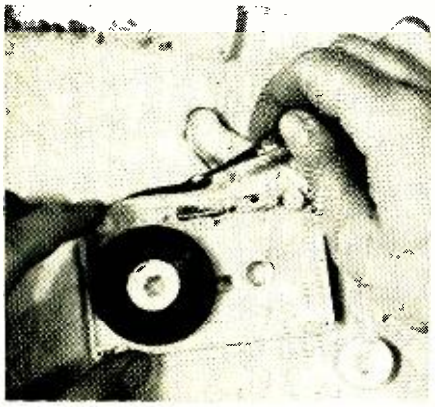


Cassettes held together by screws are easiest to repair. Finger points to older type 3M cassette with Phillips screw. Newer cassette (foreground) has slotted bolts and nuts.

Lift out the tape and hub carefully with tweezers to keep that wispy ribbon from unraveling. Note tape is twisted around other hub. This portion of tape is damaged and will have to be removed.



Use ordinary splicing tape for this not-so-ordinary splicing job. Here, the transparent leader is scissor-spliced onto tape, then given "Gibson Girl" trim.



Laying that thin ribbon back in the guides is ticklish, demands tweezers, and shouldn't be hurried.

When the cassette jams—fix it yourself

Before getting to the plan of attack, note that there are two basic types of cassettes—those held together with microscopically small Phillips (naturally) screws and those that are heat-sealed. Both types can be repaired. The ones held together with screws are the easiest. Just remove the screws and the two halves of the cassette come apart like two slices of bread peeled apart from a sandwich. It's the liverwurst in this sandwich that's important. It could be tangled around one of the hubs. The fragile ribbon of tape could have slipped out of its guides. Or perhaps the trapped leader (or trailer) has pulled out of the clamp that's supposed to hold it securely in place on the hub. Any of these problems can be fixed by obvious and nerve-wracking repairs that will try your patience. Be careful about one thing in particular—don't let that hub full of tape roll off the table. If this happens, you're likely to chuck the whole business and go back to an Edison phonograph.

Let's assume you've got the tape mended, placed nicely back in its guides (with tweezers, please), and the felt pressure pad assembly is laid gently in place. Now comes the aggravating job of mating the second slice of bread exactly to the tape, pressure pads, hubs and plastic alignment posts. Gently, gently, and just as you snap it into place, "Boing" goes the spring brass clip behind the pressure pads, some tape unravels, you curse a few times (or pound the table and weep—whichever is your forte), and start all over again. Don't despair; it *can* be done.

Now for the cassettes that are heat-sealed. There are two variations: one is simply heat-sealed; the other has a single Phillips screw in the geometric center, apparently to hold the whole shabang together when the heat treatment was applied. Remove that cotton-pickin' screw first. Then with a sharp penknife, pry the crack in the plastic open all the way around. Circumnavigate that cassette with your knife blade several times, each time biting a little deeper into the cassette. Eventually, you'll hear a satisfying "crack" as the blade breaks the heat seal once and for all. Crack the seal all the way around and the two slices of bread will peel off this sandwich neat as can be. After the repairs have been done, reseal the cassette with ordinary cellophane tape—Scotch "magic mending" tape is most suitable since it hides its presence by disappearing, and wears well in normal use.

Cassettes for your car are here

One of the nicest features of cassettes which you'll discover—especially with a unit installed in your car—is that you can roll your own. Unlike the 8-track cartridges, you can tape off the air, from your records or prerecorded open-reel tapes, or from the telephone. This last method can give you a nice side benefit. Ever try to find a strange place with a long list of complicated directions on a sheet of paper you can't read because you're busy driving? Next time you're faced with this prospect, hook up that cassette recorder to the telephone, and let your friend gab away, giving you all those "important" landmarks that you wouldn't bother to write down. Then replay that cassette in your under-the-dash machine or in a portable on the front seat. You've got perfect, detailed directions from the horse's mouth without taking your eyes off the road.

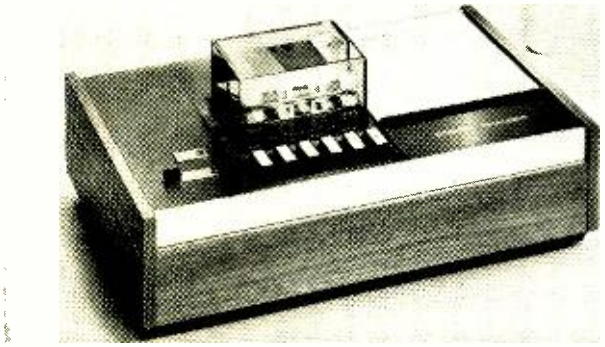
Trouble with those under-the-dash cassette recorders is most of them aren't theft-proof. About the only way

to deburglarize them is to use a miniature unit and keep it locked in the glove compartment. To play it, plop the unit on the front seat. Hopefully, some auto manufacturers will start to offer cassette options in new cars soon. Trouble is, nobody is quite certain just what has been committed by whom and to whom in the way of 8-track contracts. Time will tell.

Gimmicks and gadgets

Gadgets have a habit of cropping up whenever there's a successful product, and cassettes are no exceptions. Philips introduced a cassette changer a couple of years back, and this is now being handled by the usual Norelco outlets—including Ampex and Bell & Howell (below). This lets you stack up to six cassettes for longer playing periods. It retails for $130 and is available in a deck version only.

The changer is in a way a stopgap measure—a hedge against the day when the auto-reversing cassette machine will bow. Such a unit may not be far off. At least one manufacturer (Nortronics) has licked the ticklish head design problem. The cassette is designed to admit only



Bell & Howell automatic changer provides several hours of interruption-free music.

two heads—the erase and the combination record/playback. It has two holes for the heads, so each of these holes must have a three way, all-purpose head in auto-reversing machines. Triggering the reverse mechanism is easy—all cassettes have trapped trailers and leaders. All the machine needs is a tension-sensing trigger. The heads are here now. The machines are sure to follow soon.

Bell & Howell has come up with an unusual and highly appealing movie soundtrack system using a cassette recorder and a Super-8 camera and projector. All three elements must be purchased for the system to work. The photographer carries the cassette recorder which is plugged into the camera. When the camer runs, so does the recorder. So far so good. But here's the difference: the recorder makes two recordings—something like two-track stereo—one mono sound track plus a sync-control track. The sync track has a series of audio spikes on it and these spikes sync the recorder with the projector during playback. One still-unanswered question—how do you edit the movie?

Chromium dioxide to the rescue

Some cassette enthusiasts point gleefully to chromium dioxide tape (DuPont's "Crolyn") as the panacea that's going to give slow-speed cassettes true high-fidelity response at long last. True, Crolyn tape does increase frequency response—actually doubling it (or adding an octave if you prefer) over conventional iron oxide tape. This has been borne out by experiences at Crown International—a firm specializing in quality professional recorders made in U.S.A. plus a line of consumer-priced consumer-type tape gear made in Japan. Some of Crown's pro recorders feature front-panel-adjustable recording bias, a feature that makes the switch to Crolyn tape rather painless. You see, Crolyn requires a different recording bias than the usual used for iron oxide. Strictly speaking, every different iron oxide formulation needs some bias optimization, but that's another story.

Crown proudly plays Crolyn tape recordings at 1-⅞ ips that certainly sound every bit as good as iron oxide tapes made at 3-¾ ips and even some 7-½ ips tapes. But Crolyn is not ubiquitous material. DuPont has manufactured it only in instrumentation-grade, with some of it slit to ¼-inch width. This has been for test purposes only, being sold on a limited basis for something like $10 per 1200-foot reel (in quantity).

Crolyn has a serious disadvantage that will keep it out of your cassettes for some time yet—it's highly abrasive to recording (and playback) heads. Once this problem is licked, the mass tape duplicators can start to use it in prerecorded cassettes. So far, DuPont has licensed Memorex, Sony and Philips (naturally) to manufacture this tape. More may be coming, but these three seem to cover the international marketplace pretty thoroughly.

In another new tape development, Tokyo-based TDK Electronics Co., Ltd. has released significant cassette products. One is an extended-frequency-range tape with claimed frequency response from 30 to 20,000 Hertz. According to the firm's own response curve, the tape is flat from about 70 to 10,000 Hz. At 30 Hz, it's down about 6 dB, and it's down roughly 4 dB at 20 kHz. So much for the charts.

In actual practice, the sound was unbelievable. I tested a prerecorded demo cassette, and soon discarded it as too artificial sounding. Then I dubbed a London Phase 4 tape made with Dolby masters (Stokowski's performance of Night on Bald Mountain). This was admittedly playing dirty pool, since this London tape has about as many wide swings in dynamic range, and individually spotted special effects as any I've ever heard. Then I synchronized the original 7½-ips reel tape and the dubbed cassette and A-B'd them.

Astounding point number one: the curve doesn't lie! The dubbed cassette sounded incredibly good. Granted, it lacked much of the dynamic range of the original, and tended to get muddy in sections where there were lots of loud transients, but by and large, an excellent job for a cassette.

TDK pulls off this feat by using a significantly smaller magnetic domain size than normal—about 0.4 micron long compared to the usual 1.0-micron domain length. This has roughly the same effect as doubling the tape-to-head speed, so presumably we're getting something like 3-¾ ips instead of 1-⅞ ips. Still, the cassette has the usual limitations of its 1-⅞-inch speed—mainly wow and flutter. Yet, these were not serious in the test recording, in fact were hardly noticeable. No, it's not nearly as good as the Phase 4 original, but it's certainly the equivalent of lots of prerecorded open-reel tapes currently on the market.

The other innovation from TDK—one that wasn't ready for testing at press time—was an endless-loop cassette. Presumably this tape is super-lubricated as all endless cartridges must be. And presumably it will be beset by the same problems of wow and lubricant rubbing off onto the heads. But it suggests itself immediately for use in certain commercial sound applications, for stores, telephone answering equipment and other compact uses.

But what about right now, you want to know. Okay. Buy a $20 player for your kids; get yourself a $50-60 mono recorder for general-purpose use; buy a stereo deck that you can add to your living-room rig for $99; buy a stereo unit for the car for $79; buy a bunch of prerecorded and lots of blank cassettes; and don't forget to buy a pair of tweezers—the wife might not lend you hers. **R-E**

SOLID-STATE FUZZ BOX

Add a new dimension to your guitar amplifier

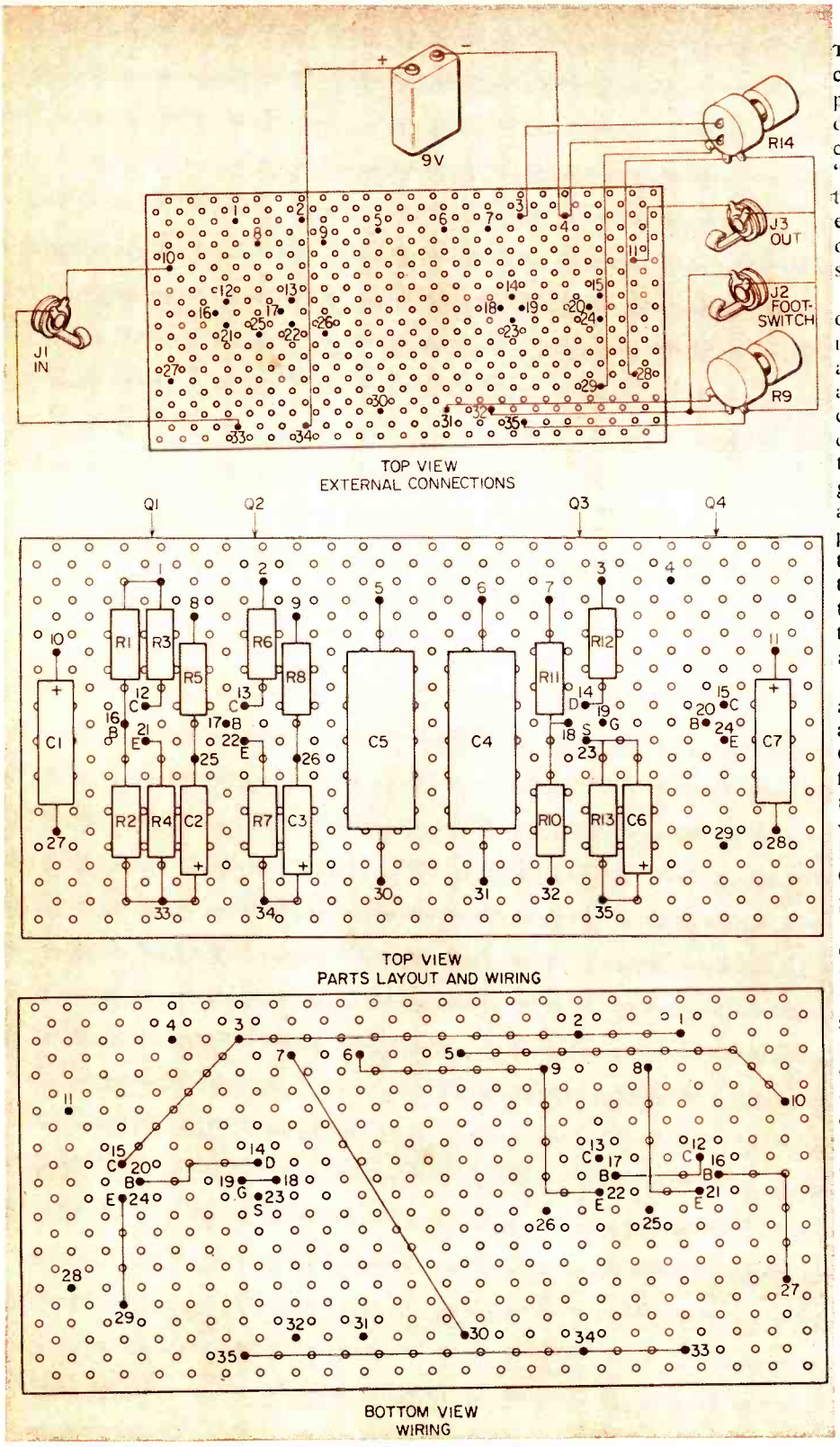
by JACK JAQUES

THE "FUZZ BOX" IS VERY USEFUL FOR converting the essentially "clean" output tone of an electric guitar into a distorted sound with a high harmonic content that gives the guitar a more "dynamic" sound. This "Fuzz Box," through the use of a footswitch, will either give the guitar a "clean" output or add a variable amount of distorted sound.

The circuit performs two functions: one a squaring amplifier and one a mixer. The squaring amplifier generates a square wave with rapid rise and fall times. This shape of wave contains many harmonics of the fundamental and the wave is clearly distorted. Q1 and Q2 comprise a high-gain easily saturated amplifier. For any signal above about 10 mV the output is a square wave. The output of the squaring amplifier is taken from the emitter of Q2 and as a result, there is a 180° phase shift between the input and output of the squaring amplifier.

The output of the squaring amplifier and input to the Fuzz Box are then applied to the audio mixer, Q3 and Q4. Transistor Q3 is a P-channel field-effect-transistor (FET) which, through its reverse biased gate has a very high input impedance. The mixing is done through R10 and R11 and Q3. Q4 is an emitter follower used to provide a low output impedance.

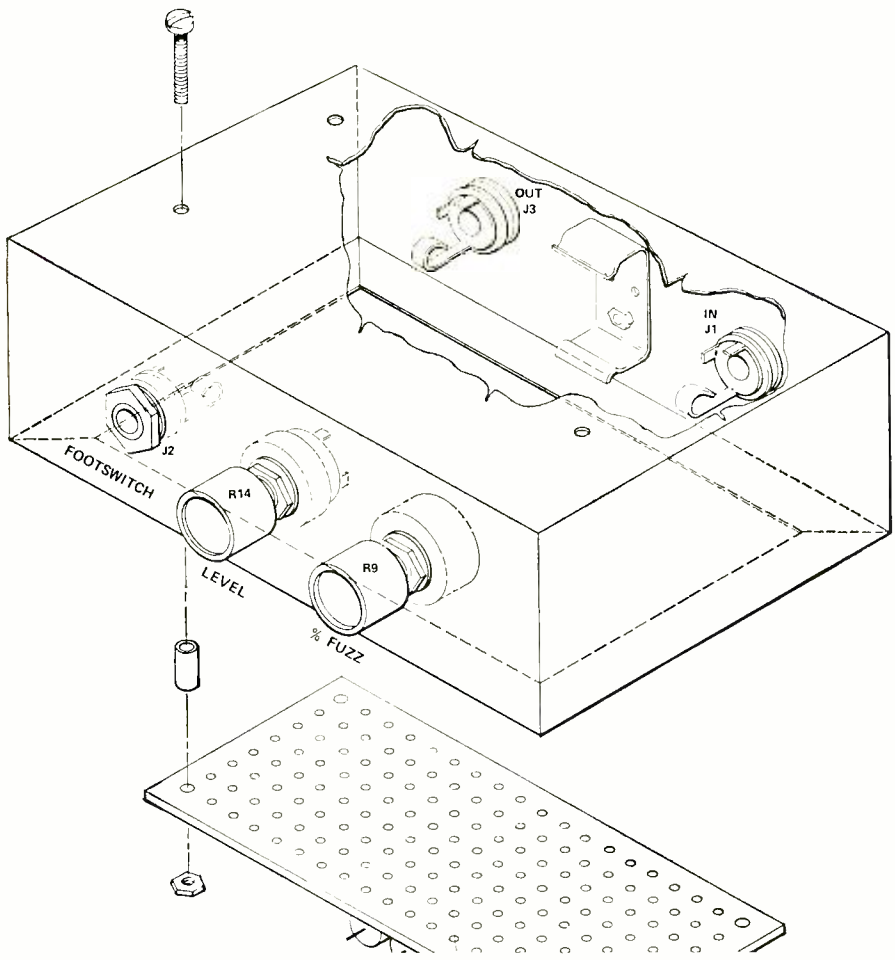
Potentiometer R9 varies the level of the square wave applied to the mixer. This varies the amount of distortion in the output from none to a square wave with slightly decreased peaks. The presence of the fuzz is controlled by the footswitch. The contacts are normally closed to ground out the square wave input and allow only the guitar input to go to the audio mixer. When the footswitch is depressed the square wave and guitar output are mixed. As the two signals



Top view shows numbered connections to various controls, inputs and battery.

Middle: top view of perf board showing positioning of most of the components.

Bottom view shows wiring between numbered terminals underneath the board.



are mixed 180° out-of-phase, the fundamental is suppressed and the harmonics become more apparent.

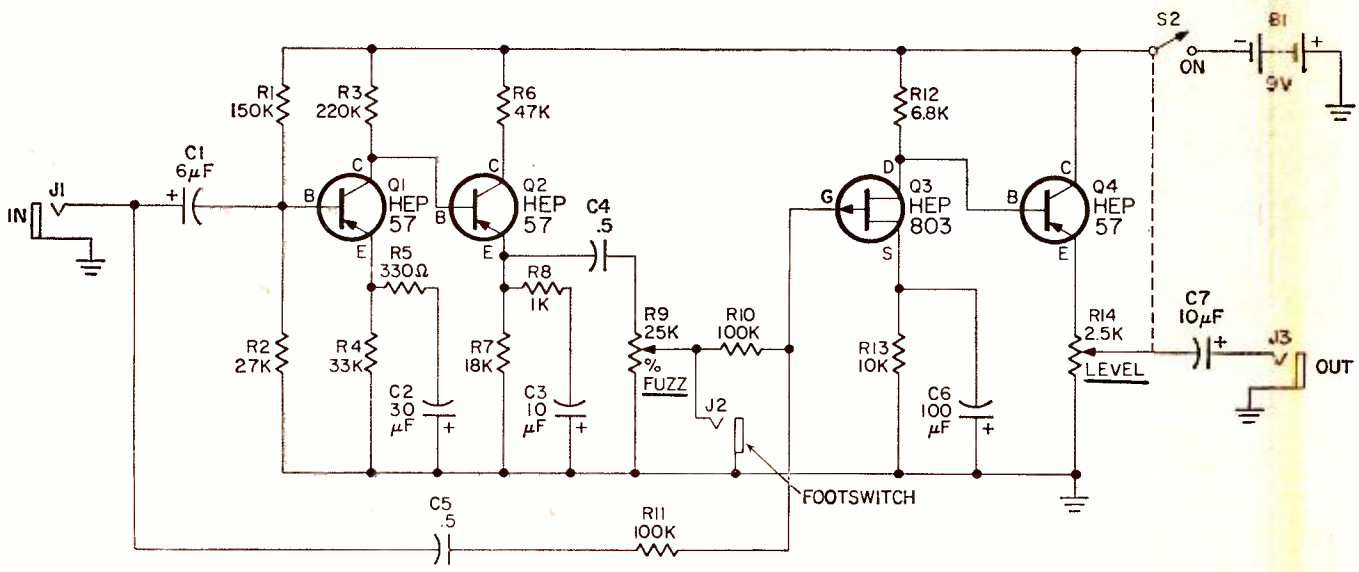
Potentiometer R14 along with switch S2, to turn the unit on and off, varies the output level. Since the audio mixer has a small gain, R14 can be used to adjust the gain to make the output comparable to the guitar's output.

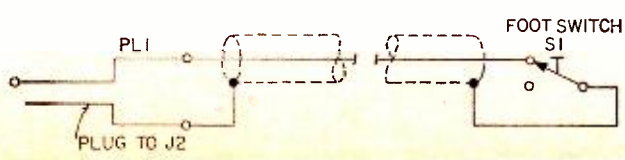
To use the Fuzz Box connect the guitar's output to J1. The output level of the guitar should be from 10 to 100 mV with 45 mV being ideal. This will allow for the most effective control of the PERCENT FUZZ. The footswitch is plugged into J2 and left alone for a "clean" output and depressed to get the "fuzz" output. The footswitch listed has spdt contacts and must be disassembled to connect the cable. The cable's shield should be connected to the contact arm and the case while the inner cable should be connected to the normally closed contact. The output, J3, is connected to the guitar amplifier, which is then operated in a normal fashion.

To keep from having a large change in volume occur when switching from no "fuzz" to maximum "fuzz," the guitar's output should be adjusted to a level that is comparable to the squaring amplifier's output. **R-E**

PARTS LIST

C1—6-μF, 15V capacitor, electrolytic
C2—30-μF, 15V capacitor, electrolytic
C3, C7—10-μF, 15V capacitor, electrolytic
C4, C5—0.5 μF, 100V capacitor
C6—100 μF, 15V capacitor, electrolytic
All resistors ½W, 10%
R1—150,000 ohms
R2—27,000 ohms
R3—220,000 ohms
R4—33,000 ohms
R5—330 ohms
R6—47,000 ohms
R7—18,000 ohms
R8—1000 ohms
R9—25,000 ohms, linear potentiometer
R10, R11—100,000 ohms
R12—6800 ohms
R13—10,000 ohms
R14—2500 ohms, linear potentiometer
Q1, Q2, Q4—HEP57 pnp transistor (Motorola)
Q3—HEP803 p-channel field-effect transistor (Motorola)
J1, J2, J3—Phone jack
PL1—Phone plug
B1—9-volt battery
S1—spdt switch
S2—spst switch
MISC—Battery holder, 6 x 4 x 2-inch chassis (Bud AC-431), mounting board (Keystone 1905), connecting terminals, cable, transistor sockets.





Dynamic "fuzz" sound occurs when output of squaring amplifier Q1–Q2 is mixed with input to the Fuzz Box in Q3.

of the voltage indicates how much the antenna must turn to restore balance.

The RCA circuit

In this unit (Fig. 2), elements R1–R4 correspond to those in Fig. 1-a, with trimmers R2 and R3 being represented by R2-a/R2-b and R3-a/R3-b. The transistors make up the detector and amplifier.

To orient the antenna, the control knob is turned to the desired direction. The knob—on R4—is ganged to

main in the counterclockwise (rest or normally closed) position because there is no current through its coil. With RY1's contacts holding the power on, the motor rotates counterclockwise, turning the antenna and R1.

When the desired aiming point is reached, the error voltage is around −0.25. At this bias level, Q1 and Q2 start conducting so Q2's collector current energizes RY2, causing its contacts to move to the clockwise position. During the interval that the relay

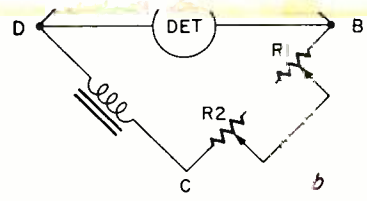
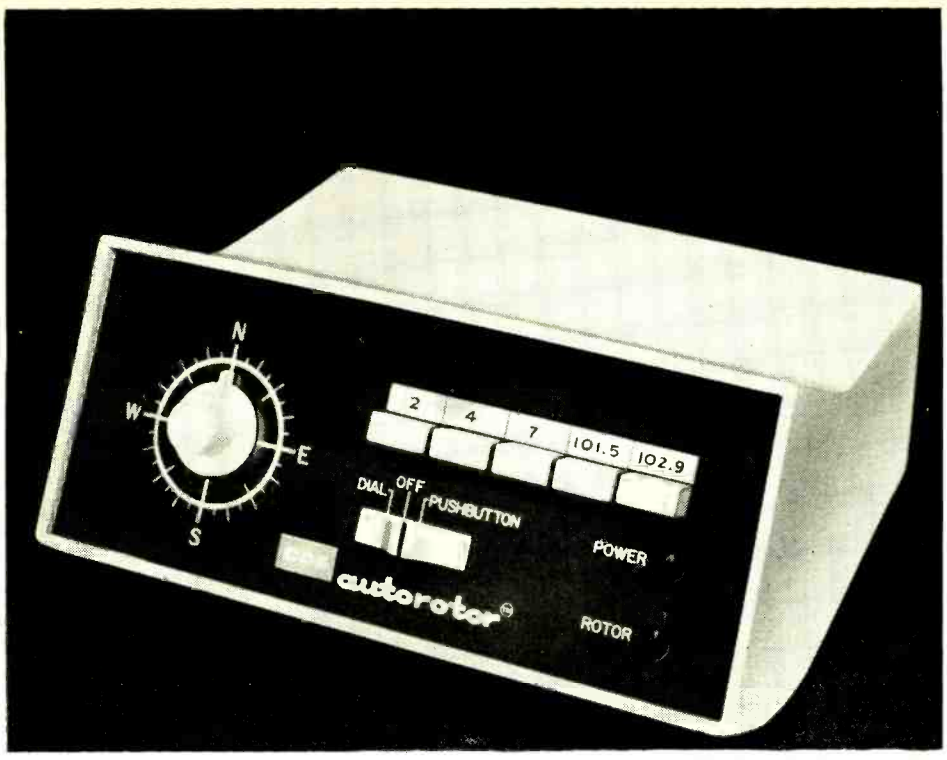


Fig. 1—Basic bridge circuits used to control the rotators. One (a) is a resistive Wheatstone bridge. The other (b) is a R-L phase-sensitive type.

Fig. 2—Schematic of the RCA 10W707 solid-state automatic rotator. It uses a Wheatstone bridge with potentiometers R1 and R4 as the variable components.



Pushbutton feature on Cornell-Dubilier AR-33 permits fixed settings.

How they work—

New solid-state TV rotators

by **ROBERT F. SCOTT**
SENIOR TECHNICAL EDITOR

AS HIS INTEREST IN COLOR OR UHF TV reception is aroused, many a homeowner finds his original black-and-white antenna system is obsolete. It covers only channels 2 through 13 and lacks the gain and bandwidth for good color reception. Too, it is sited for receiving reception from only one direction, while he is now within range of stations at several points around the compass. So, his new vhf/uhf installation must include a rotator that will aim the antenna at the desired station.

If he wants simple operation, pinpoint accuracy and positive sync between the rotator and control unit, he will probably select one of the new solid-state automatic rotators such as the Alliance C-255 Tenna-Rotor, Cornell-Dubilier AR-33 or RCA's model 10W707. You are going to install and service many of these units, so you'll want to know how they work and how to service them.

Like the more common nonelectronic rotators, the control circuits are based on a bridge with two potentiometers as variable elements. One potentiometer is turned by the dial on the control box and the other is driven by the rotator motor so the position of the arm is directly related to the antenna position. When the bridge is unbalanced by turning the pot on the control box, solid-state circuits amplify the error voltage and determine the direction the antenna (and potentiometer in the rotator) must be turned to restore the bridge to balance. The antenna points in the direction indicated on the control box when the bridge is balanced.

Two types of bridges (Fig. 1) are used in the rotators described in this article. In the basic resistive Wheatstone bridge in Fig. 1, a dc voltage is

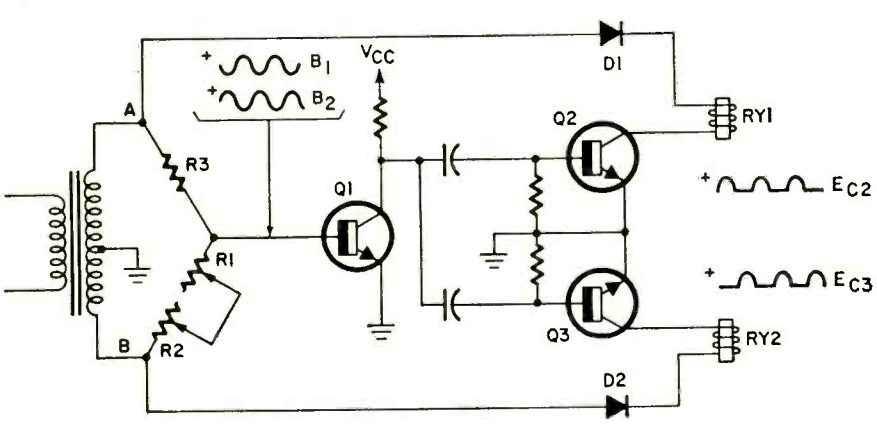


Fig. 3—Basic circuit of the AR-33 by Cornell-Dubilier. Phase relationship of waveforms and direction motor turns depend on setting of pot R1.

contacts are moving from the counterclockwise to clockwise position, the circuit to RY1's coil is opened. The contacts of RY1 quickly open, turning off the power to the motor and detector/amplifier circuits.

Now, if the bridge had been unbalanced clockwise, the voltage on Q1's base would have ranged from −0.3 to −0.1 volt. This would have turned on the transistors and energize RY2 so the motor would turn clockwise. The motor runs until the voltage across the bridge again approaches −0.25. The transistors cut off, de-energizing RY2 so power is turned off during the switching interval.

(Note that the operating threshold voltage is around −0.25 volt in either case. The transistors turn off at this level if the bridge has been unbalanced in the clockwise direction and turn on if the initial bridge unbalance was counterclockwise.)

Phase-sensitive controls

Cornell-Dubilier's AR-33 Autorotor uses a phase-sensitive bridge as the heart of a control system operated by either five preset pushbuttons or a 360° dial. Positioning accuracy is 1°. The basic circuit of the AR-33 is shown in Fig. 3 and the complete schematic is in Fig. 4. The functions and positions of R1, R2 and R3 correspond to those in Fig. 1-b.

When the bridge is unbalanced, an ac voltage is fed to the base of Q1. The phase of this ac error voltage with respect to ground is determined by the direction of unbalance. Wave-form B_1 and B_2 show relative phase relationships for cw and ccw unbalance.

Diodes D1 and D2 supply out-of-phase, half-wave positive pulses to the collectors of Q2 and Q3. Points A and B—the opposite ends of the center-tapped secondary—are 180° out of phase. When A is positive, D1 conducts and a positive pulse appears at Q2's collector. At the same time, point

Fig. 4—AR-33 Autorotor has dial and pushbutton control for pointing an antenna with ±1% accuracy.

B is negative, D2 is blocked and Q3's collector is at zero volts. Waveforms E_{c2} and E_{c3} show the out-of-phase positive pulses on the Q2 and Q3 collectors.

If the bridge is unbalanced in one direction, the amplified ac error voltage is in phase with the voltage on one collector and out of phase with the voltage on the other. Transistor Q2 and Q3 can conduct only when positive pulses appear simultaneously at the collector and base. If Q2 turns on, RY1 is energized, contact RY1-1 closes and the motor turns clockwise. The motor turns counterclockwise when Q3 is conducting. The motor continues to run until the bridge balances and the error voltage drops to around zero. At this point, the conducting transistor turns off, releasing its associated relay and turning off the motor.

Switch S1, the DIAL-OFF-PUSHBUTTON switch (Fig. 4), is used to select either pushbutton or dial operation. When it is in the PUSHBUTTON position, dial control R1 is switched out and replaced by one of the preset pots selected by pushbuttons S2–S6. The AR-33 comes with a set of dry-transfer numbers for marking the buttons with either TV channels or FM station frequencies.

Alliance Tenna-Rotor

The basic operation of the C-255 (Fig. 5) is similar to that of the Aurorotor, with R1, R2 and R3 corresponding to the same components in Fig. 1-b. Transistor Q2 determines the direction the motor rotates. Control pot R1 is ganged to S1 so the slightest movement in either direction closes S1-a and opens S1-b.

Switching transistor Q2's collector is fed through two paths. One path is through D1, R4 and RY2; the other is through D2, RY1 and RY2. The motor turns in one direction when RY2 is energized and reverses when it is de-energized.

The paths to Q2's collector carry half-wave negative pulses that are 180° out of phase. Collector current flows through the path where the pulses are in phase with the error voltage on the base.

Assume that the resistance of control R1 must be *reduced* to start the antenna turning in the desired direction. The error voltage on Q1's base is in phase with the voltage at B and out of phase with the voltage at A. When A is positive, the negative half-cycles on the base drive Q1 to greater conduction. This increases collector current through R5. A positive pulse through C1 keeps C1 completely cut off, even though its collector is receiving a negative pulse through D2.

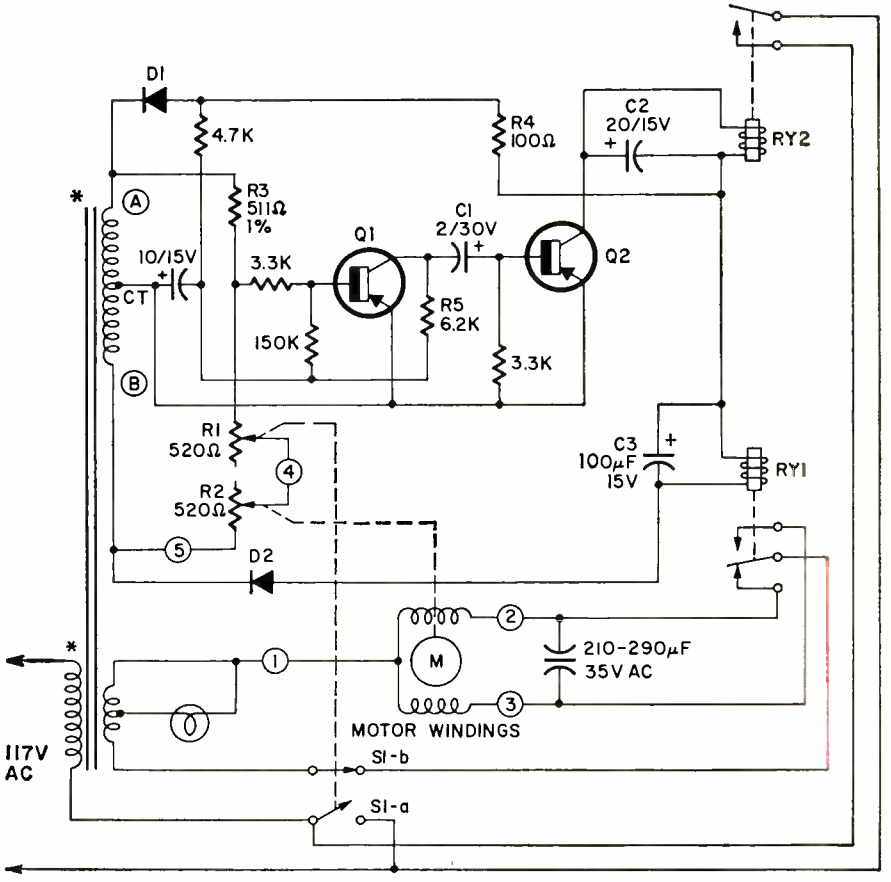
During the next half-cycle point, B and the error voltage on Q1's base are positive. Transistor Q1's collector current drops and develops a negative pulse on Q2's base. At this time, point A (180° out of phase with B) is negative. Diode D1 conducts and delivers a negative pulse to the collector of Q2. A half-wave pulse of current flows through R4 and RY2 and RY2 is energized. Capacitor C2 charges, keeping RY2 closed during the next half-cycle. When RY2 is closed it completes the circuit to the transformer primary after the control knob is released and S1-a opens. (Collector current cannot flow through RY1 because D2 is back-biased by the positive voltage on its cathode from point B.)

Relay RY1 has not been energized so the motor is supplied through the normally closed contacts and turns clockwise. The motor runs until R1's resistance rises enough to balance the bridge. At this point, the error voltage drops to zero, RY2 releases and opens the primary circuit.

Now, let's see what happens when R1's resistance must be increased to start the motor turning in the right direction. The error voltage is now *in phase* with the voltage at point A and out of phase with point B. On the half-cycles that A swings positive, the positive half-cycles of error voltage drive Q1 toward cutoff. Q1's collector swings negative and feeds negative pulses to Q2's base. These base pulses are in phase with the negative pulses fed to Q2's collector through D2. Collector current flows through RY1 and RY2, energizing their coils. Capacitors C2 and C3 keep the relays energized during the intervals that Q2 is not conducting in the circuit.

Relay RY2 closes the primary circuit as before, while RY1 completes the motor circuit through its normally open contacts so the motor turns counterclockwise. When the bridge is balanced, error voltage drops to zero and RY2 drops out, again opening the primary circuit.

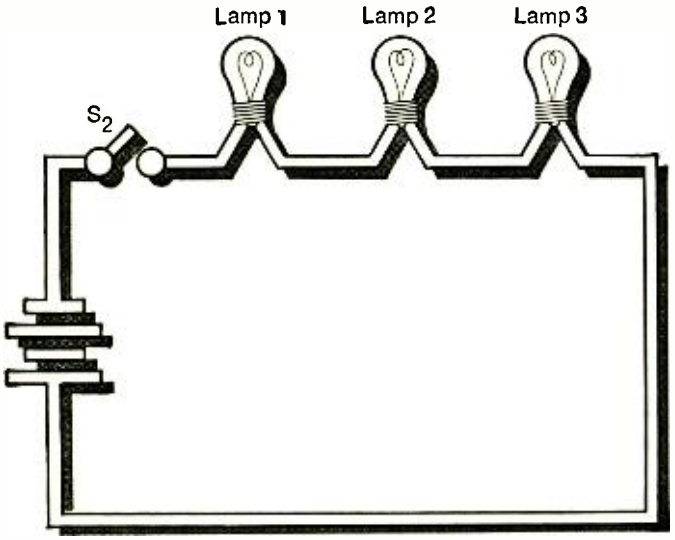
The time constant of RY1 and its 100-μF capacitor (C3) is longer than that of RY2 and C2, 20 μF. Thus, RY2 is always the first to pull in and the first to drop out. This prevents the motor from starting in the wrong direction when power is first applied and also prevents last-second motor reversals just as power is being cut off. **R-E**



NOTE:
CIRCLED NUMBERS INDICATE LEADS ON 5-CONDUCTOR CABLE BETWEEN ROTATOR AND CONTROL BOX.
*PART OF PWR TRANS

Fig. 5—The Alliance C-255 uses this circuit. Its operation is based on the phase-sensitive bridge (see Fig. 1-b).

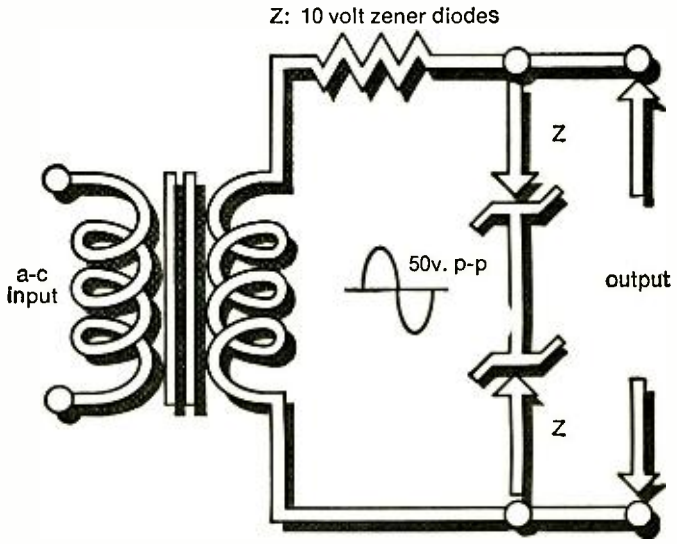
Can you solve these two basic problems in electronics?



This one is relatively simple:

When Switch S_2 is closed, which lamp bulbs light up?

Note: If you had completed only the first lesson of any of the RCA Institutes Home Study programs, you could have solved this problem.



This one's a little more difficult:

What is the output voltage (p–p)?

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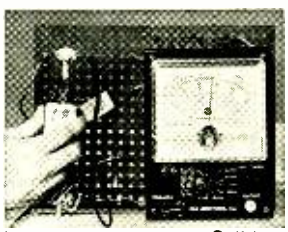

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Build An Automatic Enlarger Timer

Solid-state reliability. Resets itself after 1 to 69-second interval

by HERBERT ELKIN

AN AUTOMATIC PHOTOGRAPHIC enlarger timer is an invaluable darkroom accessory. The timer leaves the photographer's hands and mind free to concentrate entirely on the photographic creation.

The schematic in Fig. 1 is a solid-state, automatically resetting timer.

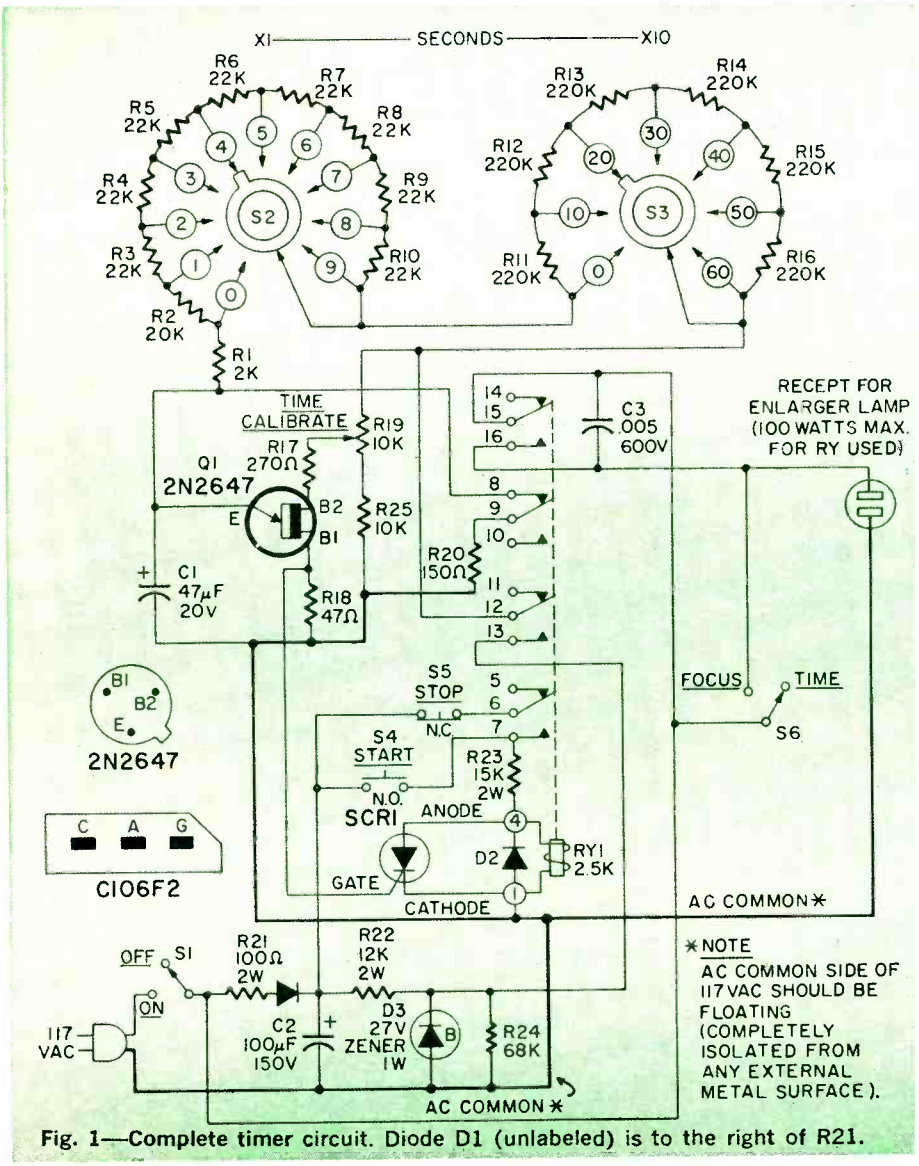


Fig. 1—Complete timer circuit. Diode D1 (unlabeled) is to the right of R21.

PARTS LIST

C1—47-μF, 20V, 10% electrolytic tantalum capacitor (Mallory type CSR13-E476KL or equal; see note below under relay RY1)
C2—100-μF, 150V electrolytic capacitor
C3—0.005-μF, 600V ceramic capacitor
All resistors ½W, 10% or better unless noted
R1—2000 ohms, 5%
R2—20,000 ohms, 5%
R3–R10—22,000 ohms
R11–R16—220,000 ohms
R17—270 ohms
R18—47 ohms
R19—10,000-ohm, ¼W linear potentiometer
R20—150 ohms
R21—100 ohms, 2W
R22—12,000 ohms, 2W
R23—15,000 ohms, 2W
R24—68,000 ohms
R25—10,000 ohms
D1, D2—750-mA, 400PIV, diode
D3—27-volt, 1W, 5% Zener diode (Motorola 1N4750A or equal)
Q1—2N2647 unijunction transistor (G.E.)
SCR1—C106F2 silicon controlled rectifier (G.E.)
Other parts
RY1—4pdt, 125-mW, 2500-ohms, 8.4-mA dc relay (Allied Control TS154-4C. Available from Newark Electronics Corp., 500 N. Pulaski Rd., Chicago, Ill. 60624 for $3.96 plus 2 oz. postage ppd. Stock No. 59F512, 1969 catalog). Capacitor C1 is $2.82, Stock No. 17F1542.
S1—slide switch
S2, S3—1-pole, 12-position rotary switch (Mallory 32112J or equal)
S4—N.O., momentary pushbutton switch
S5—N.C., momentary pushbutton switch
S6—rocker switch
MISC—ac socket, 6⅜ x 3 3/16 x 1⅞-inch bakelite case with aluminum panel (Lafayette 99T 6272), knobs, perf board, transistor socket

The advantages of a solid-state device over a mechanical timer are the elimination of noise, vibration, manual resetting, and increased reliability. The device is capable of timing intervals from 1 second to 69 seconds in 1-second intervals.

The time interval is set by two rotary switches. Switch S3 sets intervals of 10 seconds and switch S2 sets unit intervals additively. The timer is activated by momentarily pressing START switch S4. When the timing cycle terminates, the device is automatically reset and is ready to be activated again by pressing the momentary START switch. STOP switch S5 provides an abort capability before the end of the timing period if a timing interval has been erroneously set. The unit's recovery time is in the millisecond range, which is advantageous when making test strips.

Timing accuracy is better than 2% up to 30 seconds, after which accuracy falls off slightly due to the leakage current of tantalum capacitor C1. The unit provides exact time interval repeatability, which is important for consistent print results. Time interval resettability is of more importance than the slight loss of accuracy (2–5%) at intervals above 30 seconds. Most enlarging situations call for less than 30 second exposures.

How it works

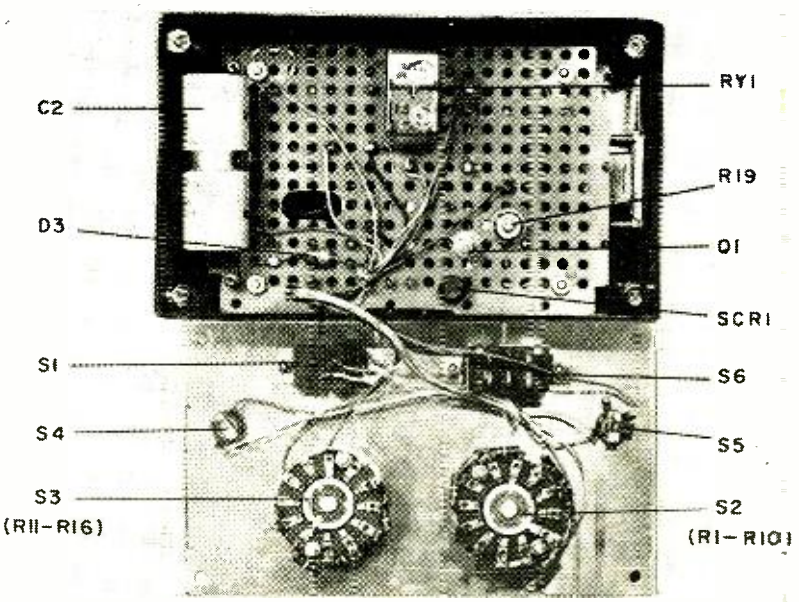
Relay RY1 is energized during timing and applies 117 Vac to the enlarger via the ac receptacle. The power supply is a half-wave type consisting of R21, D1, C2, R22, D3 and R24, and supplies an unregulated dc voltage to operate relay RY1 and a +27 volts dc, regulated by Zener diode D3. The regulated voltage provides an accurate reference voltage to the timing section of the device.

The heart of the timer is unijunction transistor Q1, used as a single-cycle relaxation oscillator. The timing interval is varied by switching resistance values (R1–R16 additively) in the unijunction emitter circuit to vary the RC time constant.

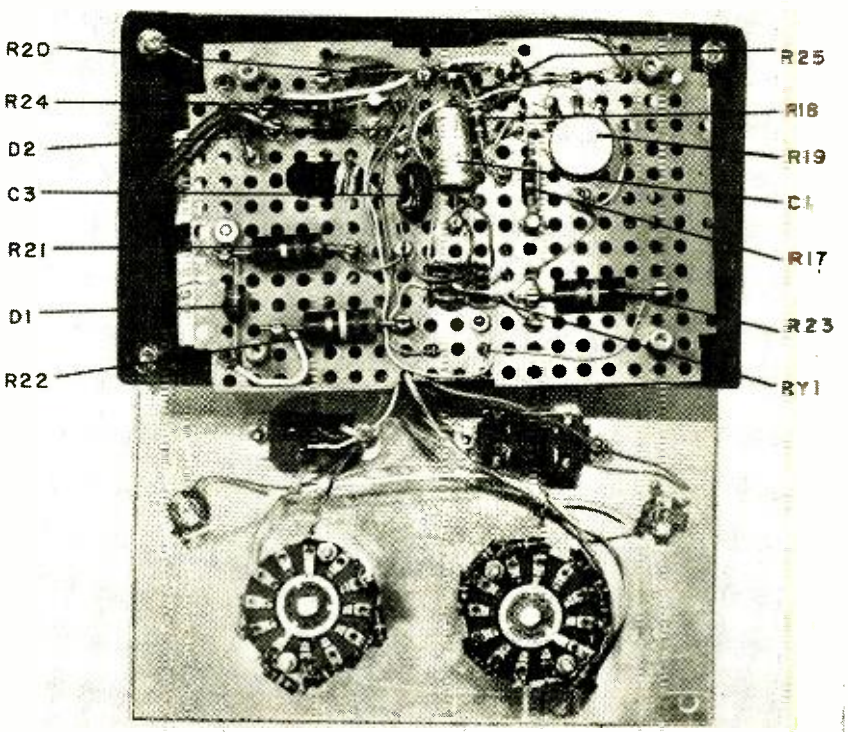
At the end of the timing cycle (when C1 charges to the proper stand-off voltage at the unijunction emitter), a pulse is generated at Base 1 of the unijunction. The pulse is applied to the gate of silicon controlled rectifier (SCR1), which then conducts current around RY1 causing the relay to release and end the timing cycle.

Here is an outline of the timing cycle:

1. Momentarily depressing START switch S4 applies the unregulated voltage through R23 to RY1, which puts the four relay contacts in the activated position.
2. When the START switch is released, the relay remains activated as the holding current is supplied through the normally closed STOP switch S5 and through the closed relay contacts 6 and 7. If it's desired to terminate a timing cycle before the interval set, the STOP switch can be momentarily pressed, interrupting the relay holding current and releasing the relay.
3. With RY1 activated, the enlarger lamp receives 117 volts ac through contacts 15 and 16, +27 volts is supplied to the unijunction circuit through contacts 12 and 13, and R20 is removed (contacts 8 and 9 are open) from across C1.
4. When Q1 fires at the end of the timing interval, the positive pulse generated at Base 1 triggers the SCR, which then bypasses current around the relay coil, causing the relay to release.
5. Since the SCR anode voltage is supplied through relay contacts 6 and 7, the SCR anode voltage is removed when the relay releases. Therefore, the SCR is restored to a nonconducting state and the timer is automatically ready for a new timing operation initiated by the START (S4) button.



Top view of mounting perf board. Make sure S2 and S3 have adequate clearance.



Bottom view of component board. An external relay extends wattage capability.

6. When the relay releases, contacts 15 and 16 open, the enlarger lamp is turned off, the regulated +27 volts is removed from the unijunction circuit, and R20 is placed across C1. R20 completely discharges capacitor C1 within milliseconds to assure that when a new timing cycle is started the initial voltage on C1 will always be zero. This insures an accurate timing interval.

Capacitor C3 is across relay contacts 15 and 16 for arc suppression. Diode D2 is across the coil of RY1 to eliminate transient spikes during relay turnoff, which could damage the SCR and/or the relay coil. The 1-second timing resistance is divided into two resistors, R1 and R2. R1 is always in the timing circuit and provides protection for Q1 if the timer is started with switches S2 and S3 accidentally left in the 0 second position. R1 contributes only a small error (less than 1%) when S2 is set to 0 and the S3 (x10) resistances are in use.

Provision is made for accurate calibration using potentiometer R19. By means of R19, the interbase voltage can be varied, thus controlling the firing point of the unijunction transistor (the firing point voltage at Q1's emitter is equal to the stand-off ratio (η) x the voltage across Q1, Base 1 to Base 2). The ±10% tolerance of C1 and the variation in the stand-off ratio of Q1 (0.68–0.82) are balanced out using R19. Although the timing resistors are ±5% tolerance, it can be shown that the timing accuracy is better than 2% (if the leakage current in C1 is considered negligible).

Construction

The cabinet is a 6⅜ x 3⅜₁₆ x 1⅞-inch bakelite utility case. A 117-volt isolation transformer was not used to make the unit compact. If the bakelite case is used and all circuitry is isolated from the metal front panel, the transformer is not required in the circuit.

The components were mounted on a phenolic perforated board which was fastened to the bottom of the bakelite case using spacers (legs) to allow clearance for the components mounted on the bottom side of the board. Rotary switches S2 and S3 were mounted on the front panel so that the space left between them was sufficient for the relay clearance. FOCUS-TIME switch S6 is a "see-saw" (or "rocker") type which adds to the convenience and simplicity of operation. The relay was selected because of its low operating power (175 mw). The contact rating of the relay will allow it to switch an enlarger lamp of up to 100 watts (within the range of most home enlargers).

If you wish to use the timer with a higher-wattage lamp, use the unit to switch another external high-contact-current relay. Capacitor C1 is a tantalum capacitor and no other type should be used since a low-current-leakage capacitor is required. The ac common points on the schematic in Fig. 1 should be joined together and connected to the indicated side of the power line; do *not* ground this side of the power line to the front panel.

Calibration and use

As with all electronic gear, the power supply should be checked out first before connecting the circuitry. Leave the connection to relay pin 13 open until the voltage is checked. Double check the power supply wiring and then turn power on. The voltage on the open lead should be +27 volts dc.

Set potentiometer R19 to mid-range and the FOCUS-TIME switch S6 to TIME. Set the timer for 5 seconds (S2 to 5 and S3 to 0. Start the timer by momentarily pressing the START switch S4. Adjust potentiometer R19 for a 5-second cycle. You will hear the relay drop out at the end of the cycle. Check the timing interval at 10, 15, 20, and 30 seconds and touch up the adjustment of R19 if necessary. All time intervals up to 30 seconds should be accurate to 2%. Check the timing at 40, 50, and 60 seconds. The accuracy should be from 2 to 5%. A 5% error at these settings will not at all be noticeable in the finished print.

If the error above 30 seconds is large (which will be rare) it is because C1 has exceptionally high current leakage. If C1 is not completely defective, the accuracy above 30 seconds can still be improved. Since C1 is a relatively high-cost item, the following procedure should be followed rather than to discard the capacitor. Set S3 to the shortest time at which the accuracy is to be improved (say 50 seconds) and S2 to 5 seconds. Replace R15 with a 500K pot and adjust for an accurate 55-second interval.

The potentiometer can be left in as part of the circuit or the potentiometer resistance can be measured and a fixed resistor substituted. Repeat the procedure for the next highest time setting of S3 (60 seconds and R16 in this example) after the selected resistor is soldered into the circuit. Leave S2 set to 5 seconds.

With switch S1 on and the FOCUS-TIME switch S6 set to FOCUS, the enlarger will be continuously on. After selecting negatives and focusing the enlarger, set S6 to TIME. The lamp will be switched off and the timing interval set by S2 and S3 can then be initiated by pressing START switch S4. **R-E**

TOOLS FOR ELECTRONICS

by TOM HASKETT

This issue, starting on the facing page, is the fourth part of our new series of articles on tools for electronics. It winds up our description of screwdrivers. Next month we will continue the series with the first part of an article on wrenches and how to use them. We believe you will find all of this material a handy, practical addition to your R-E Reference Manual.

If you wish you can purchase a special hardcover binder to keep your Reference Manual pages together. It has a dark blue fabric cover and is gold stamped Radio-Electronics Reference Manual. The cost is $1.00, postpaid. Order from N. Estrada, 17 Slate Lane, Central Islip, L.I.

Another way of obtaining greater torque with a given screwdriver is to use GC Electronics' **Twistmaster** handle No. 9320 (Fig. 22). It's a

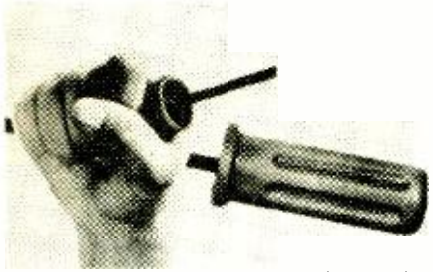


Fig. 22—Need more torque? Try the G-C Electronics Twistmaster handle No. 9320. Slip it over existing tool handles to increase diameter, improve grip and boost torque.

hollow handle which you slip on the handle of your present driver, giving you greater driving power.

A somewhat similar device, called the **Torque Amplifier,** is made by Xcelite (Fig. 23). It is used with screw- and nut-driver sets. The

Fig. 23—This torque amplifier is made by Xcelite. It is a part of many of their "tool kits". These are sets of small screwdrivers, nutdrivers and other similar tools. They go a long way to help speed removal of "tight" hardware.

hollow handle slips over the handles of miniature drivers, to give you more turning power. Several kits available from Xcelite using the **Torque Amplifier** include slot, Phillips, Scrulox and Allen blades.

Amalite's **swivel-top handle** driver (Fig. 24) is made in two parts, with the end of the handle turning freely. Thus you can apply steady

Fig. 24—Swivel-top screwdriver is made in two parts, with the end of the handle turning freely. Lets you apply steady pressure while turning this Amalite driver.

pressure to the handle end while turning the body of the handle, thereby speeding up the job.

Specialized screwdrivers

If you have to install or remove a lot of screws, your forearms get tired and you may work up a blister. One comfortable solution is a **ratchet** screwdriver (Fig. 25). It has a button on the blade near the handle, and can be set for ratchet left, ratchet right, or no ratchet

for the driver and one hand? How do you hold the screw in place to start it? One way is to use a **screw launcher** (Fig. 27) which holds the screw and lets you start it in the threads. Then you remove the launcher from the screwhead and use a regular driver.

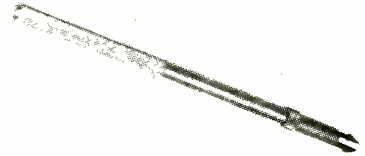


Fig. 27—Screw Launcher starts screws in tight corners. Then tool is retracted and standard driver is used to complete procedure. Unit shown is the Vaco model K-19.

Another way of overcoming the problem is to use a **screw-holding driver** (Fig. 28). It's similar to a conventional screwdriver, but the blade is split and a movable ring allows you to wedge the split tip apart inside the screw slot, holding the screw so you can drive it in (or remove it).

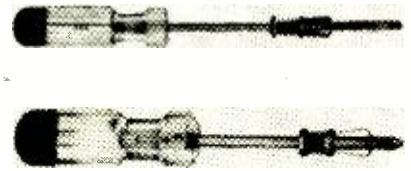


Fig. 28—These screw-holding drivers do about the same job. The top one (Crescent model 247) is for standard screws. The bottom one (Crescent model 261) is for Phillips head screws. Other types of screw-holding drivers are also made.

Some screw launchers and screw-holding drivers are available for Phillips and Reed & Prince screws.

Stevens Walden **In-a-Grip** wrenches are a bit unusual; they're screw-holding Allen drivers (Fig. 29). The blade is a split-spring hex,

Fig. 29—Here's a screw-holding Allen driver. The blade is a split-spring hex you insert in the screwhead. The driver shown is a Stevens Walden model 36HP4.

which you force together and insert in the screwhead. Thus you can drive the screw with one hand, and simply pull the driver out when you're finished.

Some screwdrivers have removable, **reversible blades** (Fig. 30) which double the usefulness of a single driver. The reversible blade usually has a slot tip on one end and a Phillips on the other, although Vaco has a clutch-head blade available.

(straight screwdriver action). You simply turn the driver and drive the screw in, ratcheting back to get another bite (or vice versa). You don't

Fig. 25—Ratchet screwdriver can speed up inserting or removing screws considerably. Unit shown is the Vaco model 11101.

have to change your grip on the handle.

A ratchet mechanism is also used in the right-angle/offset screwdriver shown in Fig. 26. This type of driver is quite useful if you must

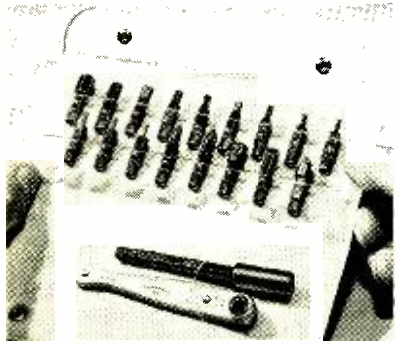


Fig. 26-a—Some offset drivers also use a ratchet action. On the left is the Chapman kit. It uses a ratchet drive and a set of interchangeable bits. The bits can be screwdriver or Allen head styles. The unit shown includes both kinds.

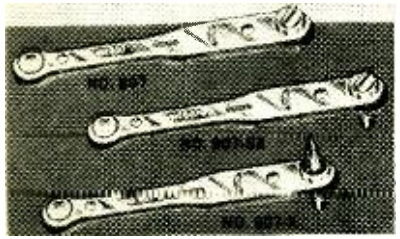


Fig. 26-b—Another type of ratchet driver has captive tips. These three different models offer a variety of tip combinations. All are manufactured by General Hardware.

work in close quarters where it is often difficult to remove and reseat the driver blade. Also, you may not have space to work the handle very far, but with ratchet action you need only a small space to turn the screw a little at each throw. Right-angle rachet drivers are often socket types; a single handle comes in a kit with various insertable heads available—slot, Phillips and Allen (hex).

Have you ever tried to start a screw where there was room only

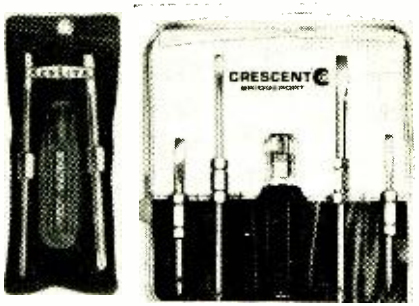


Fig. 30—These two screwdriver kits have reversible interchangable blades, so each blade is actually two drivers. On the left is the Xcelite CK20 kit; on the right is the Crescent model 2700-4 kit.

The **handle-and-blade kit** (Fig. 31) carries the preceding idea a bit further, combining one or two handles with a number of interchangeable blades. It's useful for work away from your bench, since you can

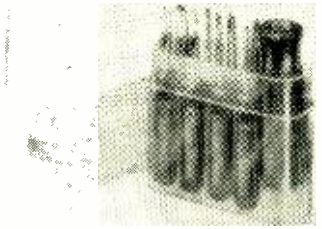


Fig. 31-a—Handle and blade kits are another common convenient combination tool set. The Channellock model SD-5 combines standard and Phillips head drivers in one handy pocket-size package.

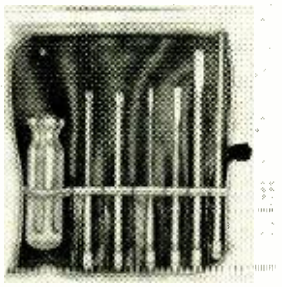


Fig. 31-b—Another type handle and blade kit is shown here. It rolls up into a neat package.

carry lots of tools in a compact space. Most kits contain one or two slot-tip blades, a Phillips and possibly an awl and a tack puller. Several manufacturers (Hunter, Peer, Vaco and Xcelite) have other blades: Reed & Prince, clutch, Scrulox, Allen and Bristol. Xcelite furnishes a taper-reamer blade with its kit. The best kits have snap-in blade seating; less expensive types have a screw-down finger chuck which takes more time to work.

Jeweler's screwdrivers are simply miniature drivers for tiny screws (Fig. 32). They usually have knurled handles and a swivel-end

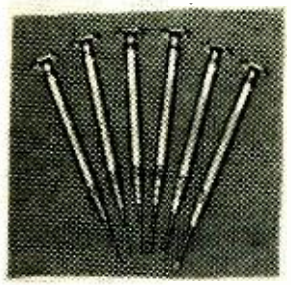


Fig. 32—Miniature jeweler's screwdrivers are often handy when you've got really tiny screws to handle. The set shown here is the Peer 41-068. A word of warning. Many of these tools are not insulated at all. The bit and shaft are all metal—please be careful.

finger-rest plate, and some have removable blades. They are generally available only with slot tips. You can buy these drivers individually, but most persons buy a kit of five or six, with tip widths from .025 inch to 0.100 inch.

Some color- TV receivers have dual, concentric setup controls, and it is often desirable to adjust both controls simultaneously. GC Electronics' No. 9299 **dual concentric** screwdriver (Fig. 33) has been designed for just that job.

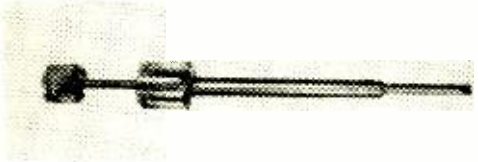


Fig. 33—This special dual-concentric screwdriver is specially made by General Cement (model 9299) for setting dual concentric controls simultaneously.

Shelton's **Versatool** (Fig. 34) is a multipurpose ratchet driver with both slot and Phillips blades which swivel to work straight-on or offset.

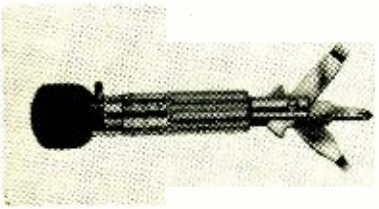


Fig. 34—Shelton Versatool offers three different screwdriver blades plus a ratchet in a single package. A nice novelty.

The same company's **4-Way Orbit Driver** (Fig. 35) is an unusual driver with four blades—two slot and two Phillips. It's palm-sized and useful for field work.

than a few months, spend a buck or two and get a professional-quality tool. A cheap screwdriver is no bargain.

Screwdriver use and care

Use the longest driver available which will fit the screw and the work space. You get more torque with a longer blade. Be sure the tip is thick enough to fit the screw slot; if it isn't, the driver will slip and deform both the tip and the screwhead. If you're driving anything but a slotted-head screw, you'll have to get a mating tool of the correct tip size. Don't use a slot tip that's wider than the screwhead, or you'll mar the surface of the work when you run the screw home.

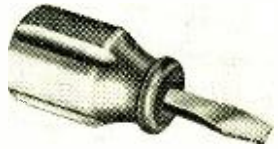
If you're driving screws in wood and the hole's small and tight, rub a little soap into the screw threads. A clean machine screw should

Standard Stanley screwdriver has large plastic handle and conventional screwdriver tip. You need a variety of these tips to handle the many different screw sizes effectively and prevent damage to screw slots.

run into a threaded metal hole easily, but if either the screw or the hole is dirty or rusty, use a drop of oil to smooth the way; then you won't take a chance in breaking the screw off in the hole.

If you can't seem to get a screw out, squirt a little oil under the head and work the screw back and forth with the driver. You can usually loosen it this way.

A self-tapping screw threads its way through a panel, and you need a lot of torque to start it. Use a large driver and start with screw slowly and carefully. After the screw cuts threads in the panel the going gets easier.



A stubby screwdriver is an important part of any tool kit. You should have both standard and Phillips types in at least two different sizes. In tight quarters you'll find them hard to beat.

Always remember to use the right sized screwdriver for the job, and keep the blade clean. Never carry a driver in your pocket unless it has a clip; a loose driver can injure you severely if you trip and fall.

Fig. 35—4 Way Orbit Driver is palm sized and handy for field work. The one shown here has a G-E trademark, but the tool is actually made by Shelton.

You can buy **magnetized** screwdrivers, which are useful for starting or retrieving steel or iron screws. You can also magnetize a steel driver by rubbing its tip across a speaker magnet.

Sometimes magnetized screwdrivers can be a nuisance—especially around a tape recorder or a color TV receiver—where they may cause trouble. If you have a magnetized driver, you might want to keep it away from your other tools. If you want to demagnetize a screwdriver, use your solder gun or a degaussing coil. Energize the gun or coil and pass the driver blade through the coil (or into and back out of the gun-tip loop.)

Little screwdrivers with pocket clips are a great convenience but look for clips that are permanently attached. Slide on clips can also slide off when you least expect it.

How to buy screwdrivers

You will probably want to keep on hand an assortment of the drivers you need for the various screwheads you encounter in your work or hobby. You'll want small and large sizes, slotted, Phillips and perhaps others.

Try to get your hands on a driver before you buy it. The handle should be comfortable and not cut into your hand when you apply torque to a screwhead. The blade should be anchored with a pair of wings in the handle, and the best blades are made of tool steel or a good alloy with temper. Look at the tip closely; it should be clean and even, with no burrs or rough edges. You will find various prices, from perhaps 39¢ to several dollars. If you plan to use a driver for more

Don't use a screwdriver as a pry bar or a chisel, and don't hit the handle with a hammer. Never use pliers to turn a driver blade when removing a frozen screw. Get a square-bladed driver and use the corect size of right-angle wrench.

If a screwhead slot or recess is dirty, clean it out before applying a driver to it. Otherwise you may damage both the driver tip and the screwhead.

Grind the sides of the blade flat and you've got a more expensive driver. But it's a more convenient tool to use too; especially if the screw you want to get at is recessed or countersunk.

When a screwdriver becomes nicked or its edges rounded, or when other damage occurs and the tip doesn't fit the screw slot, you should file the tip or grind it back into shape. Put the driver in a vise and file it carefully until its shape is restored. If you grind a driver tip, dip it into water from time to time to prevent it from losing its temper.

Long bladed drivers are another must in any complete set of screwdrivers. Again a variety of tips are a must. You may not need this kind of driver often, but when you do . .

Some drivers are plated with nickel or chrome, to keep them from rusting. Others aren't, and since they're made of tool steel they'll rust if you don't work them over with an oily rag now and then. If a driver does rust or gets dirty or grimy, clean it with sandpaper, emery cloth, steel wool or a wire brush until it's bright. Then rub it with a slightly oily cloth.

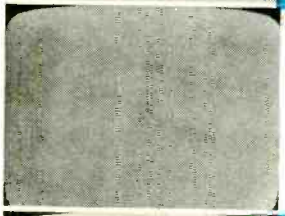
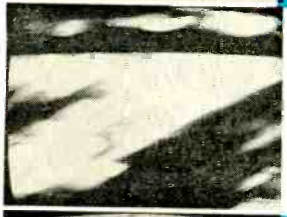
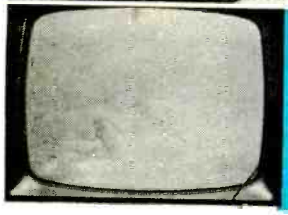
If you work with tape heads, color TV or similar magnetically sensitive equipment, you may want to demagnetize your screwdrivers from time to time. They have a bad habit of accidentally getting magnetized. R-E

NEW R-E EXCLUSIVE

6HS8 noise-canceling sync/agc stage sync separator section

Kwik-Fix™ picture and waveform charts

by Forest H. Belt & Associates*

SCREEN SYMPTOMS AS GUIDES		WHERE TO CHECK FIRST		
SYMPTOM PIC	DESCRIPTION	VOLTAGE	WAVEFORM	PART
	Agc overload, no sync, sound buzz	cathode-pin-1 screen-pin-2	WF2	R8 C5
	Weak picture, sync okay	G1-pin-7	WF2	R6 R7
	Weak picture, sync poor	G1-pin-7	not much help	C2
	Whiteout, sound remains	G1-pin-7	WF2	R7
	Whiteout, no sound	screen-pin-2 cathode-pin-1	WF3	R10 C5
	No sync, signs of overload, sound may buzz	G3-pin-9	WF4	C7 R12
	Agc lets i-f overload, sync fairly normal, sound buzz	screen-pin-2 G3-pin-9	WF2 WF5	R10

Use this guide to help you find which key voltage or waveform to check first.
Study the screen and the action of the agc and noise gate controls.
Most helpful clues to the fault are found at the key test points indicated.

Make voltage or waveform checks as indicated for screen symptoms.
Use the Voltage Guide and Waveform Guide to analyze results.
For a quick check, test or substitute the parts listed as the most likely cause of the symptoms.

THE CIRCUITS

This sync separator stage is popular, especially in color sets. The tube has twin-pentode construction, with elements common to both sides—cancelling noise for both sync separation and agc. This issue of Kwik-Fix™, number 7, covers the sync separator section: the prior issue, number 6, described the other half of the tube—keyed automatic gain control.

Grids 1 and 2 and the cathode are common to both sections, terminated in pins 7, 2 and 1, respectively. The sync section has its own separate G3 and plate, pins 9 and 8 (pins 3 and 6 are plate and grid 3 for agc section). Grid 1 is the noise-canceling grid for both sections. Grid 2 is the screen grid for both; constant positive voltage there affects general conduction for the entire tube.

SIGNAL BEHAVIOR

Video-and-sync signal from video amplifier is applied through compensating network C6-R11-C7 to pin 9, which is separator grid. Sync pulses here are positive-going. They exercise strong control over conduction in this section of tube, when tube can conduct.

At same time, video signal with negative-going sync is applied to noise-canceling grid at pin 7 through C2. Bias is enough on grid-pin-7 that any signal of higher amplitude than sync pulses (such as noise) drives tube far into cutoff. No noise pulse can therefore be amplified, even if it reaches grid-pin-9, because same noise impulse (but opposite polarity) is cutting tube off at grid-pin-7.

Long time-constant of R12, load for grid-pin-9, lets signal level determine bias for G3. Grid-leak action sets bias voltage just above pedestal level of incoming sync-and-video signal. Video can't make tube conduct, nor can blanking pedestal. Sync pulses can, though. Output is sync signal minus video and blanking.

Any noise that appears above or between sync pulses is canceled by opposite version at grid-pin-7. Noise therefore doesn't appear in output, and can't foul up sync.

Capacitor C4 decouples screen grid, using cathode-bypass capacitor C5 as easy signal path to ground.

Horizontal sync and vertical sync both show up in output of sync separator. Small-value capacitor (not shown) couples horizontal sync to horiozntal afc stage; resistor and integrator network (not shown) couple vertical sync to vertical oscillator.

DC DISTRIBUTION

Plate voltage for this section of 6HS8 comes from 250-volt line through R13. Screen voltage comes through R10.

Bias between cathode and grid 1 of tube is set by controls R7 and R8. Noise-gate control sets level of operation for G1. Control is set for dc voltage level just below tips of incoming sync pulses, so pulses won't quite overcome dc voltage. Agc control R8 adjusts cathode voltage —thus sets grid-cathode bias. R8 determines conduction for the amplitude of signal applied to separator grid (pin 9): it has little or no direct effect on sync, except in way age affects signals in rf and i-f stages.

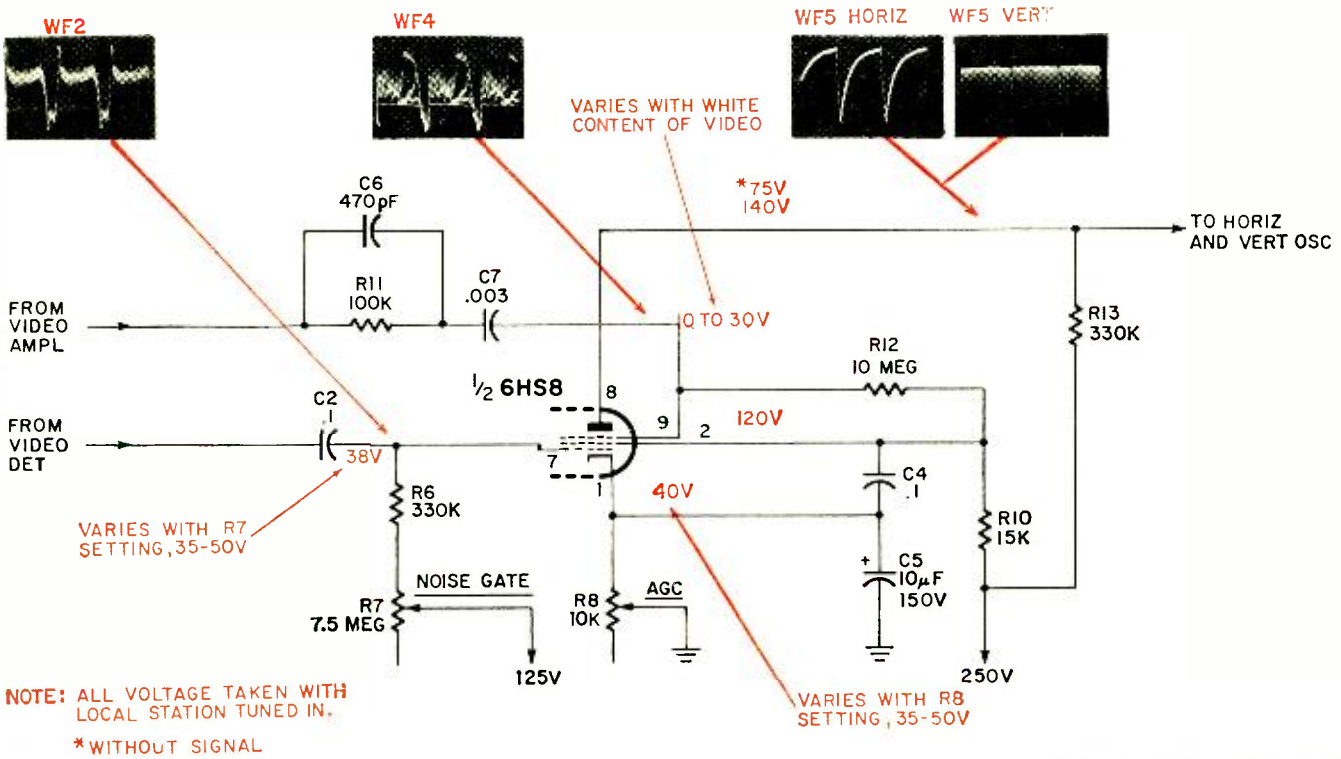
Operating value of dc bias at grid 3 (pin 9) depends on level of blanking pedestals. A stronger signal develops more grid-leak bias across high-value R12, reducing amplification of sync pulses as well as keeping bias above pedestal level. A weaker video signal develops less grid-leak bias: amplification is higher, and bias drops down *almost* to pedestal level. Output is fairly constant-amplitude sync pulse.

QUICK TROUBLESHOOTING

When this section is faulty, it may also upset agc section. ALWAYS start troubleshooting by clamping i.f. agc stage at whatever value lets video get through normally to video detector and video ampl. Don't apply too much clamp voltage. Just clip variable dc supply to i.f. agc line and turn up voltage control until picture is visible. If it's out of sync, that's okay. Leave agc and noise gate set at center of rotation.

With video on screen, even though out of sync, use scope to check waveforms (see Waveforms as Guides). Many troubles in this section leave no dc clues; waveform analysis is usually quickest. If waveforms seem fairly normal, then check voltages with dc voltmeter.

Also see last Kwik-Fix™, number 6, which is companion to this one showing agc side of the stage. **R-E**



DC VOLTAGE AS GUIDES

Voltage change	to zero	very low	low	slightly low	slightly high	high
Cathode-pin-1 Normal 40 V. Varies from 35 to 50 volts with setting of R8. Develops as result of average plate conduction in tube.	R10 open C5 shorted	R7 open	R10 high C2 leaky C5 leaky	C7 open	C2 open C4 leaky	R8 open R10 open C2 open
Screen-pin-2 Normal 120 V. Is applied through R10 from 250-volt line.	R10 open C4 shorted	C4 shorted C5 shorted	R10 high C4 leaky C5 leaky	C4 leaky	R6 open C2 open C7 open	R7 open R8 open R10 low C2 leaky
G1-pin-7 Normal 38 V. Varies from 35 to 50 volts with setting of R7. Comes through R7 from 125-volt line.	R6 open R7 open R10 open	R6 high	R10 high C2 leaky C5 leaky	C2 open	C4 leaky	R8 open R10 low
Plate-pin-8 Normal 140 V. Varies with station signal rf level. Comes from 250-volt line through R13. In some chassis, also fed from lesser B-plus source—not shown here.	R13 open[1]	C2 leaky C7 shorted	R13 open C7 open C7 leaky	R12 shorted C5 leaky C7 leaky	R8 open	R13 shorted
G3-pin-9 Normal 10–20 V. Voltage depends on white content of video signal applied by C6-R11-C7. Developed by gridleak action across R10.	R10 open R12 open C5 shorted	C5 leaky	R10 very high C2 open C2 leaky C5 leaky		R6 open C5 open C7 open C7 leaky	R7 open R8 open R10 low C4 leaky C7 shorted

[1] In sets without extra (not shown) B-plus connection

Use this guide to help you pinpoint the faulty part. BE VERY SURE to clamp i.f. agc line as described in text; all indications in this chart are under those conditions.

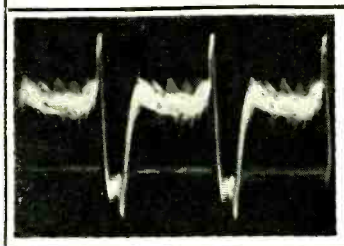
Measure each of the five key voltages with a vtvm.

For each, move across to the column that describes the change you find.

Finally, notice which parts are repeated in the combination of changes you find.

Test those parts individually for the fault described.

WAVEFORMS AS GUIDES



WF2 Normal 0.6V p-p

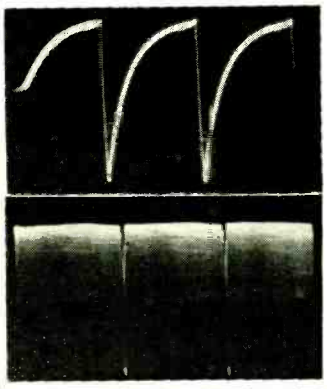
Taken at G1-pin-7, noise-canceling grid, this is video-and-sync signal directly from video detector. Sync pulses normally point negative. There is no compensating network at input, just dc-blocking capacitor C1. Note trailing edge is sharp, rather than leading edge as in WF4. This signal doesn't affect operation of tube much unless there is noise accompanying signal. In that case, noise pulse blocks conduction momentarily to keep its own counterpart from appearing in sync output (which is WF5, taken from plate-pin-8).

V p-p low	V p-p high	V p-p zero					
	R8 open C4 leaky C5 open	C2 open	2V p-p R7 open	3V p-p R8 open	0.4V p-p R10 open	0.5V p-p R12 shorted	2V p-p C7 shorted
			0.4V p-p C2 open	2V p-p C2 leaky	2V p-p C5 open	0.6V p-p C5 leaky	0.6V p-p C7 open

WF4 Normal 30 V p-p

Taken at G3-pin-9, this is high-amplitude signal containing video and positive-going sync pulses. It has been amplified and inverted by video amplifier before being applied to input network C6-R11-C7. Compensating network puts slope on trailing edge, leaving leading edge fairly sharp. Sync pulses in this signal are ones that drive tube, developing horizontal and vertical sync in output (taken from plate-pin-8).

V p-p low	V p-p high	V p-p zero					
R12 shorted C5 leaky C7 open	C2 open		20V p-p R7 open	40V p-p R8 open	2.5V p-p C2 leaky	2V p-p C7 open	40V p-p C7 shorted



HORIZ

WF5 Normal (H) 40 V p-p
(V) 75 V p-p

This is output of sync separator section, taken from plate-pin-8. Scope sweep is set at V or about 20 Hz to show vertical sync output; at usual 5-kHz sweep rate for horizontal. Vertical-sync spikes are almost twice amplitude of horizontal pulses (which you can see as shading between vertical pulses). Both horizontal and vertical sync pulses are negative-going, being inverted in amplifying/separating process. Note video has been removed—that's important.

VERT Top waveforms horizontal, bottom vertical. Vertical malfunction applies to horizontal waveforms. (see below)

V p-p high	V p-p zero	V p-p low					
R10 open R12 open R12 shorted R13 shorted C2 leaky C4 leaky C7 open	C5 leaky	R13 open[1] C2 leaky C4 shorted	2V p-p	2.8V p-p		3V p-p	40V p-p
			20V p-p R8 open	20V p-p R10 open	18V p-p C2 leaky	4V p-p C7 open	60V p-p C7 shorted

[1]In sets without extra (not shown) B-plus connection.

NOTES:
Use this guide and the Voltages Guide *to help you pin down fault possibilities.*
ALWAYS clamp the i.f. agc line at whatever voltage lets video reach the TV screen, even if sync remains poor. All waveform symptoms in this chart are under those conditions (see text).
With the direct probe of the scope, check the three key waveforms. The scope should be set at H or about 5 kHz, to show three cycles of waveform.
Note amplitude. If it's low or high, check parts under those descriptions.
Note waveshape. If there's a change from normal, check the parts indicated.

MOSFET's

Part 2—Circuits you can build and use

by **RAY CLIFTON**

HAVING LEARNED THE BASIC THEORY OF MOSFET operation last month, you're ready to build simple circuits using some of the low-cost devices available.

If you experimented with JFET's, as outlined in the previous article (June 1969, R-E), you should have an idea of the parts you'll need for breadboarding a circuit. You might check Fig. 1 for more ideas on parts values. For ease of breadboard experimenting, I recommend a few perforated boards with push-in terminals.

Another indispensable accessory is a bias box, to furnish gate bias while you're setting up a circuit. Fig. 2 shows the simple arrangement I used—two 9-volt transistor-radio batteries across a 1-megohm linear-taper pot, with a switch to save the batteries when not in use.

You'll need a power supply capable of 20 volts and about 10 mA; batteries will do. To set up circuits dynamically, you will need an audio generator. A single frequency between 400 and 2500 Hz is all you need, and output voltage can be quite low—50 mV rms. If you built the simple JFET audio oscillator shown in the June article, it will do nicely.

You should have an oscilloscope to observe waveforms, but it need have only audio-frequency response. A high-impedance electronic voltmeter (vacuum-tube or transistor) is essential, and a milliammeter is nice, but not a necessity.

In the previous article, you learned how to design a microphone preamplifier. This is just as good a starting place for MOSFET design, because it's simple and immediately useful. Assume a high-impedance crystal or ceramic microphone with an output of about 30 mV rms. Stage Q1 of Fig. 1 is representative of what you can do with a MOSFET, and here's how to design and build the circuit. I used a 40467, but the MPF157, MPF158, 40468 and 40559 would also be good choices.

Because of the high gate impedance of the MOSFET, it's wise to use 2.2 megohms for gate resistor R1. Since the circuit will be entirely MOSFET, assume roughly the same value of gate resistor for the following stage. To provide good low-frequency response with such high gate resistance, coupling capacitors C1 and C2 should be 0.1 μF. Using .05 or even .01, however, won't cause noticeable loss of low frequencies. If you want only speech-quality response, use .005 μF.

Drain-load resistor R2 is 100k because that's a good compromise between maximum voltage gain (A_v) and distortion. In a preamp stage you want lots of gain, and the input voltage swing is small, so 100k is about right.

The 40467 operates best with some reverse gate bias. You want to bias the source positive with respect to ground (so the gate is negative with respect to the source). This bias is developed across R3.

Previously you learned that MOSFET's must be handled carefully to avoid permanently destroying the insulated gate. Some authorities recommend using soldering irons rather than guns. You must ground the iron tip and use heat-sink pliers on the MOSFET leads when soldering them in the circuit. But a much simpler method is to use transistor sockets. Push the socket leads through the holes in a perforated board and solder the circuit components to the terminals. Be sure the gate, source and substrate terminals each have a dc return to chassis, and ground the chassis. When you have the components in place (soldered or clip-leaded) you are ready to install the MOSFET in the socket. Be sure no hot wires are near the circuit, and ground the chassis or common bus to bench ground (ideally, the earth). Then ground yourself. I work at a bench with a grounded metal molding around the edge. When I rest my forearms on the front of the bench, I am grounded through the molding. You might also try a metal sheet, and rest your elbows upon it.

If your arms are grounded, you can handle a MOSFET with impunity. Pull off the shorting ring, spread the leads with long-nose pliers, and insert the device in the socket. If it doesn't go in easily, don't push heavily on the can—you'll only bend the leads and have to straighten them out. Use your pliers to ease each lead in, one by one. Once the MOSFET is in the socket, never allow the gate terminal to float. It must *always* have a dc return path to ground, or it may build up a static voltage which will destroy it.

Once the device is in the socket, don't remove it, except to replace it. If you have to solder or unsolder a component wired to the socket, hang heat-sink pliers on the MOSFET lead itself (*not* the socket terminal). Then clip-lead the pliers to chassis ground. Don't heat the terminal any more than necessary. If you use a soldering gun (as I do) keep the tip and the tip loop away from the MOSFET.

Setting bias dynamically

The value of R3 can be determined experimentally. Connect a resistor of

Applications: Types A, B, and C FET's

In general, all type-A FET's are junctions, and all Types B and C are MOS.

Type-A FET's are preferred in the following applications:

1. As a dc amplifier, the JFET is more stable than the MOSFET.
2. As a low-noise, low-frequency amplifier.
3. As a differential amplifier.
4. As a low-drift single-ended amplifier.

Types B and C FET's are preferred in the following applications:

1. Where very high input impedance is required, as in a picoammeter or electrometer. The MOSFET has the lowest input current of any amplifying device.
2. As a low-noise hf, vhf and uhf amplifier.
3. As a vhf amplifier and converter, the MOSFET has the lowest cross-modulation of any amplifier device.
4. As a variable resistor or voltage-controlled attenuator, the MOSFET has the greatest control-to-signal isolation of any device.
5. Anywhere a device is needed which can withstand positive and negative input voltage swings without decreasing input impedance or drawing input current. The MOSFET can operate with reverse, zero or forward bias.
6. As an analog or digital switch, the MOSFET requires no offset voltage, has low on resistance, high off resistance, low capacitance and high switching speed.
7. As an extremely sensitive proximity detector. MOSFET's have extremely low input capacitance (1 to 10 pF).

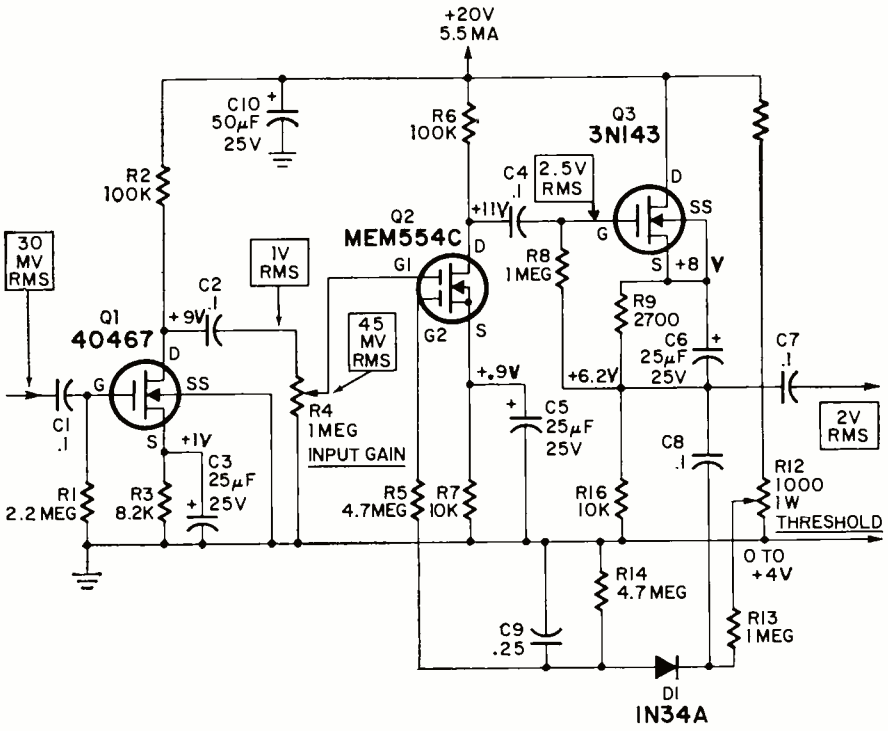
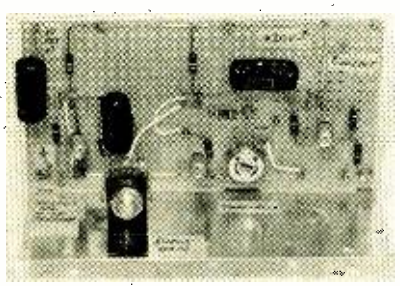
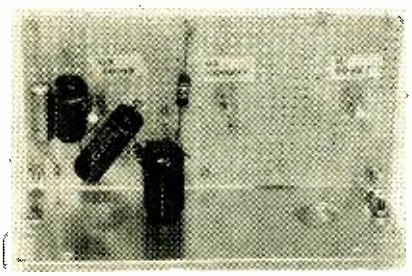


Fig. 1—MOSFET microphone preamp has agc circuit to compress signal range.



Front view of mike preamp breadboard.



Rear view of mike preamp breadboard.

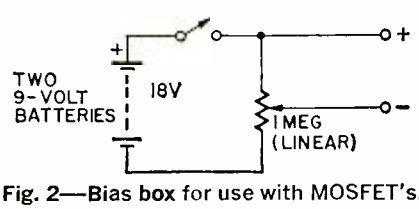


Fig. 2—Bias box for use with MOSFET's.

1000–2000 ohms in series with the bias box. If you have a milliammeter, put it in series with the box. Clip a high-impedance voltmeter from the source terminal to ground, to measure bias voltage.

Tie the power supply to R2 as shown in Fig. 1, hang a scope and a monitor amplifier across the stage output (through C2), and feed about 30 mV rms into C1 (400 to 2000 Hz, approximately). Turn on the power supply and vary the bias-box setting carefully until you see a sine wave coming out of the stage. You'll find a range of bias voltages which produce a sine wave; choose a voltage that gives you maximum gain with minimum distortion. Try to get in the middle of the useful range, as this gives the circuit the most leeway against temperature and supply-voltage variations. Figure the value of source-bias resistor R3 from the current and voltage you read. If you haven't a milliammeter, compute current through your temporary R3. I found 8200 ohms necessary to bias the 40467 I used, but because of parameter spread from device to device, you may have to use another value. Ordinarily the nearest 10% resistor value will do—unless you are right in the middle between two values. In that case, use a 5% value.

Adding agc

One thing about the MOSFET—because the gate is insulated from the channel, there's nearly perfect input–output isolation. A dual-gate MOSFET is therefore a natural choice for an agc amplifier. Audio agc amplifiers are plagued by *thump*—the sound of the dc control signal, which gets into the audio path. A MOSFET can't thump, because the gate's insulated from the drain-source channel. Adding automatic gain control to the mike preamp is useful because you don't have to ride gain while making a tape recording, for instance. It has the same advantage in PA work.

The MEM554C dual-gate MOSFET makes a good agc-controlled stage; one gate accepts the audio signal, and the other the dc control signal. Gate 1 works best with reverse bias, while gate 2 can operate with reverse or forward bias. Thus it's best to reverse bias the stage. Fig. 1 shows the circuit. Since input stage Q1 puts out about 1 volt rms, you must use a pot between Q1 and Q4. A standard value is 1 megohm, which will work in the circuit. Slightly less gate-input loading is obtainable with a 5-megohm pot. Either should be audio taper, of course.

You can again use a 100k load resistor, and temporarily ground gate 2 through a parallel combination of a 4.7-megohm resistor and any capacitor from .001 to 0.1 μF. Set up the stage as before, using about 30–45 mV rms into gate 1. Find the value of source resistor R7 and install it.

You can omit stage Q3 is you're willing to use a high-impedance preamp output, for that stage is simply a source follower to furnish a low-impedance output. The 3N143 I used has a fairly high I_{DSS} rating, and thus will work well with a fairly low load resistance. I chose 10k for R10. To set up this source follower, insert about 1k as a temporary R9 source-bias resistor, again placing the bias box and milliammeter in series with it. Don't forget source-bypass capacitor C6; without it the stage gain will be quite low. Determine the exact value of bias needed to produce maximum undistorted output, compute the resistor, and put it in the circuit. I found about 2700 ohms about right (2820 was my calculated value).

DC feedback network

To demonstrate how controlled-stage Q2 works, tie your bias box to gate 2 of the MEM554C. *Caution*: Use a clip lead and ground the gate 2 terminal before you unhook R5 from ground. Then connect the bias-box negative terminal to R5 and the positive terminal to ground. Remove the temporary bypass capacitor from gate 2, set the bias to −5 volts, unshort the gate, and fire up the power supply. You'll see that varying the bias on gate 2 affects the gain of Q2. The more negative the bias, the less the gain.

Now turn off the power, short the gate 2 terminal to ground again, and reverse the bias box; connect the positive terminal to R5 and the negative terminal to ground. Unshort the gate and turn on the power supply. By varying the bias, you will see that positive gate 2 voltage increases the gain of Q2. You are enhancing the channel of the MEM554C.

I found using enhancement voltage on gate 2 a more effective means of gain control than using negative voltage. (It also produces more gain.) Here's how the dc feedback network shown in Fig. 1 works: R11 and R12 form a voltage divider from the supply to ground, and the arm of threshold control R12 can be set from 0 to +4 volts. R13 is an isolating resistor between D1 and the bias source. The positive voltage from the arm of R12 reverse-biases D1. Resistor R5 isolates the gate from the rest of the circuit, preserving its high impedance value.

Audio signals through the preamp are coupled through C8 to the cathode of D1, which conducts, adding a nega-

tive dc voltage to gate 2 of Q2. In other words, audio through C8 causes the bias on gate 2 to be *less positive*, which decreases stage gain. If the audio signals increase, so does the negative dc produced by D1, which reduces the gain of Q2 still more.

Of course, you can't use a constant-amplitude sine-wave oscillator to check out an age stage. You'll have to use a varying-amplitude signal. Best is a live microphone or a tape recording of uncompressed speech. You *can* use a commercial disc or tape recording or the signal from a receiver, but they'll contain some compression and/or limiting, which will tend to smooth out their amplitude variations.

Whatever source you use, couple it to the input and set the level carefully, to avoid overdriving input stage Q1. Tie a high-impedance voltmeter to the point between D1 and R5 to monitor gate bias on gate 2. Use the scope on the output to monitor the waveform and check audio output level. Vary the setting of R12 until you get the compression you want.

Resistor R14 and C9 set the time constant of the control line, which is about 1 sec. This provides for rather slow overall gain control, which is what an age or compressor amplifier should have. If you want a faster time constant, simply change the values of C9 and R14. Use the formula $T = RC$, where T is time in seconds, R is resistance in megohms and C is capacitance value in microfarads.

Voltage-variable attenuator

The input–output isolation of the MOSFET makes it ideal as a noiseless attenuator, which has no coupling between the controlling and the controlled circuits. As you saw last month, the ohmic region of a MOSFET transfer curve shows a rapid change in I_D with a variation in V_{GS}. In this region of the curve, channel resistance changes abruptly from a few hundred ohms to several megohms. In other words, by applying a variable dc voltage to the gate, you can control drain-source resistance.

Fig. 3 shows the circuit of a simple shunt MOSFET attenuator in gate circuit of a JFET common-source stage. The amplifier is conventional and follows the principles outlined in the previous article.

Attenuator Q1 should be used at a point with no less than about 150 mV rms; otherwise, series resistor R1 will degrade signal-to-noise ratio. Mount Q1's socket with the drain terminal as close as possible to the gate terminal of the following stage (Q2, in this case). If you don't do this, you may get undesired stray pickup at the amplifier gate. Likewise, mount R2 close to Q1's gate terminal, so that it properly does its job of isolating the gate and preserving its high impedance.

A simple way of providing the required dc control voltage for the gate of Q1 is to use batteries. You can then realize the great advantage of this circuit. You can put the pot and batteries at almost any distance from the amplifier,

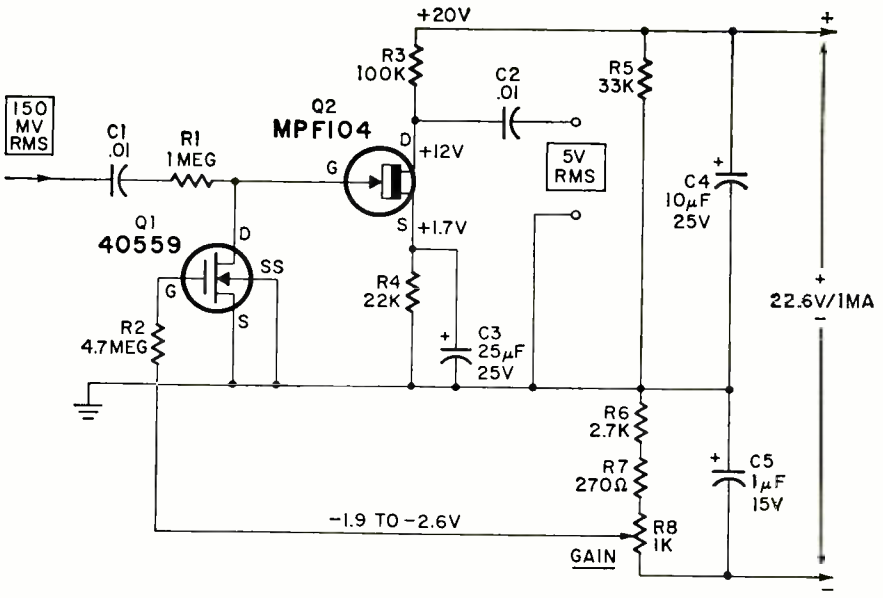


Fig. 3—MOSFET voltage-variable attenuator for use as a remote volume control.

with no detriment to amplifier gain or frequency response.

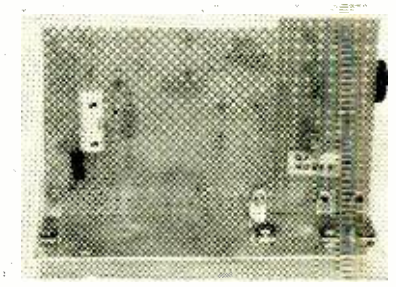
An alternate method, however, is what I chose for my breadboard circuits; I put a voltage divider across the supply. This method is perhaps even simpler, because you need only a pot and three-wire line at the remote location. Here's how to determine the values of the divider resistors.

Since you have no way of knowing the location of the ohmic region of the transfer curve on the particular MOSFET you use (due to parameter spread) you must determine it dynamically. (I used a 40559 MOSFET, but almost any n-channel Type-B device could be used.) Connect Q1, R1 and R2 in the circuit. Then connect R8, a 1000-ohm linear pot, across a 5-volt source. Tie the arm of R8 to R2.

Bias the MOSFET gate to −5 volts and feed a sine wave through the circuit. Use a scope to monitor the output so you can see the change in gain. Hang a voltmeter (any impedance) from the arm of R8 to chassis. Vary the setting of R8 and watch the scope. Record the voltmeter reading at the point just past where the sine wave is completely unattenuated (maximum gain). Then do the same for the maximum attenuation point. In my case, these two readings were −2.0 and −2.6 volts.

Since you are using a 1000-ohm pot, and you want a variation of 0.6 volt across it, Ohm's law calls for 0.6 mA to flow through the divider. Now you know the current value, and the drain supply for Q2 must be 20 volts, so R5 must be 33k. Resistor R8 must vary the bias from −2.0 to −2.6 volts, so you need a 2-volt drop between ground and the pot. By Ohm's law, this is 3300 ohms. I tried this value and found a range of −2.3 to −3.0 volts across R8. Then I tried 2700 ohms for the dropper and found a range of −1.7 to −2.4 volts. Probably my resistors were off just enough to spread the ranges. At least I had bracketed the range I wanted. I then used a 2700-ohm and a 270-ohm (10%) in series (R6 and

Front view of attenuator breadboard.



Rear view of attenuator breadboard.

R7), and got a range of −1.9 to −2.6 volts, which worked out just fine. Attenuation is spread across the entire range of the pot.

To preserve isolation between the dc control circuit and the audio signal path, be sure to use two filter capacitors, C4 and C5, instead of a single one across the supply. Note that the supply floats across the chassis. At the light load of 1 mA, a 212.5-volt battery (NEDA 215) would work just fine.

455-kHz generator

This device is simple and has but one purpose—to furnish unmodulated output of 455 kHz for AM receiver i.f. alignment. (You don't need modulation because your readout indicator should be a voltmeter across the receiver avc line. And you don't need other frequencies; align the front end on BC stations.)

(*continued on page 68*)

One of our students wrote this ad!

Harry Remmert decided he needed more electronics training to get ahead. He carefully "shopped around" for the best training he could find. His detailed report on why he chose CIE and how it worked out makes a better "ad" than anything we could tell you. Here's his story, as he wrote it to us in his own words.

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By Harry Remmert

AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss, and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because it is right there in print for as many re-readings as I find necessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams,

*CIE backs its FCC License-preparation courses with this famous Warranty: graduates must be able to pass the applicable FCC License exam or their tuition will be refunded in full.

and the material had always seemed just a little beyond my grasp. Score another point for CIE.

Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

If a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. Because I wanted to be a full-fledged student instead of just a tagalong, CIE's exclusively home study program naturally attracted me.

Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later. I'm getting to be known as a theory man around work, instead of one of the screwdriver mechanics.

These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

In closing, I'd like to get in a compliment for Mr. Chet Martin, who has faithfully seen to it that my supervisor knows I'm studying. I think Mr. Martin's monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. Mr. Martin has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

And finally, there is Mr. Tom Duffy, my instructor. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

I'm very, very satisfied with the whole CIE experience. Every penny I spent for my course was returned many times over, both in increased wages and in personal satisfaction.

Perhaps you too, like Harry Remmert, have realized that to get ahead in Electronics today, you need to know much more than the "screwdriver mechanics." They're limited to "thinking with their hands"...learning by taking things apart and putting them back together...soldering connections, testing circuits, and replacing components. Understandably, their pay is limited—and their future, too.

But for men like Harry Remmert, who have gotten the training they need in the fundamentals of Electronics, there are no such limitations. As "theory men," they think with their heads, not their hands. For trained technicians like this, the future is bright. Thousands of men are urgently needed in virtually every field of Electronics, from two-way mobile radio to computer testing and troubleshooting. And with this demand, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

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MOSFETS
(continued from page 63)

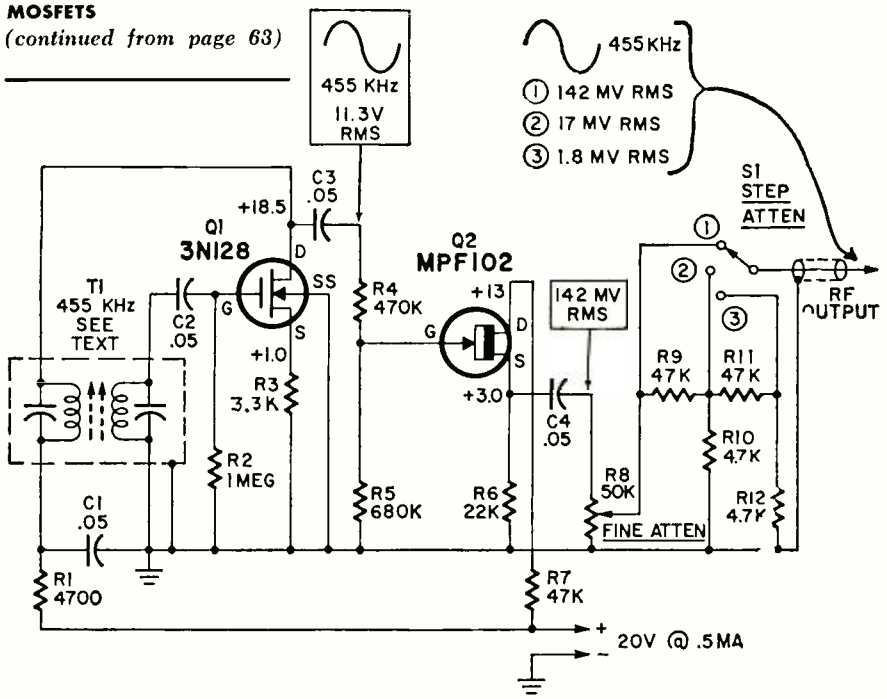
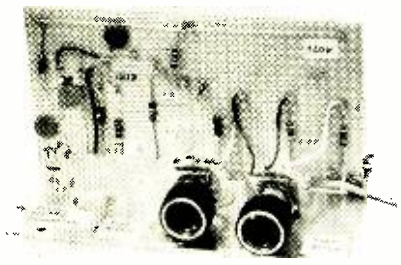
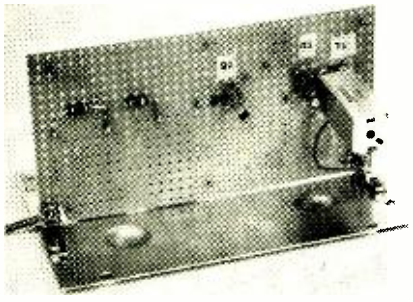


Fig. 4—MOSFET 455-kHz generator is variation of tuned-plate, tuned-grid oscillator.



Front view of 455-kHz generator board.



Rear view of 455-kHz generator board.

I didn't use a crystal because it's expensive and unnecessary. You can zero-beat the second harmonic of this generator with a BC station on 910 kHz and end up very close to 455.

Winding a coil and juggling L and C values can be a tiresome job. Besides, hundreds of 455-kHz i.f. transformers are thrown away with old vacuum-tube radios every week. Such hi-Z cans match FET's nicely.

Fig. 4 shows the circuit I used. It's a variation of the tuned-plate, tuned-grid oscillator. In the classic TPTG, the two tank circuits aren't coupled; here they are, but this only provides more feedback.

If you must buy an i.f. can, find out how it's supposed to be connected.* If you cannibalize an old fire-bottle chassis, note how the can was wired in. You want to tie the *plate winding* to the *drain circuit* of Q1. Then you want to tie the *grid winding* to the *gate circuit* of Q1. One big difference between the original i.f. hookup and this one: Reverse connections from *one* winding, so the gate circuit gets positive feedback.

The MOSFET makes an excellent oscillator. Its high impedance means you can use vacuum-tube circuits with little or no change. The small mass of the MOSFET allows it to warm up fast. Its thermal and frequency stability is very good. I used a 3N128, but the 3N143 and 3N152 will also work well.

Resistor R1 and C1 decouple Q1 from Q2 and the power supply. (None of the capacitor values here are critical; I used .05's because they have an X_c of 7 ohms at 455 kHz and I had some discs of that value. Don't use tubulars; they have more L than discs.)

Start with about 1k for R3 until you get the oscillator going. Then hang a scope across a 1-meg load resistor in place of R4 and R5. Adjust the value of R3 for the purest sine wave and highest output you can get. You'll have to compromise, but remember you only want a little second harmonic (910 kHz) and no higher orders in the output.

As the diagram shows, I got about 11.3 volts rms out of the oscillator. If you use this much rf you'll overload an i.f. strip. Besides, you can't couple the oscillator to the i.f. strip without detuning it. What you need is an isolation amplifier.

Almost any JFET or MOSFET could be used as Q2, which is merely a buffer stage. I chose the MPF102 because it has a high y_{fs} rating. Also suitable are the 2N5163, MPF105, 2N3819 and TIS-34 low-cost, MOSFET devices.

*Any of these will work: Lafayette 32 T 0946, Meissner 16-6758, Miller 12-C1 or Vidaire 119-67-09.

The 11.3 volts of rms from Q1 will overdrive Q2, so you'll need a divider in the gate circuit. Use a 1-meg pot temporarily. Strap in the values shown for R6 and R7, and don't forget C4 and R8 as a load. Then juggle the values of drain load R7, source load (and bias) R6, and the setting of the gate pot. You may not get a perfect sine-wave output from Q2, but try for the least distortion with fairly high output: 100–200 mV rms are all you really need for i.f. alignment purposes.

When you tie down the variables, install fixed resistors. Unhook the temporary gate pot and measure the arm-to-end resistances on an ohmmeter. Then select the nearest 10% values, making the total of R4 and R5 approximately 1 megohm. If R5 is less than 470k, use a larger R_T of 2 megohms. (You want to keep the gate of Q2 at a fairly high impedance.)

Don't bypass R7 in Q2's drain circuit; it provides degeneration which keeps the output linear. And don't take output from the drain circuit. The source-coupled output isolates the load from the oscillator more effectively.

The step attenuator gives approximately 10:1 decade attenuation. The fine attenuator lets you adjust for any value in between.

Be sure you build this generator in a metal box, but leave two holes for the transformer slugs, so you can zero-beat the oscillator every now and then.

General notes

The above procedures and circuits are, of course, merely an introduction to MOSFET circuits. For better performance and more complex circuits, obtain manufacturers' literature and study device characteristics more closely.

More advanced circuits using MOSFET's include vhf oscillators, rf amplifiers and mixers, where the device performs excellently due to its low noise figure and minimum cross-modulation. Because of its extremely high input impedance, the MOSFET also does an excellent job in a picoammeter circuit. It is additionally good as an rf switch, pulse generator and Wien-bridge oscillator.

Already FET's are being modified for even more sophisticated circuits. A few photoFET's are available which generate current when exposed to light. And MOSFET's are being fabricated in the inputs of IC's, where their high input impedance is of special value.

It looks like you'll be seeing a lot of FET's in the years to come. **R-E**

References

FET Applications Handbook, J. Eimbinder, Ed. Tab Books, Blue Ridge Summit, Pa.; 1967. $12.95.

FET Principles, Experiments, and Projects, by Edward M. Noll. Howard W. Sams & Co., Inc., Indianapolis, Ind.; 1968. $4.95.

MOSFET in Circuit Design, by Robert H. Crawford. McGraw-Hill Book Co., Inc., New York, N.Y.; 1967. $10.00.

CAREERS IN ELECTRONICS

By BYRON G. WELS

TECHNOLOGICAL PROGRESS COUPLED with automation continues to eliminate unskilled jobs while creating an unprecedented demand for people with the background to design, test and service complex new equipment.

Today's $20 billion electronic industry is expected to double in dollar volume in the next 10 years. How can you become a part of this growth?

Electronic aptitude

You might save a great deal of time and money pursuing a career field to which your abilities are not suited by first asking yourself, "Do I have the aptitude for a career in electronics?"

Each year, for example, a large percentage of the first year class at technical and engineering schools "drop out." Many of them have an interest in electronics, but quickly find this motivation is not enough to overcome a lack of needed technical and mathematical aptitudes.

You might avoid disappointment and needless expense by first arranging to take a battery of aptitude tests through high school guidance counselors, state employment agencies or the psychology department at a local college. Many schools give preliminary aptitude tests to applicants.

Training and education

Once you've set your sights on a career in electronics, there are many paths to your goal. First, the demand for personnel in the electronics industry is so great today, that firms have established on-the-job training programs and hire trainees without prior experience. Job training is coupled with classes in electronics, and tuition refunds are offered to permit further study through correspondence courses or at night school.

What about self study? Bookstores can provide study material covering basic electronics, but this approach demands considerable self discipline and motivation. Due to the diversity and growing complexity of the field, it's becoming more and more difficult to organize a worthwhile self-study program. Employers prefer some evidence of formal study—a degree or certificate.

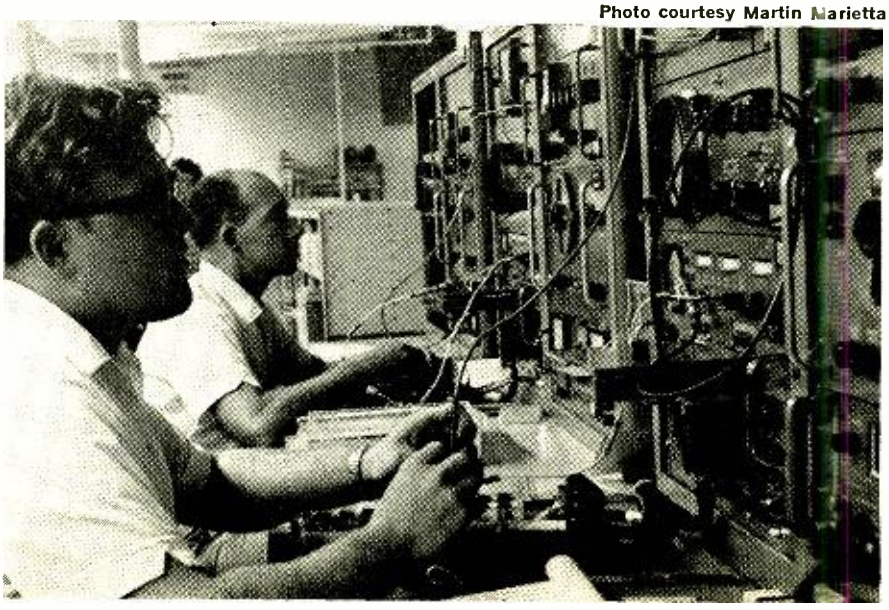
Military training not only offers a means of obtaining electronic skills but can be a rewarding career in itself. Increasingly, the armed forces are recognizing the importance of career-oriented personnel and are rewarding them accordingly. Many civilian electronics technicians and engineers began their careers in military electronics, furthering their education later under the GI Bill.

Two-year technical schools offer excellent training. Proprietary or private schools, the best of which require high school graduation for admission, stress theory and equipment training. Many have night school and correspondence programs. A growing trend in technical education is the community college or public institute. These two-year schools offer Associate of Applied Science degrees, and program humanities courses that private technology schools usually do not include.

Correspondence courses have the advantage of letting you set your own study pace. Study material is prepared by experts and you receive professional guidance through the mail. Most of the larger schools offer sequences in several areas, such as radio/TV, computers, industrial electronics, communications, etc.

A B.S. degree in electrical engineering is generally required to become an electronics engineer, although

Photo courtesy Martin Marietta



there are other means: Federal and state civil service boards set training and educational requirements for professional engineer ratings, as does the IEEE. Some companies assign engineering titles to employees without B.S. degrees. (Salaries, however, do not necessarily correspond to titles, and skilled technicians sometimes earn more than engineers.)

Industrial electronics

Industry is desparate for trained men at all levels, from engineers on down. Work in industrial electronics is widely diversified, depending on the field you choose, and the areas in which you are interested. You'll find openings for production and production control people, where the concentration is one of selecting areas of mass production suitable for automation, and the design and implementation of this automated equipment. Where automation is not feasible, studies are made to break the work down in stages that can be most easily handled by a given group of workers.

The quality control group concentrates its efforts in seeing that the company product is up to required standards and specifications. This is done by a series of tests on the product with sophisticated test equipment. The Q/C operators must be thoroughly familiar with the use of meters, oscilloscopes, and related equipment.

Maintenance men keep the exotic test equipment used in the lab and shop in peak working condition. They see to it that laboratory standard equipment is well-calibrated by periodic checks, and remove equipment to the maintenance shop on a routine basis, for clean-up and test. No product is ever more accurate than the equipment used to test and align it, so the laboratory maintenance crew does a critical and important task.

But probably the most interesting work goes on in the research and development lab. Here, the prototype equipment is built, that starts with a basic idea, and comes out completed and packaged. Here an engineer works up his diagrams, and turns them over to a lab technician. Consulting with the engineer, they come up with a breadboard model for preliminary testing. Then a finished unit is assembled.

Along with all of this, the industrial field offers such other tasks as writing technical manuals, preparing blueprints and drawings, and even technical electronic photography, a field in itself!

Career in communications

Today, more than ever before,

Photo courtesy Martin Marietta

communications is coming into its own in a big way. What with transaltantic signals being bounced off echo satellites, with space pioneers depending on communications with the ground, technology is becoming more and more crucial every day. Without communications nothing can move, whether it's a business radio installation in a fleet of oil trucks to an elaborate intercontinental radio telephone system. This equipment must be manufactured, installed, and maintained.

Communications goes even further. A part of this vast complex includes ship-to-shore radio phones, and a vast array of accessory equipment for ships of all sizes, including radar systems, depth sounders, and a complex network of radio navigational equipment both on ship and ashore.

Closely related to this are the necessary communications and accessory equipment used by the air services. These include multi-frequency transceivers, coupled with Omnirange transponders. The omni system brackets the nation, with stations spread overland to form a network of high-

Photo courtesy RCA

ways in the sky. Along with these, one finds the distance-measuring equipment, weather radar, auto pilot systems, radio altimeters, and other electronic devices necessary to assure the safe completion of every flight. You also find an elaborate complex of communications equipment on the ground as well, with most major facilities offering radar and control transceivers, and even the smallest airports equipped with Unicom transceivers to provide pilots with landing information.

Career in broadcasting

The appeal in broadcasting is usually one that permits you to rub shoulders with celebrities. If you plan to break into this highly competitive field, you will probably start, as most of those who are successful in this field did, at a small radio station out in the hinterlands. In a small station, you do double-duty. Your day might begin at five in the morning, when you turn on the transmitter, and sleepily make the morning identification. You might then read the early news, and run a DJ show for a while. But to do these things, you must have an FCC license!

Many of today's top disc jockeys still proudly retain their second-class commercial tickets!

In television, you can go into audio work, camera work, and even make it in the control room.

Career in servicing

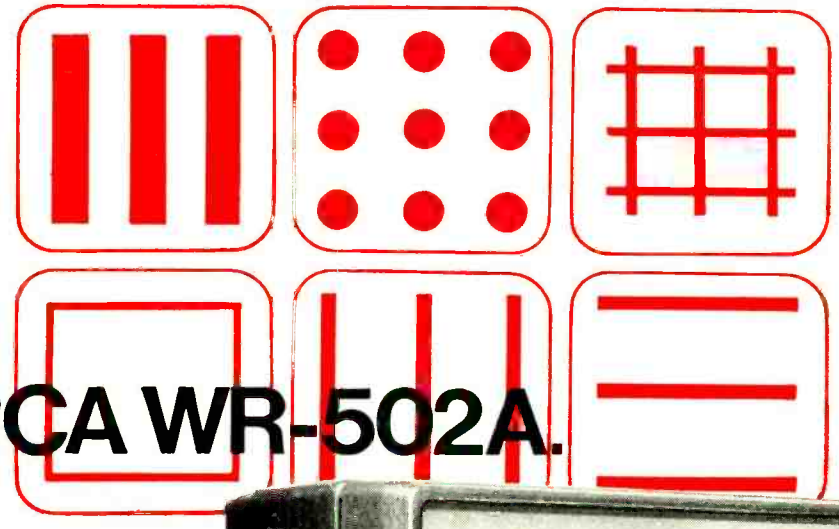
Do you like dealing with the public? Do you enjoy meeting people? Perhaps a career in radio and television repair is your dish.

The basic philosophy here is that a set worked once, then something went wrong, and it stopped. Fix what went wrong, and the set will work again until something else goes wrong. The radio/TV service technician knows how to find what's wrong quickly and correct the trouble.

In the larger repair facilities, two types of technicians are employed. The "outside" man is skilled in dealing with people, and making minor, emergency repairs. He can do the small alignment jobs, install antennas, change tubes. But when he runs into a set with really tough problems that require some fancy test equipment or a major repair, he takes the set into the shop for the "bench" man to work on.

The bench man stays in the shop, is usually a highly skilled technician. He works behind the scenes. When something goes wrong that the outside man can't fix, the bench man gets the job. He restores the set to factory specifications, and then the outside man returns it to the customer. **R-E**

Now there is a better Color-Bar Generator for your servicing work



THE RCA WR-502A.

New . . . solid state . . . battery or AC operated . . . portable, weigh ng only four pounds.

The RCA WR-502A "CHRO-BAR" color-bar generator provides *six* separate test signals: color bars, dots, cross-hatch, vertical lines, horizontal lines, and blank raster.

The sound carrier, pattern, RF output, and color subcarrier are all crystal controlled. Designed for exceptional stability with no flicker.

Included as part of the package — at no extra cost — is an AC adaptor for line operation. This unit was formerly available only as an accessory at a cost of $9.00*.

The new CHRO-BAR Generator WR-502A, complete with separate AC adaptor — now only $148.50*.

RCA Electronic Components, Harrison, N. J. 07029.

* Optional Distributor resale price.

Circle 32 on reader service card

COMING NEXT MONTH

JANUARY 1970

- **Add Automatic Tint Control**
  Magnavox has come up with a new kind of automatic tint control. Here's how to add that circuit to your set.

- **Protect Against X-Rays**
  Here's a simple circuit to add to most any set with a shunt regulator. It shuts down the high voltage if the regulator fails.

- **Inside The New Color Tubes**
  This year the color picture tube is changing. See what's happening and how it may affect your picture.

- **IC Color Pattern Generator**
  To set up a color TV you must have a pattern generator. Here's a small portable unit built with IC's. Make one for yourself.

- **New Color TV Circuits**
  Take the grand tour of color TV circuits. See the new ones and discover how they work.

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Please mail me your free Bulletin, which explains how the Grantham educational program can prepare me for my Associate in Science Degree in Electronics Engineering.

Name_____ Age_____

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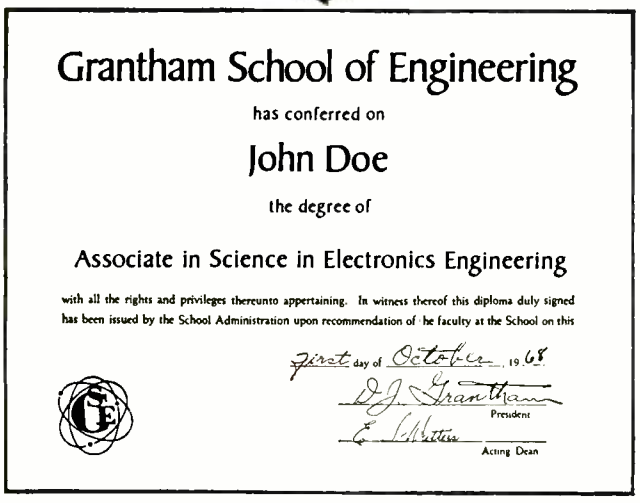

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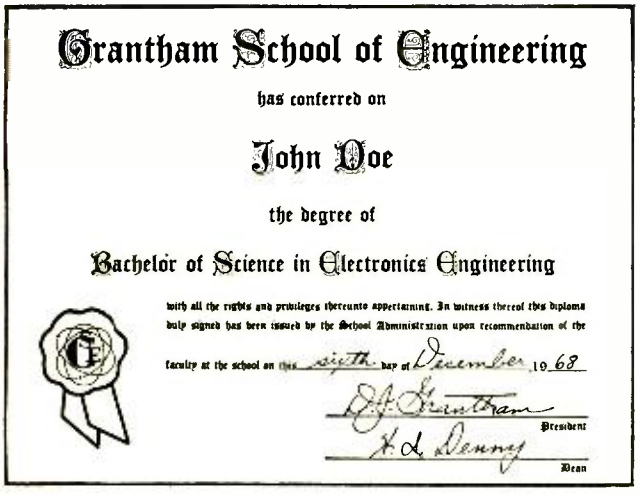

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Three Big Steps to Success... in ELECTRONICS ENGINEERING

1

There they are – three big steps that lead electronics technicians to *greater success* – three deliberate steps to *greater recognition* and *more income*. Your future is shaped by the moves you make – by the steps you take. Begin now with Step #1.

STEP #1 is a simple request for full information on the Grantham Electronics Degree Program. You take this first step by filling out and mailing the coupon. Then, we *mail* our catalog to you; we do not send a salesman.

STEP #2 is earning your Associate in Science Degree in Electronics Engineering (the ASEE). If you have completed at least one year of fulltime experience as a bona fide electronics technician, you may earn your ASEE Degree almost entirely by correspondence – including a minimum resident attendance of only two weeks.

STEP #3 is earning your Bachelor's Degree in Electronics Engineering. Upon completion of either the home-study or resident program leading to your ASEE Degree, you may have reached your objective, or you may wish to continue and earn your BSEE Degree. The BSEE Degree program is offered in evening classes (two evenings a week) in Hollywood, and is designed especially for employed electronics enginering technicians who hold the ASEE Degree.

Accreditation and G.I. Bill Approval

Grantham School of Engineering is accredited by the Accrediting Commission of the National Home Study Council, is approved to offer its home-study and resident courses under the G.I. Bill, and is legally authorized to grant academic degrees.

Home-Study and Resident Programs

The Grantham ASEE Degree curriculum is offered by *home study* (plus a two-week seminar in Hollywood) to *experienced electronics technicians*. However, the home-study program is not available to beginners. The ASEE-Degree *resident* program, on the other hand, is *available to beginners* and is offered in Hollywood and Washington, D.C.

In addition to the home-study and resident programs leading to the ASEE Degree, Grantham also offers a combination program (referred to as Supplemented-Correspondence), in which the student attends the School (in Hollywood or Washington) one evening per week and does the remainder of the work by correspondence.

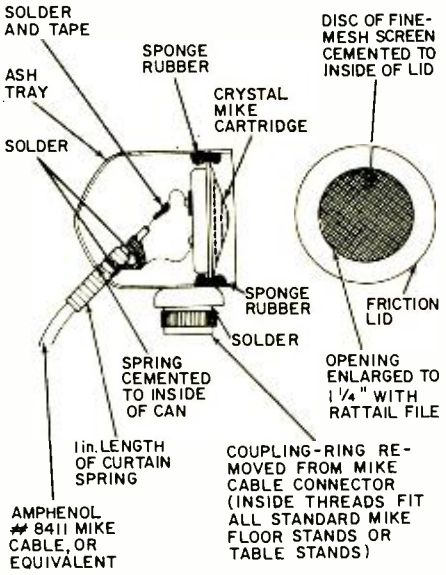
For a free Bulletin describing the Electronics Degree Program in which you are interested, just complete the coupon at the top of this page, and mail it to the School.

Circle 34 on reader service card

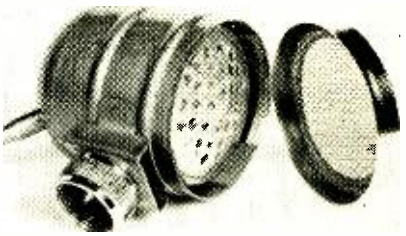
FIVE MINUTE MICROPHONE HOUSING

Fellows who like to build their own mikes from mike cartridges will find that some auto ashtrays are just about made to order for the purpose. These all-metal ashtrays sell for around 35c at Western Auto and Sears, Roebuck stores, and they will accept mike cartridges up to 1⅝ inches in diameter.

The drawing gives complete details for assembly and wiring. I used a Lafayette Radio crystal mike cartridge 1½ in. in diameter. To shield the cartridge, the ground lead and the cable shield should both be soldered to the cord protecting spring or to the inside of the metal tray, as shown. To make it easy to solder the ⅝-27 coupling ring to the bottom of the tray, scrape the enamel off the bottom of the tray and file the chrome or nickel plating off the coupling ring at the places to be soldered.



A photo shows the completed mike with the friction lid removed. The mike cartridge is held in the tray



with three or four small pieces of sponge rubber. The opening in the friction lid has been enlarged with a

rat-tail file, and a disc cut from fine-mesh wire screen has been cemented to the lid.—*Art Trauffer* **R-E**

1969 ANNUAL INDEX

RADIO-ELECTRONICS January-December 1969 of Vol. 40

*Construction articles; † part of larger article, ER (equipment report), NC noteworthy circuits, Corr (correction), CI (service clinic)

(continued from page 36)

display, equal to 0.5 V/cm. Thereafter the gain control is left untouched. The vertical attenuator is usually calibrated in multiples and can be changed to suit conditions without affecting the gain control adjustment.

The horizontal input to the scope is turned to EXT and a 10-volt p–p audio signal fed to it. A horizontal line will appear on the scope tube. The horizontal gain is adjusted for a line 5 cm long, equivalent to 2 V/cm. This gain control is also left untouched.

When making various tests it is sometimes necessary to readjust the horizontal gain to other calibration values. Usually 1, 2 and 3 volts p–p/cm will cover most requirements. These points should be found and noted before starting the next steps.

After the scope has been initially calibrated, the tracer sweep dial is marked so that future calibrations can be made utilizing the tracer outputs.

When S3 is at CE, a vertical line is presented on the CRT, and at OFF a horizontal line is displayed (no transistor in socket). The amplitude of these two voltages as well as the ratio between them is determined by the setting of the sweep pot.

With the scope vertical attenuator set at 0.5 V/cm, vertical lines 2, 4 and 6 cm long should be successively displayed by adjusting the sweep pot with S3 at CE. The sweep dial is marked 1, 2 and 3 volts p–p, respectively.

The length of the horizontal lines shown with S3 at OFF is then, with the sweep at 1V p–p, 5.4 cm long with the horizontal gain adjusted for 1 V/cm; with sweep at 2V p–p, 9.6 cm long with horizontal gain at 2V/cm; with sweep at 3V p–p, 9.2 cm long with horizontal gain at 3V/cm. These lines are therefore related to the previous calibration in p–p volts of a sine wave. The horizontal gain can thereafter be calibrated by setting the sweep pot to a calibration mark and obtaining a horizontal line of the correct length.

The values given above will probably vary with different units, but the method should be applicable in all cases.

The maximum current and voltage applied to a transistor must be held within transistor specifications. With the sweep set at 3 volts p–p, the collector current can reach a value of 30 mA at $V_{CE} = 0$, and a collector–emitter voltage of 27 volts at $I_C = 0$. In some cases it may be advantageous to change the value of

(turn page)

TRANSISTOR CURVE TRACER

(continued from page 77)

the sweep pot. A lower value would decrease the ratio.

In summary, with the tracer outputs connected to the calibrated scope, displaying curves is done by inserting a transistor in the tracer socket, S4 at RUN. Adjust sweep to a calibrated point on the dial and obtain a "set" value for the bias of trace 6. Make notations of the scope vertical and horizontal settings and the base current of trace 6.

The front panel measures 5 x 8¼ inches. A U-bracket 2 5/16 x 8⅛ inches with ⅜-inch lips fits behind this panel.

The chassis measures 4½ x 8 x ⅝ inches and is secured to the lower lip of the bracket by sheet-metal screws. The center of the chassis is cut out to accommodate an epoxy board 3½ x 6¼ inches upon which power supply components are mounted. Two threaded metal spacers 2¼ inches long serve as rear supports for the top board. This board is 4½ x 6¼ inches. The front end is secured to the top lip of the bracket.

The lower transformer is mounted on the left side of the chassis far enough back to allow replacement of the sweep pot if necessary. Sweep transformer T2 is mounted on a bent metal plate secured to the top lip of the bracket at one end, and to the chassis at the other end. The fuse holder fits on the vertical section of this plate. *Since this is an exposed location be careful and avoid accidental shock.*

The case is a Cowl-type box 5 x 8⅜ x 7 inches, reduced in depth to suit the chassis.

Reverse log taper pot R4 gives the maximum resistance in the first 100° or so for minimum base current. This permits higher biases to be set easily.

The miniature trimmers are mounted on a small board raised above the height of the components on the main circuit board and are adjusted from the rear. Also, fixed resistors are used in series with two of the trimmers for ease of adjustment.

Sample curves

A few characteristic curves are shown to illustrate traces produced at different settings of the tracer and scope. The photo of the 2N708 npn transistor curve (Fig. 5) was reversed in the printing process. The top example of the 2N1038 (Fig. 6)

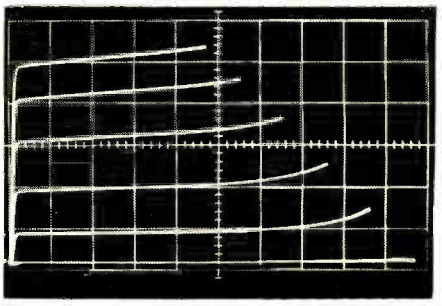


Fig. 5—Scope photo of a 2N708 transistor that was "flopped" in the process.

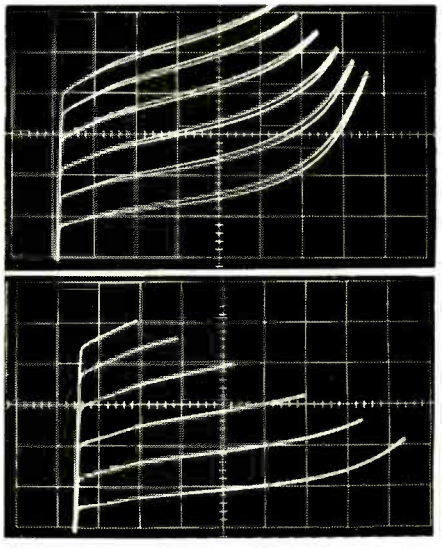


Fig. 6—Photos show temperature distortion (top) and correct curves (lower).

(continued on page 93)

NEW PRODUCTS

More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card at the left and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

STEREO CALIBRATION STANDARD, *Model 1000ZE* stereo cartridge is individually calibrated for flat frequency response within ±1 dB from 20 to 20,000 Hz. No electrical or mechanical resonant peaks. Total IM distortion at standard 3.54 cm/sec groove velocity does not exceed .05% at any frequency within

the full spectrum. Stereo separation is better than 35 dB at 1 kHz and remains at least 25 dB or better out to 20,000 Hz. Overall frequency response 4 to 40,000 Hz. Output voltage 5 mV per channel. $99.95. **Empire Scientific Corp.,** 1055 Stewart Ave., Garden City, N. Y. 11530

Circle 46 on reader service card

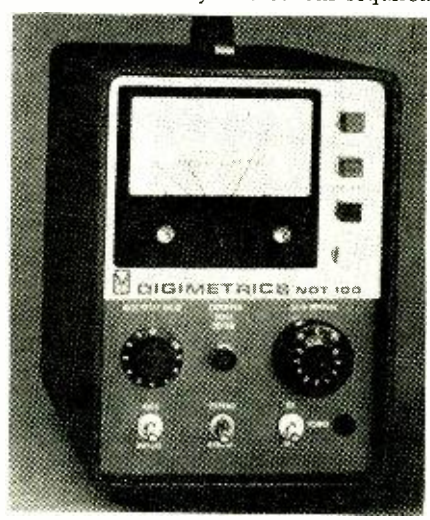
EMERGENCY REPLACEMENT KITS AC MOTOR CAPACITORS, *AK-100, AK-200* can be used to replace almost any

capacitor encountered in day-to-day work. The 4 motor-run capacitors in the *AK100* can be used singly or in combinations to replace almost any capacitor with voltage ratings from 165 through 440 Vac. *AK-100* includes assortment of jumper leads with quick-connectors, plus instructions.

AK-200 has 6 motor-start capacitors usable singly or in parallel to obtain 87 capacitance/voltage ratings. Housed in molded plastic cases for complete moisture and mechanical protection, they are equipped with dual-blade universal terminals. Included are four bleeder resistors, six pairs of clip-on terminal adapters, four jumper leads with quick-connectors, and instructions. Packed in strong, compact "Travel-pak" cases for protection of capacitors and accessories en route to and from a job. *AK-100,* $32.95. *AK-200,* $25.39.—**Sprague Products Co.,** North Adams, Mass. 01247

Circle 47 on reader service card

WELD QUALITY MONITOR, *Digimetrics NDT 100,* offers nondestructive 100% inspection of resistance welds as each weld is made. Only connections required



are 117-Vac power and simple wire contact to electrode holders of welder. $975.—**Digimetrics Inc.,** 717 Court St., Utica, N. Y. 13502

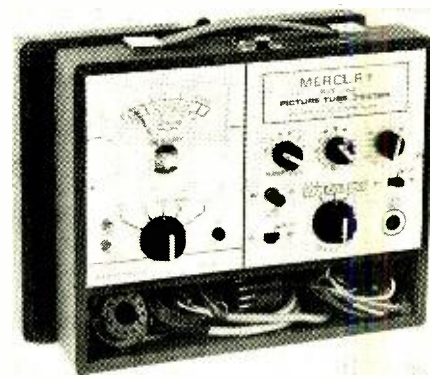
Circle 48 on reader service card

AUDIO AMPLIFIER, *Model LT-1005,* has six individual microphone and/or program inputs which are all transformer-balanced with low impedance. Inputs 1, 2 and 3 are directly coupled from their respective preamplifiers to the tone amplifier. Input 4 has a selector switch for conversion to RIAA phono input. Input 5 is switchable from microphone to an auxiliary 10K unbalanced input. Input 6 features selection of two high-

level lines. Tone controls are full ±15 dB for bass and treble at 50 Hz and 15 kHz, respectively. Microphone inputs may be changed to 10 dB controlled roll-off at 30 Hz during installation. All inputs and master gain can be remotely controlled through LDR circuits with remote volume controls. Automatic protective circuit protects output stages. Circuit provides instantaneous reduction of output power when short or open occurs in speaker line. Full recovery is achieved in less than 1 msec after the overload or shorted condition is removed.—**McMartin Industries,** 3104 Farnam St., Omaha, Neb. 68131

Circle 49 on reader service card

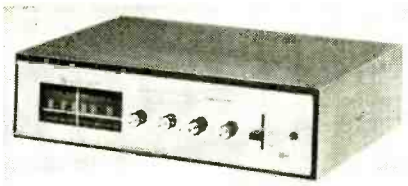
COLOR PICTURE TUBE ANALYZER AND REJUVENATOR, *Model 880,* checks all color tubes in accord with CRT makers' recommended procedures; checks shorts or interelement leakage. Life test for remaining useful cathode-



emission life. Each gun of color tube is adjusted to cutoff before beam-current reading is taken. Comes with data book. $79.95—**Mercury Electronics Corp.,** 315 Roslyn Road, Mineola, N. Y. 11501

Circle 50 on reader service card

PAGING RECEIVER, *Model MTA-20.* Combines monaural FM receiver, 15-watt, 20-20,000-Hz audio amplifier and microphone input circuit. For paging, background music and hi-fi listening, feeding its own monitor speaker and up to 4 remote speakers simultaneously. Front panel carries tuning, tone and volume controls, hi-fi FM/phono/tape switch, silent spring-return paging switch plus microphone jack. Back panel has microphone paging volume control, switched power outlet, connections for 4 speakers, auxiliary and magnetic phono inputs. Size 14 x 10 x 4" in walnut with



brushed-aluminum panel. $79.95. Available at Radio Shack stores.—**Radio Shack**, 730 Commonwealth Ave., Boston, Mass. 02215

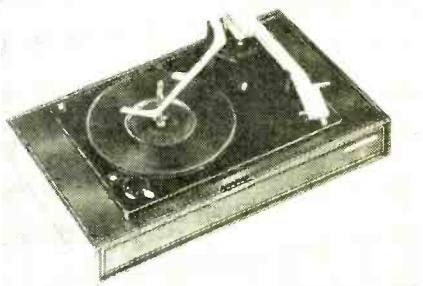
Circle 51 on reader service card

FIELD ENGINEER'S TOOL KIT, *JTK-17*, includes standard tools required for maintenance of complex electronic and data processing equipment.

Totaling 100 pieces, kit holds 13 screwdrivers, 7 pairs of pliers, electronic alignment tools, burnishers, crimping tool/bolt cutter, feeler gauge, hammer and center punch, flashlight, scribe, electrician's knife, dental mirror, nutdriver set, instrument oiler, pin-punch set, stainless rule, scissors, soldering iron, solder aid, solder brush, tweezers, spring tools, wire stripper, ignition-wrench set, ¼"-drive-socket set with ratchet handle, metric-type hex-key set. Simpson vom tester is available as optional accessory. $169.00 (less test meter).—**Jensen Tools and Alloys**, 4117 N. 44 St., Phoenix, Ariz. 85018

Circle 52 on reader service card

STEREO MINI CHANGER, *Model MC22*, features automatic or manual play at 4 speeds; automatic shutoff after last record; low-mass tone arm with high-quality ceramic turnover stereo cartridge and diamond LP needle; detachable spindle; dynamically balanced 2-pole motor. Premounted on simulated leather base with walnut vinyl trim, heavy-gauge tinted plastic dust cover and all audio cables. Size (including



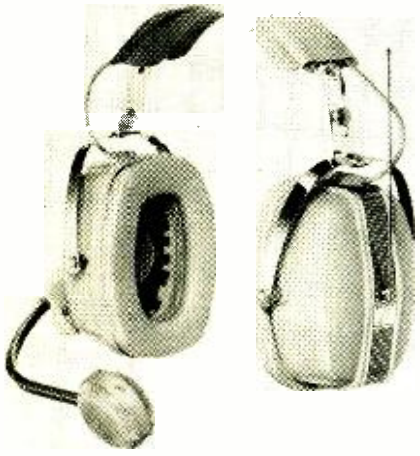
base) 14¾ x 5 x 10". $34.95. For 110-130-V, 60 Hz ac, Stock No. **21-01632** W.—**Lafayette Radio Electronics Corp.**

Circle 53 on reader service card

FOCUS SILICON RECTIFIER, *CLR 7.* Replaces selenium cartridge rectifiers in TV focus-diode applications. It has maximum recurrent peak inverse voltage of 7,000 volts and maximum average forward rectified current of 5 mA at 65°C. Can operate in temperatures up to 70°C with maximum storage temperature of 125°C.—**Scientific Components, Inc.,** 350 Hurst St., Linden, N. J. 07036

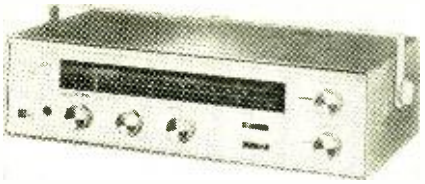
Circle 54 on reader service card

WIRELESS MIKE AND HEADSET. The *Sharpe RH-27* is wireless with complete rf transmitters, receivers and power supply. Electronics are housed in circumaural cup design including active boom-mounted microphone. Lightweight construction insures freedom of movement. Will not require FCC licensing since it operates at less than 100 milliwatts.—**Sharpe Audio Div., Scintrex, Inc.,** Amherst Industrial Park, Tonawanda, N. Y. 14150



Circle 55 on reader service card

PRO-2 MONITOR RECEIVER, *#20-160,* high-frequency FM unit with complete tuning system using color-coded scale for 30-50- and 152-174-MHz bands. Delivers 2 watts of audio to built-in speaker or 8-ohm external phones or speaker. Its 28 semiconductor circuit needs less than 0.5 μV input. Squelch control limits noise for band monitoring. Audio signal for tape recording or external audio system available at rear panel. Installation requires steel bracket supplied with unit. Size 12¾ x 9 x 3¾". $99.95. Cat. No. 20-160.—**Radio Shack,** 730 Commonwealth Ave., Boston, Mass. 02215



Circle 56 on reader service card

BUSINESS INTERCOM. Solid-state design offers background FM/AM radio/tape records in any selected area; choice of four modes of operation to suit changing office requirements. Can be silent. Only call light notifies station being paged. Background music automatically muted. Many optional accessories.—**NuTone,** Div. of **Scovill,** Madison and Red Bank Roads, Cincinnati, Ohio 45227

TV SALES AND SERVICE AIDS; *How to Double Your Business With Unique Column Ads* and *Television Repair Promotion.* These two manuals pinpoint simple, automatic, effective methods of selling the TV repair shop to gain new customers. Sample ads, typical humor columns and comments on effective use are detailed.—**H. K. Simon Co.,** Inc., Box 236, Dept. REE-1, Hastings-on-Hudson, New York, N.Y. 10706 **R-E**

Circle 57 on reader service card

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 81 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

ELECTRONICS FOR EVERYONE is a 552 page catalog which illustrates and describes with detailed specifications the major brands of high-fidelity components and music systems; record changers and phonographs; tape recorders in all price ranges FM-AM and multibrand radios; TV sets; Citizens band 2-way radios; public address amplifiers; electronics hobby kits; audio radios and tape players; test instruments and meters plus almost everything else you can think of —**Allied Radio Corp.,** Chicago, Ill.

Circle 76 on reader service card

ELECTRONIC PARTS CATALOG lists precision electronic components with new illustrations and drawings for the established line of components as well as for the new ones. There is a product index that is alphabetically and numerically listed by prefix as well as the table of contents. This 56-page general catalog also provides space for the user to make notes.—**Mallory Distributor Prod. Co.,** Indianapolis, Ind.

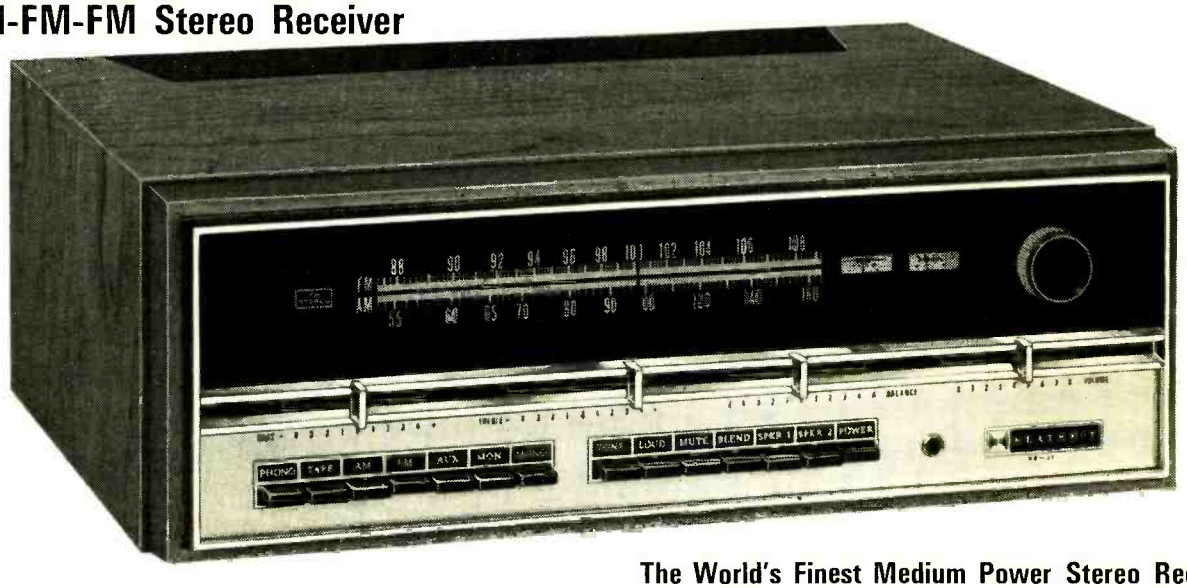
Circle 77 on reader service card

SPRING 1969 CATALOG *No. 695,* 148 pages, illustrates fully with specs and line photos more than 4000 items on science, maths, optics, kits, lamps, tapes and tools etc. for hobbyists, schools and industry. Prices also included.—**Edmund Scientific Co.,** Barrington, N. J. **R-E**

Circle 78 on reader service card

Put The Sound of Christmas In

Announcing The New Heathkit® AR-29 100-Watt AM-FM-FM Stereo Receiver



The World's Finest Medium Power Stereo Receiver . . . Designed In The Tradition Of The Famous Heathkit AR-15 . . . $285.00*

Quietly distinctive when not in use . . . its impressive midnight black and chrome face unmarred by dial or scale markings. A touch of the power switch and the dial and scale markings appear.

All solid-state design . . . 65 transistors, 42 diodes and 4 Integrated Circuits.

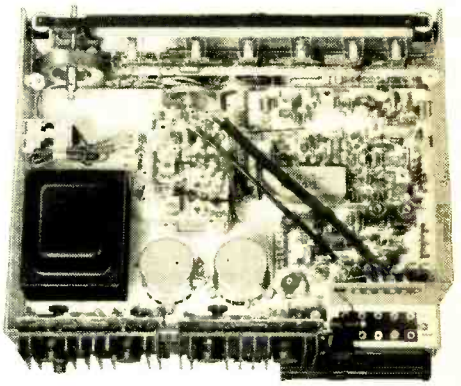
Assembled, aligned FET tuning unit.

Advanced 9-pole L-C Filter for greatest selectivity . . . a first in the industry.

Plug-In Circuit Boards for easier assembly, easier service . . . another first in kits.

Built-In Test Circuitry for voltage and resistance checks without external instruments during construction and after.

Massive Power Supply . . . just loafs along at 100 watts output.



• All solid-state design • 100 watts music power output at 8 ohms • 7-60,000 Hz frequency response • Less than 0.25% Harmonic & 0.2% IM Distortion at full output • Transformerless, direct-coupled outputs with dissipation-limiting circuitry for output protection • Ball-bearing inertia flywheel tuning • Advanced L-C filter gives 70 dB selectivity and elimination of IF alignment • Assembled, aligned FET FM tuner for better than 1.8 uV sensitivity • New Mute Control attenuates between-station FM noise • New Blend Control attenuates noise on FM-Stereo stations • SCA filter • Linear Motion Controls for Bass, Treble, Balance & Volume • Individually adjustable input level controls for each channel of each input keeps volume constant when switching sources • Switches for 2 separate stereo speaker systems • Center speaker capability • Two front-panel meters for precise station tuning • Stereo indicator light • Stereo headphone jack • Swivel AM rod antenna • 300 & 75 ohm FM antenna inputs • Massive, electronically regulated power supply • New Modular Plug-In Circuit Board designed for easy enjoyable assembly

Another Design Leader . . . reflecting the heritage of the world-famous Heathkit AR-15. A new milestone in audio history is here: the world's finest medium power stereo receiver . . . the Heathkit AR-29.

The Finest Stereo Amplifier In Any Receiver . . . delivers a full 100 watts music power, 70 watts continuous — drives even the most inefficient speakers. A giant fully regulated & filtered power supply, 4 individually heat-sinked and protected output transistors and the best specs in the industry add up to unmatchable audio fidelity.

The Heath Mark Of Quality: FM Stereo Performance . . . now more apparent than ever. The assembled, aligned tuning unit uses FET circuitry for high overload capability, low cross modulation and 1.8 uV sensitivity. Three IC's in the IF give greater AM rejection, hard limiting, excellent temperature stability & reliability. Another IC in the Multiplex section performs four different functions . . . assures perfect stereo reproduction.

Kit Exclusive: 9-Pole L-C Filter . . . delivers an ideally shaped bandpass with greater than 70 dB selectivity, superior separation and eliminates IF alignment forever.

AM That Sounds Like FM. Three FET's in the AM RF section combine superior sensitivity with greater signal handling capability to give the finest AM reception available. A built-in AM rod antenna swivels for best signal pick-up.

Kit Exclusive: Modular Plug-In Circuit Board Construction . . . for simplified assembly . . . easier, faster service.

Kit Exclusive: Built-In Test Circuitry lets you not only assemble, test & align your new AR-29, but also *completely* service it — without external test equipment.

You Be The Judge. Compare the specifications . . . exciting styling concepts . . . the dozens of features . . . the price. You'll find that the new Heathkit AR-29 is, indeed, the world's finest medium power stereo receiver. Order yours soon.

Kit AR-29, (less cabinet), 33 lbs. **$285.00***
Assembled AE-19, oiled pecan cabinet, 10 lbs. **$19.95***

PARTIAL AR-29 SPECIFICATIONS — AMPLIFIER: Continuous power output per channel: 35 watts, 8 ohms. **IHF Power output per channel:** 50 watts, 8 ohms. **Frequency response:** —1 dB, 7-60,000 Hz, 1 watt level. **Power Bandwidth for constant 0.25% THD:** Less than 5 Hz to greater than 30 kHz. **Total harmonic distortion:** (Full power output on both channels) Less than 0.25%, 20-20,000 Hz; less than 0.1% @ 1000 Hz. **IM Distortion:** Less than 0.2% (full output, both channels). Less than 0.1% (1 watt output, both channels). **Hum and noise:** (phono input) —65 dB relative to 100 uV signal. **Phono input sensitivity:** 2.2 millivolts (overload 155 millivolts). **FM: Sensitivity:** 1.8 uV or better. **Volume sensitivity:** Below measurable level. **Selectivity:** Greater than 70 dB. **Image rejection:** 90 dB. **IF Rejection:** 90 dB. **Capture ratio:** 1.5 dB. **Total harmonic distortion:** 0.5% or less. **IM Distortion:** 0.4% or less. **Spurious rejection:** Greater than 90 dB. **FM STEREO: Separation:** 40 dB min. @ mid-frequencies; 30 dB @ 50 Hz; 25 dB @ 10 kHz; 20 dB @ 15 kHz. **Frequency response:** ±1 dB, 20-15,000 Hz. **Total harmonic distortion:** 0.5% or less @ 1000 Hz, 100% modulation. 19 kHz & 38 kHz. **Suppression:** 55 dB. **SCA Suppression:** 55 dB. **AM SECTION: Sensitivity:** (using built-in rod antenna): 200 uV/M @ 600 kHz; 300 uV/M @ 1400 kHz (IHF rated). **Selectivity:** Greater than 40 dB alternate channel. **Image rejection:** 60 dB @ 600 kHz; 45 dB @ 1400 kHz. **IF Rejection:** Greater than 50 dB. **Harmonic distortion:** Less than 2%. **Hum & Noise:** —35 dB.

Your Home With Heathkit® Stereo

Kit AR-15
$349.95* (less cabinet)
Wired ARW-15
$540.00* (less cabinet)

HEATHKIT AR-15 Deluxe Solid-State Receiver

The Heathkit AR-15 has been highly praised by every leading audio and electronics magazine, every major testing organization and thousands of owners as THE stereo receiver. Here's why. The powerful solid-state circuit delivers 150 watts of music power, 75 watts per channel, at ±1 dB, 8 Hz to 40 kHz response. Harmonic & IM distortion are both less than 0.5% at full rated output. The world's most sensitive FM tuner includes these advanced design features ... Cascode 2-stage FET RF amplifier and an FET mixer for high overload capability, excellent cross modulation and image rejection ... Sensitivity of 1.8 uV or better ... Harmonic & IM distortion both less than 0.5% ... Crystal Filters in the IF section give a selectivity of 70 dB under the most adverse conditions. Adjustable Phase Control for maximum separation ... elaborate noise operated squelch ... stereo only switch ... stereo indicator light ... two front panel stereo headphone jacks ... front panel input level controls, and much more. Easy circuit board construction. For the finest stereo receiver you can buy anywhere, order your AR-15 now. 34 lbs. **Optional walnut cabinet, AE-16.** 10 lbs... **$24.95***

Kit AD-27
$179.95*

HEATHKIT AD-27 FM Stereo Compact

Heath engineers took the highly-rated AR-14 solid-state Stereo Receiver circuitry, matched it with the precision BSR McDonald 500A Automatic Turntable and put this quality component combination in a sliding tambour door walnut cabinet. Performance? The AD-27 delivers 30 watts music power ... full 15 watts per channel — enough to drive any reasonably efficient speaker system. Response is virtually flat from 12-60,000 Hz, and Harmonic & IM Distortion are both less than 1% at full output. Tandem Volume, Bass, Treble & Balance Controls give you full range command of the sound. Flick the rocker-type switch to select the FM stereo mode, and tune smoothly across the dial with the inertia flywheel tuning. You'll hear stations you didn't know existed, with a clarity and separation that will amaze you. An adjustable phasing control assures best separation always, and the automatic stereo indicator light comes on when the station is broadcasting in stereo. AFC eliminates drift too. The BSR McDonald 500A includes cueing/pause control, variable anti-skating adjustment, stylus pressure control, automatic system power and many other features usually found only on very expensive units. Includes a famous Shure diamond stylus stereo cartridge too. Add this handsomely-styled, top performing stereo compact to your home now. 41 lbs.

Kit AR-14
$119.95* (less cabinet)
Assembled ARW-14
$169.95* (with AE-55 cabinet)

HEATHKIT AR-14 FM Stereo Receiver

The AR-14 has been rated as the best value obtainable in a medium power stereo receiver ... and it's easy to see why. The all solid-state circuit delivers 30 watts music power from 15-50,000 Hz ... total distortion is less than 1% at full output. The AR-14 may be small, but its FM tuner section boasts high sensitivity, excellent selectivity and very low noise to give you FM stereo performance you will marvel at. Complete inputs and outputs, of course, for greatest system flexibility. Other features include stereo headphone jack, stereo indicator light and filtered outputs for beat-free taping. Make this amazing little receiver the heart of your new stereo system now. 18 lbs.

New Heathkit "Component Credenza" Combines Quality Stereo Components With Beautiful Mediterranean Styling ..$299.95*

• Combines all solid-state FM stereo receiver, 4-speed automatic turntable with diamond stylus and two full-range, two-way speaker systems into a luxurious Mediterranean cabinet • 15 watts per channel music power output • Full range tone controls • Very low Harmonic & IM Distortion • Excellent channel separation • Transformerless output circuit for minimum phase shift, wide response • Electronically filtered power supply • Stereo headphone jack • Auxiliary input • Filtered tape output • Excellent FM tuner selectivity & sensitivity • 4-stage IF • AFC • Stereo indicator light • SCA filter • High quality BSR McDonald 500A Automatic Turntable with low mass counterbalanced aluminum tone arm plays up to 6 records • Comes with Shure diamond stylus magnetic cartridge • Vernier stylus pressure adjustment • Anti-Skate control • Cue/Pause control • Two ducted-port reflex 2-way speaker systems for performance comparable to fine component-type separate speaker systems • Each system contains 10" high compliance woofer & 3½" ring-damped tweeter for 60-16,000 Hz response • Complete system housed in a magnificent factory assembled Mediterranean cabinet of beautiful oak veneers with solid oak trim • Easy assembly with the famous Heathkit Manual ... build only the receiver & install the components • The finest value anywhere in quality stereo consoles

Real Stereo Performance Demands Real Stereo Components ... the kind used for custom-designed systems. The new "Component Credenza" as the name implies, integrates separate components into a single functional unit. Here are those components ...

Component-Quality FM Stereo Receiver. The heart of the new AD-19 is the famous Heathkit AR-14 FM-FM-Stereo Receiver circuitry. The amplifier produces a solid 30 watts IHF music power. The FM Stereo tuner features 5 uV sensitivity, excellent separation and flywheel tuning. The AR-14 has been rated as the best value obtainable in a medium power receiver.

Component-Quality 4-Speed Automatic Turntable with such professional features as Cue/Pause control, Anti-Skate control, adjustable stylus pressure and famous Shure diamond stylus magnetic cartridge.

Component-Quality Speaker Systems. Two independent, ported speaker systems, each with a 10" woofer and 3½" tweeter deliver 60-16,000 Hz response for remarkable fidelity.

Elegant Mediterranean Oak Cabinet ... a fine example of cabinet-making, flawlessly executed in oak veneer with solid oak trim. Rigidly constructed using fine-furniture techniques.

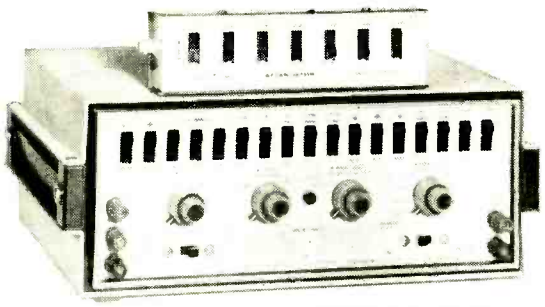
The New Heathkit AD-19 "Component Credenza" ... A Masterpiece in sight and sound. Put it in your home now.

Kit AD-19, 158 lbs. **$299.95***

Lifting the spring loaded hinged top reveals the heart of the new AD-19 ... the famous Heathkit AR-14 Stereo Receiver circuitry, combined with the precision-crafted BSR McDonald 500A Automatic Turntable. Note the clean control layout ... everything easily in reach from a standing position. A handy compartment in front keeps your records clean and convenient.

Component-Quality Speaker Systems. The new AD-19 cabinet houses two completely independent, ported speaker systems for reproduction comparable to that of systems of individual components. The 10" woofer and 3½" tweeter combine to give clean, lifelike response from 60 Hz to 16,000 Hz.

Make This Christmas a

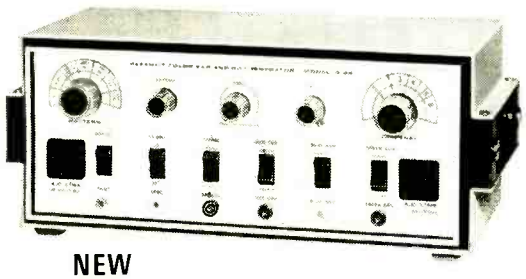


NEW Kit IG-57A

$135.00*

NEW, Improved Heathkit IG-57A Solid-State Post Marker/ Sweep Generator... Now With Built-In Video Sweep Modulator

Now align virtually every color and B&W TV set on the market with the new Heathkit IG-57A. New built-in Video Sweep Modulation eliminates the need for external equipment—the IG-57A and a scope are all you need to check the overall frequency response from the antenna terminals thru the tuner, IF strip, video detector to the color bandpass amplifier outputs. And you don't have to worry about video detector diode load. Another new feature is the addition of two individually adjustable 15 volt bias supplies with switchable polarity. Additional features: 15 crystal-controlled markers for color bandpass, TV sound, IF frequencies between 39.75 & 47.25 MHz and picture & sound carriers for channels 4 & 10 . . . switchable retrace blanking . . . adjustable phase control . . . trace reverse function for proper display . . . built-in switchable 400 Hz modulator . . . Zener regulated power supply . . . external attenuator for 1, 3, 6, 10 & 20 dB steps up to 70 dB . . . complete with all test leads, cables, connectors & plugs. Put complete servicing facilities on your bench now, with the new Heathkit IG-57A. 14 lbs.

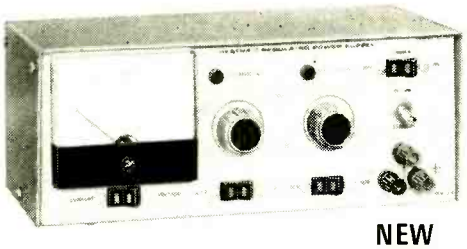


NEW
Kit IG-28

$79.95*

NEW Heathkit Color Bar-Dot Generator... Advanced Integrated Circuitry Produces 12 Patterns Plus Clear Raster, Eliminates Divider Chain Instability Forever

The new IG-28 is the signal source for all color and B&W TV servicing. No other instrument at any price will give as much stable, versatile TV servicing capability. Its solid-state circuitry produces dots, cross hatch, vertical and horizontal bars, color bars, and shading bars in the familiar 9x9 display . . . plus exclusive Heath 3x3 display of all these patterns . . . plus a clear raster that lets you adjust purity without upsetting AGC adjustment. Fifteen J-K Flip-Flops and associated gates count down from a crystal controlled oscillator, eliminating divider chain instability and adjustments. And for time-saving convenience the IG-28 has variable front panel tuning for channels 2 through 6. Plus & minus going video signals at the turn of a front panel control . . . for sync, in-circuit video or chroma problems, use the front panel sync output. Two front panel AC outlets for test gear, TV set, etc. Built-in gun shorting circuits and grid jacks too. Add any service-type scope with horizontal input and you have vectorscope display capability as well. Fast, enjoyable circuit board-wiring harness construction. You can't beat the Heathkit IG-28 for versatility or value . . . put it on your bench now. 8 lbs.



NEW
Kit IP-28

$47.50*

NEW Heathkit 1-30 VDC Solid-State Regulated Power Supply

The new modestly priced IP-28 is an excellent power supply for anyone working with transistors. Compact Heathkit instrument styling with large, easy-to-read meter . . . two voltage ranges — 10 V., 30 V. . . . two current ranges — 100 mA, 1 A. External sensing permits regulation of load voltage rather than terminal voltage. Adjustable current limiting prevents supply overloads and excessive load current. Convenient standby switch. Fast, easy assembly with one circuit board and wiring harness. Order yours today! 9 lbs.

NEW
Kit GR-78

$129.95*

NEW Heathkit GR-78 Solid-State General Coverage Receiver... Tunes 190 kHz To 30 MHz In Six Bands

The new GR-78 combines wide coverage, superior performance and portability with sharp styling to provide a remarkable value in general coverage receivers. Tunes AM, CW & SSB signals from 190 kHz to 30 MHz in six switch-selected bands. The all solid-state circuit employs modern FET's in the RF section and 4 ceramic filters in the IF to deliver maximum sensitivity and sharp selectivity. Bandspread Tuning is built-in, and can be calibrated for either Shortwave Broadcast or Amateur Bands. Completely portable . . . comes with a nickel-cadmium rechargeable battery pack and built-in charger that operates from 120 or 240 VAC and 12 VDC. Many built-in features . . . 500 kHz crystal calibrator . . . switchable Automatic Noise Limiter . . . switchable Automatic Volume Control . . . Receiver Muting . . . Headphone Jack and many more. Order yours today. 14 lbs.

NEW
Kit GD-209A

$149.95*

NEW Heathkit Deluxe Radio-Controlled Screw-Drive Garage Door Opener Semi-Kit

The next best thing to a personal doorman. The "wireless" factory assembled transmitter operates up to 150 feet away. Just push the button and your garage door opens and the light turns on . . . and stays on until you're safely inside your home. The giant 7 ft. screw mechanism coupled with the ¼ HP motor mean real power and reliability and the adjustable spring-tension clutch automatically reverses the door when it meets any obstruction . . . extra safety for kids, pets, bikes, even car tops. Assembles completely without soldering in just one evening. Easy, fast installation on any 7' overhead track (and jamb & pivot doors with accessory adapter). Order yours now. 66 lbs.

Adapter arm for jamb & pivot doors, Model GDA-209-2, $7.95*

Heathkit® Holiday

HEATHKIT®

Heathkit "681" Color TV...AFT...New Brighter Picture Tube For More Vivid Colors, Better Resolution

The new Heathkit GR-681 is the world's most advanced Color TV with more built-in features than any other set on the market. Automatic Fine Tuning on all 83 channels ... power push button VHF channel selection, built-in cable-type remote control ... or you can add the optional GRA-681-6 Wireless Remote Control any time ... plus the built-in self-servicing aids that are standard on all Heathkit color TV's. Other features include high & low AC taps to insure that the picture transmitted exactly fits the "681" screen, automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs, top quality American brand color tube with 2-year warranty. With optional new RCA Matrix picture tube that doubles the brightness, **Model GR-681MX only $535.00.**

GRA-295-4, Mediterranean Cabinet shown **$124.95***

Heathkit "295" Color TV...New Picture Tube For Brighter, Sharper Pictures

With Optional RCA Matrix Tube ... with the same high performance features and built-in servicing facilities as GR-681 above ... less AFT, VHF power tuning and built-in cable-type remote control. You can add the optional GRA-295-6 Wireless Remote Control at any time. New optional RCA Matrix tube doubles the brightness, **Model GR-295MX, $485.00.**

GRA-295-1, Contemporary Walnut Cabinet shown **$64.95***

Both the GR-681 and GR-295 fit into the same Heath factory assembled cabinets; not shown Early American style at $109.95*

Heathkit "581" Color TV...Sharper, Brighter Viewing With New Picture Tube...AFT

The new Heathkit GR-581 will add a new dimension to your TV viewing. Brings you color pictures so beautiful, so natural, so real ... puts professional motion picture quality right into your living room. Has the same high performance features and exclusive self-servicing facilities as the GR-681, except with 227 sq. inch viewing area, and without power VHF tuning or built-in cable-type remote control. The optional GRA-227-6 Wireless Remote Control can be added any time you wish. And like all Heathkit Color TV's you have a choice of different installations ... mount it in a wall, your own custom cabinet, your favorite B&W TV cabinet, or any one of the Heath factory assembled cabinets.

GRA-227-2, Mediterranean Oak Cabinet shown **$109.95***

Heathkit "227" With New Picture Tube For Increased Brightness & Better Resolution

Same as the GR-581 above, but without Automatic Fine Tuning ... same superlative performance, same remarkable color picture quality, same built-in servicing aids. Like all Heathkit Color TV's you can add optional Wireless Remote Control at any time (GRA-227-6). And the new Table Model TV Cabinet and roll around Cart is an economical way to house your "227" ... just roll it anywhere, its rich appearance will enhance any room decor.

GRS-227-5, New Cart and Cabinet combo shown **$54.95***

Both the GR-581 and GR-227 fit into the same Heath factory assembled cabinets; not shown, Contemporary cabinet $64.95*

Heathkit "481" Color TV with AFT

The new Heathkit GR-481 has all the same high performance features and exclusive self-servicing aids as the new GR-581, but with a smaller tube size ... 180 sq. inches. And like all Heathkit Color TV's it's easy to assemble ... no experience needed. The famous Heathkit Color TV Manual guides you every step of the way with simple to understand instructions, giant fold-out pictorials ... even lets you do your own servicing for savings of over $200 throughout the life of your set. If you want a deluxe color TV at a budget price the new Heathkit GR-481 is for you.

GRA-180-1, Contemporary Walnut Cabinet shown **$49.95***

Heathkit "180" Color TV

Feature for feature the Heathkit "180" is your best buy in color TV viewing ... has all the superlative performance characteristics of the GR-481, but less Automatic Fine Tuning. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart. Get the value-packed GR-180 today.

GRS-180-5, Table Model Cabinet & Cart combo **$42.50***

Both the GR-481 and GR-180 fit the same Heath factory assembled cabinets: GRA-180-2, Early American Cabinet $94.95*

Add the Comfort And Convenience Of Full Color Wireless Remote Control To Any Rectangular Tube Heathkit Color TV . . . New Or Old!

Kit GRA-681-6, for Heathkit GR-681 Color TV's **$64.95***

Kit GRA-295-6, for Heathkit GR-295 & GR-25 TV's **$69.95***

Kit GRA-227-6, for Heathkit GR-581; GR-481 & GR-180 Color TV's **$69.95***

Now There Are 6 Heathkit® Color TV's To Choose From

2 Models In 295 Sq. Inch Size

NEW
Kit GR-681
With AFT
$499.95*
(less cabinet)

Kit GR-295
$449.95*
(less cabinet)

2 Models In 227 Sq. Inch Size

NEW
Kit GR-581
with AFT
$419.95*
(less cabinet)

Kit GR-227
NOW ONLY
$379.95*
(less cabinet & cart)

2 Models In 180 Sq. Inch Size

NEW
Kit GR-481
with AFT
$359.95*
(less cabinet)

Kit GR-180
NOW ONLY
$329.95*
(less cabinet & cart)

Reception Is Simulated On All Sets Shown

HEATHKIT®

a Schlumberger subsidiary

NEW FREE 1970 CATALOG!

Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, electric guitar & amplifier, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

HEATH COMPANY, Dept. 20-69
Benton Harbor, Michigan 49022

☐ Enclosed is $_____, plus shipping.

Please send model (s)_____

☐ Please send FREE Heathkit Catalog. ☐ Please send Credit Application.

Name_____

Address_____

City_____ State_____ Zip_____

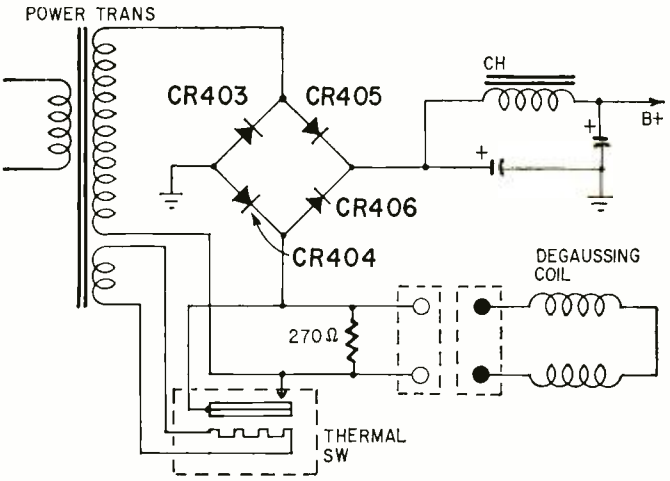
*Mail order prices; F.O.B. factory. Prices & specifications subject to change without notice. CL-370

Circle 110 on reader service card

TECHNOTES

DEFECTIVE DEGAUSSING CIRCUIT

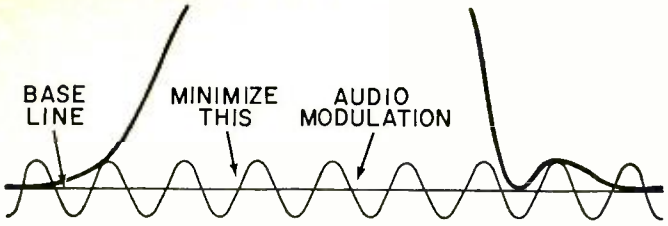
If you run across a color set where the degaussing circuit *magnetizes* the picture tube instead of demagnetizing



it, check the bridge rectifier (CR-403, CR404, CR405) or CR406 in the diagram) for an open rectifier element or a poor solder joint.—*Admiral Service News Letter*

TV TRAP ALIGNMENT

A new TV trap alignment procedure consists of using the alignment generator set at the trap frequency in the usual way and then adding a small amount of audio modulation, usually available from the generator. In theory, we are using the trap frequency as a carrier while the modula-



DO NOT CONFUSE AUDIO MODULATION WITH CALIBRATING BEAT, WHILE NULLING TRAPS

tion forms sidebands which appear on the base line as sine waves (see drawing).

To adjust the trap, observe the trace on the scope and vary the trap adjustments to minimize or null the audio on the base line. This method gives a much more useable indication—you really know when the trap is set correctly. Be sure to keep the audio modulation at a low level as shown in the drawing.—*Admiral Service News Letter*

OLYMPIC CTC 19/21/31

Some of these late-production chassis may have complaints of intermittent color. This problem is occasionally brought on by vibrating or flexing the chroma board. Inspecting the socket of tube V703 (the 6GH8 color oscillator and control tube) may show that resistor R746 (1500 ohms going to pin 9) may be shorting against capacitor C724 (82 pF at pin 3) due to a shift in the position of spaghetti insulation. Relocate the resistor to provide sufficient clearance.—*Olympic Service Bulletin* **R-E**

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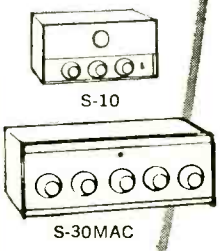

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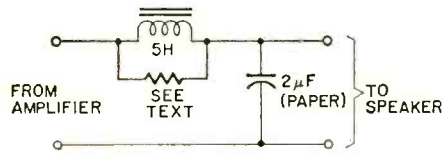
The Inch-Expander (see diagram) is a simple low-pass



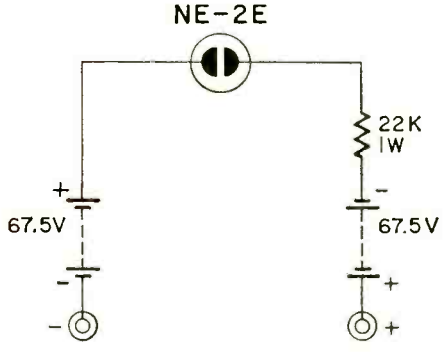
filter with a relatively fixed impedance over the middle and high frequencies and a much lower impedance over the all important bass octaves. Some power is lost in the resistor, but the added bass more than compensates for this inefficiency.

The components can be mounted in a small utility box or within the speaker enclosure. The resistor value should approximate the speaker's impedance. I use 3 ohms for 4-ohm speakers, and 7.5 and 15 ohms for 8- and 16-ohm speakers, respectively.—*P. Rodger Magriney*

SIMPLE CAPACITOR CHECKER

This simple capacitor spots open units and leakage that can't be detected with a vom. It checks disc, mica and tubular units. All you have to do is watch the neon lamp as you connect the test leads across the capacitor.

Good capacitors will show a single flash of light on the initial charge. The flash will be faint on smaller capacitor values. On larger units, the lamp glows until the capacitor is fully charged. The capacitor is open if the lamp does not flash. Intermittent or continued flashing indicates the capacitor is leaky.—*L. E. Keene, Jr.*



(You can use this checker for electrolytics if you watch polarity and operating voltage. Around 135 volts is applied to the capacitor under test so you cannot use it on low-voltage types used in transistor equipment.

When checking electrolytics, the lamp glows brightly and then dims until it goes out. It will then begin to flash. All electrolytics have some leakage and will cause the lamp to flash. If it flashes more than once a second, the capacitor is too leaky to use. A flash-rate of once per second or longer shows that the capacitor is good.—*Editor*) **R-E**

Service Clinic

By JACK DARR
SERVICE EDITOR

Raster size and brightness

After my RCA CTC17 color set has been on for about a half hour, the picture starts to get dim and loses size. Finally it goes clear out. Focus is poor, too, at all times. What causes this?—K. N., Dallas, Tex.

Let's go back to basics. This symptom shows a power supply loss; notice that you lose height, width and brightness simultaneously. The cause must be something common to all three, and this is the power supply.

It could be your boost voltage (a weak damper tube, for instance) or it could be a gradual drop in the B+ dc supply voltage, due to a partially open filter capacitor such as the 80-F input filter at the rectifier output. This set uses a bridge-rectifier circuit with silicons. Silicons do not normally "get weak," as the original seleniums did. When they fail, they usually short out completely. A gradual drop in the dc supply voltage would probably be due to the input filter capacitor losing normal storage capacity.

Monitor the +405-volt dc supply. If the dc supply goes down, the boost will go with it. If the picture goes out and the dc supply voltage stays the same or even rises a little (due to reduced current drain), check the boost voltage.

Since the focus is a percentage

of the high voltage, this could be affecting it, too. Focus voltage should be about 4500 with 24 kV of high voltage.

Low volume in auto reverberation unit

I just installed an auto radio reverb unit in a car with a built-in rear-seat speaker. I can't get much volume out of the rear-seat speaker, and have no reverb effect. Could this be the fader in the original radio circuit?—D. H., Shuylkill Haven, Pa.

Probably something in the switching. In standard reverb units, the rear-seat speaker can be switched on alone, with the front speaker or cut out. A reverb works with the rear-seat speaker *only*.

Each reverb unit has its own small amplifier. The rear-seat speaker *input* is switched to the input of the reverb amplifier, and the rear-seat speaker is then connected to the reverb's *output*. To get the reverb effect, the signal must *go through* the reverb unit on its way to the rear-seat speaker. Check your wiring and switches. **R-E**

TRANSISTOR CURVE TRACER

(*continued from page 78*)

shows the effect of high temperatures caused by excessive sweep voltage. The lower photo was taken after the condition was corrected and the transistor had cooled down.

The 40481 is a four-lead rf-type transistor in which the fourth lead is connected to the case. Distortion is quite evident in the lower bias curves (Fig. 7).

The actual Zener voltage of the 12-volt Zener (top, Fig. 8) is seen as 12.2 volts and has a sharp Zener characteristic. The knee of the 3.3-

(*continued on page 95*)

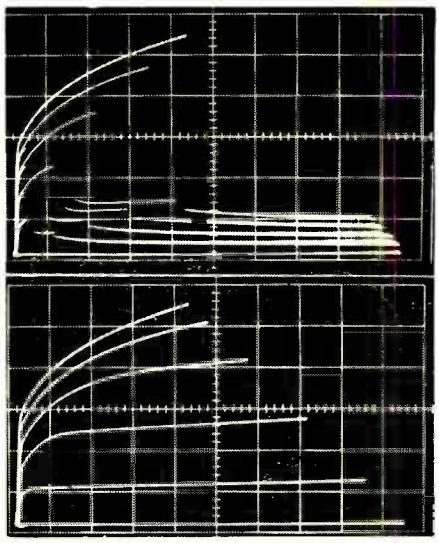
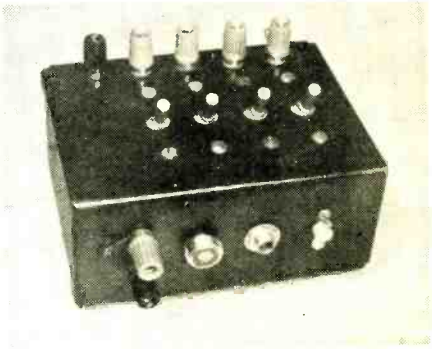
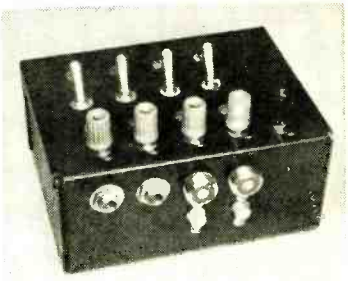
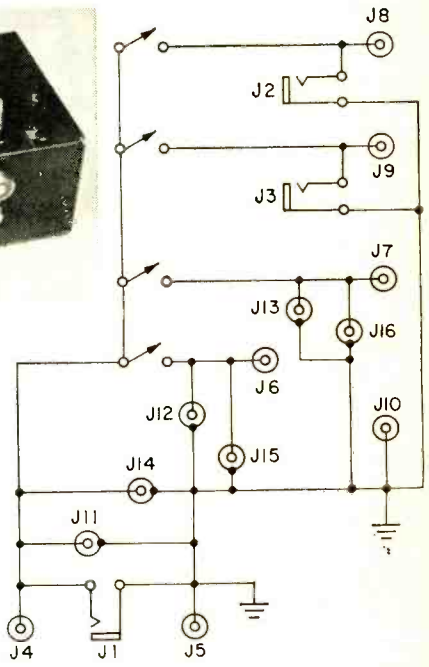


Fig. 7—Distortion is obvious.

JACK IN THE BOX







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Construction should be in a metal box (see photos) to provide shielding. The binding posts should be spaced to take dual banana plugs on the ground and adjoining post. As many jacks or types can be used as needed. Also the number of switches used depends on your needs.—*Arthur T. Grahn* **R-E**

TRANSISTOR CURVE TRACER
(continued from page 93)

volt Zener (bottom, Fig. 8) is comparatively rounded and does not reach its nominal voltage rating until

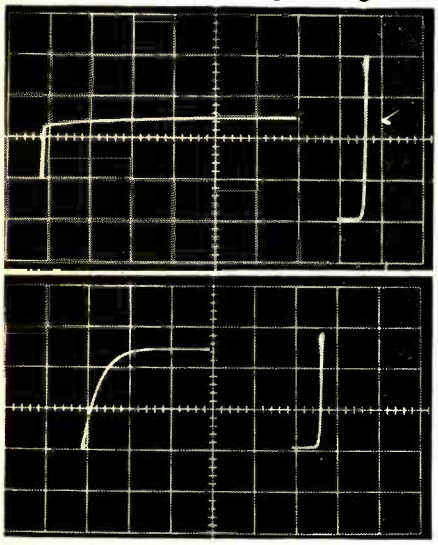

Fig. 8—Top photo shows 12V Zener voltage; bottom shows 3.3V Zener curves.

after the current increases to about 12 mA. The forward and reverse conduction curves are obtained separately, though shown in the same photo. R-E

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1. Date of filing: October 1, 1969
2. Title of publication: RADIO-ELECTRONICS
3. Frequency of issue: Monthly
4. Location of known office of publication: Ferry Street, Concord, Merrimack County, New Hampshire 03302.
5. Location of the headquarters or general business offices of the publishers: 200 Park Avenue South, New York, New York 10003.
6. Names and addresses of publisher, editor, and managing editor: Publisher, M. Harvey Gernsback, 200 Park Avenue South, New York, New York 10003; Editor M. Harvey Gernsback, 200 Park Avenue South, New York, New York 10003; Managing Editor, Larry Steckler, 200 Park Avenue South, New York, New York 10003.
7. Owner: Gernsback Publications, Inc., 200 Park Avenue South, New York, New York 10003; M. Harvey Gernsback, 200 Park Avenue South, New York, New York 10003; Mary H. Gernsback, M. Harvey Gernsback, Maurice Coyne, Benjamin E. Winston As Trustees Under Trust Agreement dated September 30, 1965, c/o Benjamin E. Winston, Esq., 2 W. 45 St., New York, New York.
8. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages or other securities: None.
9. For completion by nonprofit organizations authorized to mail at special rates: Does not apply in this case.
10. Extent and nature of circulation. Average number of copies each issue during preceding 12 months are: (A) Total No. of copies printed (net press run): 218,550; (B) Paid circulation: (1) Sales through dealers and carriers, street vendors and counter sales: 43,972; (2) Mail subscriptions: 109,971; (C) Total paid circulation: 153,943; (D) Free distribution (including samples) by mail, carrier or other means: 1,769; (E) Total distribution: 155,712; (F) Office use, left-over, unaccounted, spoiled after printing: 62,838; (G) Total: 218,550. The number of copies of single issue nearest to filing date: (A) Total number copies printed (net press run): 207,112; (B) Paid circulation. (1) Sales through dealers and carriers, street vendors and counter sales: 43,001; (2) Mail subscriptions: 105,013; (C) Total paid circulation: 148,014; (D) Free distribution (including samples) by mail, carrier or other means: 1,670; (E) Total distribution: 149,684; (F) Office use, left-over, unaccounted, spoiled after printing: 57,428; (G) Total: 207,112.

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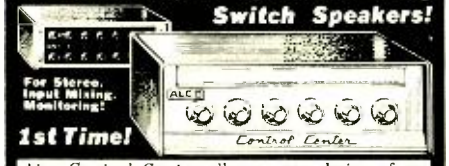

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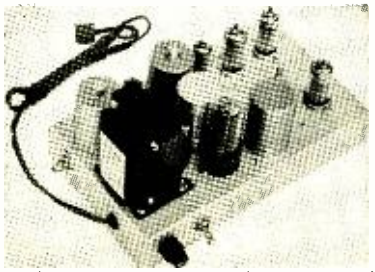

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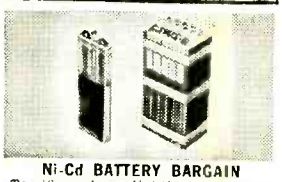

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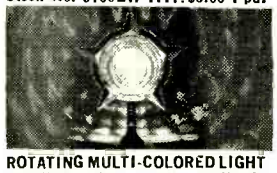

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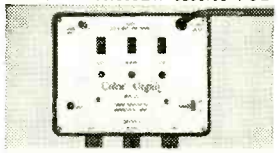

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CALIBRATOR AND MORE STABILITY FOR VTVM

Many owners of vtvm's are plagued by instability and the need for a quick and accurate method of recalibrating the instrument. These problems can be solved by adding a voltage regulator tube to the unit's B-plus line and a push-button switch to connect the regulated B-plus to the input terminals so it can be used as a calibrating voltage.

Most vtvm's have a supply delivering about 130 volts so a 105-volt regulator tube such as the OA3 should be used. Connect a 1-megohm resistor (or the same value of resistance as in the dc probe) in series with the switch between the B-plus line and the vtvm's dc input. Press the switch and adjust the calibrate pot so the meter reading equals the regulated B-plus voltage.—*Allan Glaser, WA4-REM*

AC VOLTMETER SPOTS TAPE RECORDER WOW

You don't have to have an expensive wow meter to check a tape recorder. You can do it with a simple ac voltmeter. Do it this way:

Using the filter/limiter in Fig. 1, record about two minutes of 60-Hz signal from the power line with the recorder's level control set to 100%. Use an ac voltmeter and measure the signal being fed from the filter net-

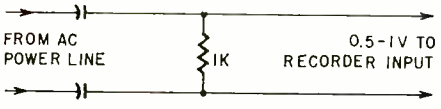

Fig. 1

work to recorder's input–0.5–volt. When you have a 2-minute recording, rewind the tape and set the recorder to playback.

Start the machine and set the volume control so the voltage across the speaker terminals is the same as the signal fed in while recording. Now, arrange the meter and R-C network as in Fig. 2. The input side of the filter is still connected to the power line and the meter and output end are con-

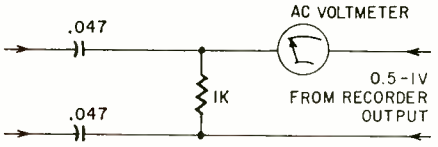

Fig. 2

nected to the recorder output terminals.

Restart the tape and watch the meter. The voltage will slowly rise to nearly twice the preset output level. The maximum voltage depends on the phase relationship between the power line and the recorded 60-Hz signal.) Now, the meter reading will slowly drop toward zero as the two voltages approach an in-phase condition. The number of dips per minute is determined by the condition of the recorder's drive system.

Normal readings for an ordinary hometype tape recorder are:

1 dip per minute at 7½ ips
3 dips per minute at 3¾ ips
4 dips per minute at 1⅞ ips

If you get more than the desired number of dips per minute, something is wrong. Check the drive system and capstan. The meter movement must be slow. If it jumps from one end of the scale to the other, you have trouble and the entire drive system should be overhauled.—*Konrad Larsson*

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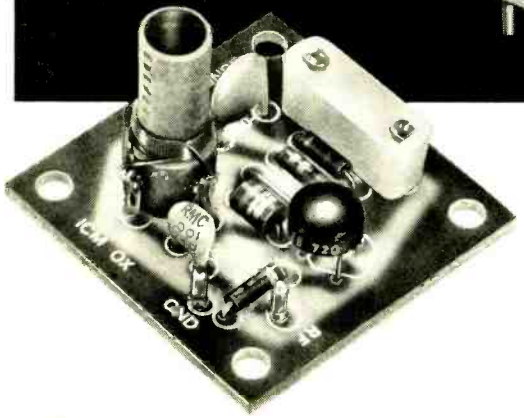

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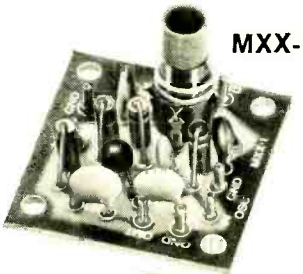

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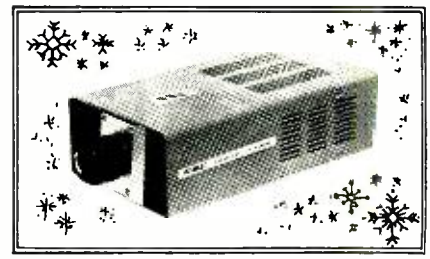

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