Fix Color TV brightness faults fast

MASTER

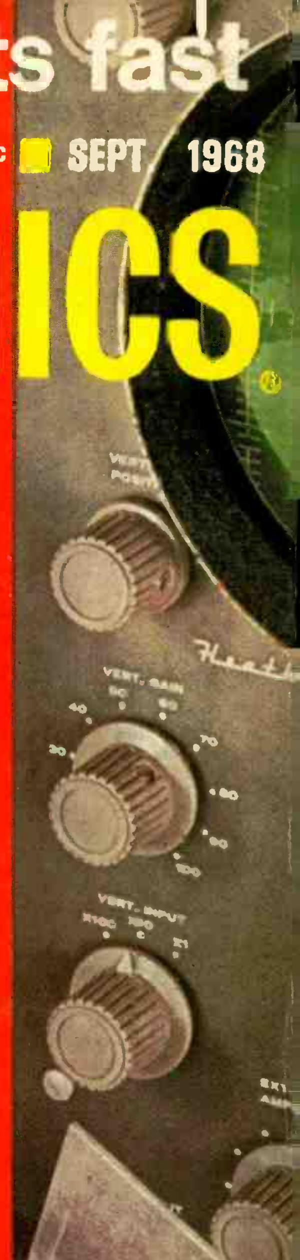
60c ■ SEPT 1968

Radio-Electronics

TELEVISION · SERVICING · HIGH FIDELITY

—SPECIAL 16-PAGE SECTION—

- Hi-Fi testing on a budget
- New tools save time and dollars
- Newcomer's guide to new test gear



BONUS: Build your own IC Guitar Amplifier

BUILD: 3-way Scope Calibrator

Checks Voltage-Time-Frequency

PAGE 51

A GERNSBACK PUBLICATION

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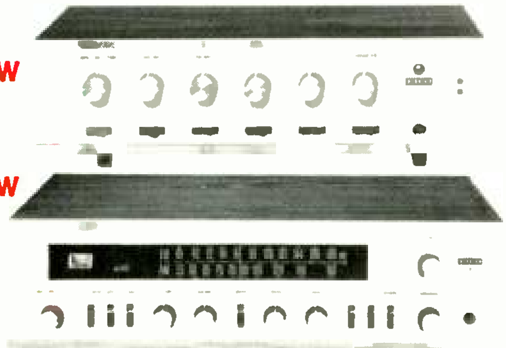
Uncompromising engineering—for value does it!
You save up to 50% with Eico Kits and Wired Equipment.

NEW



NEW

Cortina Stereo

THE VERDICT IS IN. High fidelity authorities agree: Cortina's engineering excellence, 100% capability, and compact dramatic esthetics all add up to Total Stereo Performance at lowest cost.

A Silicon Solid-State 70-Watt Stereo Amplifier for $99.95 kit, $139.95 wired, including cabinet. Cortina 3070

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NEW 70-Watt Solid State AM/FM Stereo Receiver for $189.95 kit, $279.95 wired including cabinet. Cortina 3770.

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The newest excitement in kits. 100% solid-state and *professional.* Fun to build and use. Expandable, interconnectable. Great as "jiffy" projects and as introductions to electronics. No technical experience needed. Finest parts, pre-drilled etched printed circuit boards, step-by-step instructions.

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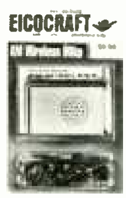
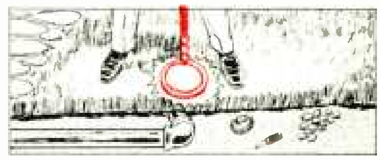
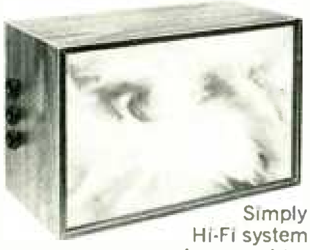




6 EXCITING NEW PROJECTS

EC-1700 Ham/CB Vox $8.95,
EC-1800 Electronic "TOX" $8.95,
EC-1900 "Treasure Finder" $9.95,
EC-2000 Electronic Organ $9.95,
EC-2100 Electronic "Eye" $9.95,
EC-2200 "Magic Switch" $9.95

Color n' Sound



Add a new dimension to your music system. Introducing the first inexpensive solid-state electronic system which provides true synchronization of color with sound. Watch the music you love spring to life as a vibrant, ever shifting interplay of colors. Simply connect to speaker leads of your Hi-Fi system (or radio). Kit can be assembled in several hours — no technical knowledge or experience necessary. Kit $49.95, Wired $79.95.

Automotive

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Model 232 Peak-to-Peak VTVM. A must for color or B&W TV and industrial use. 7 non-skip ranges on all 4 functions. With exclusive Uni-Probe.® $34.95 kit, $49.95 wired.

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Circle 7 on reader's service card

LOOKING AHEAD

By DAVID LACHENBRUCH
CONTRIBUTING EDITOR

Ready, Cassette, Go

1969 will be the year of the cassette. The tiny two-reel tape cartridge concept promoted by Philips of Holland (and Norelco in the U.S.) has swept through the American consumer electronics industry like a forest fire, and it now appears to be the catalyst which will convert tape recording into a true mass consumer market.

Cassette recorders and players are now being merchandised under at least 100 brand names—most of them imported from Japan or the Netherlands. While 1968 cassette recorder/player sales are expected to total close to 2 million out of perhaps 6 million of all types of tape instruments, cassette units may well account for the majority of tape instrument sales next year.

Admittedly no substitute for the high-fidelity reel-to-reel recorder, the cassette apparently isn't cutting into that market at all—but rather winning new converts to tape from among those who have never owned a recorder before. The cassette is capitalizing on the simplicity and flexibility which make it adaptable to a wide variety of uses and formats. Not the least of its flexibility is its mono-stereo compatibility. Any stereo cassette may be played on a mono cassette recorder; any mono cassette will play on a stereo unit.

This fall and winter, cassette machines will be available at retail prices varying from $9.50 for a playback-only portable to more than $400 for a deluxe stereo component system. The variety of devices which will be on the market seems almost endless, including—but not limited to—battery and ac portable players and recorders, both mono and stereo; portable recorders combined with FM-AM radio; home stereo decks and players, with or without AM and FM stereo and/or phono turntables; automatic changers which can accommodate up to six cassettes; automobile cassette players and recorders.

Evaluating the Trinitron

Sony's single-gun, three-beam Trinitron color tube, which uses a vertically slitted "aperture grill" in place of the conventional shadow mask (R-E, July 1968), is under intensive study by American picture-tube manufacturers. On the basis of still-scanty technical information, most tube makers are trying to duplicate the Sony tube for study and evaluation.

One major tube manufacturer studied all available information and came up with this summary of the Trinitron's apparent advantages and disadvantages:

Single three-beam gun: Advantages—Theoretically better focus. Claimed 50% increase in brightness. **Disadvantages**—Electron beam is bent from its path twice, not once as in conventional tubes; bending of the beam creates detrimental effects. Gun is highly complex and may be difficult to manufacture.

Electrostatic convergence system: Advantage—lower circuit cost. **Disadvantages**—Neck contact button required, adding to cost of glass and creating manufacturing problems. No vertical convergence control. Electron gun is longer, resulting in longer tube.

Common Grid 1 and Grid 2 construction: Advantages—Separate grid assemblies not required for each beam. **Disadvantages**—Tube can't be used for signal matrixing. Linearity of video amplifiers must be better than currently available or color tracking problems will result.

Vertical grid-type shadow mask: Advantage—Theoretical 30% increase in beam transmission (brightness). **Disadvantages**—Vertical stripes ("pin-striping") in picture. Because grill apparently can't be made in the spherical contour used in American color tubes, the picture tube face probably must be cylindrical. This would limit picture tube size to 14 inches (diagonal) or less, because spherical faceplates are required in larger tubes to provide proper structural strength.

The tube maker concedes that too little is currently known for a complete evaluation, but calls Trinitron "a skillful combination of concepts that have been singly investigated by many color picture tube development organizations."

The Transistor That 'Isn't There'

When is a transistor not a transistor? When it's not "improving performance capabilities," says the Federal Trade Commission in a new rule aimed at ending inflated transistor-content claims for radios and walkie-talkies. Effective next Dec. 10, the FTC makes it an unfair trade practice to include in advertising and on radio cases and boxes such identification as "15 transistors," when this count includes transistors which don't aid in "detection, amplification and reception of radio signals."

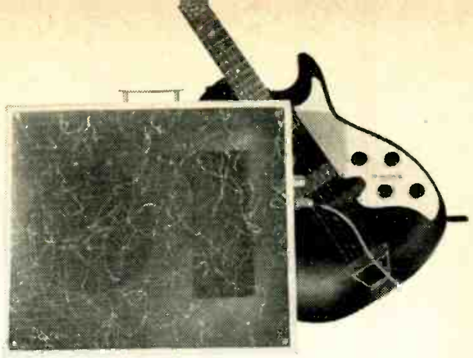
Designed as a clampdown on the use of "dummy" transistors, or transistors used as diodes, to inflate the transistor content of a radio, the ruling actually goes a little further—perhaps further than the FTC really intended. It also is construed as banning the counting of transistors wired in parallel or cascade if they don't improve performance. In addition, it may exclude from the count transistors used in FM multiplex or afc circuits, since, strictly speaking, these may not have "detection, amplification or reception" functions.

Phone Gadgets Coming

A little-noted decision by the FCC could open the way for a whole new category of electronic devices in this country. The Commission has voided AT&T's long-standing rule which prohibited the use of "foreign" attachments to Bell System telephones (unless these were supplied by the phone company). FCC said AT&T may set reasonable standards for attachments, to protect the quality of telephone service. The ruling was made in the Carterfone case, involving a device connected into the telephone system to permit remote phone conversations by radio. Previously, the only "foreign" gadgets permitted with AT&T telephones were those which had no physical connection to the system. The FCC's new decision could lead to hundreds of new devices, with varying degrees of sophistication, designed to be wired directly into telephone instruments or lines. **R-E**

Radio-Electronics

September 1968 • Over 60 Years of Electronics Publishing



IC music maker converts any guitar into an electronic guitar. Take a few hours and build a miniature amplifier for yourself. It's easy to build and fun to use indoors or out.

see page 69

TOOLS AND TEST EQUIPMENT

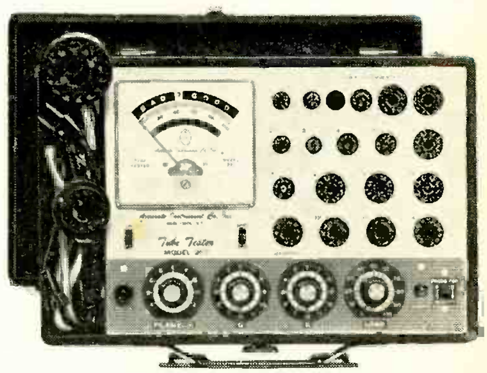
BUILD ONE OF THESE

Know what this is? It's the latest in blind-riveting tools. There are lots of other new tools around too. Find out what's new in hand and power tools.

see page 32

SERVICING

GENERAL ELECTRONICS



Getting started in TV repair? Then you've just got to know about the latest TV and radio test gear. We'd like to bring you up to date on what's available and what it can do.

see page 40

DEPARTMENTS

RADIO-ELECTRONICS, SEPTEMBER 1968, Volume XXXIX, No. 9
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NEWS BRIEFS

COMPUTER EYE ON THE SKY

Instant aircraft display—a new control system operating at New York's JFK airport. It is an important step toward nationwide computer control of dense air traffic at terminals. The system's two UNIVAC 1219 computers "watch" instrument aircraft traffic at JFK, LaGuardia and Newark airports. One computer processes radar or beacon tracking data from aircraft, while the other generates information to constantly update large- and small-screen displays in a centralized control room. The displays, like the 9 x 12 ft screen in the composite picture above, show radar blips indicating aircraft location and letter-number blocks that provide identity and altitude. Up to 250 aircraft can be handled simultaneously. Photo (below left) shows flight progress panel with flight plans for controllers, teletype and programming equipment.

COMPUTER-TAUGHT TYPING

A device originally developed to teach Morse Code to Armed Forces personnel has been adopted into a compact computer system to help students learn typing faster. The system allows each student to develop typing skills at a speed matching their ability. The student's console has a keyboard similar to that of a standard electric typewriter. The front panel consists of a colored-light display, each light corresponding to a keyboard key. The bottom portion of the panel includes a letter-and-number unit that can display numbers, letters or words. When a student's performance indicates failure, the computer back tracks.

THREE-YEAR TUBE WARRANTY

Owners of new Admiral color TV sets now don't have to worry about picture-tube replacement for 3 years. In addition to an extended warranty, the company is offering a 2-year add-on warranty to owners, of 55 models introduced in December 1967. Improved quality control and greater automation at Admiral's Chicago tube plant helped make the warranty possible.

WEATHER WATCHER

Newest member of the "space ham" family is Rex L. Smith, a senior Westinghouse technician. Using borrowed and second-hand equip-

ment, Smith records weather-satellite signals with a home-built antenna that leans against a basement workshop wall. Signals are decoded, taped on a home recorder, fed to an electronic storage tube and photographed. Weather-satellite photography is becoming popular with skilled do-it-yourselfers.

ELECTRONIC COMMUTING

Dial-a-buses and electronically guided personal vehicles for commuters of the future were among the proposals recently sent to Congress by the Johnson Administration. The buses proposed could be summoned by telephone through a computer

(continued on page 6)

NEWS BRIEFS
(continued from page 4)

that would record the number of potential passengers, the availability of vehicles and then dispatch a bus. Small personal vehicles for rapid transportation could be electronically guided over separate roadways in low- to medium-density urban areas. Private and public development costs over the next 5 to 10 years will be about $1 billion.

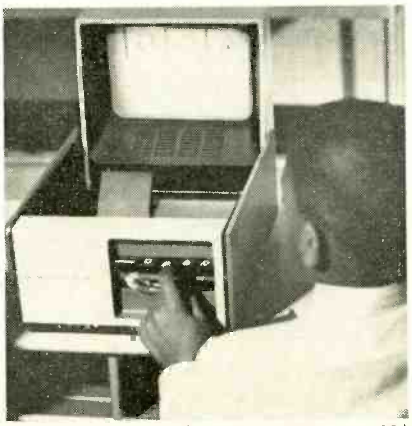
ROBERT H. HAINES

Winner of the annual Hugo Gernsback Scholarship Award is Robert H. Haines, 26, of Forest Hills, N.Y. The $1000 grant is presented

each year to a New York University student selected by the College of Engineering faculty. After attending college for 2 years, Haines worked for 5 years as an electronic technician. He returned to college at New York University in 1965, and for the last four semesters has been on the dean's list. Haines is a member of Eta Kappa Nu, electrical engineering honor society, Pi Lamda Phi and is treasurer of the NYU student chapter of IEEE.

PORTABLE TEACHING MACHINE

Thirty New York City school children are using a new desk-top



(continued on page 12)

Radio-Electronics

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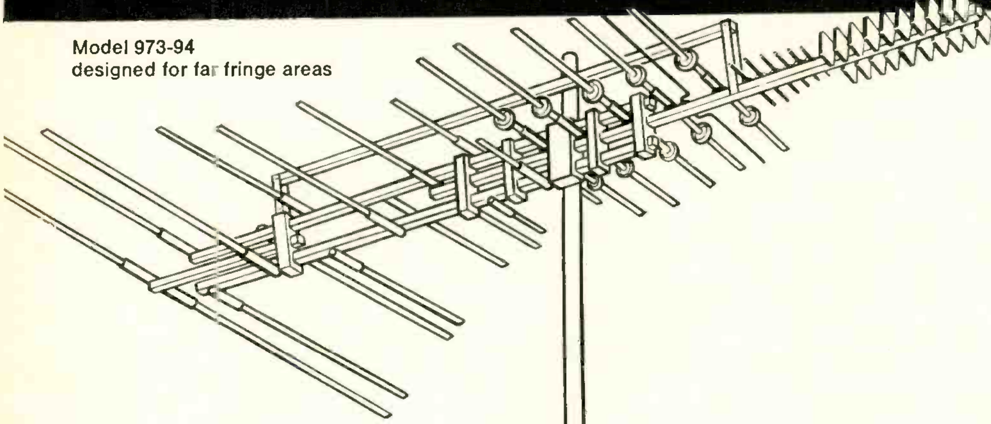

Model 973-94
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Fun for all!
Get the details
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- Capacitor coupled cap-electronic VHF dipoles.
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You can choose from twelve all-new Zenith VHF/UHF/FM or VHF/FM antennas. All are gold color alodized aluminum for better conductivity, greater corrosion resistance and longer service.

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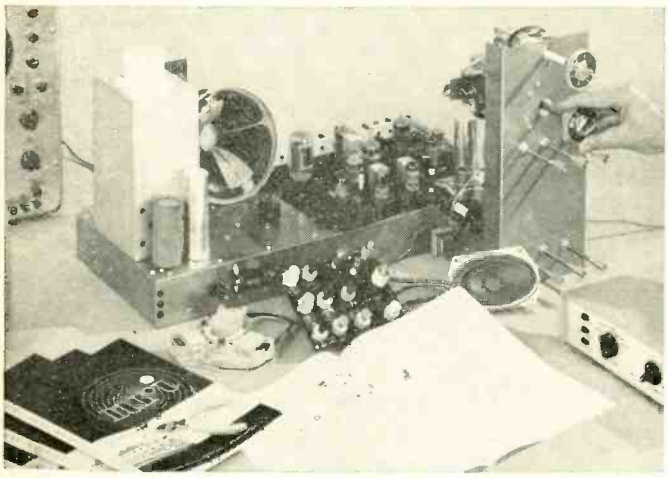
The quality goes in before the name goes on

Circle 11 on reader's service card

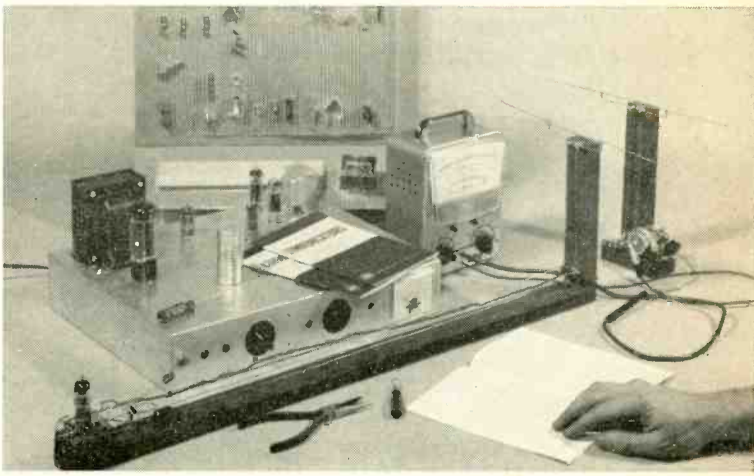
NRI firsts

make learning Electronics at home fast and fascinating — give you priceless confidence.

Some NRI firsts in training equipment



first to give you Color Television training equipment engineered specifically for education — built to fit NRI instructional material, *not* a do-it-yourself hobby kit. The end product is a superb Color TV receiver that will give you and your family years of pleasure. You "open up and explore" the functions of each color circuit as you build.



first to give you transmission lines and antenna systems that include experiments not otherwise attempted outside of college physics laboratories. The experience gained with this kind of Communications training equipment is matched only by months — sometimes years — of on-the-job experience.

NRI's "discovery" method is the result of over half a century of leadership simplifying and dramatizing training at home

The FIRSTS described below are typical of NRI's half century of leadership in Electronics home training. When you enroll as an NRI student, you can be sure of gaining the in-demand technical knowledge and the priceless confidence of "hands-on" experience sought by employers in Communications, Television-Radio Servicing and Industrial and Military Electronics. Everything about NRI training is designed for your education . . . from the much-copied, educator-acclaimed Achievement Kit sent the day you enroll, to "bite-size" well-illustrated, easy to read texts programmed with designed-for-learning training equipment.

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There is no end of opportunity for the trained man in Electronics. You can earn $6 or more an hour in spare time, have a business of your own or qualify quickly for career positions in business, industry, government. And if you enroll for any of five NRI courses in Communications, NRI prepares you for your FCC License exams. *You must pass* or NRI refunds your tuition in full. No school offers a more liberal money-back agreement. The full story about NRI leadership in Electronics training is in the new NRI Catalog. Mail postage-free card today. No salesman is going to call.
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first to give you true-to-life experiences as a communications technician. Every fascinating step you take in NRI Communications training, including circuit analysis of your own 25-watt, phone/cw transmitter, is engineered to help you prove theory and later apply it on the job. Studio equipment operation and troubleshooting become a matter of easily remembered logic.

first to give you completely specialized training kits engineered for business, industrial and military Electronics. Shown above is your own training center in solid state motor control and analog computer servo-mechanisms. Telemetering circuits, solid-state multi-vibrators, and problem-solving digital computer circuits are also included in your course.

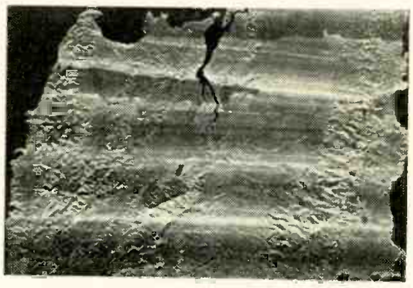
NEWS BRIEFS

(continued from page 6)

device that combines sight and sound on a 5-inch program cartridge to help them improve their reading skills. The Viewlex system developed by CBS Labs presents words and pictures on a 5″ x 8″ viewing screen while a prerecorded voice reinforces the selection of the proper answers. Should the student select a wrong answer the machine remains silent, flashes a red light and waits for him to try again. Results to date show a steady improvement in reading. The average time in learning to read words is less than 25 hours.

RADAR PENETRATES CLOUD COVER

Panama's Darien Province, one of several regions in the world poorly mapped or unmapped because of perpetual cloud cover, has been



photographed by the US Army using Westinghouse-developed side-looking radar. Radar image composite is a mosaic made from continuous strips produced during several passes over the area. North is at top of picture.

CIRCULATING-LIQUID LASER

An experimental laser system developed by General Telephone & Electronics may be a significant step toward continuously operating liquid lasers for future communications and optical display systems. The device can produce at least 2 pulses per second because the liquid is circulated continuously through cooling equipment that carries off the heat. Stationary liquids used in earlier lasers were affected by the intense heat from the bright "pumping" lamps that stimulated the fluids into producing light. The heat altered the liquids' "index of refraction" and caused the laser light pulses to stray from their designated paths, making it difficult to aim and focus the beam reliably.

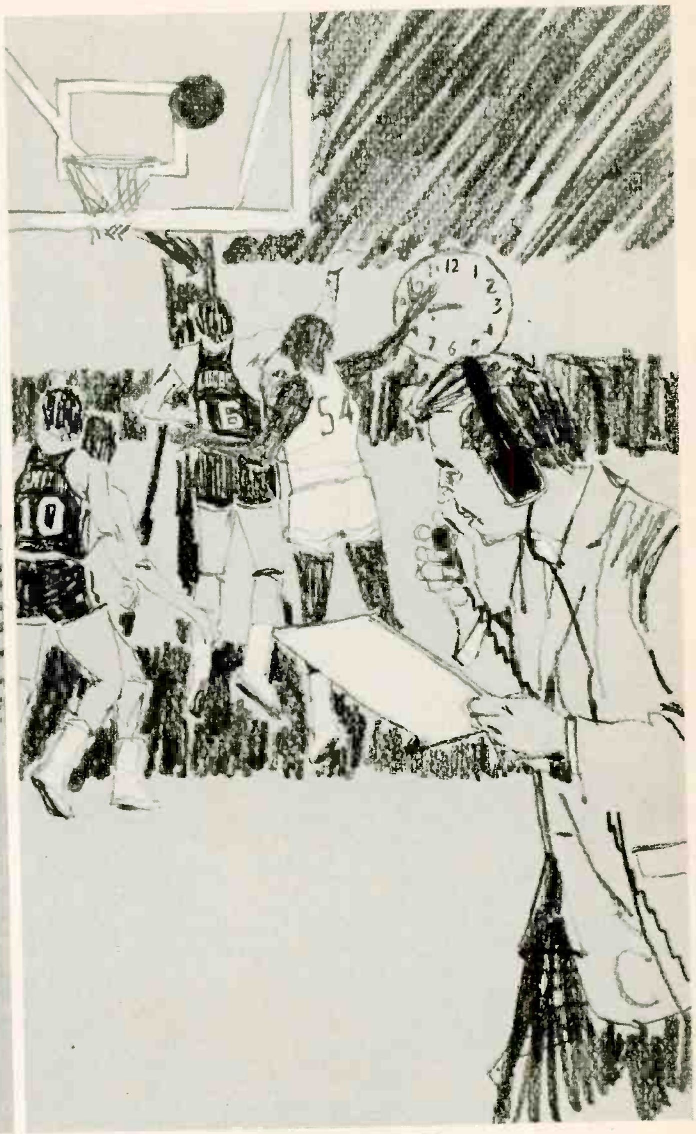
ELECTRONIC TECHNICIAN CERTIFICATES

A 75% grade on a multiple-choice test, proof of 4 years electronics schooling and/or experience and a $5 fee can earn certification as an electronic technician from National Electronic Assns., Inc. Chairman of the NEA certification committee is Howard L. Bonar, 108 N. Center St., Marshalltown, Iowa 50158.

AIRBORNE STEREO

Passengers on Lockheed's L1011 trijet in the 1970's will be able to enjoy stereophonic music without

headphones. Loudspeaker systems built by JBL (dotted lines) will span the 345-passenger cabins. Bass response of the 8″ L75 speakers is effectively doubled by a matching passive radiator. **R-E**



Correspondence

GREMLINS EXIST

It seems a Gremlin inserted itself into my manuscript "Recipe for a Preamp" (June 1968). The solution of formula 21 should be:

$= (1.5 \times 10^3)\,(4.07 \times 10^{-5})$
$= 0.06.$

B. E. JOHNSON
Portland, Ore.

ALARM CIRCUIT IS PATENTED

All of us at Heath appreciate the article on our Heathkit Home Protection System which appeared in the June issue of RADIO-ELECTRONICS.

As usual, the reporting is technically very accurate. However, one important detail was omitted: the basic signaling method used in the Heathkit Home Protection System is the basis of two patent applications (Nos. 504, 918 and 44952) filed by Berkeley Scientific Laboratories of Berkeley, Calif., who have named Heath Company as exclusive licensee.

EARL F. BROIHIER, MGR.
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GIVE US MORE

RADIO-ELECTRONICS is already my favorite magazine, but please give us more articles like "Recipe for a Preamp," which appeared in the June issue. You can't guess how many books I have bought searching for exactly this information.

Can you suggest a good book that has transistor and/or FET circuit design explained this closely?

EARL M. LOLLEY
Andalusia, Ala.

Several good texts are available. But one of the newest is called "Transistor Circuits and Applications" by Laurence G. Cowles, and is published by Prentice-Hall.

TACH-DWELL REVISITED

In the June 1968 issue I read the article "Build Low Cost Solid-State Tach-Dwell Meter." I am contemplating building this test instrument, but am completely baffled by the drawing of the meter scale. I just can't reproduce it. Can you supply me with a better copy?

ALEXANDER KARMAN
New York, N.Y.

Sorry to have caused so much trouble, Alex, but our printer forgot to drop out the color background. A copy of the meter dial is already on its way to you. For any other readers who had a similar problem we are reproducing the meter dial at foot of this column.

I LIKED JUNE

You guys have done it again. I am referring to the June issue. That article on unijunction transistors was great! Let's have more of them in the future. And the programed course in semiconductor fundamentals on page 52 is just too much.

I have a question about the Poor Man's Power Supply in the same issue. Could a stereo power amplifier be run off it? Or a power amplifier for an electric guitar?

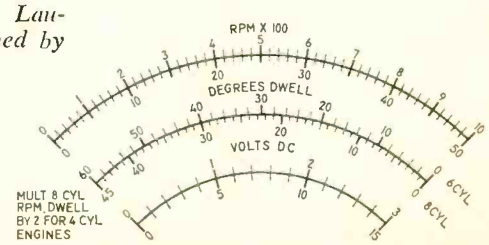
JIM PERLBERG
Racine, Wis.

Thanks for the kind words, Jim. We'll keep those high-interest stories coming. As to your question, that's a low-power supply and will hardly handle the requirements of high-wattage amplifiers.

MORE COLOR TROUBLES

Jack Darr's column on "Station Color Troubles" in your June issue omitted one of the chief causes of color variation from station to station—differential gain and differential phase errors in transmission. These effects are basically due to intermodulation between the luminance and chrominance components of the color signal and are caused by incorrect gamma correction and band-shaping at the transmitter and by multiple transmission paths between transmitter and receiver.

European receivers, operating on the PAL system, are not subject to the errors in transmission. In fact, these receivers do not have a tint control as the lack of standardization of levels between program sources, mentioned



Circle 15 on reader's service card

by Jack Darr, is not tolerated in European studios.

These effects, the differential errors due to poor broadcasting technique and the wide differences in color quality due to careless studio practice, make color TV viewing a continual parade to the tint control and certainly do not help the image of the color TV industry.

NORMAN P. DOYLE
Communications Systems and Applications
Fairchild Semiconductor
Mountain View, Calif.

Thanks for filling in the gaps. But let's not hint at changing the system of color TV in the US because the PAL system has some advantages. Instead, let's work toward eliminating the problems in the system we use.

IT'S NOT PERPETUAL MOTION

E. Mitch mentioned in the June 1968 letters column he has a perpetual-motion problem. This result is quite common with capacitor discharge installations. Besides dieseling, the cause can be a faulty ignition switch, voltage regulator or the generator or alternator. One cheap and easy remedy is to place a 25-ohm 15-watt resistor or a parking lamp bulb between 12 volts and ground at the ignition system.

E. W. HALAYKO
Ottawa, Ontario, Canada

Mr. Mitch's problem is not dieseling and his unit is likely hooked up properly. He was on the right track though—something is shunted, probably the generator light.

The generator light is connected between the cold side of the ignition switch and the generator or alternator output. When the ignition switch is turned off, a small current can flow from the generator to the ignition circuit via this lamp. With a standard ignition system the engine stops and this flow ceases. But with some C-D systems it is enough to idle the engine. The cure is to replace the generator lamp with a lower-wattage type.

F. L. WINTERBURN
Captain, Canadian Armed Forces
CFB Bagotville, P. Q., Canada

In some cases when an idiot light is used in place of an ammeter, the engine may not always stop when the ignition is turned off. This can be corrected by installing a 50-PIV, 1-amp diode (Motorola 1N4001 or equivalent) in series with the lamp. Check to make sure diode polarity connection will permit the lamp to light.

ROBERT C. METIVIER
Keene, N.H.

R-E

And you have to go back and fix your repair job one week after you've fixed the set. It's your fault, and your money.

Replacement parts ought to last longer than that.

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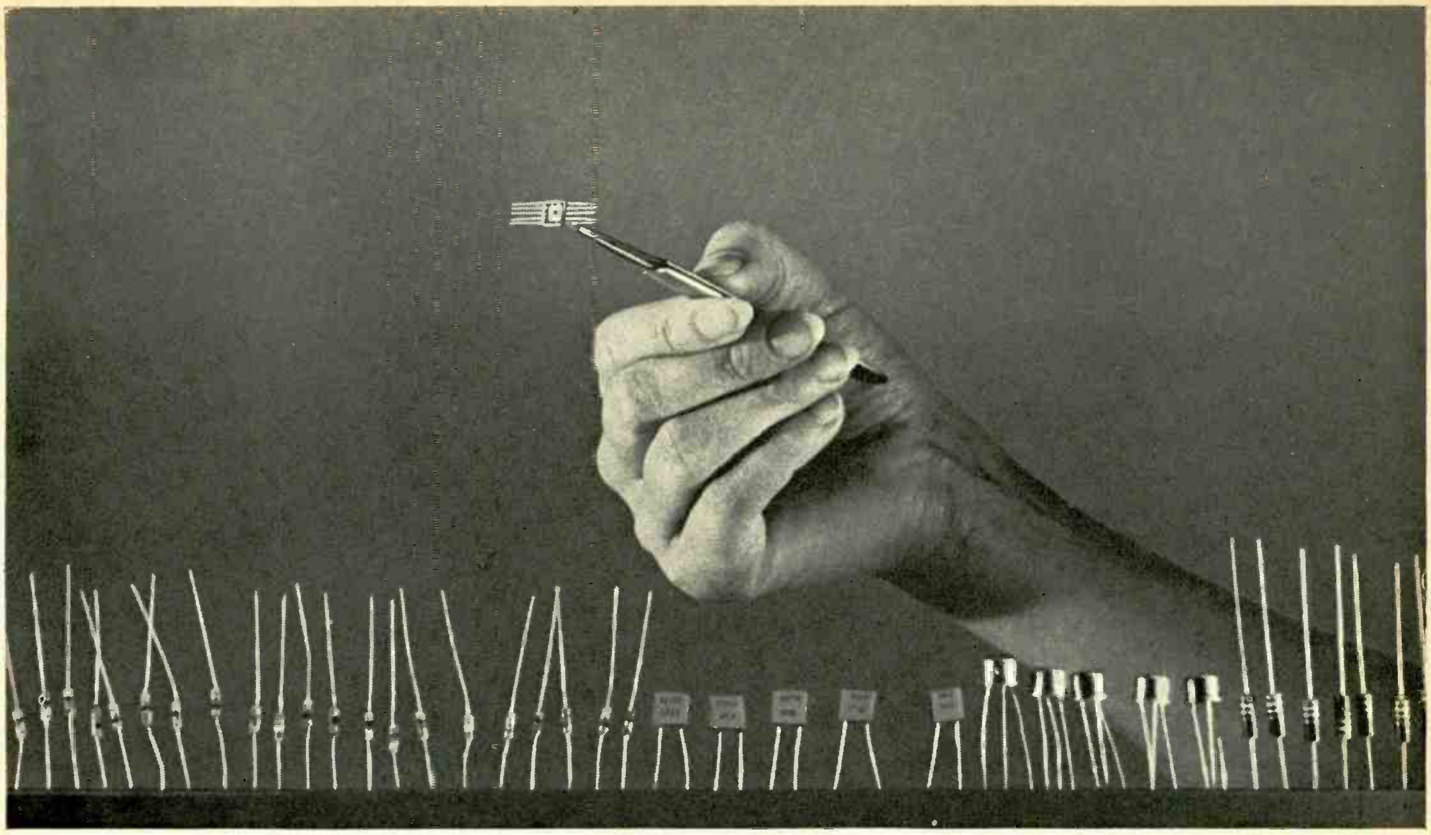
Circle 18 on reader's service card



50 functions in a single chip. *The functions of 50 separate transistors, diodes, resistors and capacitors can now be formed by the tiny dot in the center of the integrated circuit held by the tweezers.*

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...will it make or break your job future?

THE DEVELOPMENT OF INTEGRATED CIRCUITRY is the dawn of a new age of electronic miracles. It means that many of today's job skills soon will be no longer needed. At the same time it opens the door to thousands of exciting new job opportunities for technicians solidly grounded in electronics fundamentals. Read here what you need to know to cash in on the gigantic coming boom, and how you can learn it right at home.

TINY ELECTRONIC "CHIPS," each no bigger than the head of a pin, are bringing about a fantastic new Industrial Revolution. The time is near at hand when "chips" may save your life, balance your checkbook, and land a man on the moon.

Chips may also put you out of a job...or into a better one.

"One thing is certain," said *The New York Times* recently. Chips "will unalterably change our lives and the lives of our children probably far beyond recognition."

A single chip or miniature integrated circuit can perform the function of 20 transistors, 18 resistors, and 2 capacitors. Yet it is so small that a thimbleful can hold enough circuitry for a dozen computers or a thousand radios.

Miniature Miracles of Today and Tomorrow

Already, as a result, a two-way radio can now be fitted inside a signet ring. A complete hearing aid can be worn entirely inside the ear. There is a new desk-top computer, no bigger than a typewriter yet capable of 166,000 operations per second. And it is almost possible to put the entire circuitry of a color television set inside a man's wrist-watch case.

And this is only the beginning!

Soon kitchen computers may keep the housewife's refrigerator stocked, her menus planned, and her calories counted. Her vacuum cleaner may creep out at night and vacuum the floor all by itself.

Money may become obsolete. Instead you will simply carry an electronic charge account card. Your employer will credit your account after each week's work and merchants will charge each of your purchases against it.

When your telephone rings and nobody's home, your call will automatically be switched to the phone where you can be reached.

Doctors will be able to examine you internally by watching a TV screen while a pill-size camera passes through your digestive tract.

New Opportunities for Trained Men

What does all this mean to someone working in electronics who never went beyond high school? It means the opportunity of a lifetime—if you take advantage of it.

It's true that the "chip" may make a lot of manual skills no longer necessary.

But at the same time the booming sales of articles and equipment using integrated circuitry has created a tremendous demand for trained electronics personnel to help design, manufacture, test, operate, and service all these marvels.

There simply aren't enough college-trained engineers to go around. So men with a high school education who have mastered the fundamentals of electronics theory are being begged to accept really interesting, high-pay jobs as engineering aides, junior engineers, and field engineers.

How To Get The Training You Need

You can get the up-to-date training in electronics fundamentals that you need through a carefully chosen home study course. In fact, some authorities feel that a home study course is the best way. "By its very nature," stated one electronics publication recently, "home study develops your ability to analyze and extract information as well as to strengthen your sense of responsibility and initiative." These are qualities every employer is always looking for.

If you do decide to advance your career through spare-time study at home, it makes sense to pick an electronics school that specializes in the home study method. Electronics is complicated enough without trying to learn it from texts and lessons that were designed for the classroom instead of correspondence training.

The Cleveland Institute of Electronics has everything you're looking for. We teach only electronics —no other subjects. And our courses are designed especially for home study. We have spent over 30 years perfecting techniques that make learning electronics at home easy, even for those who previously had trouble studying.

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Always Up-To-Date

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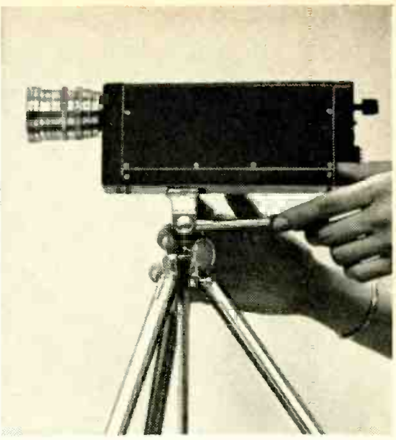
Tiny TV camera *for space and military use is one of the miracles of integrated circuitry. This one weighs 27 ounces, uses a one-inch vidicon camera tube, and requires only four watts of power.*



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Students who have taken other courses often comment on how much more they learn from CIE. Mark E. Newland of Santa Maria, California, recently wrote: "Of 11 different correspondence courses I've taken, CIE's was the best prepared, most interesting, and easiest to understand. I passed my 1st Class FCC exam after completing my course, and have increased my earnings $120 a month."

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In the Shop . . . With Jack

By JACK DARR
SERVICE EDITOR

"E = IR"

DON'T KEEP OHMS LAW LOCKED UP IN a desk drawer (I've got it pinned up over my bench!) and don't let it get "locked up" in the dark recesses of our hard heads, either. Time after time, I have run down some "very obscure and complicated trouble" only to find that it could have been done about an hour faster if I'd remembered that E = IR.

In other words, watch those voltage drops. *Use* Ohm's Law! It was important in tube-servicing, and still is. In transistor work, it's even more important. Look at any transistor circuit, and you'll see fixed resistors that set the bias on a stage; voltage dividers connected from B+ (V_{cc}) to ground which also set bias; transistors themselves used as parts of voltage dividers; and a lot of others. All of these can be checked out very quickly with a couple of voltage measurements and a quick swipe at Ohm's Law.

Current measurements can be made without unsoldering a single joint, *IF* you read the voltage drop across any resistor in series with the circuit. A 1.0 volt drop across 1,000 ohms means that 1.0 mA is flowing. One of the most frequently needed tests in all transistor circuits tells you whether there is any current flowing, which is what you want to know.

"Ohms, watts, volts, amplifiers, capacitors and audio frequency he understands. Faucets and drains are too complicated!"

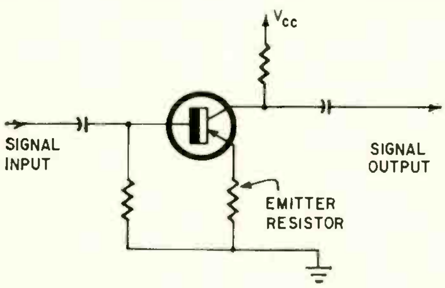

Fig. 1—Voltage across the emitter resistor shows the circuit conditions.

Just measure the voltage on the emitter. In common-emitter circuits (the most often-used) this will be the voltage-drop across the emitter resistor (see Fig. 1). If the voltage here is close to that shown on the schematic, the transistor is drawing current. Since this voltage is developed by both collector and base currents, the chances are that this stage is ok if this voltage is ok.

Collector currents? Same thing. Look at the circuit of Fig. 2, with the "grounded" collector. No voltage is applied to the collector, but! There is a load-resistor. If the transistor is drawing the proper collector current, the output signal voltage is developed across this resistor. So, just read the collector voltage and there you are.

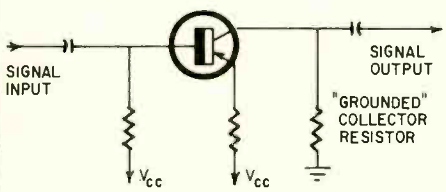

Fig. 2—No collector voltage drop, no current flowing. It's as simple as that.

If there is no voltage the transistor is open, or it is biased to cutoff. Either way you have found some trouble, and it must be fixed before you go any farther.

You'll run into some real wowsers in certain circuits; AGC in transistor TV's, for example. These generally look like quite a bag of worms at first glance, but if you break 'em down, you'll see that they're nothing but a bunch of simple stages tied together.

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Where Electronic Innovation Is A Way Of Life

Circle 21 on reader's service card

Ohm's Law and the voltages on the schematic will help you pin the trouble down in the shortest possible time.

Some of the "unusual" things you will find are AGC or sync-clipper transistors with zero-bias. In transistor circuits, "zero-bias" means base and emitter at the same voltage. A transistor is cut off, under these conditions. There can be no collector-current flow, and thus, no signal output. So, what? If this is the voltage shown *on the schematic,* ok. It simply means that this is the *no-signal* voltage, and that this stage is meant to be a sync-clipper—its *operating bias* is developed by the input signal! If this sounds exactly like a tube sync-clipper, you're right—it is.

In the output transformerless output stages you'll find the same thing. No-signal voltages will be quite

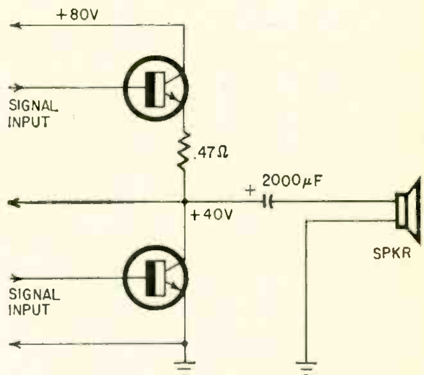

Fig. 3—Two indentical transistors should have identical voltage drops unless something's wrong. (The 40 volts in the middle is developed by the drop across the transistor in the top half of the circuit.)

different from those under full load. In this type of output stage, the transistors themselves make up a voltage divider (see Fig. 3). Note that the two transistors divide the output voltage supply equally. If one of them should get selfish and want more than his fair share, then we get trouble.

Here, we're getting back to one of the first applications of Ohm's Law. Two identical transistor "in series" should have identical voltage drops, just like two identical resistors. If one of the transistors has too much leakage, its bias will be upset, and it will take more than its share of the voltage. (Ohm's Law says that the current through both transistors has to be the same.) So, any unbalance in a circuit like this has to be caused by some "imbalance" in the transistor characteristics. Active or passive elements, transistor or resistor, Ohm's Law still works! **R-E**

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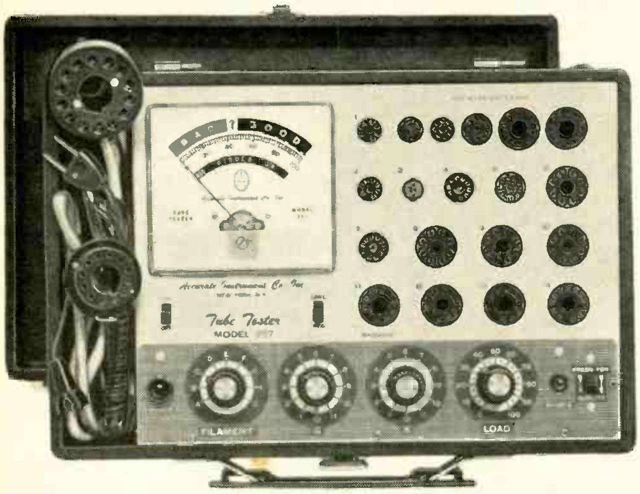

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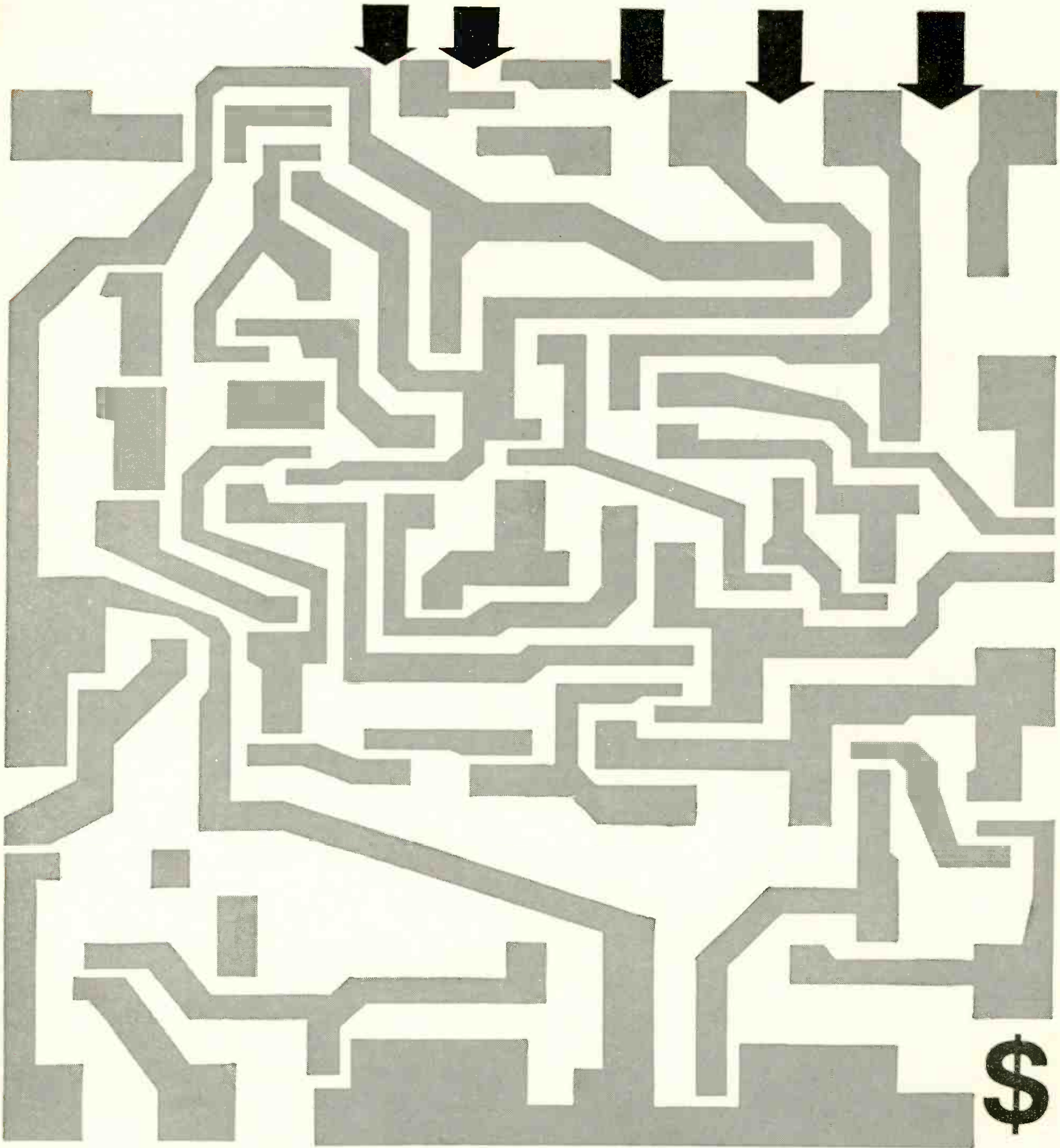

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New Tools Save

Having the right tool for the job is especially important in electronics. Find out why

By BYRON G. WELS

UNLESS YOU'VE GOT A FANCY SHOP AND A WIDE ASSORTMENT of tools at your disposal, you use a minimum group of hand tools. As a result you are probably doubling up, making one tool do some second job for which it wasn't intended. A typical example is the guy who can't see a ½" nut driver because he doesn't use one that often, and when the need does come up, he attempts to tighten those big switch nuts with gas pliers. Result? Scarred and scratched panels at the least and bruised knuckles when the tool slips.

It seems like there are always new and better tools to choose from. Being practical, you don't need them all. Still, a little variety in your tools will make your work or hobby that much more enjoyable, and easier.

Electronic hand tools fall into several major categories. Let's run through these one at a time.

Metalworking tools for building a chassis

Your biggest problem in metalworking is undoubtedly making holes in a chassis or cabinet. While you can probably make a sort-of round hole by scribing a circle and drilling out a series of small holes in the perimeter, you're going to save a lot of time and work by using socket punches. You can get round ones, square ones, D-holes and keyed holes. Simply mark the center of your circle, drill a pilot hole to pass the punch screw, and tighten the nut.

To drill the starter hole, you will need a ⅜" drill. If you have only a ¼" chuck on your drill, don't despair. You can get a ⅜" drill with a ¼" shank to fit your drill chuck. Another way out is to drill a ¼" hole and use a tapered hand reamer to enlarge the hole to the needed diameter. Reamers are handy to have around the shop anyway, for even a hole as small as ⅛" can be easily and quickly expanded to ½" or more.

Mounting flat-head screws requires a countersink, and that's another accessory for your drill. It will enable you to use flat-head screws on outside chassis work, and do away with protruding screw heads completely.

If you can, get hold of a 1" twist drill. While you won't use it to make 1" holes, it's a delight to insert the point of this drill into a hole and give it a half-turn. It neatly deburrs the holes, leaving them clean and ready, even with a slight chamfer around the perimeter!

In this day of etched circuits, you may require an odd-shaped cutout in your chassis, and nothing does this job better than a hand nibbler. I like to start by using a chassis punch on all four corners of such holes, and then I run the nibbler from hole to hole. The result is a straight-line cut with neatly rounded corners.

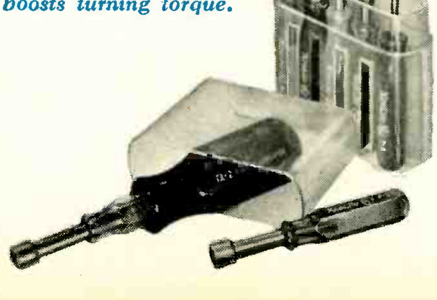
Chassis layout is an important aspect of electronics work. You should have the basic tools to accomplish it properly. Using a square and a scribe, mark off all the holes you need. Where holes are to be made, center-punch the marks. You can use a center punch and hammer or an automatic center punch. With the automatic device, you place the point of the punch on the mark, and press down. A spring releases under sufficient pressure to make a dimple in the chassis.

Many chassis are ruined by improper drilling. Let's assume you have a bunch of holes to drill, and the smallest is a No. 24 hole. Drill all the holes with that drill first. Those that must be enlarged can be enlarged later, the No. 24 hole serving as a pilot for the larger drill. By progressively drilling the larger holes, you'll find that you have to hog out less metal with each succeeding pass, making the work that much easier and neater. Your larger drills will last longer between sharpenings too.

Assembly tools make mounting easier

Now that you've put all the required holes in your chassis, you have to mechanically mount various components to the chassis. The basic assembly tool is the screwdriver, and you'll need an assortment of these. If ever a tool was misused, the screwdriver is it. Naturally, you'll want a flat-bladed driver for slotted-head screws. But if you

Chassis can be riveted from one side with special tools like Vaco's Pow-'Riveter. Prices start at $4.95 for rivet tool.



Drop a nutdriver set into your pocket. Xcelite makes this one. Oversize handle boosts turning torque.

Automatic nutdriver takes 15 standard sizes of nuts and screws and locks into position. Stanley Hex-a-Matic, Price: $10.50.

Time And Dollars

use one too small for a large screw, all you're going to do is chew up the blade. Get a small driver, with a ⅛" blade for installing and tightening setscrews in knobs, and one with a ¼" blade for larger work. A ¼" blade "stubby" will give you additional leverage for snubbing screws down tight. Starting screws is always easier if you use screwdrivers that grip the screw until you release it.

Trying to drive a Phillips-head screw with a flat-bladed driver is another mistake. Frankly, it can't be done properly, with the emphasis on the "properly." To drive a Phillips-head screw properly, you need a Phillips type driver. Again, you'll need an assortment, for the larger sizes just won't grip a small screw and the small ones will just turn in a large screw until the blade gets chewed up.

You'll also need a set of Allen wrenches. You know, those hexagonal L-shaped tools required to tighten some setscrews. While the most frequently used size is 1/16" across the flats, price is so low that you ought to buy the entire set and, at the same time, get a set of splined wrenches just to have them around.

Holding a nut in place while you tighten the screw is usually the job of the lockwasher. However, you can do a far better job with a set of nut drivers, which look like screwdrivers with sockets on the end. A good set will contain the most often used sizes, including ⅛", ¼", 5/16", ⅜" and ½". Spend about another six bits, and round out your collection with a ⅝" and maybe a ¾" for those large switch-retainer nuts.

The ring nuts used on some switches often pose a problem, but there is a ring-nut wrench available that holds and secures these nuts professionally.

Finally, make sure you've got slip-joint pliers for your assembly work. This rugged tool is the one to use for bending back those electrolytic capacitor tabs when you're mounting them to the chassis.

Aids for faster wiring

Wiring tools? Sure! A long-nose pliers and a diagonal wire cutter! Yes indeed, that's an excellent start, but it's far from a finish! Take the pliers, for example. You can get them in a variety of types and sizes, some with built-in springs to open them after you close them. Others come with right-angle noses for easier wiring; still others are available with side cutters or end cutters. You can get them with short, square, or needle noses.

Cutters? An equally endless variety! One of the latest in wire cutters is a special cutting jaw that makes a cut and then flattens the end of the wire. It's an ideal tool for etched-circuit work, for the flattened lead wire can't drop out of the hole. You can get all these tools, incidentally, with an insulated, cushioning handle.

Shortly after World War II, surplus medical supplies made their way into the field, and the most popular among these was a device called a hemostat, or forceps, or medical clamp. Now these units are being manufactured expressly for the electronic trade and make a handy wiring tool, for they act as a third hand. Clamp something into place, and it stays there until you release the clamp.

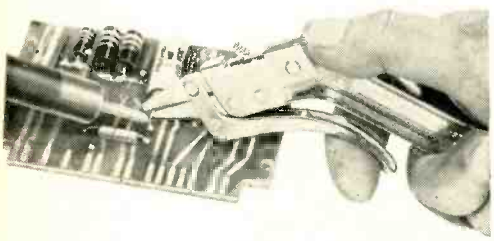
Wire strippers are another tool that come in goodly assortment. Oh sure, you can use a knife or an old razor blade, but a good wire stripper soon pays back its cost in time saved, not to mention blood.

A crimping pliers is another great time-saver when it comes to mounting connecting lugs on wires. The pressure exerted by this tool is so great that tests have shown an actual dendritic seal between the wire and the connector, at least as good a connection as you could get by soldering.

Soldering doesn't have to be hard

The purpose of a soldering device is to heat a joint sufficiently to melt the solder through the joint. By far the most convenient tool toward this end is the soldering gun. Even the soldering gun, however, has undergone a number of drastic changes. You can get them in variable-heat or controlled-heat models. Modern soldering-gun accessories include a solder feeder that applies solder to the tip when you press a trigger mechanism. An assortment of tips is available for every type of soldering job.

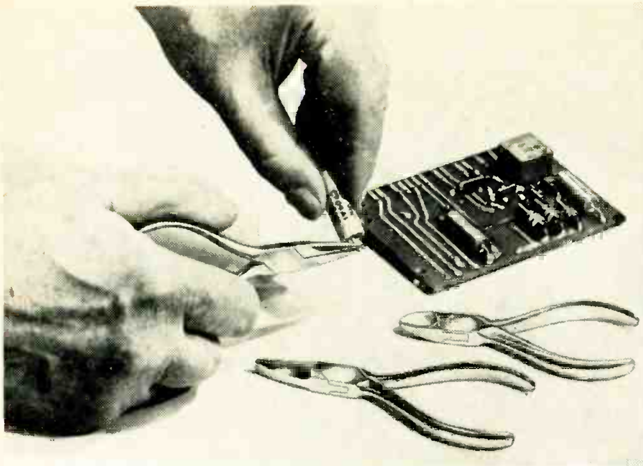
Soldering irons are available in a wide variety of types, wattages and sizes. The advent of printed circuitry has produced a family of soldering tools that are a breed unto



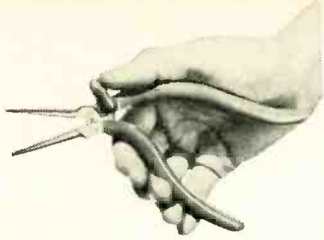
A "third hand" for small assembly work, the X-Acto Lock-Griplier also serves as a wrench, stripper, wire cutter and pliers.

Vacuum created by spring-loaded piston on Edsyn's Soldapullt draws in solder.

Self-feeding soldering guns leave one hand free to hold work in place. Squeeze trigger on this Skil Model 340 to advance up to 3/16" of solder and heat tip. Dispenser holds 10' of solder.



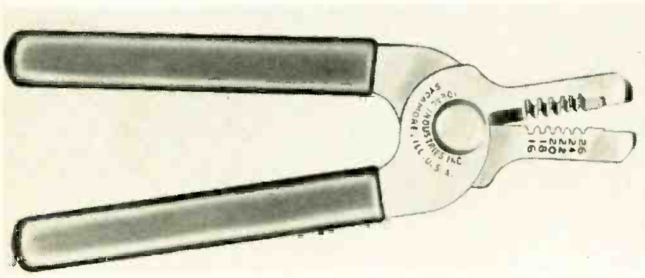
Miniature pliers are handy in tight corners. Here 4½-in. long-nose with side cutters is being used to bend component leads for printed circuit board mounting. X-Acto No. 54, $4.75.



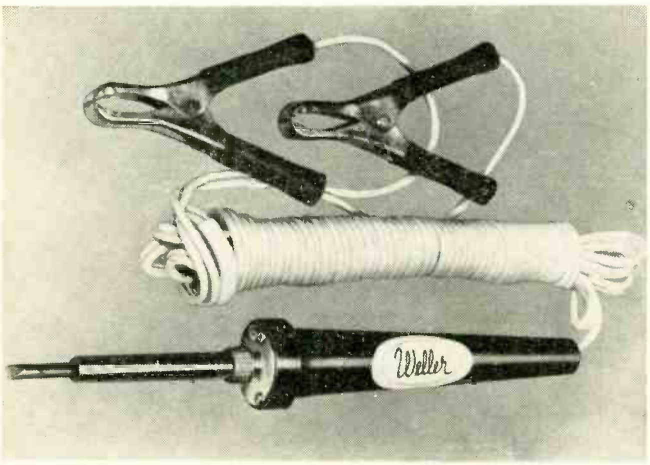
Curved handle on long-nose pliers (above) makes it easier to use. Spring action keeps jaws open. Mathias Klien & Sons.

Self-adjusting wire stripper (top right) takes any wire from AWG No. 8 to AWG No. 24. Plastic grips. Telvac Model T-52.

Desoldering iron (right) makes for fast removal of solder on miniature circuit boards. One-hand operation. Endeco 300.



Wire stripping is easier when you use the proper tool. This unit, made by Ideal Industries handles six different wire gages. It also has a slim nose for getting into tight corners.



Battery-powered soldering iron makes it easy to solder outdoors. Clamps onto 12-volt car battery terminals. Temperature controlled with 700°F, 3/16 in. tip. Weller Model TCP-12.

themselves, including a wide disc-type tip used for melting the entire circuit at a time, essential for removing i.f. transformers or tube sockets from a circuit board.

Recent innovations in soldering tools include solder suckers, an aluminum tube with a flexible bulb at the end. You dip the tube into the molten solder, and release the bulb. The liquified solder is drawn up the tube and away from the circuit. Aluminum brushes are available to help sweep away melted solder, too. Why aluminum? Solder doesn't easily adhere to aluminum. If it did the tool would be ruined.

Special coatings on soldering tools have all but eliminated the need for periodic tinning. But to keep your soldering tools in good shape, you ought to have a wire brush for removing oxidation, and perhaps a file for dressing down the tip occasionally.

Another change has taken place in recent years, and that is the trend away from electrical soldering tools, especially for heavy-duty work or outdoor soldering. I've noticed a growing interest in the use of flame-type soldering tools. Miniature blow torches using compressed gases such as liquid propane and oxygen are coming on the scene. These tools place a highly concentrated pinpoint of heat on a joint and, while it seems drastic, users claim that they never get cold solder joints.

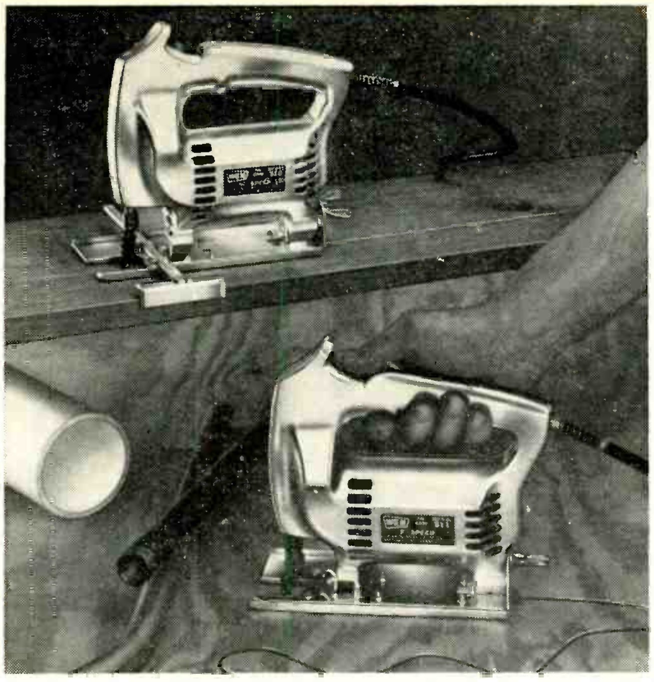
No one soldering tool can do every job. For work in the field, the soldering gun is ideal. It heats quickly and cools equally fast, ready to go back in the kit. Some people prefer an iron or soldering pencil for a few hours of bench work, however, for the absence of a transformer makes the tool lighter and easier to handle. But soldering takes many forms. You'll be working on delicate etched circuit boards one minute, and then trying to solder a No. 12 wire to a ground formed by a slot in a massive chassis. An iron large enough to make that ground will burn up a circuit board, and the little pencil iron for the circuit board won't even flow the solder on the ground. The answer? At least two soldering tools.

Circuit alignment requires the right tools

Now we come to an area that can easily fill your tool kit. However, only a few basic tools are needed if you select them wisely and in the field of your own interests. Again, be sure to consider these tools in the light of the work you will expect them to do.

Alignment tools are generally used to adjust circuit elements, often in inaccessible places. How inaccessible and what sort of adjustments are the factors that control your decision here. One essential is a small mirror, preferably illuminated. For if you can't see it, you can't adjust it.

More often needed is a small plastic or phenolic screwdriver for adjusting ferrite cores in coils and i.f. cans. These tools must be nonferrous and nonmagnetic. That's why plastic is so common. Some slugs are rather brittle, and



When it's wood that needs cutting this pair of power saws can handle just about any task. The WEN Model 510 is a high-speed jig saw. The Model 511 is a 2-speed jig saw.

the wrong tool can cost you a new coil. Other slugs have hexagonal sockets for Allen-wrench alignment tools, and these are also available in plastic. Many can be obtained with two or more sizes on the one tool.

Many military electronic devices use a system in which a hexagonal nut locks an adjusting screw in position. To tune these units, a special alignment tool is available, which is constructed coaxially. An outer shell is fitted with a hexagonal socket and inside this shell a plastic screwdriver turns freely.

Anybody who has ever adjusted the slugs in a TV tuner knows that you're going to have to buy a special screwdriver with about a foot-long blade to reach them in some sets.

Power does it easier

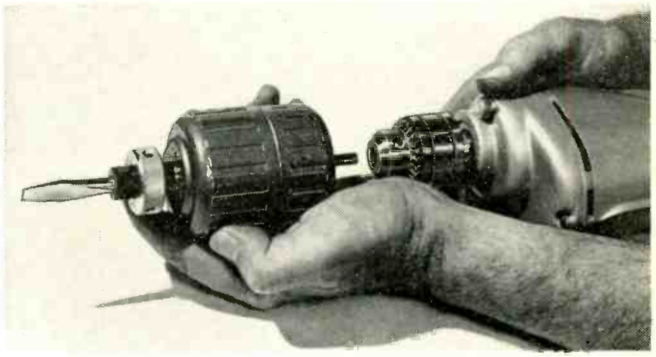
Just about any tool you can get in hand-operated form is available powered these days. These work-savers go a long way toward simplifying the dog work that used to be required in electronic metal forming. Most popular, of course, are the electrically powered tools, although many are also available with air power. The old standby, the 1/4" electric drill, now boasts a series of attachments that include powered screwdrivers, sanders, saws, and buffers.

New features are springing up all the time, and the very latest units off the assembly line have electronic controls that provide you with infinitely variable drill speeds, depending on the pressure you exert on the trigger. One unit recently announced has a lever just ahead of the trigger. Chuck a screwdriver blade into this tool, start the tool turning slowly, and you can easily run a screw into wood. Flip the little lever the other way, resume pressure on the trigger, and the screw comes right out again. These reversible tools are made possible by the great advances in solid-state controls.

To make these tools more flexible, get a bench mount that locks your drill to the workbench. It now becomes a bench motor for any bench-top operation, including use of a flexible shaft. Other attachments turn your drill into a drill press.

If you do industrial work, an electric wire wrapping tool can save a lot of time and effort. This Thor Model E101 is typical of the many available.

Quarter-inch power drills are a must. But this one has an added feature—it's reversible. Adjustable speed too. It's a Skill Model 596-5. Ac only.



Older single-speed drills can be used to drive screws. All you need is an add-on screwdriver accessory. This one, made by Channellock is for a 1/4-in. drill. It turns in both directions.

Three-wire vs double-insulated

About a year or so ago, one manufacturer announced that all his power tools were going to be double-insulated instead of three-wire grounded. The three-wire grounded tool was recognizable by the third grounding terminal that protruded from the plug. Unfortunately, while this idea was a good one, not all ac outlets are set up for that third leg. Too often, technicians took to clipping the ground leg off or plugging it into an ungrounded 3-to-2 adapter. The result, of course, was no safety factor at all, and a lot of bad electrical shocks, should the internal insulation break down.

The double-insulated tool has a doubled layer of internal insulation arranged to insure that the wiring inside can never contact the outer parts of the tool itself. Only the familiar two-pin plug is used, and the tool is electrically safe.

This announcement created a furor in the industry. Manufacturers who hadn't planned to retool for the new system started looking for ways to punch holes in the idea. "Drop the double-insulated tool in a tub of water, and see what happens!" "What happens if you drill into a wall and hit an electrical wire?" The answer came back: "How do you force your customer to use that third wire ground properly?" "What happens if the outlet is used properly and the ground leg is burned open from a previous short?"

To sum it all up, there's a tool for just about every job you have. And having the right tool can make that job very much simpler. Having read this article you should now be ready to select the specific tools you need, and choose them wisely. **R-E**

Hi-Fi Testing On A Budget

Make accurate audio measurements yet keep equipment costs low

By PETER E. SUTHEIM

YOU DON'T NEED HUNDREDS OF DOLLARS' WORTH OF exotic equipment to make valid and accurate audio measurements. If you have the money, instruments are available that can make the job easier, or the results more precise, but you can accomplish a lot with basic instruments you may have already acquired.

Suppose we begin by drawing up a list of instruments and devices useful in making audio measurements:

- Audio oscillator
- Dummy-load resistor(s)
- Oscilloscope
- Audio vtvm
- Intermodulation meter
- Harmonic-distortion meter

Let's examine each of these instruments and see just how much accuracy you need, what kinds of features are desirable, and what you can expect to pay.

Audio oscillator is a must

If you want to do no more than measure an amplifier's maximum power output at its overload point, you don't even need an audio oscillator (or audio generator, as it's sometimes called). The 400-Hz audio test tone from an all-purpose rf service generator will do. Even 60-Hz current from the ac power line will serve (brought through a filament transformer for isolation and stepdown).

But a variable-frequency audio oscillator is a must for checking tone-control and equalization curves, finding resonances in speakers and enclosures or in transformers and measuring frequency response.

Oscillators in the service-and-hobby price range are all resistance–capacitance feedback types—either Wien-bridge or Sulzer circuit. Most are continuously variable over about a decade of frequency (e.g., from 20 to 200 Hz); a range switch provides four decades (sometimes five are provided).

Another type of audio generator uses a set of three switches to select two significant figures and a decade multiplier. For example, you would select 1400 Hz by setting one switch to 10, the second to 4, and the multiplier to 100. You can get 1300 or 1500, but not 1420 or 1435. This has an advantage: it lets you return precisely to a particular frequency. Increments are small enough for ordinary frequency-response measurements.

Two instruments of this kind (Heath IG-72 and Eico 378) both have front-panel meters calibrated in volts and decibels. This dual calibration is a useful feature, since one way or another it is important to monitor generator output level. A frequency-response curve is meaningless if the input level to the circuit under test is not constant (or at least known) at all frequencies.

What about square waves?

Several generators also produce square waves over a broad frequency range. My advice would be to spend your money on the best (lowest-distortion, most-convenient) sine-wave generator.

First of all, square waves are useless without an oscilloscope to observe them. Second, you can easily and cheaply buy or build a device for generating square waves or converting sine waves to square waves. Square waves are useful for checking certain aspects of amplifier performance, but they are not essential.

On the other hand, square waves tell absolutely nothing about an amplifier's nonlinear distortion, a characteristic most important to audible sound quality. An amplifier that perfectly reproduces a 10-kHz square wave at full power may still sound lousy, but you'd never know it from the square-wave test alone.

Measuring harmonic distortion

If you don't plan on measuring harmonic distortion, almost any audio generator will do. If you do want to measure distortion, the generator's own distortion must be as small as possible. This is getting to be a problem. The best service-and-hobby generators have distortion of 0.1% to 0.2%, but even that is too high for precise measurements on today's audio equipment. Modern preamps often have as little as one-tenth that amount. Unless you can afford a several-hundred-dollar lab generator and a suitable filter, you will have to be content with the 0.2% of inherent distortion.

At least as important as the generator's distortion is its *flatness*, or uniformity of output. It is a nuisance to have to monitor the output level and reset it every time you change frequency. If you have the chance, run the generator through its ranges before you buy it. It should be flat within 1 dB (about 10%) from 20 to 20,000 Hz, at least. Check especially the extremes of each decade range.

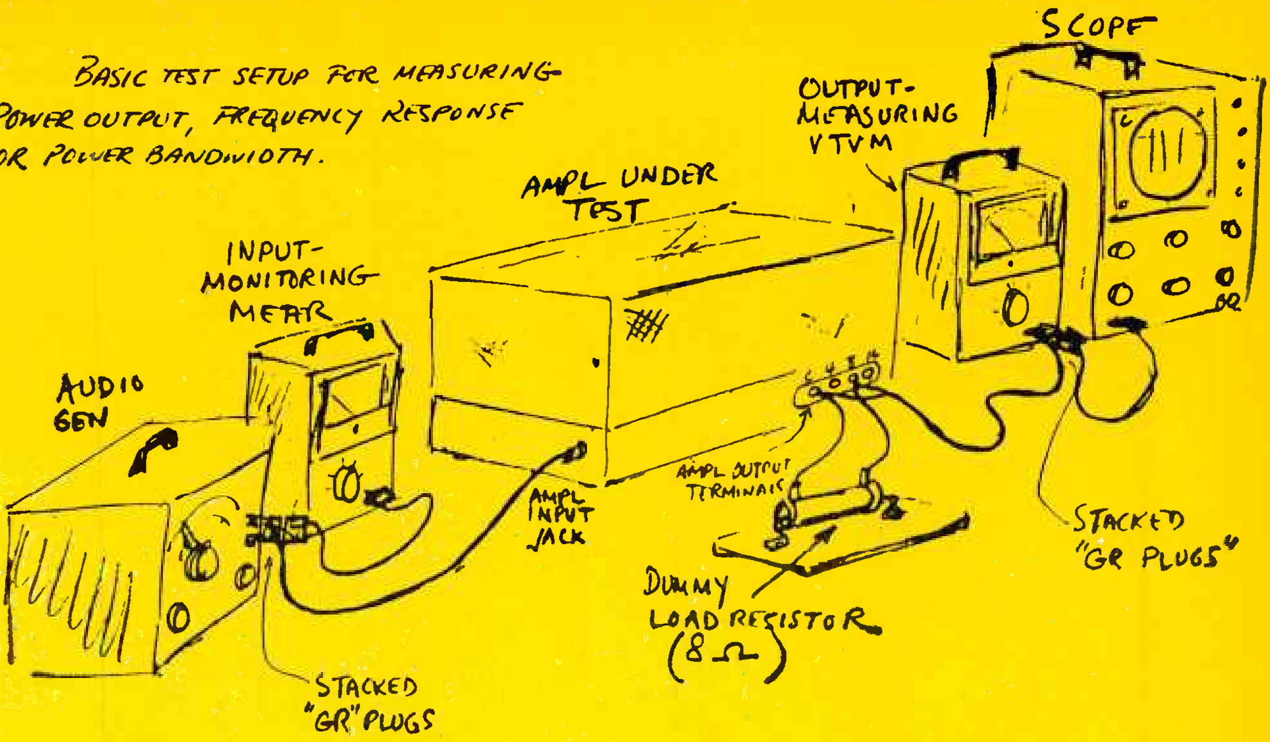
It's convenient if the generator has a relatively low output (source) impedance: 600 ohms is standard, but not necessary. A high source impedance means that the output level will drop, and the distortion possibly rise, when you feed the generator output into a relatively low load impedance. This can be important with transistor circuitry. Also, with a high source impedance, a capacitive or inductive load will affect the flatness of the output.

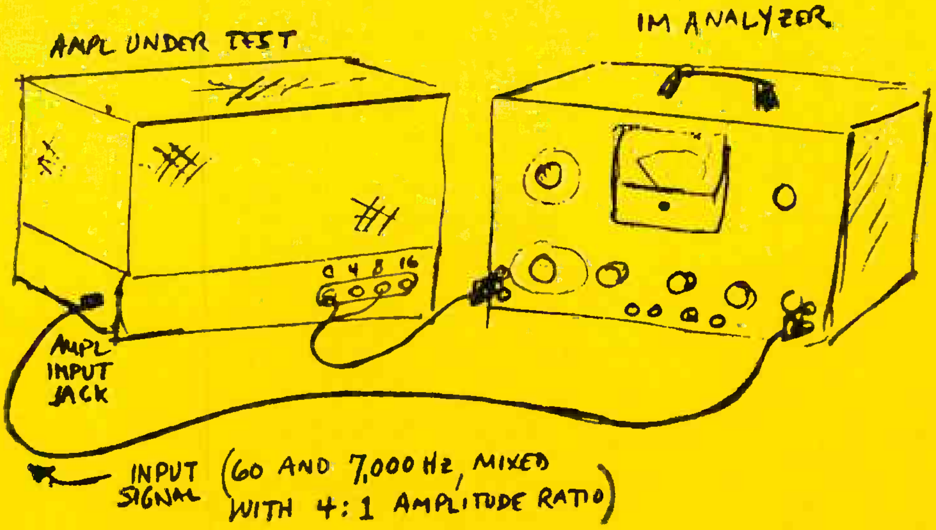
Dummy loads—when you check output power

For its own safety, and to get a meaningful measure of power output, a power amplifier must be terminated in a resistance. Usually it's 8 ohms, because that's the nominal impedance of most hi-fi speaker systems.

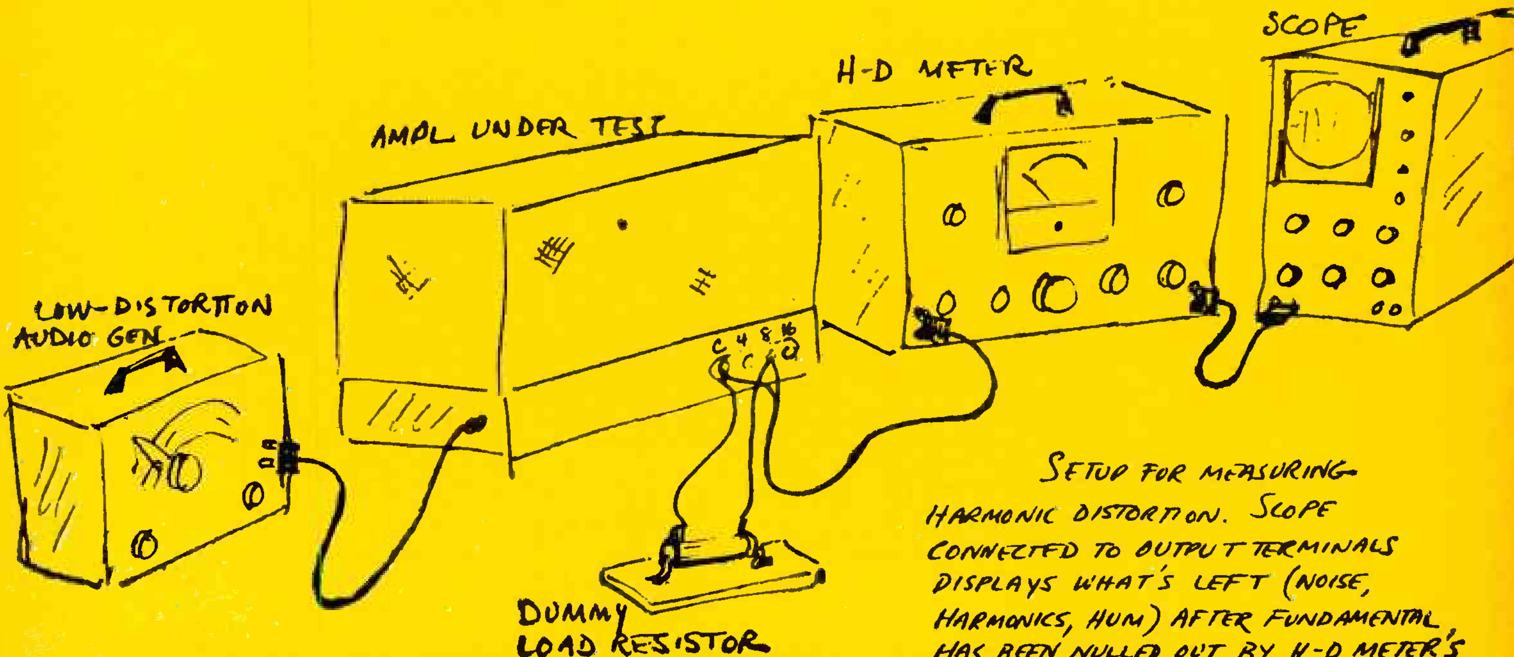
For critical measurements at high frequencies, especially ones involving square waves, the resistor should be noninductively wound. Most wirewound resistors are simple coils of wire and have some inductance, which increases

BASIC TEST SETUP FOR MEASURING POWER OUTPUT, FREQUENCY RESPONSE OR POWER BANDWIDTH.





TEST SETUP FOR MEASURING IM DISTORTION. TEST SIGNAL IS PROVIDED BY ANALYZER, WHICH MAY ALSO CONTAIN SUITABLE LOAD RESISTORS.



SETUP FOR MEASURING HARMONIC DISTORTION. SCOPE CONNECTED TO OUTPUT TERMINALS DISPLAYS WHAT'S LEFT (NOISE, HARMONICS, HUM) AFTER FUNDAMENTAL HAS BEEN NULLED OUT BY H-D METER'S WIEN-BRIDGE CIRCUIT their impedance at high frequencies. For ordinary measurements, this increase is small enough not to be troublesome, so an ordinary 8-ohm, 50-watt wirewound resistor is suitable for most hobby and service work. A 10% tolerance is adequate, but 5% is desirable. Unfortunately, 8 ohms is not a common stock value for wirewound power resistors. You may have to purchase two 4-ohm resistors, or a 5 and a 3. Dale manufactures on 8-ohm, 50-watt, 1%-tolerance resistor with a finned aluminum housing for just over $2 (Allied Radio Industrial Catalog).

To measure the total power output of a stereo amplifier, you will need two load resistors, one for each channel. Try to get two 8-ohm resistors. Then you can get 4 ohms by paralleling them or 16 ohms by connecting them in series.

Oscilloscopes for audio

A scope is one of the most useful electronic test instruments ever invented. I think of it as a window into a circuit. Once you've learned to interpret scope patterns, you can *see* what goes on in a circuit in a way you can't do with any other device. It is almost indispensable for serious audio work.

For audio work the most modest oscilloscope will suffice. Even the least expensive kit scopes now have vertical-deflection response to about 200 kHz, which is adequate for reproducing even square waves up to about 10 kHz. Wider response is useful, but not absolutely necessary—ditto for response down to dc.

The most important application for a scope in audio work is seeing what kind of distortion or junk is coming along with the signal. It lets you distinguish between hum and noise, or hum and harmonic distortion. You can learn whether you have mostly odd- or mostly even-harmonic distortion, and come to certain conclusions about the performance of the circuit.

A scope with triggered ("one-shot") sweep is a great convenience, but comparatively expensive. It is not really necessary until you begin making more sophisticated measurements, like tone bursts, which are a bit beyond the needs of audio hobbyists and servicers. If you already own a scope, it is probably adequate for general audio work. You will soon find yourself hooking the scope across the output of every amplifier, as a matter of routine. Without it, you'll feel blind.

Voltmeters for audio testing

Almost any kind of ac voltmeter is usable for audio testing, but the simple iron-vane meter has serious limitations. Its impedance is low, its frequency response is limited, and its sensitivity is insufficient for almost everything except power-output measurements. Much better are the conventional vom's and vtvm's.

A vom is suitable for power-amplifier output measurements, because the source impedance is only a few ohms and the voltage is relatively high. For measuring the output of a preamp, you must use an instrument with a high input impedance. A conventional service-type vtvm will do (its input impedance is usually about 1 megohm on ac ranges), but its lowest range is usually about 1.5 volts rms full scale.

That will take care of a lot of work, but occasionally you will have to measure much lower voltages, at high-impedance points, and for that you will need an audio vtvm. Modern ones have input impedances of the order of 10 megohms, with very little shunt capacitance, and full-scale ranges of 0.01 volt (10 millivolts) or lower. With them you can measure the outputs of many microphones or pickups directly.

An additional advantage of audio vtvm's is that they are calibrated in dB as well as in volts. Their ranges are set up in "root-decade" fashion, with each range 10 dB higher or lower than the adjacent one. This simplifies reading and calculation. (An excellent build-it-yourself audio voltmeter, all-transistor and battery-powered, appeared in the March 1966 issue of RADIO-ELECTRONICS.)

Measuring intermodulation distortion

One of the most important characteristics of an amplifier is its linearity—the degree to which the output voltage or power remains exactly proportional to the input voltage or power. Any deviation from perfect linearity results in distortion. Harmonics (frequency multiples) of the input signal appear. If two (or more) signals of different frequency are applied simultaneously to a nonlinear amplifier, they intermodulate, and produce undesirable sum-and-difference tones.

But to reproduce sound with high fidelity, an audio amplifier must be perfectly linear. What went in should come out unchanged—just bigger. For a sensitive indication of an amplifier's nonlinearity, apply two input tones.

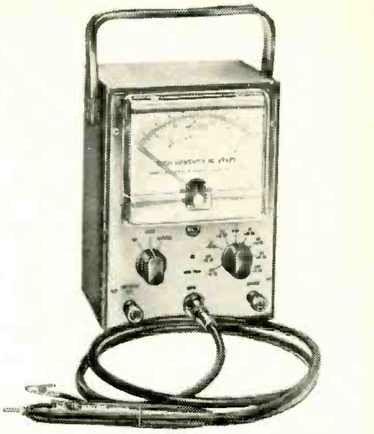
The two frequencies most commonly used are 60 Hz and 7000 Hz. At the output, the 60-Hz tone is filtered out. Then the 7000-Hz signal is rectified (demodulated). The output from the rectifier should be pure dc, but if the amplifier is even slightly nonlinear (as all amplifiers are) some

Heathkit IM-12 Harmonic Distortion Meter

Eico 902 IM/Harmonic Distortion Meter

Scope for audio needs only moderate response. Sencore's PS 148 has plenty.

Knight KG-688 Sine/Square Wave Generator. Square wave function is useful.



Use an ac vtvm for audio. RCA's WV-76A response is flat from 10 Hz to 1.5 MHz.

60-Hz signal will appear because it will have modulated the 7000-Hz signal. *Mixed* tones can be separated with filters; intermodulated tones can't. The amplitude of the 60-Hz signal is read on a meter that is calibrated in percent intermodulation.

There is continuous argument in audio engineering circles about the validity of this test. It is influenced to some extent by the frequencies chosen. Certain kinds of non-linearity are not uncovered by this method. Still, it seems to be true (in practice if not in theory) that if an amplifier's intermodulation distortion is low (well under 1%), its harmonic distortion will also be small and it will sound pretty good (assuming, of course, that its bandwidth, signal-to-noise ratio and overload characteristics are good also).

Harmonic distortion—the production of integral multiples of the signal frequency—is really another aspect of the same thing. You can gauge the nonlinearity of an amplifier by the IM method or the harmonic method—and, again, expect good (but not perfect) correlation.

Most audio design labs measure both during the design process. Some choose to quote only an IM figure in their published specs, some quote only harmonic distortion, and some give both.

If you expect to do some audio design work, you will probably want to acquire both types of instrument. If you will work mainly with existing amplifiers—repairing or improving them—an instrument like the Heathkit IM-22 is an excellent buy. It is a complete intermodulation measuring instrument (it even provides the low- and high-frequency signals), and it incorporates a wide-range audio vtvm. It has 4-, 8-, 16- and 600-ohm load resistors built in, and the meter reads power in watts directly.

The Eico 902 (wired only) combines harmonic and IM measuring facilities with an audio vtvm. Combined with a low-distortion generator and a scope, it makes a basic audio lab.

As I pointed out when we spoke about generators, distortion levels in today's hi-fi equipment are so low that attempts to measure distortion are often frustrated. To check the performance of the best of modern components, you need instruments costing many hundreds of dollars. Quite often, you'll find when measuring, say, a recent audio preamp, that it makes no difference to the distortion reading when you remove the preamp and replace it with a piece of wire across the meter's terminals. The distortion-meter pointer is down in the mud either way. In other words, the inherent distortion of your measuring equipment is very likely a whole order of magnitude greater than the distortion of the preamp!

Miscellaneous bits and pieces

Clip leads! Test leads! Make your own if you like or buy them ready-made (see your catalogs), but *do* equip yourself with enough reliable clip leads. Most audio test instruments are fitted with binding posts spaced ¾" apart; these accept standard dual banana plugs.

For example, it is often convenient to connect one test-lead pair, with alligator clips at one end, to the dummy-load resistor, and to plug the other end into, say, your audio vtvm. If you wish, you can now connect your harmonic-distortion meter and your scope also in parallel with the load and the vtvm simply by connecting a patch-cord with G-R plugs on both ends from scope to distortion meter, from distortion meter to audio vtvm—plugging into the back of whatever plug is already in there. This avoids the need for having eleventeen alligator clips hanging precariously onto one set of terminals.

This procedure can make unforeseen trouble when you are working with high-impedance circuits and high audio frequencies. In effect, you are paralleling all the instruments, and therefore adding up not only their own input shunt capacitances but also the capacitances of each of the interconnecting cables. At a typical coax-cable capacitance per foot of 25 pF, the total capacitive load on the amplifier stage under test can easily reach several hundred pF, which at 15,000 Hz might have a reactance of only 20,000 ohms or so. This could affect the distortion and frequency response of a high-impedance stage very severely.

For checking amplifier noise or crosstalk, you will find it helpful to make up some shorting phono plugs. Bend about 2" of No. 12 or No. 14 bare solid-copper wire into the shape of a screw eye. Push the straight end into the center pin of a photo plug (RCA plug) and solder it. Flow solder around the shank of the plug and into the gap where the wire loop closes on itself. You have now solidly shorted the inner and outer contacts of a phono plug, and also provided a handy loop for pulling on. With this shorting plug, you can short signal inputs to prevent erroneous indications during noise measurements.

So there you have a list of basic audio instruments and accessories from which to choose in setting up your own audio lab. One final word: You'll probably be happiest, and make the wisest purchases, if you buy just one or two of the most important instruments at first (like generator and scope) and wait before buying others until you really *need* them—until you feel you can't get on without them. Otherwise you may feel overwhelmed by a shelf of instruments you haven't yet learned how to use, and whose purpose isn't too clear. That can be scary. **R-E**

Newcomer's Guide To New

Modern test gear has increased versatility and accuracy. Update your bench with solid-state portability.

By MATTHEW MANDL
CONTRIBUTING EDITOR

PROPER TEST EQUIPMENT IS A MUST FOR RAPID, ECONOMICAL servicing of receivers. For the newcomer, careful selection is necessary to keep within budget limits and yet have enough equipment to do a job.

For the experienced technician problems also exist. What equipment should be replaced with newer and better units? What types will cut troubleshooting time; which can serve both radios and television sets, and which can test tube as well as solid-state circuits?

A certain minimum number of test devices must be on hand to handle repairs. Additional equipment can be obtained later to expedite servicing of hard-to-find troubles and intermittents. To get the most from equipment the technician must understand its capabilities, and be able to apply this knowledge to faulty circuitry.

Vom's and vtvm's—the basic instruments

Modern volt-ohmmeters and vacuum-tube voltmeters offer overload protection, greater ranges, portability, solid-state components, and higher accuracy. The vom or vtvm is a must for the servicing group and electronic hobbyist or novice. Essential meter functions include ac and dc voltage readings and resistance measurements. High input impedance assures minimum loading of circuits (tube or transistor) and better accuracy.

Typical meter applications for checking a solid-state power supply are shown in Fig. 1. Solid blocks are checks made with power on, while the broken-line blocks represent tests with circuit power off. Note the variety of checks possible on such a relatively simple circuit. Similar checks apply to all radio and TV circuits. The tests illustrated cover:

1. Ac input and switch operation
2. High-voltage secondary ac output
3. Heater voltage
4. Rectification (diode operation)
5. Diode forward and reverse resistance
6. R1's resistance value
7. Shorted or open filter capacitor
8. Voltage at filter network output
9. High- and low-voltage output
10. Open R3 bleeder section.

A vtvm has an input impedance of about 10 megohms for the dc scale, but the input impedance of a vom depends on the sensitivity of the meter movement. You can get inexpensive multimeters with a 1000-ohms-per-volt rating, but a 20,000-ohms-per-volt or higher rating is preferred. If you are reading 2 volts across a 2000-ohm resistor in a transistor circuit, your 1000-ohms-per-volt meter will shunt another 2000-ohm resistance across the resistor you are measuring and the reading will be inaccurate. With the 20,000-ohms-per-volt meter, there would be a 40,000-ohm input impedance. (At a 100-volt reading the input impedance is 20 megohms—higher than the average vtvm's.)

Whether you build a kit or buy a finished product, get the best instrument (in terms of sensitivity, versatility, etc.) within your budget capabilities. Kits will provide you with knowledge of the circuitry of the instrument so that you can make repairs more easily when necessary. A disadvantage is the resale or trade-in value when you want to switch to a new or better model.

A variety of vom and vtvm kits is available. Eico Electronic Instrument Co. has vom units ranging from a 1000-ohms-per-volt type (less than $10) to a 100,000-ohms-per-volt meter (over $30). Eico's vtvm also reads peak-to-peak voltages and hence is useful for TV servicing measurements. As with kits by other manufacturers, these units can also be purchased completely wired and assembled if desired.

Heath has a new solid-state portable vom (IM-17) with an 11-megohm input on dc, 1 megohm on ac and four ranges on dc, ac and ohms. Preassembled, transistorized vom units are also available from Triplett, Sencore, and others, using field-effect transistors. The Triplett Model 600 TVO has a 400-mV dc range at 2.7-megohm impedance for solid-state circuit testing. The Sencore FE14 meter features a zero-center scale of 0.5 volt for simplification of transistor circuit testing.

High-voltage probes and other accessories are generally available for TV high-voltage testing and high-frequency measurements.

Tube and transistor checkers

Despite the increase in solid-state radio and TV receivers, we will have to service tube sets for some time yet. Thus, a tube checker is still a valuable test-bench instrument. Modern checkers can test picture tubes, compactrons, nuvistors and other special tubes found in modern receivers.

Lower-priced testers check tube emission and compare current flow (for a given voltage) with standards for a good tube. More expensive tube checkers test mutual con-

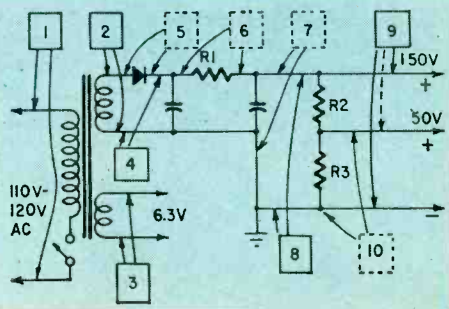


Fig. 1—Meter test on this solid-state power supply shows versatility of vom's and vtvm's. See text for tests.

Radio And TV Test Gear

ductance, a dynamic test simulating actual circuit conditions: the ratio of plate-current change to a grid-voltage change, with plate voltage held constant. Prices for mutual-conductance tube checkers range from slightly below $60 to over $175, and selection again depends on our budget limitations.

One lower-priced commercial type is the Model 257 of Accurate Instrument Co. This unit tests novars, nuvistors, 10-pins, magnovals, compactrons, decals, and all TV picture tubes—in all, more than 2500 tube types. Accurate's checker can be used to test emission, interelement shorts and leakage.

The B&K Dyna-Jet 606 is another emission-type tube tester selling below $100. This is a portable tester with a multiple 13-socket design using only 4 test settings. Model 707, a dynamic mutual-conductance tester, is also available from B&K, selling at close to $200. It features in-set tube checking, and tests each section of multisection tubes separately.

Another dynamic mutual-conductance checker is the Sencore MU140, which uses four-way testing: mutual conductance with a 5-kHz square wave, full cathode emission, 100-megohm grid leakage and internal short checking. For convenience, switch numbers correspond to pin numbers given in tube manuals.

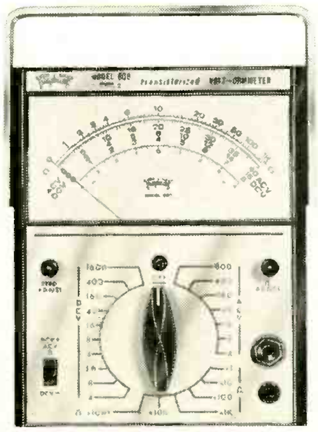
An ohmmeter in the MU140 can be used to check forward and reverse resistances of transistors. Thus, short or open circuits can be tested between base and emitter, emitter and collector, etc. Because of the great variety of solid-state devices, however, units designed for semiconductor tests should be used to find the true conditions and characteristics of components under test.

Transistor checkers are smaller and less expensive than tube checkers because of the relatively low voltages needed, plus the fact that no filament potentials are required. Some models sell for less than $25, with about a $5 saving if you build from a kit. One such model (available either in kit or finished form) is the EMC Model 212 transistor analyzer. It checks dc gain (beta) of all transistor types, as well as leakage. This unit also has a test signal for audio or rf circuits for signal-tracing purposes. The 212 can measure battery or other transistor-circuit power supplies up to 12 volts.

In-circuit testing of transistors and other solid-state devices is a convenience technicians look for. Unlike tubes, the majority of transistors are soldered into a circuit, and removing them becomes a soldering chore. The Sencore TR15A in-circuit transistor tester (less than $100) permits testing of any transistor, diode or rectifier without disconnecting leads. Beta measurements are made by pressing a test button for immediate reading of ac gain. The TR15A also reads exact leakage current (from 0 to 5000 μA).

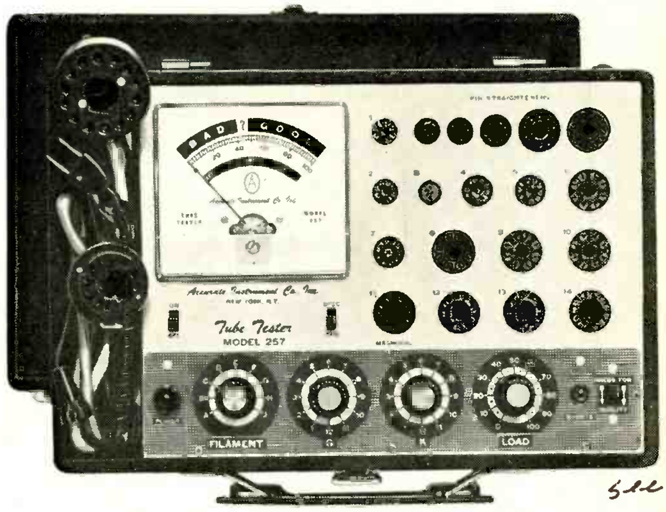
The TR15A also has built-in protection features, which prevent damage to either the transistor circuit or the instrument. This protection feature is being found more and more in test instruments, and is important since we're all apt to forget proper range settings and damage instru-

NEW TEST GEAR



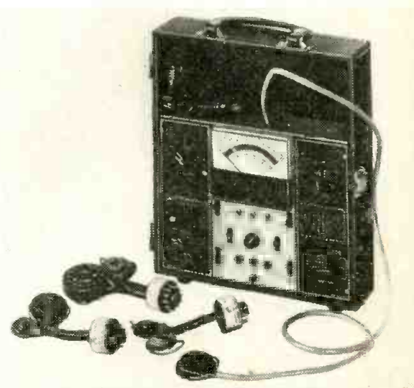
FET vom's like Triplett's model 600 have high input inpedance.

In-circuit solid-state tests are easy with Sencore TR-15A.



see 25

You can test the latest tube types for emission, shorts and leakage with Accurates Model 257. $47.50.



Test a wide range of b/w and color cathode ray tubes with Amphenol's CRT Commander Model 857.

Some color generators combine color bar and dot functions. Mercury Electronics' Model 1900 solid-state unit costs $100.

A complete signal source for b/w or color sets: B&K Model 1076 Television Analyst. The deluxe model price is $331.

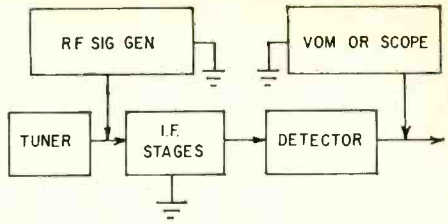
ments. This feature is also of great value in vom's. (Simpson claims protection approaching 100% for its Model 260-5P vom. A reset button pops out to indicate overload, and the button can't be reset while the overload is present.)

Most in-circuit testers will also identify whether transistors are npn or pnp types, and can also be used for out-of-circuit testing of solid-state units. When selecting such instruments compare the published specifications, features and versatility. Some testers are available in several models with varying sizes of meter scales, etc. (The deluxe Sencore TR-139 has a 6″ meter instead of the 4½″ in the TR15A—and a $20 price differential. The B&K Model 161 in-circuit transistor tester features a 7″ mirrored meter for easier reading.)

Rf generators for signal tracing

Radio-frequency signal generators are useful for signal tracing and alignment of radios. As shown in Fig. 2, the signal can be injected into the i.f. stages and measured at the detector with a vom or scope. The generator should have provisions for audio modulation of the rf signal, and the audio tone should be available from a terminal on the instrument for checking audio stages.

Fig. 2—Connections for signal tracing or alignment of radio and TV receiver sets.



If you expect to buy a signal generator, however, it might be well to get one that can also be used as a *marker generator* in FM and TV sweep alignment. You can then use it for radio servicing as well as TV troubleshooting and alignment.

Because FM and TV have wide-band i.f. response curves, sweep generators are a must for rapid alignment. In a sweep generator, the rf signal frequency set on the dial is increased and decreased at a rapid rate slightly below and above the bandpass limits of the i.f. response. When this signal is injected into the i.f. stages of a TV set and a scope placed at the detector, the entire response curve becomes visible, as shown in Fig. 3-a. Various dips will be in evidence (caused by traps) and these as well as the proper right-hand slope can be checked.

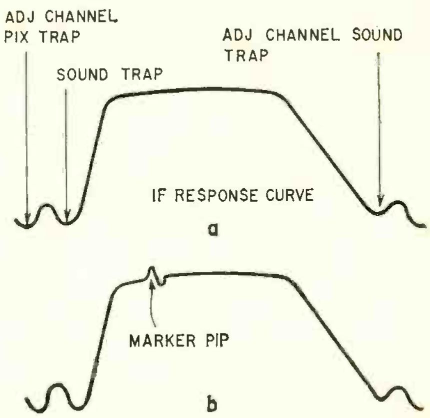
Because the signal sweeps back and forth, there's no way of telling what the frequency is at any particular location unless a marker generator is used. This is a single-frequency generator (either a separate unit or built into the sweep generator), which sends a signal into the i.f. stages along with the sweep signal. The result is a *marker pip* on the curve (Fig. 3-b). As the marker frequency is adjusted, the pip will ride to the right or left portion of the curve. By reading the marker frequency dial, frequency points along the curve can be determined.

A good sweep generator should have a phase control, an output level control, a sync input terminal and good linear sweep. Amplitude of the sweep should be constant at all times so that it doesn't distort the response curve.

The frequency indicated on the dial setting of the sweep generator need not be accurate, but the marker generator must be accurate. For this reason some marker generators use crystal control.

Heathkit's IG-14 marker kit uses crystals for 15 marker frequencies. Four marker frequencies are provided for setting color bandpass, 1 for TV sound and 8 at the i.f. frequencies between 39.75 MHz and 47.25 MHz. Markers for channel 4 and channel 10 picture and sound carriers are included for checking tuner rf response. This marker generator also provides visible markers at the 10.7-

Fig. 3—Waveform at TV detector with sweep generator input to i.f. stages is shown in a. *Marker pip in* b *enables frequency points along the curve trace to be determined.*



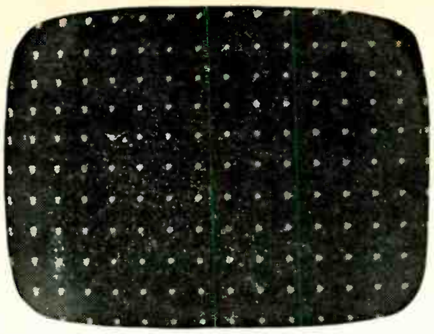


Fig. 4—Misconvergence of color beams is quickly shown with a dot generator. Dots should be circular and white for satisfactory beam convergence.

MHz i.f. for the standard-broadcast FM band, plus 100-kHz markers on each side for i.f. and FM detector alignment. Frequencies are set by pushbuttons.

Also of interest is the combination piece of test equipment by B&K, the Model 970 Transistor Equipment Analyst. This will aid in servicing car radios or transistor portables, AM or FM. The 970 has a built-in power supply for battery substitution and also has a vom. It contains rf generators for the AM and FM bands, and an audio generator for AM or FM modulation of rf signals. Price is around $200.

Test equipment for color TV

While the vom, sweep and marker generators are needed for TV servicing, other more specialized equipment is also needed for alignment of color TV. One such unit is a dot-bar generator capable of producing rows of vertical and horizontal dot patterns on the screen as well as bars.

To obtain true colors without contamination on the borders of color images, and for good reproduction of whites, the three beams must be converged properly. The dot generator indicates misconvergence when it displays distorted, multicolored dots instead of perfectly circular white dots. Fig. 4 shows this misconvergence at the sides and top of the screen. A dot generator is a must for convergence adjustments.

Vertical and horizontal bar patterns are useful for linearity adjustments by displaying even bar widths. Hence color generators are also useful for black-and-white TV. A color-bar pattern generator injects a signal into the rf, i.f. or video stages and produces a *rainbow* pattern of colors on the screen in vertical bar formation (Fig. 5).

A color-bar generator is useful for checking the color stages of a receiver for gain, phase and general function. Not used as often as the dot generator, it comes in handy when the subcarrier oscillator needs adjustment or to localize weak or defective color-amplifier stages.

Dot, bar and color-bar features are usually incorporated into a single unit with a price range from less than $100 to over $200. The portable, battery-operated types

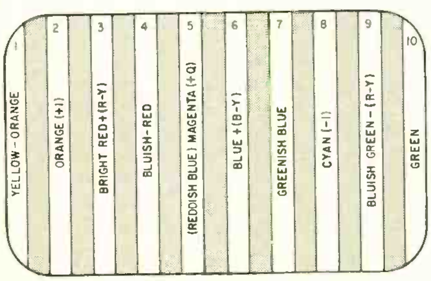
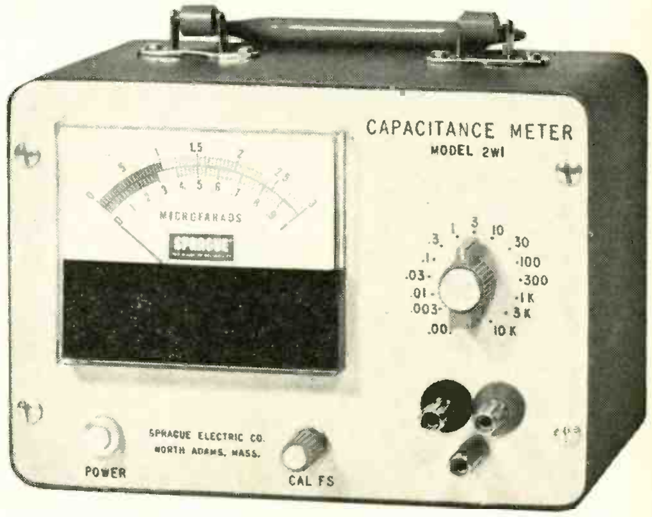


Fig. 5—Color-bar generators usually produce this pattern on the screen. Color stages can be checked for gain and phase with the bar generator.

CAPACITOR TESTER

In-circuit capacitor tester (Lafayette's Model TE-44 above) uses electron-ray indicator. Checks values from 10 pF to 2000 pF. Sprague Model 2W1 meter shows capacitor values.



(transistorized) are popular for service calls. Higher-cost units may include a 4.5-MHz crystal-controlled frequency, as well as temperature control for greater stability.

For those units containing variable rf and i.f. outputs, and composite video, chroma, horizontal and vertical sync pulses (such as the Sencore CA122B analyzer), costs range near $200. Thus, as with other test equipment, you can acquire more sophisticated equipment if your servicing activities warrant the additional cost. The added versatility of the higher-priced units will expedite many of your tougher servicing problems.

Really versatile color test equipment is available if you want to spend a little more than $300. One such item is the B&K Model 1076 Television Analyst. This unit checks every stage of a black-and-white or color TV. It has nine vhf rf channels, 20–45-MHz i.f., as well as audio, video and sync signals. In addition, it furnishes bias voltages and agc keying pulses and provides its own standard test pattern, white-dot, white-line crosshatch patterns, and color-bar-pattern slide transparencies. The 1076 includes a blank slide used for closed-circuit TV display purposes and demonstrations. **R-E**

TWO-WAY RADIO

Servicing two-way radio requires specialized test gear. Find out what's needed and what's new for SWR, power, frequency and modulation measurements

By LEN BUCKWALTER

SOME 5 MILLION TWO-WAY RADIOS ARE NOW OPERATING IN the US, and the number is increasing by about 15,000 a month. Servicing this equipment requires familiar test equipment found in radio–TV service shops—from vtvm and scope to vom and signal generator.

But two-way radio also demands special instruments. These devices enable technicians to keep two-way radio operating within close limits of power, frequency and modulation. Otherwise, heavily populated mobile bands could be submerged in a babble of mutual interference.

Dozens of services are distributed over a large span of the radio spectrum. Boating occupies channels around 2 and 156 MHz, aircraft communications are mainly between 108–132 MHz. A myriad of industrial, transportation and public safety (police, fire) stations operates on two vhf bands around 30 and 150 MHz or in the uhf region of 460 MHz. Although there are test instruments designed expressly for a specific band or set, many devices described here are common to nearly all two-way radio.

Before examining these instruments, consider a prerequisite to most two-way servicing. The FCC requires that installation and servicing of most two-way equipment be done by holders of a First- or Second-Class Commercial Radio operator's license. Actual work can be performed, however, by a technician under the supervision of a license holder. (Citizens-band work requires no special license for installation.)

Regulations usually call for signal measurements when a system is first installed or whenever any change is made that might affect transmitter stability or frequency. These checks are usually required at regular intervals to assure accuracy of transmitter power, carrier-frequency tolerance and modulation percentage. When these tests are performed, they are noted in the station log and signed by the technician. Rules are less demanding for CB, where periodic measurements are seldom required.

SWR and power output

Instruments that measure standing-wave ratio and power are basic tools. An SWR meter inserted into an antenna line reads (voltage) standing-wave ratio, a rating of the relative amount of forward and reflected power in the line. SWR readings expose a multitude of possible system faults. If the reading is more than approximately 2 to 1, a component is introducing serious impedance mismatch. The trouble could be in a damaged cable or antenna, a mistuned transmitter or possibly a defective loading coil. After the fault is corrected SWR returns to a low value, assuring the transmitter to antenna link is functioning efficiently.

One low-cost SWR tester is the Heath HM-15. This unit operates over a frequency range of about 2–50 MHz and handles up to a kilowatt of rf power. The HM-15 may be wired for either 50- or 75-ohm cables commonly found in mobile equipment. An SWR meter of this type is suitable for checking simple systems, such as CB, with the readout given as SWR ratio and percentage of reflected (wasted) power. The HM-15 sells for $14.95 in kit form.

For the technician involved with a wide range of two-way equipment, there are more sophisticated SWR instruments. An example is the Bird Model 43 Directional Wattmeter. This device reads rf watts, unlike low-cost power

TEST EQUIPMENT FOR TWO-WAY SERVICING

Items in left column may be found in radio–TV service shops. Items in right column are designed for two-way radio, and are described in text. In some cases, more than one function is found in a single instrument.

General Items	*Specialized Items*
DC Power Supply	SWR Meter
Oscilloscope	Field-Strength Meter
Audio Oscillator	Dummy Load
Rf Signal Generator	Rf Wattmeter
Vtvm	CB Combination Tester
Vom	Frequency Meter
Tube/Transistor Checker	FM Modulation Meter
	Portable Test Set

Read forward and reflected power (SWR) of an antenna system with Heath's HM-15. Meter aids tuneup and trouble-shooting.

TEST EQUIPMENT

meters which indicate relative power readings and serve mainly as a tuneup guide. The Bird instrument indicates rf watts in the antenna line with ±5% accuracy at full scale. This satisfies legal requirements for measuring transmitter power.

As shown in the photo, the Model 43 is equipped with a plug-in element marked with an arrow. When this element is reversed, the instrument reads reflected power, permitting SWR measurement. For example, if forward power is 100 watts and reflected wattage is 10, power ratio is 10 to 1. This converts to an SWR reading of 2. (A table is supplied for converting watts to SWR.)

Plug-in elements also permit the user to change the instrument's range for almost any mobile band and power rating. Standard plug-ins cover 5 to 5000 watts and 6 frequency spans from 2–1000 MHz. Cost of the basic Bird wattmeter is $95. Plug-ins cost $30 each.

Field strength—a basic measurement

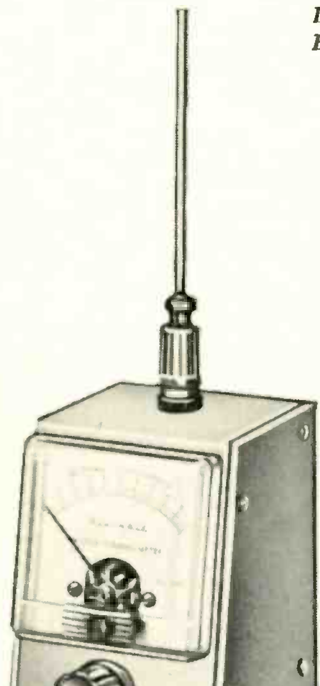
The professional instrument just described covers a wide range of transmitter output measurements, but there's another device, the field-strength meter, that could also prove attractive to a CB specialist. The field-strength meter picks up the transmitted signal, converting it to a relative reading. Since it simulates the action of a receiver, the device is an overall monitor of relative rf output. A field-strength meter is useful during installation of CB transceivers in cars. The meter is placed near the antenna and transmitter-output tuning controls are varied for maximum meter indication.

The meter may also help "prune" an adjustable antenna. If this is done while simultaneously observing an

Dummy load for CB servicing. Noninductive resistor is built into the coaxial connector. Load converts rf power into heat.

Dummy load and direct-reading wattmeter are combined in Bird Termaline Model 6154. Four ranges cover up to 150 watts.

Directional wattmeter, Bird Model 43, shows transmitter output power directly in watts on panel meter.



Simulating a receiver with Heath PM-2 presents an indication of relative field strength.

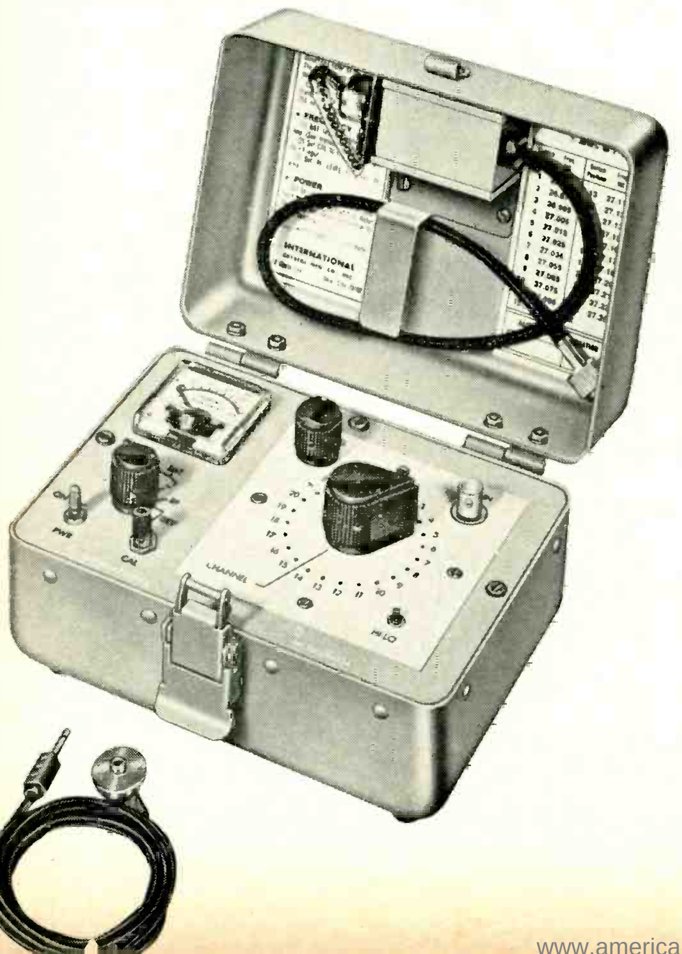
SWR meter in the antenna line, a combination of lowest SWR and highest field strength insures optimum rf output.

A field-strength meter is also convenient on a test bench. Since it requires no hookup, it provides a quick indication of whether a transmitter is functioning.

Several types of field-strength meters are available for two-way radio. Least expensive is the untuned model, which may respond to signals from 100 kHz to 250 MHz. Although untuned meters offer wide frequency coverage, their disadvantage is low sensitivity. They may require up to 0.3 rf volt induced in the instrument's antenna to produce usable readings. Higher sensitivity is offered by a tuned "wavemeter" type with resonant circuits that pick up signals more efficiently. Most costly field-strength meters are the tuned and amplified types, also the most sensitive.

CB testers like this Knight (Allied) Ten-2 model combine several useful test functions in one portable cabinet.

Frequency meter, signal generator, dummy load and modulation indicator all in one—International Crystal Model 6024.



What's the difference in application? Each model provides a gross, relative reading of the transmitted carrier. With more sensitivity, the meter may be located farther from the transmitting antenna. Distance provides several benefits. A roof-top CB antenna, for example, may not be easily accessible but an amplified meter can conveniently pick up the signal many feet away.

In another application, the technician might wish to examine radiation patterns of mobile antenna installations. An insensitive meter must be very close to the antenna, which causes the meter to respond to the magnetic component of the radio wave. A sensitive meter, on the other hand, can often be positioned more than a wavelength away, where response is mainly to the antenna's more important electric field. At such range, the technician can walk around the mobile and view the peaks and nulls of its antenna pattern.

Dummy rf loads are noninductive

An FCC regulation states that radiation from a transmitter must be curbed except for brief tuneup periods or during actual communications. A dummy load satisfies this requirement by converting rf power into heat while the transmitter is tested. The load contains a noninductive resistance, usually 50 ohms, and is available in several models.

For CB work, a dummy load is usually part of a coaxial connector, and is rated for power dissipation up to 5 watts. (The Cesco Phantom Dummyload, at $1.49, is one example.) Heath's Cantenna is a novel unit rated for transmitters up to 1 kW and frequencies from about 2 MHz to 144 MHz. To cool the Cantenna as it operates, it must first be filled with a gallon of oil. This instrument includes an output jack for connecting to a multimeter. The meter can measure voltage across the load and thus serves as an indicator of power output. Cost of the Cantenna kit is $9.95.

In the professional class is the Bird Termaline Model 6154. It combines two useful functions in a single package: a nonradiating (dummy) load and indicating wattmeter. Unlike simpler instruments, readout is directly in rf watts. The technician may perform a variety of tuning or test steps on a transmitter and observe any effects on output without radiating an interfering signal. Model 6154 includes four power scales (up to 150 watts) and covers frequencies from 25–1000 MHz. Cooling is achieved by air convection through a finned radiator. Cost of the Bird Termaline Model 6154 is $265.

Transceiver testers—specialized instruments

With the rise of CB in the 27-MHz band, manufacturers are producing "CB tester" instruments. These units house a number of functions within a portable cabinet and can be operated on the service bench or carried to a mobile or base station. The testers cost about $30–$40 and have provisions for a number of measurements. Some contain a field-strength and SWR meter to assist in installation work. A dummy load may also be included. Also, since one meter movement can be used for several functions, these instruments can often measure modulation percentage and relative power output as well.

Tests described so far are for the transmitting section. Some testers are also designed for receiver service. By plugging in a CB transmit crystal, testers can generate an accurate 27-MHz signal for receiver test or alignment. A built-in audio oscillator can add tone to the test signal for further checks in receiver stages. The tone may also serve as an audio test frequency.

This idea—packaging several functions in one cabinet —is also utilized in more complex two-way equipment. A tester might include a signal generator, vtvm, a wattmeter or frequency meter. If an audio-power meter is included, it can be used to measure the signal-to-noise ratio of a receiver.

Another variation of this idea is the "portable test set." Two-way manufacturers often provide a transceiver chassis receptacle for access to critical test points. The test set is plugged into the chassis socket and the technician can rapidly take readings to isolate malfunctions. Such instruments are usually produced by transceiver manufacturers to match their equipment.

Frequency meters for precision operation

Ability to measure carrier frequencies with precision is a major requirement of two-way servicing. Instruments for this task can be classified according to frequency coverage and whether they include some other measuring facility. International Crystal's Model 6024, for example, is a frequency meter exclusively for CB service. It contains switch-selected, crystal-controlled signals on 23 CB channels. Since accuracy can be as high as ±0.0015%, the instrument can measure CB's required frequency tolerance of ±0.005%. Also found in the 6024 are facilities for measuring AM percentage of modulation and power output. Another International Crystal meter covers the marine band near 2 MHz, while the company's wide-range model covers 25–470 MHz with ±0.00025% accuracy. Plug-in oscillators are purchased for desired frequencies.

A popular frequency meter is the Lampkin 105-B Micrometer or MFM model. This is a heterodyne unit that can measure transmitter signals up to 175 MHz. Accuracy is assured with a built-in crystal calibrator and provision for correction against WWV. To obtain accuracy beyond the instrument's 0.001%, Lampkin offers a PPM package. The FCC frequency requirement on lower bands is generally 0.01% or 0.002%, but the tolerance becomes more critical on higher frequencies because of recent channel splitting to allow more two-way operations in the crowded spectrum. With Lampkin's PPM package, accuracy rises to 0.0001% to allow measurement of new 0.0005% tolerances. Basic cost of the 0.001% instrument is $295, with the PPM available as an additional item.

How to measure modulation fast

Checking AM modulation percentage is usually accomplished by viewing signal waveforms on an oscilloscope. FM transceivers, however, require a specialized instrument. Lampkin's 205A FM Modulation Meter can pick up 25–500-MHz signals and indicate peak carrier deviation while tone or voice modulation is applied to the transmitter. The meter scale is calibrated for both 25 and 12.5 kHz (peak). This enables the instrument to handle transmitters operating on the older wide-band FM (±15 kHz) and the newer split-channel, or narrow-band system, where deviation is reduced to ±5 kHz. Depending on transmitter power and frequency, the 205A responds at a range of 10 to 2000′. Cost of the basic Lampkin 205A is $290. Another version adds two additional scales for reading peak deviation of 1.25 and 2.5 kHz. These scales are useful while working on mobile radio systems that employ selective call, since they may utilize tones as low as 50 or 60 Hz and modulation levels as low as 0.75 kHz. The extended version of the meter at $340 has improved sensitivity.

A combined instrument, the Gertsch (Singer) Model FM-9E, joins frequency and FM deviation meters in one package. This instrument may also serve as a signal generator with output on both transmitter carrier and receiver i.f.'s. The frequency-meter portion of the instrument is rated at 0.0001% to permit measurements on split-channel equipment. The FM-9E provides direct digital readout in the 150–162-MHz band. Harmonics are also available for uhf channel coverage. When the FM-9E is switched to its deviation-meter function, it reads FM modulation in any of three ranges: 1.5, 5 and 15 kHz (full scale). The cost of this solid-state, portable 3-in-1 instrument is $1825. **R-E**

Measure transmitter frequency to new 0.0005% tolerances with add-on kit and Lampkin 105-B Micrometer Frequency Meter.

Peak frequency deviation on FM mobiles can be measured with Lampkin Type 205A. Tests signals in 25-500-MHz range.

Digital readout is provided on this Gertsch/Singer FM-9E frequency deviation meter. Unit also is a signal generator.

Automatic Diplexer's For Voice Communications

Aerospace and electronics research has developed dual-purpose transducers to replace uncomfortable earphones. Commercial variations may automate the manual push-to-talk switch

By L. GEORGE LAWRENCE

IN TRADITIONAL TWO-WAY TRANSCEIVING equipment the manual "push-to-talk" switch, together with associated circuits and acoustical transducers, affords adequate isolation between receiver/transmitter signals. The equipment is simple and continues to demonstrate its reliability.

However, in critical aerospace and commercial situations, the use of discrete switches, lip microphones and speakers (or earphones) is uncomfortable and becomes nearly intolerable to the average person after several hours. With advances in applied electronics and better insight into human physiology, automatic, diplexing transceiving aids have appeared in recent years.

Diplexing systems can be defined as single, dual-purpose transducers designed to function, simultaneously, as microphone and speaker (or earphone). Research has extended, not only to orthodox electro-acoustical devices and switching gear, but also to the brain's ability to receive electromagnetic waves and fields. Devices to be worn for long periods must not press on the skin in excess of about 0.3 psi. An effective signal isolation of 32 dB or better is desirable.

Electro-acoustical diplexers

Work by R. D. Black (1957) and others has demonstrated that an acoustic transducer placed at the ear can be used as microphone *and* earphone. Specific problems reside in effective receiver/transmitter isolation. Also, the switching intervals must be fast enough for positive control over both transmission and reception.

The circuit of Fig. 1 shows the functions of an agc-controlled diplexer. In this case, the receiver activates the transmit–receive switch. However, the attack time of such a scheme is much too long, and interference could lock the system into a continuous receiving mode. A manual override switch would make the setup more cumbersome, since the operator does not know whether a given mode is a deviation. If the T/R switch were thrown rapidly back and forth, incom-

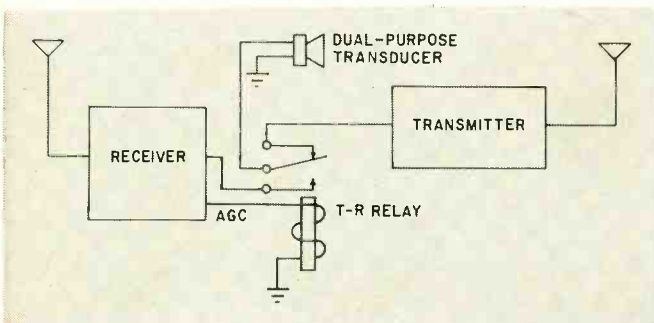


Fig. 1—Receiver is activated by T/R relay in this agc-controlled diplexer. Major disadvantage is slow response.

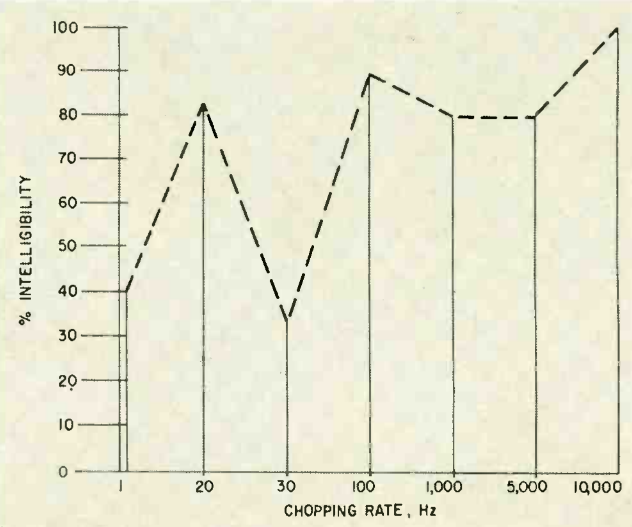


Fig. 2—Speech intelligibility varies with chopping rate. Sum-difference frequencies develop below 10 kHz and above 20 Hz.

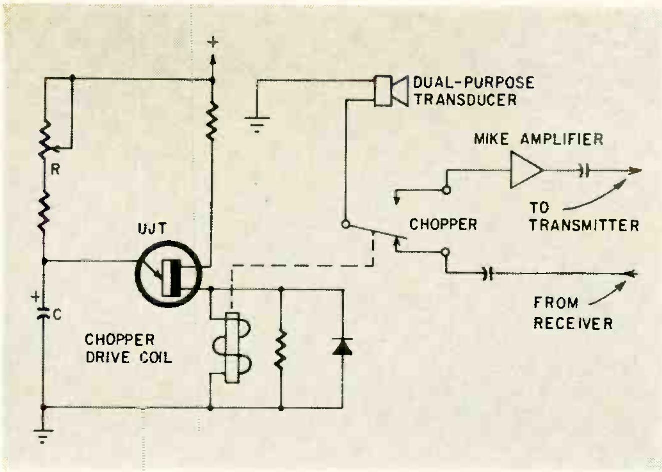


Fig. 3—Frequency of this chopper circuit is varied by potentiometer R. The coil is in series with the unijunction transistor (UJT). To extend the life of the assembly and stabilize its performance, it is sealed in an inert-gas atmosphere.

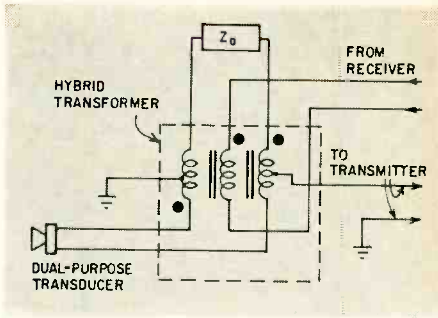


Fig. 4—Hybrid transformer diplexer, unlike chopper assemblies, has no moving parts. Device works on the bridge principle (Fig. 5). A nulling device, it can provide 50 dB isolation between circuits.

ing audio would be intelligible, and the transmitting capability would be continuous.

This method is called "chopper diplexing" and comes in two classifications: *subaudible* and *audible diplexing*. If speech is chopper-interrupted at 20 Hz at 50% duty cycle, the word-articulation score is 84%. Decrease of chopper drive frequency to 1 Hz results in approximately 40% intelligibility of incoming speech.

Basic intelligibility profiles, plotted vs frequency, are given in Fig. 2. The articulation score essentially reaches 100% at a chopping rate of 10 kHz. (However, annoying sum and difference frequencies are added if system drive frequencies are above 20 Hz and below 10 kHz.)

Unpleasant, interrupted sensations can be noticed when drive frequency falls below 20 Hz. If an operator listens to these sounds for a length of time, annoyance will develop into fatigue.

A steering circuit for choppers is shown in Fig. 3. With chopping frequency determined by potentiometer R and capacitor C, the coil of the switching system is connected in series with the unijunction transistor. The diode in the ground leg reduces transients. Installing the chopper assembly in an inert-gas atmosphere results in longer life and fairly stable performance.

It is conditionally possible to operate with drive frequencies above 20 kHz, thereby eliminating disturbing sum and difference frequencies. Unfortunately, even though low-pass filtering may be used, the inertia effect of moving parts tends to offset possible gains as far as intelligibility is concerned.

A *superaudible* mode can be obtained by selecting dual-purpose transducers with very high resonant frequencies, say five times the drive frequency, or 100 kHz. Capacitor microphones will perform relatively well in this kind of diplexing circuit, but their high polarization voltage (typically 200 Vdc) can be dangerous.

"Blank" spaces, due to chopper action, have been filled in with white noise. This improves speech quality but not intelligibility. Quality, as was shown by J. L. Stewart in 1962, can be enhanced by "reiterated speech."

Reiteration is interrupted speech with the blank periods filled with the same interrupted speech delayed by "on periods." Four delays are involved, so that four signals can be mixed in a special adder: Delay $1 = 0$, delay $2 = T/2$, delay $3 = T$, delay $4 = 3T/2$. These delays produce a reverberating effect on speech.

A hybrid transformer diplexer, shown in Fig. 4, has advantages over chopper-type designs due to the absence of moving parts. Basically, the diplexing system is similar to a resistive bridge (Fig. 5) except that the branches are formed by a multi-coil transformer.

The nulling circuit in Fig. 4 can provide 50 dB isolation (transmitter vs receiver) when Z_o and the transducer impedance are perfectly matched. If, for example, the transducer is replaced with a 2200-ohm re-

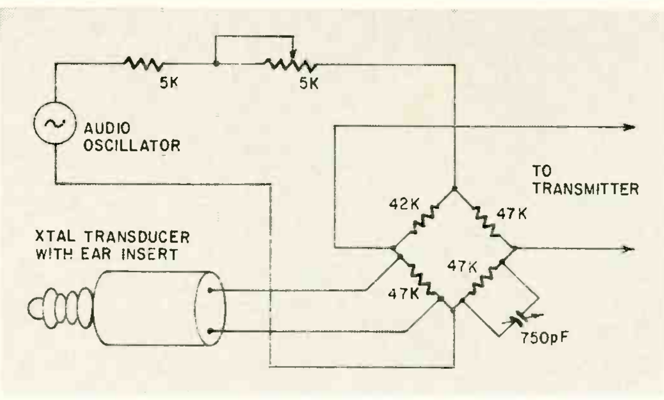


Fig. 5—Resistive bridge diplexer. The 47,000-ohm branch resistors have a nulling function similar to coils in the transformer (Fig. 4). The capacitor nulls the circuit.

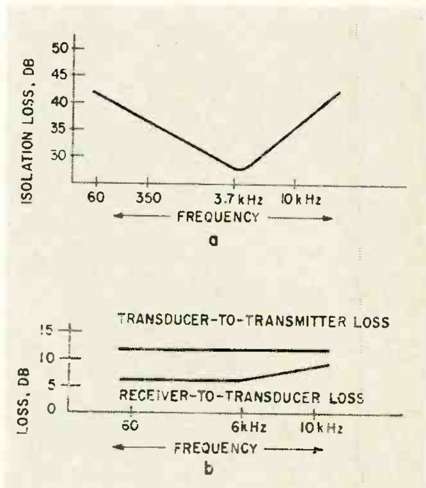


Fig. 6-a—Performance plots for the resistive bridge diplexer show receiver-to-transmitter isolation. A minimum 27-dB isolation (at 4.6 kHz) can be obtained over the voice spectrum. b—Graph shows losses from transducer to transmitter and from the receiver to transducer. The bridge arrangement is one of the simplest diplexers.

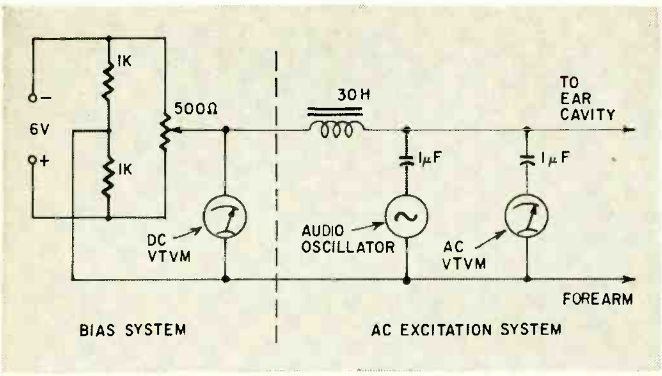


Fig. 7—Test setup for verification of the electrophonic effect. Electrophonic threshold is usually about 20 dB above 1 μW. Speech is barely recognizable.

sistance, isolation exceeds 50 dB at all frequencies from 60 Hz to 10 kHz (Fig. 6). A transducer in shunt with a 2200-ohm resistor at both "Z_o" and "transducer" yields a minimum isolation of 27 dB (at 4.6 kHz) over the voice spectrum. A hard clipper may be inserted to prevent transmitter overmodulation during receiving periods. The scheme represents one of the simplest diplexing circuits devised.

Electrophysiological diplexers

Alternating current of audio frequency, if passed through the human head, gives rise to hearing sensations. S. S. Stevens (1937) termed this phenomenon the "electrophonic effect." Later, in 1961, A. H. Frey discovered that the human auditory system can respond to electromagnetic energy in at least a portion of the radio-frequency spectrum.

Some of this work was carried out with modulated radar transmitters working at reduced power levels and using frequencies of 1.31 and 2.982 GHz. Subjects reported the perceived sound was more like that produced by the modulation pulses than by pure or complex tones or square waves. They also said more high frequencies were needed, even when listening to the modulation pulses via speaker. The physiological mechanism involved is not yet defined, but it may be direct cortical or nerve-fiber stimulation. Diplexer-type communication was not attempted by this method.

Electrophonic systems. As mentioned before, alternating current of audio frequency invokes hearing sensations in the human auditory system. This electrophonic effect can be verified by using a basic test setup as shown in Fig. 7.

This assembly is designed to work with or without low-voltage dc bias derived from a 6-volt power supply. An audio oscillator provides the actual subject voltage. The test can be conducted by placing a wet electrode into the ear cavity and the other on the arm. The electrophonic threshold usually is about 20 dB above 1 μW, which is only 20 dB below the shock level. *CAUTION* is the keyword when conducting this experiment! The effect is quite low and the loudness attainable is limited by shock or pain sensations. Popular tunes may be identified, but the fidelity is poor. Speech may be recognized, but few words will be fully understood by the one making the test.

Results with AM carrier frequencies, ranging from 50 kHz to 100 kHz, appear to be promising. This special form of electrophonic hearing can be accomplished with simple rf oscillators with provisions for modulation (Fig. 8). Again, great caution is a must! The output power level must not exceed 150 milliwatts, and the region around the eyes is *very sensitive*.

Unfortunately, taken together, electrophonic-type effects are either too weak or too unpleasant to be of immediate use in diplexing communications.

Special intelligibility tests

The intelligibility of voice transmitted through ear-canal insert transducers is of prime importance for acceptance of a diplexing system.

To be meaningful, test transmissions commonly include utterances of nonsense syllables (to exclude guesses) and coherent, highly redundant sentences. In a typical rhyme test, an individual is presented with a test sheet consisting of 50 words lacking their initial consonants and asked to fill in the missing letters after listening to a speaker intoning the complete word. Several choices are possible, since the word roots are all members of rhyme families; e.g. neat, beat, deed, lead, seed; or noon, moon, soon, loom and so on.

Conclusion

Automatic diplexers for voice communications can be an exceptional aid both on earth and in space. Chopper diplexers provide the highest receiver-to-transmitter isolation, since there is nearly zero contact resistance at "make" and infinite resistance at "break." Bridge-type diplexers, if coupled with safety clippers, are simple devices, but require correct impedance matching of feeder networks. Although the electrophonic effect is not usable in its present form, it holds hope for special applications. The same considerations apply to auditory stimulation by rf fields. **R-E**

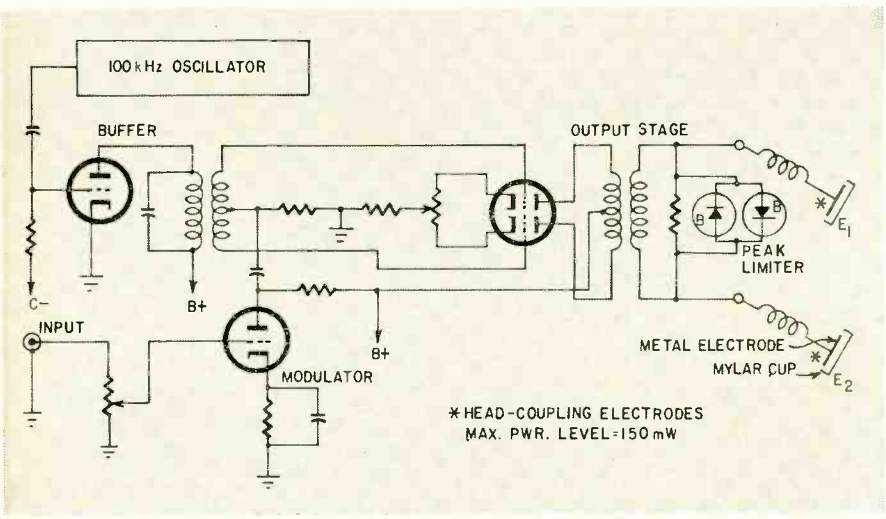


Fig. 8—Another electrophonic transmitter uses AM carrier frequencies in the 50 kHz to 100 kHz region. Output is fed to test subject through electrodes E1, E2.

Further Reading

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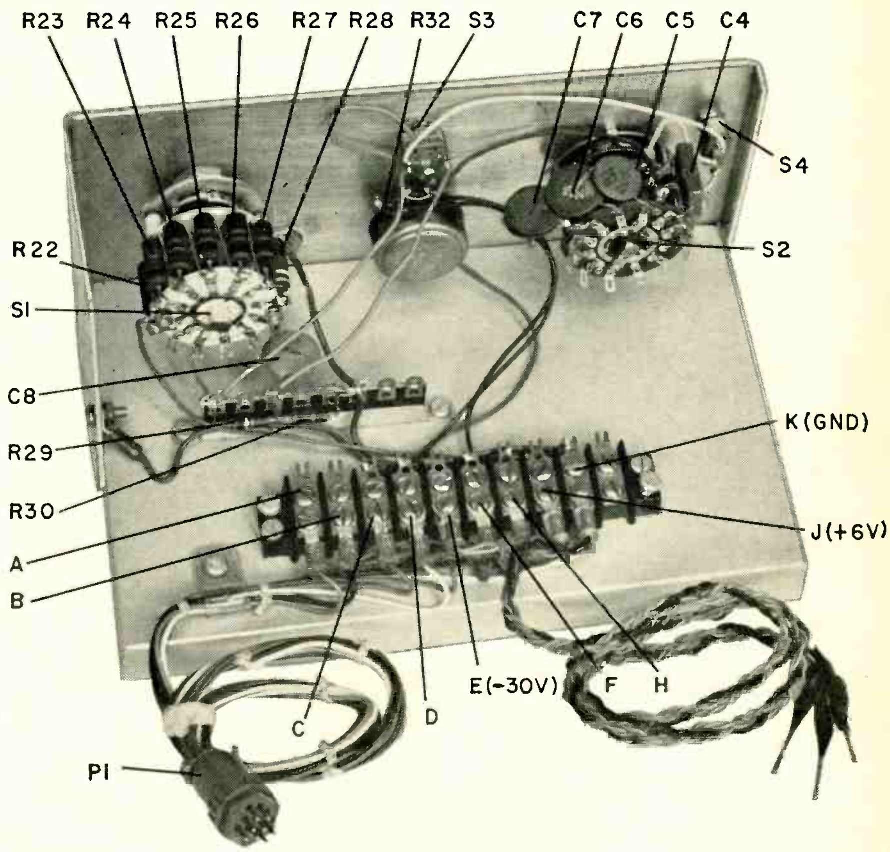
Sommer, H. C. and H. E. von Gierke: "Hearing Sensations in Electric Fields," *Aerospace Medicine*, 834–839, Sept. 1964.

Build 3-Way Scope Calibrator

Precision unit generates pulses variable in time, frequency and voltage . . . Components and controls may fit in your oscilloscope.

By JAMES ROBERT SQUIRES



Controls may be mounted on panel scope or in a separate unit as shown here.

ONE OF THE MOST VALUABLE COMMODities in a shop or laboratory is bench work space. I often find some little device that I want to build but never do because of the space it will rob from my workbench. For some time I've needed an oscilloscope calibrator like this one but I didn't decide to build it until I realized that the proper place for it was *inside* the scope.

Space requirements are small: A few square inches of front-panel space and less than 12 cubic inches of electronics for voltage and frequency calibration and a variable-delay trigger pulse with a full spectrum of scope uses.

The stick-anywhere calibrator system consists of three units. Fig. 1 shows the Box, the power supplies and the five panel controls. With the new miniature controls and switches, a minimum of scope front-panel space is needed. If space is not available on the scope's front panel a separate panel can be built.

Actually, the Box (Figs. 2 and 3) provides a calibration pulse variable in both frequency (300 to 3000 Hz) and voltage (16 Vdc to 25 Vdc), and a delayed trigger pulse. The delayed-trigger-pulse generator can be synced to either the internally generated calibrator pulse or to a negative-going external sync pulse of 30 volts or less. The external sync pulse may be a sine square or triangular wave. Fig. 4 gives pulse relationships.

The calibrator pulse is used to examine scope sweeps as a general check of frequency (horizontal time per division) and voltage sensitivity (vertical volts per division). This calibration pulse may also be passed through a positive diode clamp and applied to the Z-axis of the scope (the cathode of the CRT) to provide variable blanking for timing and sweep marking purposes (see Fig. 5).

Either a simple Zener regulator or a more involved series and shunt regulator is the power supply. Fig. 6 gives data for using the Zener regulator at various voltages tapped from the scope supply. Assuming that you find a 60-volt tap in your scope power supply, you would use a 30-volt Zener in series with an 1800-ohm resistor and a 6-volt Zener in series with a 3300-ohm resistor.

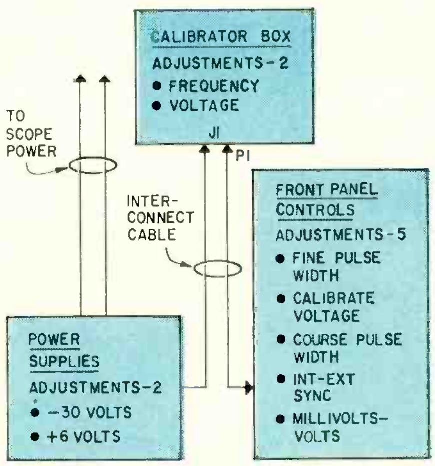
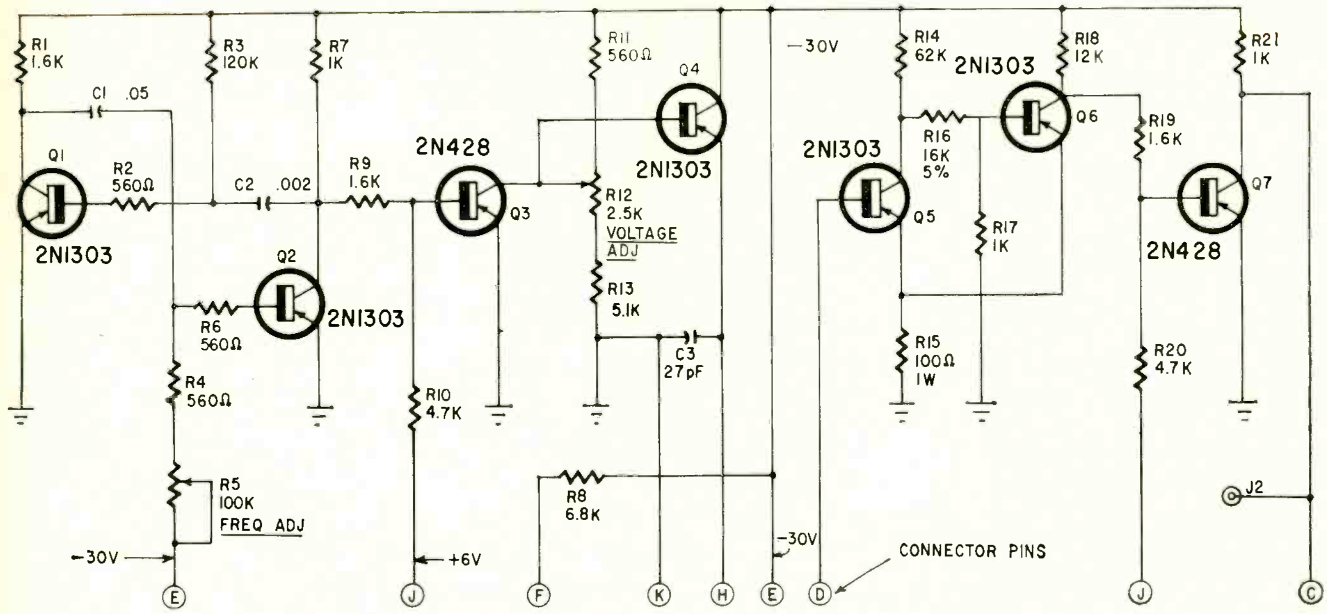


Fig. 1—Calibrator block diagram. Sections can be built into scope to save space.

Figure 7 illustrates a complete −30-volt and +6-volt combined supply that could be installed within the scope. For pulse work this sort of supply gives much better high-frequency regulation and transient response than does a Zener regulator.

Panel controls are mounted wherever possible on the front panel of the scope. The photos show these controls in open breadboard construction. Fol-



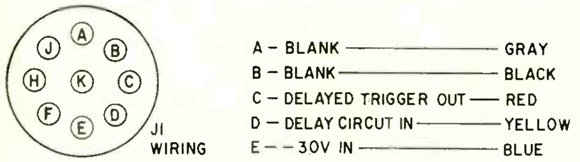


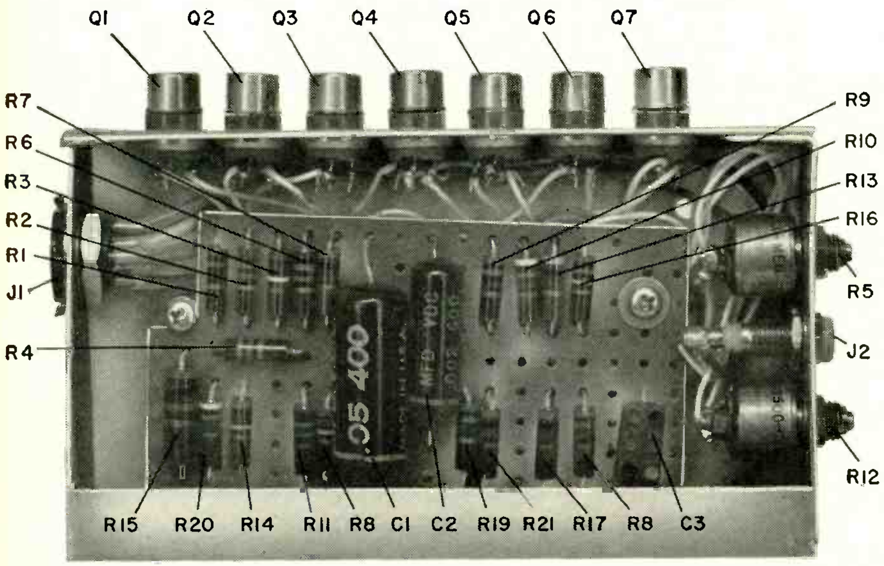
Fig. 2—Most of the components in the calibrator are in a small box and are connected to front panel controls through a cable.

low this arrangement if you build the calibrator as a separate unit.

A 5" x 7⅛" piece of aluminum sheet is used for the chassis. You may want to look under the dust cover of your own scope to see just how much space is available to house the calibrator box. Location within the scope is not critical so long as the circuit card and other components are shielded by the metal chassis. Should you find that you have the room, you could purchase a larger chassis.

The circuit card is cut from Vector prepunched board. As the components are inserted into the board, their leads extend through the card to the other side and are used in wiring the circuits.

Transistor sockets are mounted on the Box chassis with mounting rings. Orient the sockets with the emitter pin nearest the bottom or open side. This facilitates testing when the unit is completed. Use No. 24 multistrand wire to connect the transistor sockets to the circuit card to minimize wire breakage during assembly.



Interior of calibrator box. Transistors are in sockets mounted on top edge. Mounting board is 1 ⅞" x 3 ³⁄₁₆", with ¼" x ¾" corner section removed.

Calibrator box wiring

First connector J1 is wired, using nine 8" lengths of stranded wire color-coded as shown in Fig. 2. Solder 5" lengths of wire to the transistor sockets and fold out of the way for the present. Mount and wire the two potentiometers and test joint J2 as completely as possible.

completely as possible.

Next the components are inserted into the circuit card and wired according to the photograph (left).

When the card has been wired and is ready to be mated to the Box, it should be placed component side down above the transistor sockets. All wiring between J1, the circuit card, the sockets and the potentiometers should be made from this position. Wiring the card in this manner permits the card to be swung out of the way for servicing. When all wiring is completed, tuck any loose wires under the card and assemble with two 6-32, ½" screws.

When choosing a place to mount the calibrator, remember that the frequency and voltage controls must be easy to reach and adjust. The inexpensive transistors used in this unit must be kept away from heat. Heat arrives by conduction, convection or radiation, so mount your transistors accordingly.

The emitter load of Q4 (Fig. 2) is made up of seven resistors[1] (R22–

[1] Data courtesy of Tektronix, Inc.

Parts List

C1—.05 μF capacitor
C2—.002 μF capacitor
C3—27 pF capacitor
C4—250 pF capacitor
C5—.005 μF capacitor
C6—.01 μF capacitor
C7—.02 μF capacitor
C8—.001 μF capacitor
R1, R9, R19—1600-ohm, 5% ½-watt resistor
R2, R4, R6, R11—560-ohm, ½-watt resistor
R3—120,000-ohm, ½-watt resistor
R5—100,000-ohm miniature potentiometer
R7, R17, R21—1000-ohm, ½-watt resistor
R8—6800-ohm, ½-watt resistor
R10, R20—4700-ohm, ½-watt resistor
R12—2500-ohm miniature potentiometer
R13—5100-ohm, ½-watt resistor
R14—62,000-ohm, ½-watt resistor
R15—100-ohm, 1-watt resistor
R16—16,000-ohm, 5%, ½-watt resistor
R18—12,000-ohm, ½-watt resistor
R22—2000-ohm, 5% 1-watt resistor, see text
R23—1000-ohm, 5%, 1-watt resistor, see text
R24—610-ohm, 5%, 1-watt resistor, see text
R25—200-ohm, 5%, 1-watt resistor, see text
R26—100-ohm, 5%, 1-watt resistor, see text
R-27—56-ohm, 5%, 1-watt resistor, see text
R28—39-ohm, 5%, 1-watt resistor, see text
R29—100,000-ohm, 5%, ½-watt resistor
R30—100-ohm, 5%, ½-watt resistor
S1—2-pole, 7-position miniature non-shorting rotary switch (see lead photo)
S2—2-pole, 2-section, 5-position miniature non-shorting rotary switch
S3, S4—moniature spdt toggle switch
J1—miniature 9-contact socket connector
J2—Insulated tip jack
J3, J4, J5—Miniature coax receptacles
Q1, Q2, Q4, Q5, Q6—2N1303 transistor
Q3, Q7—2N428 transistor
P1—Miniature 9-contact plug connector to match J1
MISC—Transistor sockets, terminal strips, hook-up wire, knobs

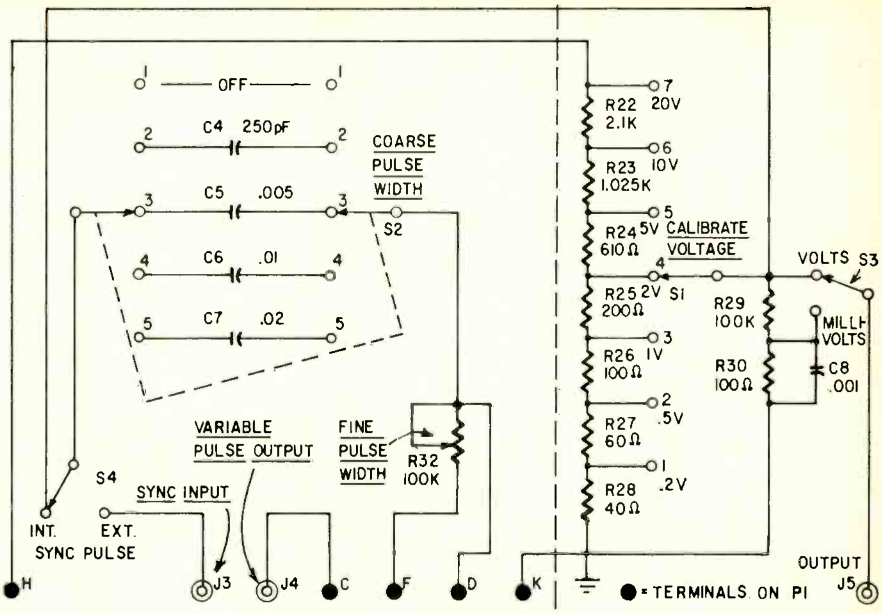


Fig. 3—Pulse-width and voltage-calibrator controls are mounted on front panel.

R28, Fig. 3). The total value of these resistors is 4135 ohms. To produce the voltage steps of 20-, 10-, 5-, 2-, 1-, 0.5- and 0.2-volt, 1-watt carbon resistors are altered to give the exact resistances needed.

Using a three-cornered file, very carefully file through the phenolic outer insulating body of the resistor until the shaft of carbon is exposed. With a good ohmmeter, measure the resistor value in ohms. For example, let us use R24, a 610-ohm resistor. A 5% 610-ohm resistor was purchased; this means that the resistor might have any value between 580 and 640 ohms. However, I have found that many 5% resistors are right on the money at 600 ohms. Let us assume the resistor you get is 600 ohms. You have measured its value on your ohmmeter and affirmed this. You have, using your three-cornered file, cut through the phenolic body of the 600-ohm resistor.

But R24 must be 610 ohms. File into the carbon of the resistance element a few strokes. Measure the resistance again. Notice that the resistor increases its value. Continue filing with the finesse of a brain surgeon until the higher value is obtained. Work slowly so as not to heat the carbon as you work on it. As you work, continuously check the zero of your ohmmeter. Alter all resistors requiring a resistance increase.

Careful work at this stage will result in a series of resistors providing exact voltage division ratios. As each resistor is filed to the needed value, apply a dab of Duco cement to the cut so that moisture will not cause future damage to the resistor.

It is true that the power rating of the resistors has been reduced, but that is why 1-watt units were used. Only ½-watt units were needed, and the minute filing did not derate the resistors below that.

Use special care when installing these units as their body has been weakened. Once they have been assembled between decks of S1, you have a strong rigid assembly.

Remember that the filing tech-

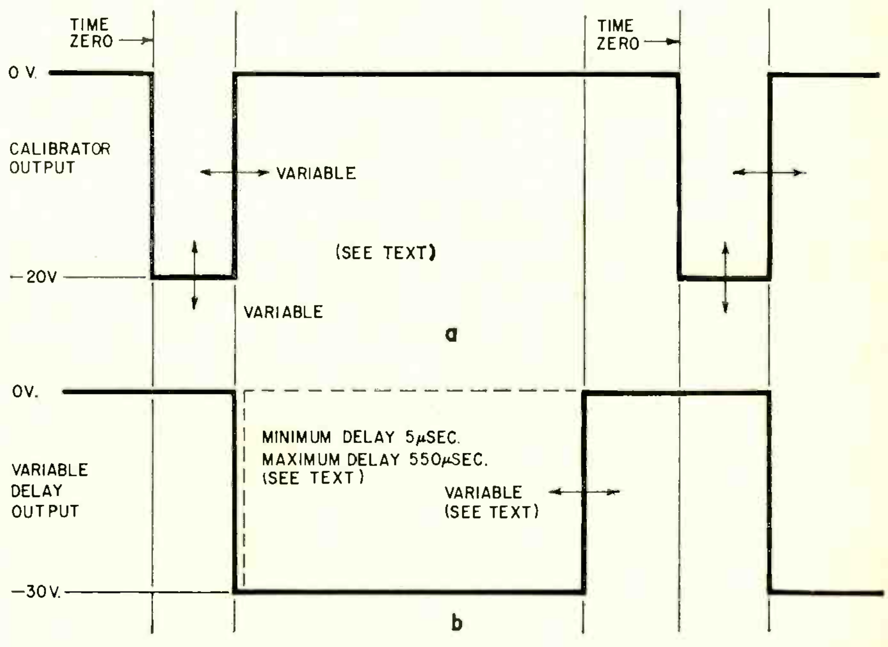
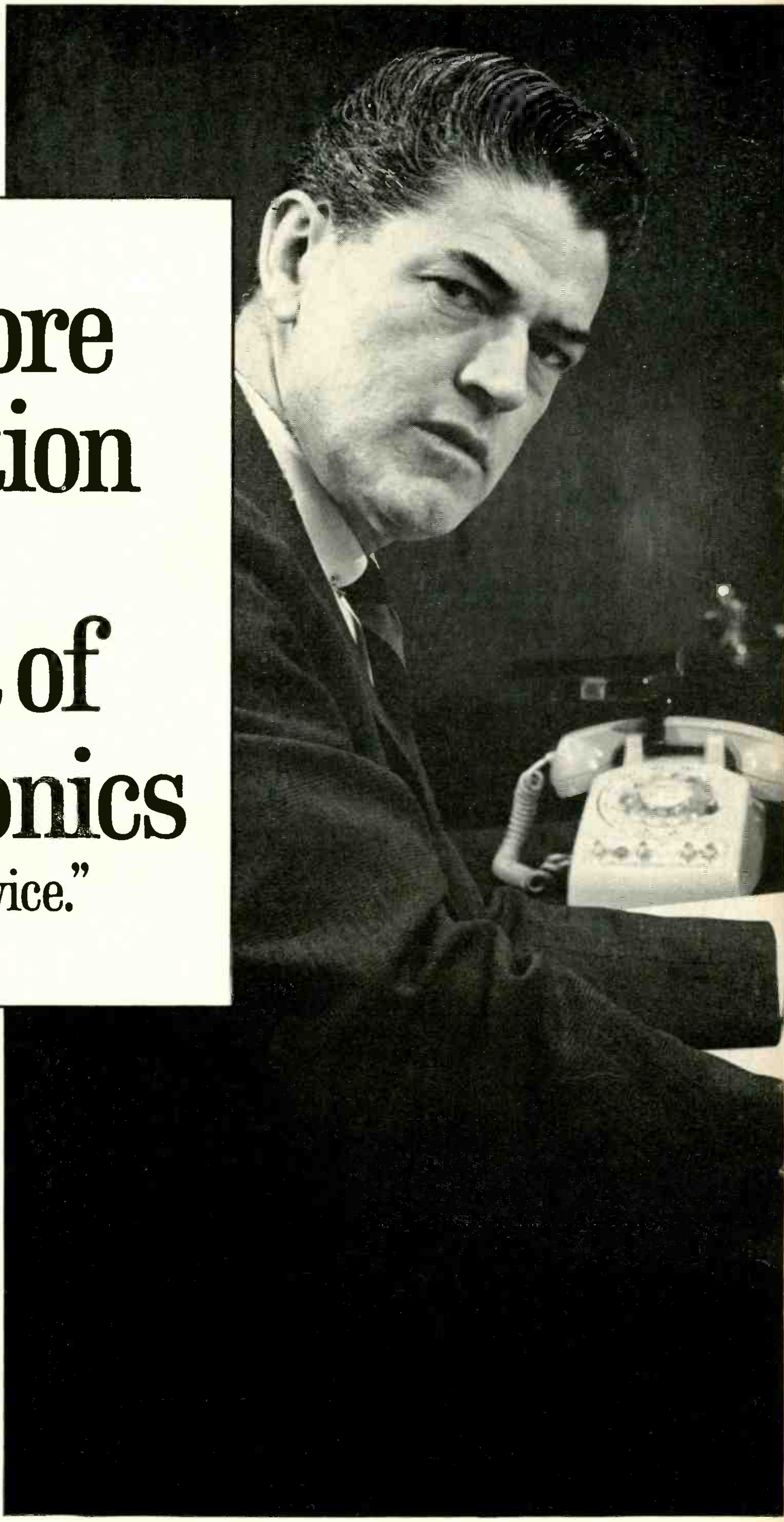


Fig. 4—Calibrator output waveforms. The one at a *is a 1000-Hz calibration pulse; 150 μsec* ON *and 850 μsec* OFF. *Its amplitude and pulse duration are variable. At* b *the 30-volt trigger pulse may be delayed over an adjustable range of 5 to 550 μsec.*

"Get more education or get out of electronics

...that's my advice."



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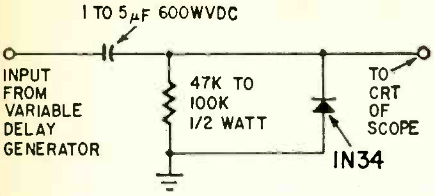
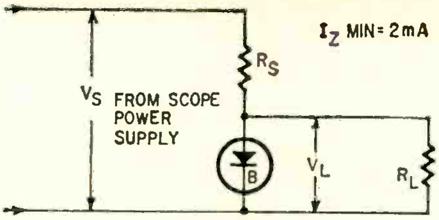


Fig. 5—The pulse output of the calibrator may be used for scope Z-axis blanking after being passed through a diode clamp.



-30 V. SUPPLY	ZENER CONNECTED AS SHOWN	R_L=15 mA at 30V
V_S	R_S	
40 V	600 Ω	
60 V	1.8 K	
80 V	3.0 K	
100 V	4.2 K	
+6 V SUPPLY	ZENER LEADS REVERSED	R_L=15 mA at 6V
40 V	2.0 K	
60 V	3.3 K	
80 V	4.2 K	
100 V	6.2 K	

Fig. 6—How to obtain Zener-regulated —30 and +6 volts from scope's power supply. The Zener's cathode always connects to the positive side of the source.

nique only increases the resistor's value and do not forget to seal the cut! This may sound like a piece of work but conservatively speaking it can save more than $5 for 1% precision resistors to gain the same ratios. If you have access to a precision or lab-type bridge, so much the better.

Operation

The voltage calibrator consists of a variable-frequency multivibrator, Q1 and Q2, driving Q3, a variable-voltage switch. The output of this switch is then fed to emitter follower Q4. Emitter resistance is ratio-divided to provide voltage ratios of 1, ½, ¼, 1/10, 1/20, 1/40 and 1/200 to ground. When the voltage-control potentiometer (R12) is adjusted so that there are 20 volts at the emitter of Q4, the voltages are as noted on the schematic of Fig. 3.

These dividing ratios apply for any voltage appearing at the emitter of Q4. S3 provides additional division either by 1 or 100. The ratios then become 1/100, 1/200, 1/400, 1/1000, 1/2000, 1/4000 and 1/20,000. In

Parts List

- T1—Power transformer, 40-V ct, 100 mA (Triad F90-X or equiv)
- T2—Power transformer, 26.8 V ct, 1 amp (Triad F40-X or equiv)
- D1, D2, D4, D5—1N1692 diode
- D3, D6—6-7-V, 150-mW Zener diode (Hoffman RS-6 or equiv)
- C1—1000-μF, 50-V electrolytic capacitor
- C2—2000-μF, 15-V electrolytic capacitor
- R1—1000-ohm, ½-watt resistor
- R2, R6—39-ohm, 2-watt resistor
- R3—7500-ohm, ½-watt resistor
- R4—1000-ohm, 2-watt potentiometer
- R5—1600-ohm, ½-watt resistor
- R7—430-ohm, 5%, ½-watt resistor
- R8—500-ohm, 2-watt potentiometer
- Q1, Q3—2N301 transistor
- Q2—2N1303 transistor

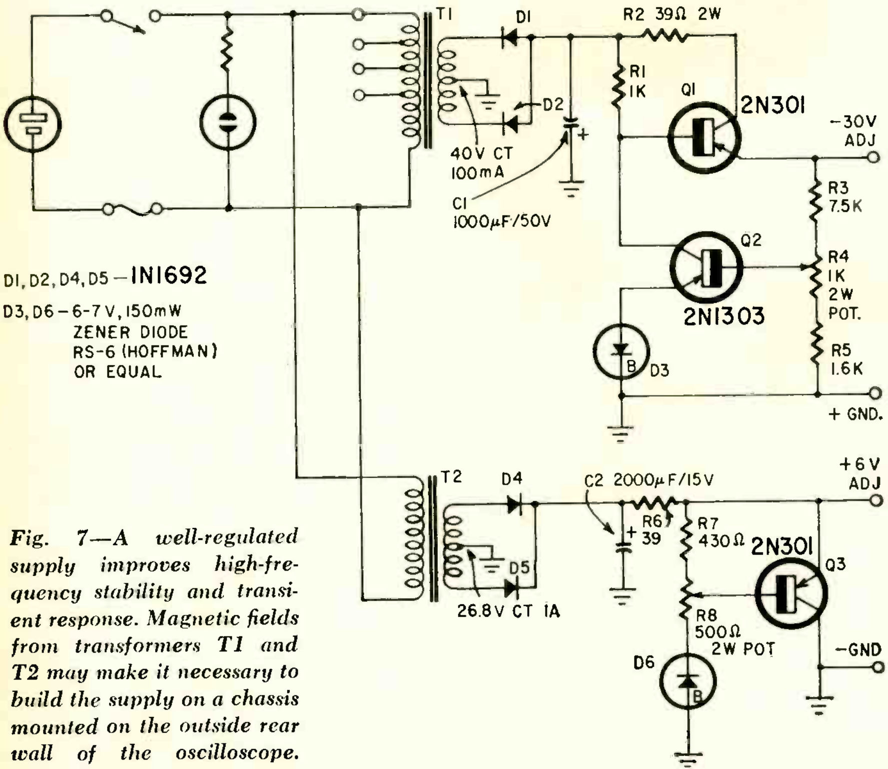


Fig. 7—A well-regulated supply improves high-frequency stability and transient response. Magnetic fields from transformers T1 and T2 may make it necessary to build the supply on a chassis mounted on the outside rear wall of the oscilloscope.

other words, the calibrate pulse output is in either volts or millivolts.

The variable-pulse generator is triggered either internally by the variable-frequency multivibrator or from an external negative-going square-wave or sine-wave trigger. Both course and fine control of the variable-pulse generator is available.

Pulse width can be varied from a few microseconds to 550 μsec. Pulse widths for this Schmitt trigger depend to some extent on the input trigger waveform. Therefore no data are given for width values on switch S2. Output of the Schmitt trigger is buffered by Q7, a fast switch. Fig. 4 illustrates the time-pulse relationships available within the Box.

Adjustments may be needed

Most scope calibrators operate at 1000 Hz. The variable-frequency multivibrator used in the Box covers from 400 to 4000 Hz. Frequency adjustment should be made against a known frequency standard such as a 1000-Hz crystal. Approach the setting from the high-frequency end of the potentiometer. R5, the frequency control, varies the symmetry of the multivibrator and can be set to shut off the circuit. When troubleshoooting this circuit, first be certain that the potentiometer arm is near the high-frequency end of its travel.

When adjusting calibrator voltage, use at least a 20,000-ohms-per-volt meter to set the emitter of Q4 to 20 volts. You may want to cut holes in the dust cover of your scope to reach conveniently the two controls, R5 (frequency) and R12 (voltage), of the Box.

The variable-pulse generator has both coarse and fine pulse-width or delay controls. For example, with proper minimum settings it is possible to obtain a 5-μsec pulse of 30 volts amplitude. As mentioned before, the range and extent of influence of these controls depend on the type of sync or trigger signal used.

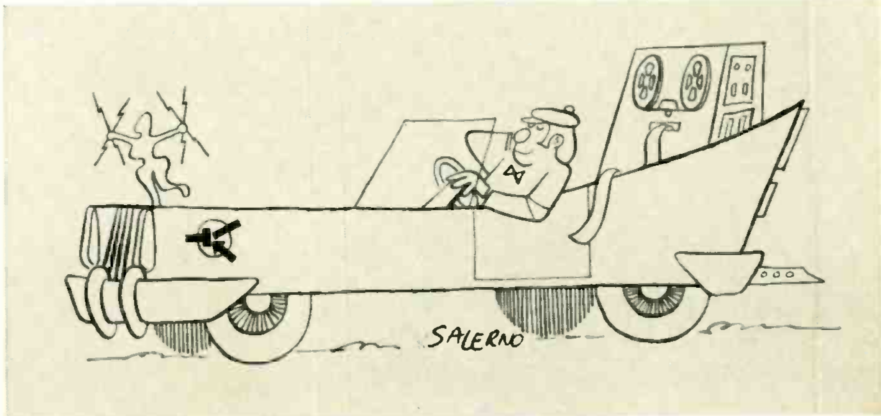
Uses of the Calibrator Box are many; they include variable sweep delay. Z-axis blanking, amplifier calibration using voltage ratios, simple signal tracing in radios. In photographing scope traces, you will find that Z-axis blanking is a fine way to add another dimension of information to your sweep photographs.

Remember that neither the calibrator nor the variable-pulse generator is a power driver and should not be loaded excessively. As an extra bonus, the Box can often be tucked neatly away in the dark recesses of your scope. **R-E**

COMPUTERIZE YOUR CAR LIGHTS

Part II—Avoid traffic tickets or a run-down battery. Put this lighting aid in your car

By R. M. MARSTON



LAST MONTH WE DEVELOPED THE COMputerized automobile lighting system to the point where it would immediately flash a warning if one of the car's lights burned out. Now, we'll add a circuit that will decide whether the lights should be on or off, determine whether they are in the correct mode and then warn the driver if they are not. These tasks are performed by the lighting-mode/driving-mode correlator that compares two sets of basic information before deciding whether to notify the driver that all is not well.

One set of information fed to the unit concerns the *lighting mode*: Is it night or day? The second set of information concerns the driving mode of the vehicle: Is the car being used, or is it simply parked, and are the lights turned on or off?

The correlator is intended to be used in conjunction with the lamp-failure detector system already described, and gives a fault indication on the same panel lamp. The full system will indicate a fault under any of the following circumstances:

(1) Vehicle is being driven at night with main lights off.

(2) Vehicle is being driven in daylight with main lights on.

(3) Vehicle being driven at night with main lights on but one or more lamps burned out.

(4) Vehicle being driven in daylight with main lights off, but with one or more brake or flasher lamps out.

(5) Vehicle parked at night with main lights on, one or more lamps out.

The faults indicated in (1) and (2) are detected solely by the correlator, and the full circuit of this unit is shown in Fig 4. This circuit can be broken down into two main sections, one the lighting-mode detector and the other a simple computing section.

The lighting-mode detector section of the unit operates as follows:

A cadmium sulphide light-dependent resistor (LDR1) is the light sensor. It has a low resistance under bright conditions and a high resistance when dark. Resistor R45 and and LDR1 form a voltage-divider network. Under bright conditions their junction is at near-ground potential, and at near −12 volts when the LDR is in darkness. The junction is connected to Q17's base through R46.

Transistors Q17 and Q18 form a Schmitt trigger or voltage-sensitive switch that can be triggered on or off by adjusting the voltage on Q17's base. The output of the Schmitt trigger is fed to the base of Q19, an inverter/amplifier, and the final output of the circuit is taken from across R53.

Under bright lighting conditions, the Schmitt trigger is held off by the low voltage on Q17's base, and Q19 is saturated, so that −12 volts is available across R53. Under dark conditions, the Schmitt trigger is driven on, Q19 is cut off, and the voltage across R53 drops to near zero. The circuit can be made to trigger sharply at precise light levels by adjusting the value of R45. C1 adds a time delay to the operation of the unit so that it operates from average light levels and is not triggered by fairly rapid changes in light level, as might occur when driving under bridges and road lamps.

The −12 volt supply line is connected to the circuit through the ignition switch. Recapping this circuit's operation: its output (the voltage across R53) is at ground potential—zero volts—when the photocell is dark and is at −12 volts when the cell is exposed to bright light.

The computing section of the unit operates as follows: Transistor Q21 is used as an electronic switch which, when driven to conduction, turns on dashboard warning light LP13. This transistor is driven on (saturated) whenever D31 or D32 is forward-biased, as when Q20 is cut off or Q22 is saturated. The base of Q22 is direct-coupled to the collector of Q23 so Q22 is saturated when Q23 is cut off, and Q22 is cut off when Q23 is saturated. Consequently, the warning lamp (LP13) is switched on when *either* Q20 or Q23 is cut off. It is switched off only when *both* Q20 and Q23 are saturated (driven hard on).

When photocell LDR1 is in darkness the output of the driving-mode detector is zero volts. When the cell is in a strong light −12 volts is developed at the top end of R53.

Similarly, when the car's headlights are off there is no voltage across R56, and −12 volts across it when the lights are on.

Thus, both R53 and R56 develop information relating to the prevailing driving conditions. This information is fed through gate diodes D29 and D30 to the base of Q20, and through gate diodes D34 and D35 to the base of Q23. These diodes are connected in such a way that Q20 is driven to saturation when either input is at zero volts, and Q23 is driven to saturation when either input is at −12 volts.

With the above points in mind, let's take a look at the action of the

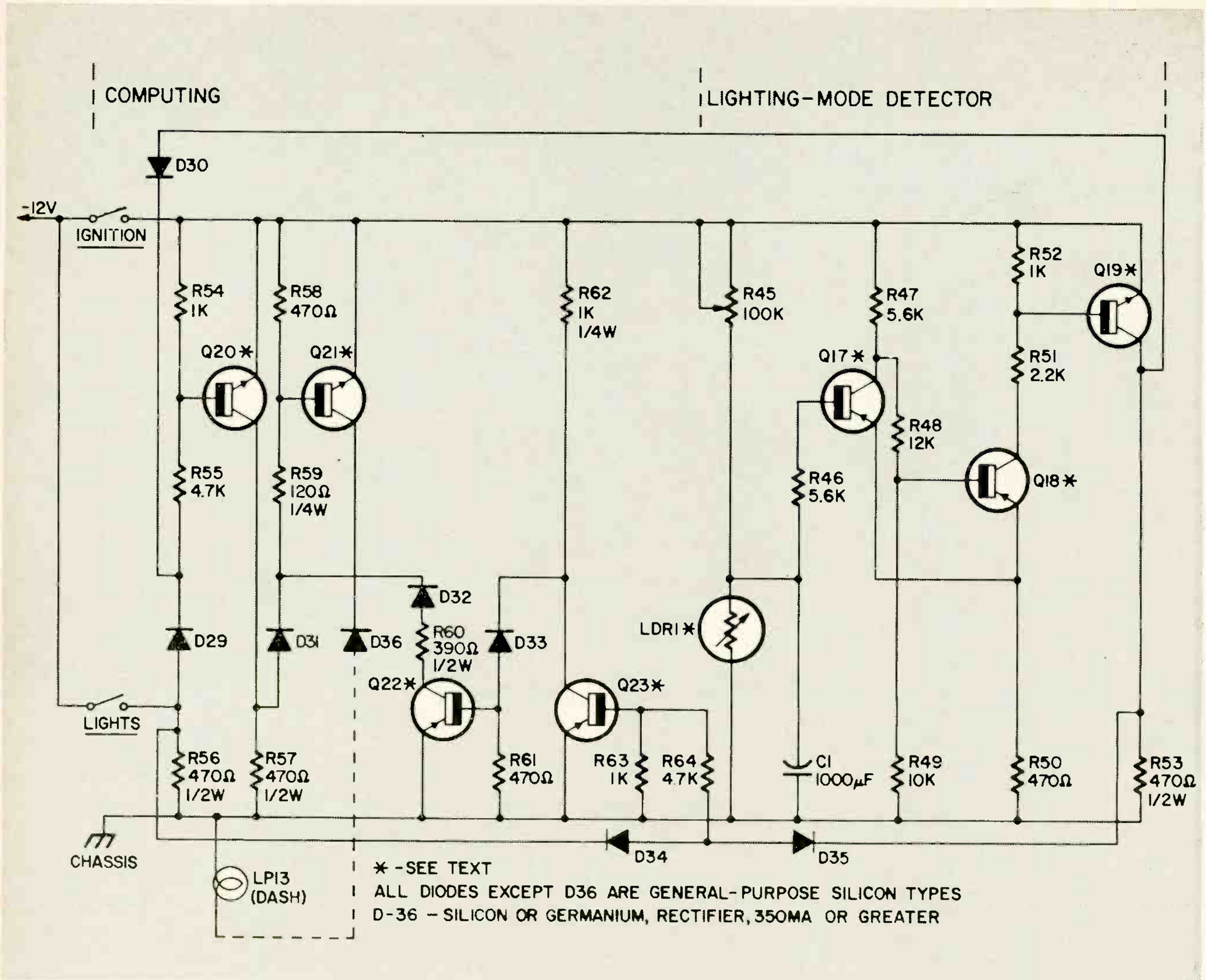


Fig. 4—This circuit decides whether your automobile lights should be on or off and warns you when corrective action is needed.

circuit under different driving conditions:

Lights on in daylight. Under this condition, −12 volts is developed across R56 so Q23 is driven to conduction through D34. Also, −12 volts is developed across R53. This voltage is applied to Q23's base through D35 and keeps this transistor saturated. At the same time, Q20 is cut off because both inputs are at −12 volts. With Q23 cut off, D31 is forward-biased and Q21 is driven to saturation. This turns on lamp LP13, indicating a fault.

Lights off in daylight. Here, zero volts is developed across R56 so Q20 is driven to saturation through D29. A −12-volt signal is developed across R53 so Q23 is driven to saturation through D35 and R64. Since both Q20 and Q23 are saturated, diodes D31 and D32 are reverse-biased. This cuts off Q21 so the warning lamp cannot come on. This is as it should be because headlights are not normally used when driving during daylight.

Lights on at night. Turning on the lights develops −12 volts across R56, so Q23 is driven to saturation. The photocell is dark so zero volts are developed across R53, and Q20 is driven to saturation through D30. Once again, both Q20 and Q23 are saturated, so both D31 and D32 are reverse-biased and Q21 is cut off. LP13 is off also, indicating that there is no fault.

Lights off at night. If you forget to turn on the lights no voltage is developed across R56, so Q20 is driven to saturation through D29. Since it is dark there is zero volts across R53, and Q20 is also driven on through D30. Q23 is cut off, since both inputs are at zero volts. Since Q23 is cut off, Q22 is driven to saturation, so D32 is forward-biased and Q21 is saturated also. This lights LP13, indicating that there is a fault.

Thus, the circuit automatically triggers a warning light on the dash panel if the car lights are *on* when they should be *off*, or are off when they

Parts list

C1—1000-μF 15-volt electrolytic capacitor. See text
R45—100,000-ohm miniature potentiometer
R46, R47—5600-ohm resistor
R48—12,000-ohm resistor
R49—10,000-ohm resistor
R50, R58, R61—470-ohm resistor
R51—2200-ohm resistor
R52, R54, R63—1000-ohm resistor
R53, R56, R57—470-ohm, ½-watt resistor
R55, R64—4700-ohm resistor
R59—120-ohm, ¼-watt resistor
R60—390-ohm, ½-watt resistor
R62—1000-ohm, ¼-watt resistor
All resistors 1/10-watt, 10% unless otherwise noted
Q17 to Q23—Transistors, see text
D29 to D35—General-purpose silicon diode
D36—Silicon or germanium rectifier, 350 mA or greater

should be on. The circuit operation, as described above, is briefly summarized in the table in Fig. 5.

Note that the circuit is operative only when the ignition switch is closed, i.e., when the car is being driven. If the ignition switch is off, the car must be parked, and there is probably no driver in the vehicle and thus no point in flashing the warning lamp.

The unit thus takes into account information about the mode of the actual car when coming to a decision For example, if the vehicle is moving (ignition turned on) at night with the lights off, a fault is evident and LP13 comes on. If, on the other hand, the vehicle is simply parked (ignition off) at night with the lights off, there is no reason to assume a fault, so LP13 stays off.

One final point about this circuit. In the description of circuit operation given above I've said that zero volts is developed across R56 when the main light switch is off. Observant readers may have noticed that this is not strictly true, since a potential divider network is formed between the negative supply line and ground via R54; R55; D29 and R56, so that about 1/12th of the supply line voltage in fact appears across R56 under this condition.

This "surplus" voltage in fact makes no difference to the circuit operation, since D34, R64 and R63 form an additional voltage divider and insure that less than 100 mV appears at Q23 base under this condition. (Remember that 600 mV is "lost" across silicon diode D34.) So, Q23 is cut off, as it should be, and the circuit operates as described. Similar considerations apply to R53 under dark conditions.

The correct values of all resistors are shown in the parts list. Component values have been carefully chosen to insure that the unit will work correctly with either germanium or silicon transistors, and using either a 6- or 12-volt electrical system. The following points should be noted when selecting components not specified in the parts list of Fig 4:

Transistors Q17, Q18, Q22 and Q23 can be any germanium or silicon pnp audio transistors with a current gain greater than about 20.

Transistors Q19 and Q20 can be any germanium or silicon npn audio transistors with a current gain greater than 20.

Transistors Q21 and Q13 through Q16 can be any npn types with a current gain greater than 20 (greater than 40 in a 6-volt system) and an I_{cmax} rating of 500 mA or greater. A germanium transistor is preferrable, but not essential.

LIGHTS	ILLUMINATION	Q20	Q23	LP13
ON	BRIGHT	OFF	ON	ON
OFF	BRIGHT	ON	ON	OFF
ON	DARK	ON	ON	OFF
OFF	DARK	ON	OFF	ON

Fig. 5—A table summarizing the operation of the circuit shown in Figure 4.

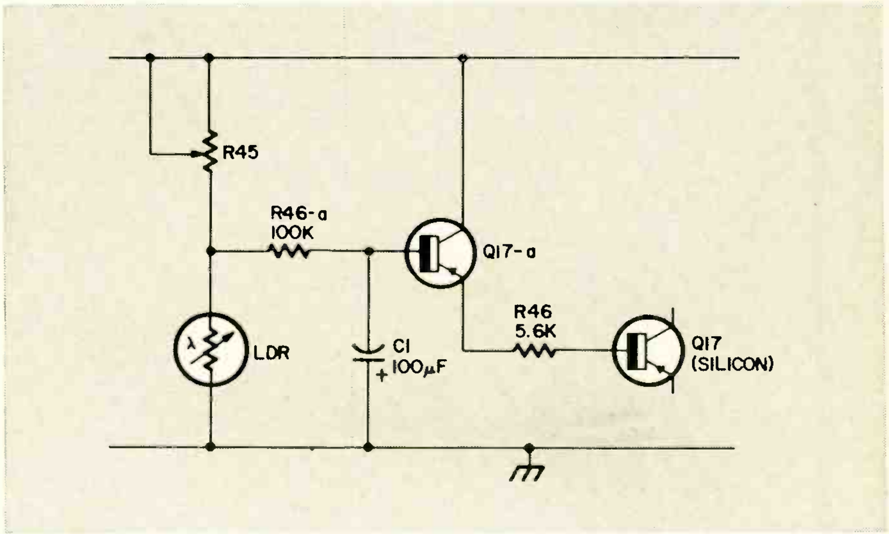


Fig. 6—The bulk of C1 helps determine the minimum dimensions of the circuit in Fig. 4. This modification reduces value of C1 and helps miniaturization.

Diodes D29 through D35 can be any general-purpose silicon units.

Diodes D36 and D25 through D28 can be any silicon or germanium rectifier with a forward current rating greater than 300 mA.

The LDR can be any cadmium sulphide photocell with a face diameter greater than about ¼" (Lafayette 99H6321, etc.).

In vehicles fitted with a negative-ground system, all pnp transistors should be replaced by npn types, and all npn transistors replaced with pnp types. In addition, reverse the polarity of C1 and all diodes. No other modifications are required.

Note that if the car battery voltage falls to about 5 volts, the circuit won't operate correctly if silicon transistors are used for Q20 and Q23, and LP13 will switch on. This trouble does not occur when germanium transistors are used in these positions, and this point should thus be considered when using the unit in cars with 6-volt lighting systems.

The electrolytic capacitors are the largest components in the entire computerized lighting system. In a recent effort toward further miniaturization, I made a few minor changes that make it possible to use smaller capacitor values. Capacitor C1 can be reduced from 1000 μF to 100 μF by adding an extra resistor (R46-a) and transistor (Q17-a) to the circuit as shown in Fig. 6. The added transistor can be any pnp silicon type with an h_{FE} greater than 60. Transistor Q17 must also be a silicon type if this modification is made.

The full system described thus far will detect and warn of any lighting fault or failure likely to occur in an automobile. However, there is one more service that the "brain" can be made to offer and that is to remind the driver to turn off the lights before leaving the car after driving at night. In the concluding article of this series we will show how to add a lights-on reminder circuit and how the warning lamp can be made more effective in attracting the driver's attention by adding a flasher circuit.

You don't have to wait for the conclusion of the article before beginning construction. The computer sections described in this three-part series are independent of each other so you can build them separately and then tie them in to complete the system.

Continued next month

Fix Color TV Brightness Faults

New servicing techniques solve old problems

By JAY SHANE

ALTHOUGH THERE ARE BASIC RULES TO APPROACHING ALL service problems, when it comes to the color set too many technicians have difficulty developing new techniques.

More often than not, a problem can be pinned down through the usual setup procedure of checking out purity and convergence. Of course, if there's no raster, then we've got a problem.

No brightness: By now we usually assume that what the customer really means is, "No raster." But when we get to the home we find the problem is, instead, a dim raster.

I recall a Magnavox 920 chassis. All tubes possibly involved with the problem were changed—just in case our outside man goofed or he had a bum tube in his caddy. No, our boy hadn't messed up.

The next approach was to take voltage readings of the CRT cathodes, grids and screens. The grids were close to normal—260 to 265 volts; screens were running around 950–1050 volts, while the cathodes were higher than the normal 310 volts. Along with the dim raster was a degree of flatness in contrast, further indicating that the video amplifier was the culprit.

The 12GN7 video output grid and cathode voltages were normal at 3 and 5 volts, respectively, but the plate was well over 300 when 270 volts was called for. This indicated the tube was not drawing normal current. Further checking revealed the grid voltage did not go from negative to positive with variations in the brightness control, and was thus not changing the tube's current flow which, in turn, would vary the beam current of the CRT.

One end of the brightness control is coupled to the video detector (a negative-voltage source) through peaking coils L212 and L214 (Fig. 1), and the other end is tied to the 140-volt line through a 3.3-meg resistor, so there should have been a definite variation of grid voltage. What the set was getting was a fixed bias through the control itself. That meant an open at the low end, since our bias remained constantly positive.

I removed the bottom plate of the video i.f. strip for further investigation. (Be sure to replace this bottom plate to prevent extraneous signals being injected into the video i.f. system.) Having in mind but a single route to travel, I quickly discovered that one of the peaking coils leading from the video detector was open, cutting off negative biasing to the video amplifier.

Man-made problem! Another Magnavox color set was brought into the shop with the complaint that brightness had been too low ever since the receiver had been last repaired. Service calls from various shops had not rectified the condition. So, as is often the case, we (the Magnavox factory service station in our area) were the last to be called. It was a 920 chassis in a combination phono, radio, FM multiplex, remote-controlled Aegean Classic.

After getting the chassis out of the cabinet the usual checks were made of the CRT circuitry—the video amplifier, blanker and color-difference amplifier (the fairly new 6MD8). All voltages were within normal ranges, except the CRT screens. Instead of being 900 to 1050 volts, they were riding at 700 to 800, or 200 to 300 volts low.

Since the screen voltage comes from boosted boost, I immediately shifted my attention to that area. I wasn't long finding the goof.

The last repair job had obviously been in this area, with the silicon rectifier (CR101 in Fig. 2) replaced, but with the diode inserted at reversed polarity. (In the Magnavox 911, 918 and 920 chassis the boosted-boost rectifier is under the 6GF7 vertical oscillator and output tube with the positive end pointed toward the rear skirt of the chassis.) Needless to say the rectifier had shorted out and the set was getting only the 800-volt boost from the 6DW4.

CRT or what? This was an RCA CTC16 chassis with a 21" round CRT. With age climbing up on some of these picture tubes, this set had all the indications of a sour picture tube. Brightness was low, focus was poor and color pretty flat, with b-w contrast reasonably good.

But before condemning the CRT and shocking the customer into a nervous breakdown, a few cursory checks

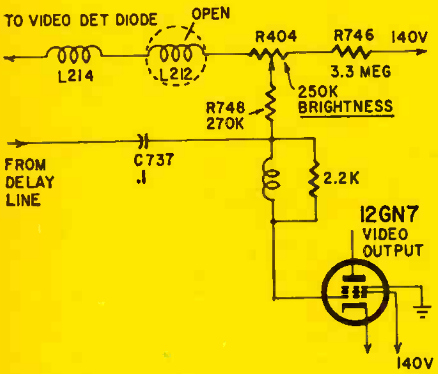


Fig. 1—Open peaking coil in detector circuit cut off negative bias on 12GN7.

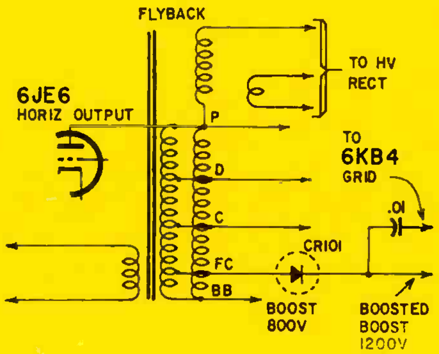


Fig. 2—Screen bias on CRT was low due to reversed polarity of CR101.

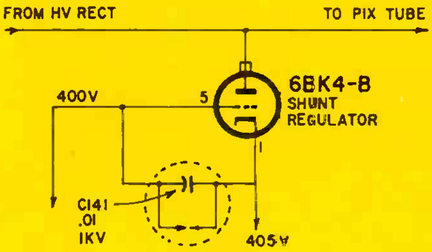


Fig. 3—Set had low brightness and poor focus. 6BK4-B shunt regulator and a replacement both ran cherry red. Shorted 0.01-µF capacitor had removed tube bias.

were made. Horizontal and video amplifiers, damper and the two 6GU7's were all replaced. No change. Then it was noted that the 6BK4 shunt regulator was running cherry red. Often an old regulator tube will go sour and glow heavily, so it was changed. In a few seconds the same glow in the new one.

It took no great amount of technical knowledge to realize this tube wouldn't last long, so the chassis was pulled and set up on the jig. No change in the condition, so a reading was made of the high voltage. It was riding at less than 10 kV.

Bad flyback? A few wax drippings were lying on the bottom of the cage, but the transformer wasn't too hot.

All other voltages seemed okay, so I pulled the cap off the regulator and high voltage rose to 26 kV. No question of the flyback being good, especially with an arc itching to jump from the dangling cap to the corner of the cage. Resistance checks of the 6BK4 circuitry were made.

Guess what? See Fig. 3. If you concluded a shorted capacitor, you're dead right. The 0.01-μF capacitor between the grid and cathode of the regulator had a 7000-ohm short. This removed the tube's bias and allowed it to conduct continuously. Replacing the capacitor and putting the old tubes back in the set had everything working fine.

The original 0.01-μF capacitor has a built-in spark gap. If you don't have an original replacement, be sure to tie a spark gap rated at least 1000 volts across the capacitor.

Emerson with no raster: This receiver landed on the service bench with a complaint of a dirty tuner. When it was fired up the set had no raster, but sound was good. This immediately revealed that the horizontal system was working because agc was operating. A check of the flyback showed that high voltage started to build up and then quickly decayed to practically nothing. Something was loading it down. The anode lead was lifted from the CRT because our shop has had the experience of a carbon path developing inside the picture tube and shorting high voltage to the focus anode. Usually an arc can be seen in the guns if the lead is held close to the button and lifted with an insulated tool.

Such was not the case this time, yet the high voltage shot up when the anode lead was disconnected from the CRT. Since video is obtained at the grid of the video amplifer, suspicion immediately jumped to this circuit. Failure of the video amplifier will not necessarily affect sound but can cause the flyback to load down when no beam current flows in the CRT.

My check immediately indicated something seriously wrong in the 12BY7 circuit—no plate voltage. This meant partial removal of the chassis because the voltage source was at the SERVICE switch (Fig 4). Here it was discovered that there was voltage on the input side of T208's primary, but none coming out of it. Simple deduction. Open primary coil. The local Emerson distributor had the part in stock and it was replaced.

After a thorough cleaning of the tuner and lubricating it with contact dope, the set was returned home.

Too much brightness: See Fig. 5. In this Magnavox 920 chassis: the CRT cathode voltage was about 50 volts low, but it did vary with the brightness control, eliminating the video amplifier as the culprit. The best thing here seemed to concentrate on voltages in the CRT cathode circuit (Fig. 5). The absence of voltage (405 volts) at point E indicated that peaking coil L602 was open. Fig. 5-a shows it is not necessary to remove the chassis to check this panel.

In another instance of the same complaint, we were pushed against the wall to resolve the problems. The customer had had numerous service calls—which we knew nothing about until our man got there—with the same complaint from the very first week the set had been installed. The owner had even been told that excessive brightness was a characteristic of this particular model. To us, this was ludicrous because the 920 chassis has for some time been the "workhorse" of the Magnavox line.

This one was hitched to the jig, noting that the drive controls were turned completely down (counterclockwise) and the raster was too bright when the brightness control barely cracked. Screen controls were also way down, although this is not an uncommon offense if someone has turned up the kine bias.

There was, however, with this condition, a definite lack of resolution, although color was good. Naturally, when the brightness control was turned up blooming resulted, with eventual loss of raster.

The cathodes of the CRT were riding at 270 volts, quite low, while the grids were running a little high, but tolerable in extreme circumstances. The screens were at 800 to 950 volts. Considering that the controls were set at zero (fully counterclockwise), boosted boost was eliminated as the problem.

I worked along the control panel above the rear skirt of the chassis (Fig. 5-a). All voltages seemed normal, except the cathodes. Instead of varying from 310 to 405 (Fig. 5-b), voltage was constant at 270.

Circuitry component checks indicated everything was normal—peaking coils and voltage dividers, right down to the last ohm. The question was: Why the lack of voltage drop across the drive controls? It seemed a logical approach to check each component separately. Resistors and controls were lifted from the panel and individually checked for resistance. Voila! Resistor R617 (Fig. 5) was lifted at one

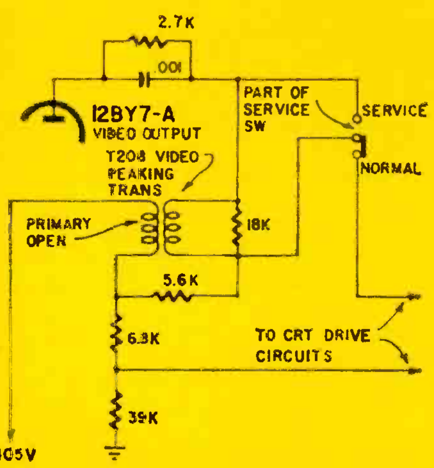
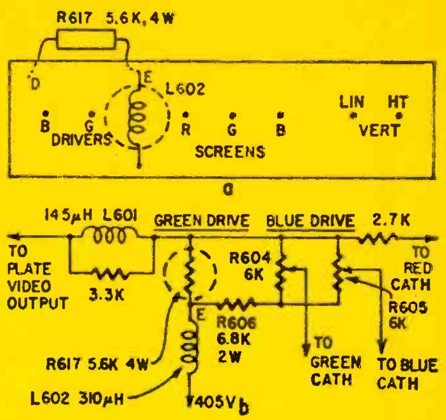
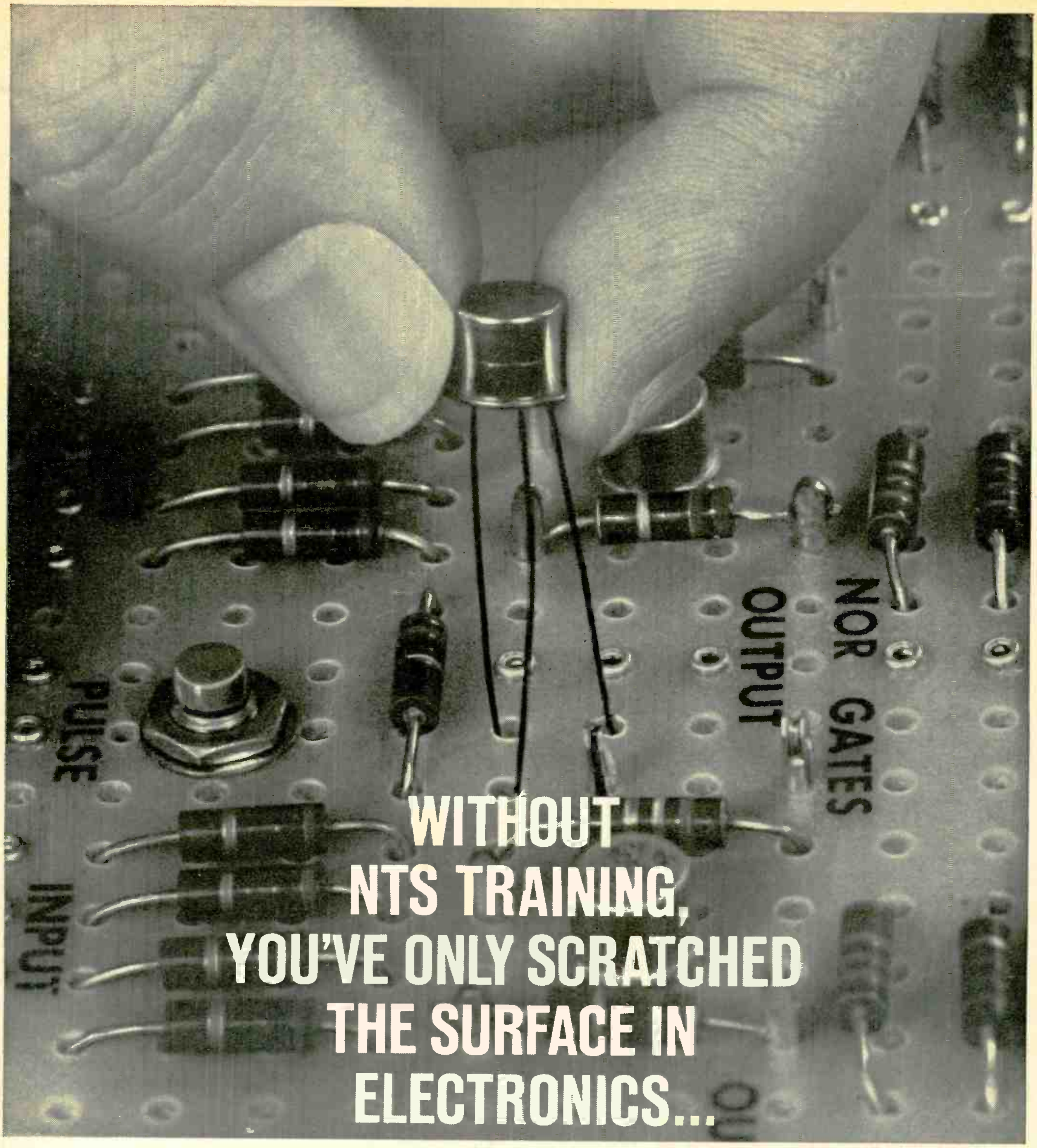


Fig. 4—Rapid decay of high voltage indicated loading of the circuit. Open coil in video output tube plate circuit indirectly cut off the CRT beam current.

Fig. 5—Excessive brightness in Magnavox set was traced to open R617. Voltages on control panel (a) were normal except on the cathodes, which bled through drive controls instead of the resistor.





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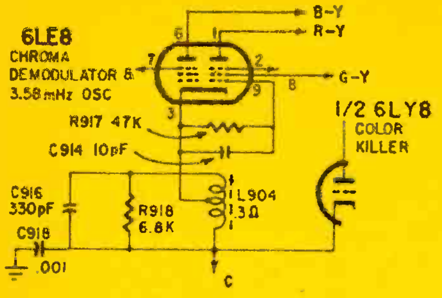


Fig. 6—Problem was a weak green raster. Open L904 cut off both 6LE8 functions.

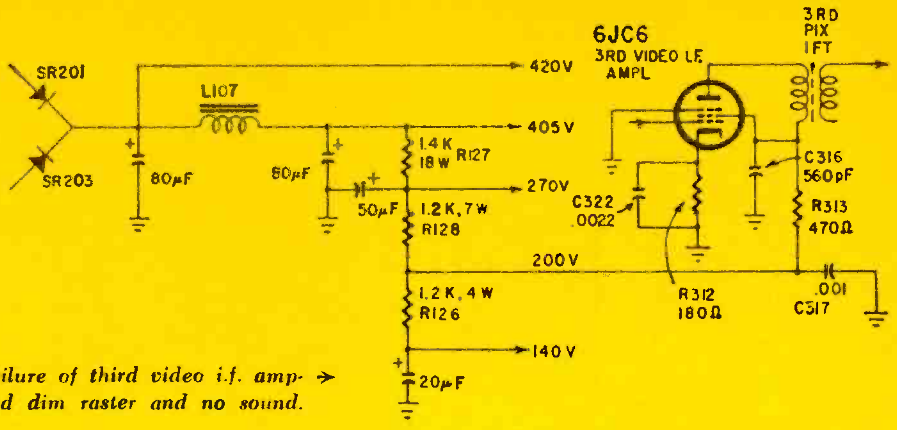


Fig. 7—Failure of third video i.f. amplifier caused dim raster and no sound.

end and found to be open. This forced the CRT cathodes to be bled through the drive controls instead of this resistor.

The reason resistive values were in the tolerable bracket is that, if we look at the drive control, we find each is valued at 6000 ohms and R617 is 5.6K, making a rough tabulation of a little under 2000 ohms for the network. But we've overlooked the 6800-ohm decoupling resistor (R606) in the bottom leg of this network. This changes things considerably. The reading across the drive controls now becomes 3500 ohms, and if, as was the case, R617 is open, the reading from D to E would have to be the combined resistance of R606 and the parallel values of the drive controls, making a total of around 9800 ohms.

Replacement of R617 cured the problem, with resolution also restored.

Flashing raster: This is a condition best described as every few seconds. The chassis, an RCA CTC16X, was brought in from a one-man shop. We allowed him to set it up on our jig and explain his procedure and what he'd done. There was nothing wrong with what he'd been doing, only he kept thinking in terms of b-w and had concentrated on the horizontal, yoke and flyback circuits.

The first thing we checked was whether he'd wired and lead-dressed the flyback properly. Everything looked okay, so the set was fired up. In a few moments the 3A3 started to glow red, indicating that heavy saturation was taking place and the tube wouldn't last long. Working quickly, we probed the anode voltage. It was pulsating rapidly to about 18 kV every few seconds.

The shop owner took off. The problem didn't indicate the blanker or the high-voltage system itself. Pulling the cap off the regulator immediately eliminated it. When all else fails, take voltage and resistance readings. To keep from destroying the 3A3 the cap was pulled from it while we took voltage readings. Things appeared normal until we came to the 6GU7's. Neither of these tubes functioned.

A voltage check quickly revealed the problem. The cathodes had the same voltage as the plates. That could only mean no current was flowing through the tubes, suggesting a bad cathode resistor. It should have read 220 ohms. We had infinity. Replacing it brought back raster.

The raster was flashing on and off because the grids of the color-difference amplifiers were slowly and intermittently biased highly positive through the 270-volt plate supply of the network feeding the demodulators.

Green screen on Motorola: Fig. 6 shows the sheet-beam or quadrature system of demodulator of a Motorola 914 chassis. The problem was weak green raster. Adjustment of drive and screen controls or changing tubes didn't help. Voltage readings were taken. Everything was normal until we came to the 6LE8, then things went haywire. We were supposed to have 21 to 23 volts on the cathode. It was riding at close to 70.

Each resistor in the cathode network was of normal value until we came to R918, which should have read something like 0.3 ohm because it was shunted by the tuned cathode coil (L904). Our reading was 6800 ohms. Obviously coil L904 was open, not only killing the 3.58-mHz oscillator and demodulator action, but also stopping the function of the color killer. Repairing the open end of the coil restored proper gray scale and color.

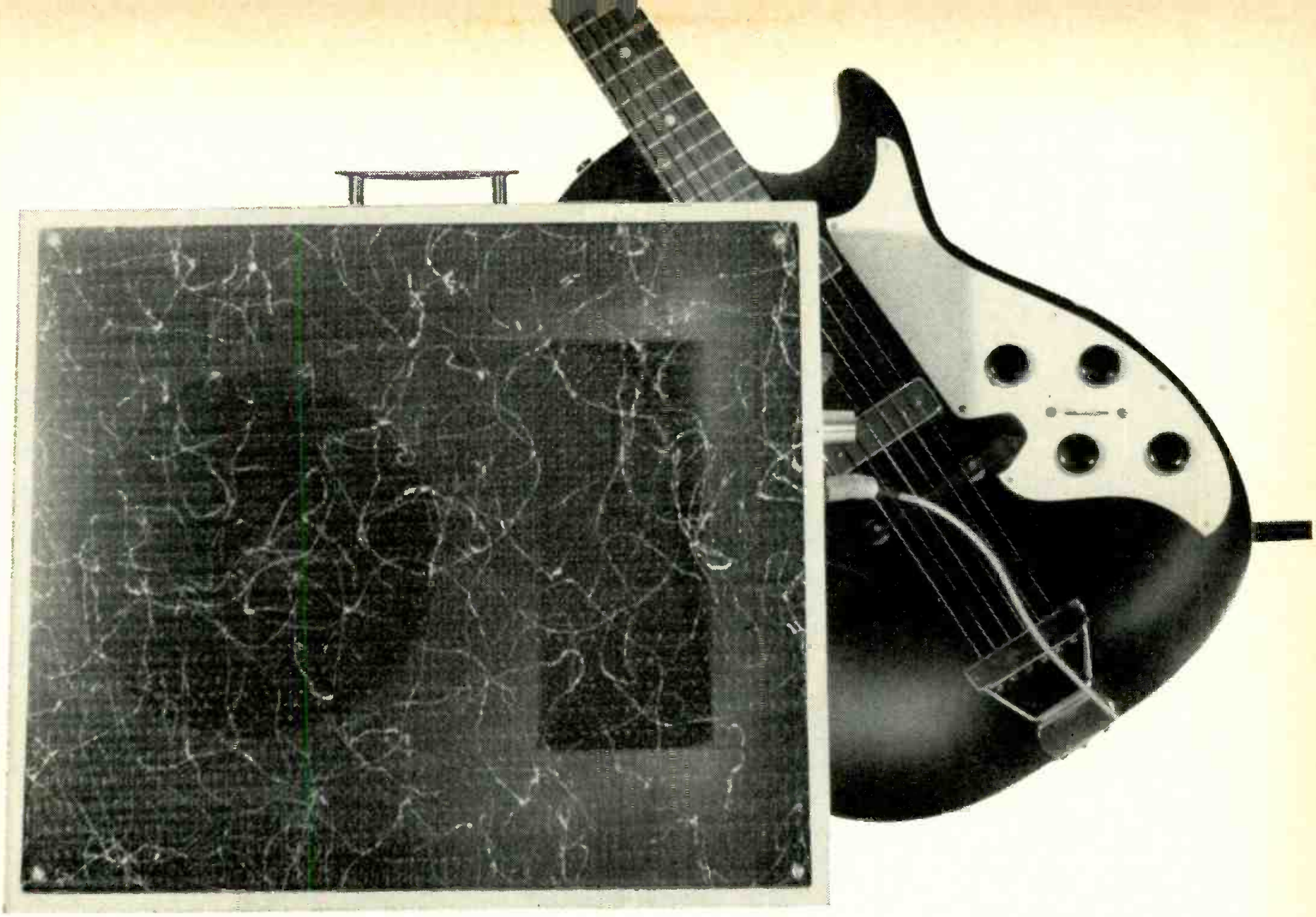
The screen tended to be green because, without B − Y and R − Y signal, only the green was functioning. Minor current flow through the screen of the 6LE8 kept the CRT green grid weakly biased.

Front-door sneak: We call it this because it's the least expected. An RCA CTC16X came in with no sound and very dim raster. Lack of sound would normally place the problem before the video output. With raster so weak one couldn't tell if video was present or not, so all suspected circuits were investigated—tubes changed, voltage readings taken, etc. The CRT cathode voltages, however, did not change with varying the brightness control, bringing us back to the 12BY7, where I found that the screen voltage of this stage was very low.

It called for a 230 volts on the screen, but the set was riding at about 94. This reduced electron flow within the 12BY7, thereby causing CRT beam current to be down, resulting in very weak raster.

Checking back through circuitry, I moved to the voltage divider network lying just to the edge of the video i f. board. As I went down the divider network, voltage drops were excessive, until I came to R127 (Fig. 7). Instead of 270 volts, it had only 195. At the output of R128, there was just about zero, with the 7-watt resistor sizzling hot. Something was sure sucking this leg down. Naturally, nothing was coming out of R126.

This was a puzzler. But, on lifting the 200-volt lead from R128, all voltages immediately came up to normal. No video, of course. Tracing the circuit revealed this 200-volt source supplied only one tube in the chassis, the 6JC6 third video i.f. amplifier. There could be only one two conclusions: either the screen bypass was shorted or the tube itself had taken the route. Replacing the tube cured the problem, but the bottom plate was removed from the i.f. board to check decoupling resistor R313 and cathode resistor R312. Both were pretty well cooked. They were replaced and the set sent home. **R-E**



BUILD YOUR OWN IC GUITAR AMPLIFIER

Battery-powered portable unit goes everywhere

By HERB GILL

YOU CAN BREAK AWAY FROM THE END of the power line with this battery-operated guitar amplifier. Beach, boat or boondocks are now fair game for your electric guitar.

Most of the "components" are in the preamp, the RCA CA-3020 integrated circuit amplifier. This little "gem" in a single TO-5 transistor case with 12 legs is a complete 550-milliwatt push-pull amplifier. Its 58 dB gain is more than enough to work directly from the guitar pickup. Distortion is less than 1%. The $2.80 price would warm the heart of a value engineer too; you couldn't buy the 7 transistors, 3 diodes and 11 resistors as individual parts, let alone connect them up and make the circuit work, for this small amount of money. Just in case you haven't seen the silicon chip used to act as a piece of real estate for all these components, it's about the size of this small letter "w".

Outdoor renditions generally need more sound power. To get this power you can add an additional output stage. While there is no limit to the size and power of the amplifier you can add, you should find this 2-watt rig surprisingly adequate. Battery drain is very low: easily available 6-volt lantern batteries provide hundreds of hours of playing time.

How it works

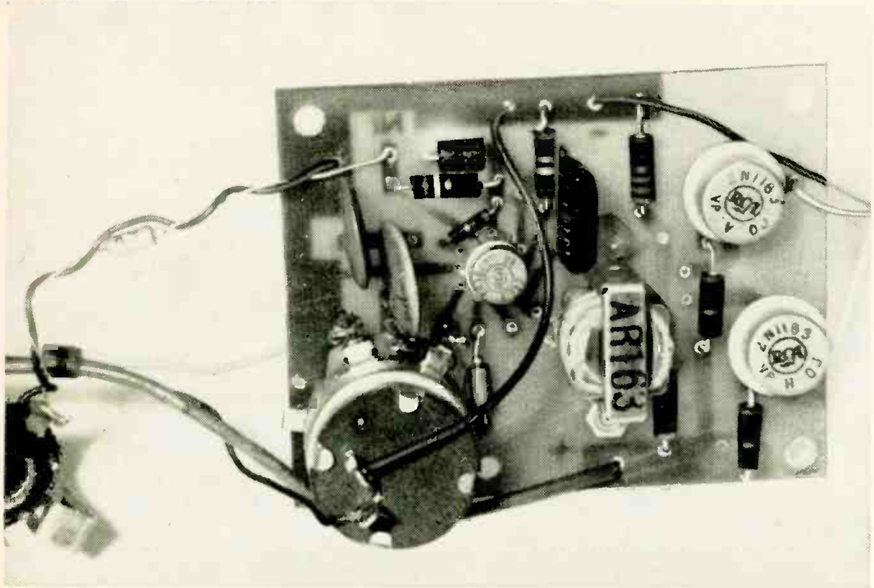
Integrated circuit IC1 performs five functions: voltage regulator, buffer, differential amplifier and phase splitter, driver, and power-output amplifier.

Now refer to Fig. 1. The signal from IC1 is transformer-coupled (through T1) to push-pull power amplifier Q1–Q2 and then fed to the speaker through T2. Diode D1 protects the IC against reversed battery polarity.

Construction

If you use the printed-circuit board (Figs. 2 and 3) practically all connections are automatic. If you use point-to-point wiring, keep parts placement as close as possible to that of the PC board to minimize the possibility of wiring error. Watch the keying tab on the IC; it is at pin 12. Watch the polarity of electrolytics C1 and C2. The negative terminal of C1 goes to the input jack, and the negative terminal of C2 is grounded.

Diode D1's polarity is the only other critical connection; connect its anode to the junction of batteries B1 and B2. This diode, incidentally, allows the use of a single-pole on–off switch. It blocks a reverse-current



Close up of the circuit board shows how easily all the components fit. The tiny 1-μF electrolytic capacitor can be seen in series with the input lead, top left. Compare this photo with the printed-circuit board and parts layout on next page.

flow between the 6- and 12-volt leads when the negative lead is opened. If the diode is omitted you will have to use a double-pole switch to open the two positive leads.

The IC leads are on a ¼" circle but holes on the PC board are on a ⅜" circle to make the board easier to construct and to wire.

My speaker did not have a mounting bracket for an output transformer so I mounted the transformer on the wall of the speaker case. Its position is not critical. The amplifier was mounted in the box, well away from the speaker to minimize the possibility of any mechanical feedback or vibration.

Figure 4 shows the parts of the speaker box. They are assembled with glue and screws and then covered with a vinyl leatherette or upholstery material.

Contact cement of the type used for bonding plastic surface material to counter tops is ideal for gluing the covering on the speaker box. However, do *not* let the cement dry—as you are instructed to do on the can—before applying the vinyl covering. Put the plastic on while the cement is thoroughly wet so you can stretch and smooth the plastic into place.

You can use some of the same cement on the grille cloth. Cement it to the face of the speaker baffle board and let the glue dry. Fold the edges around the back of the board and tack or staple in place.

You have a choice of suitable 6-volt batteries. They come with several types of terminals, and some types are more readily available than others. The most readily available is the NEDA type 908 spring-terminal lantern battery. You will need a special retainer setup with a special connector board as in Fig. 5.

If you live in an area where almost all types of batteries are available, the NEDA 915 with binding posts, the NEDA type 6 with a Cinch No. 5A4 plug and the 917 with spring clips can be used. I used the NEDA type 6. If you use the amplifier a lot, two NEDA 918 batteries will last about two and a half times as long as

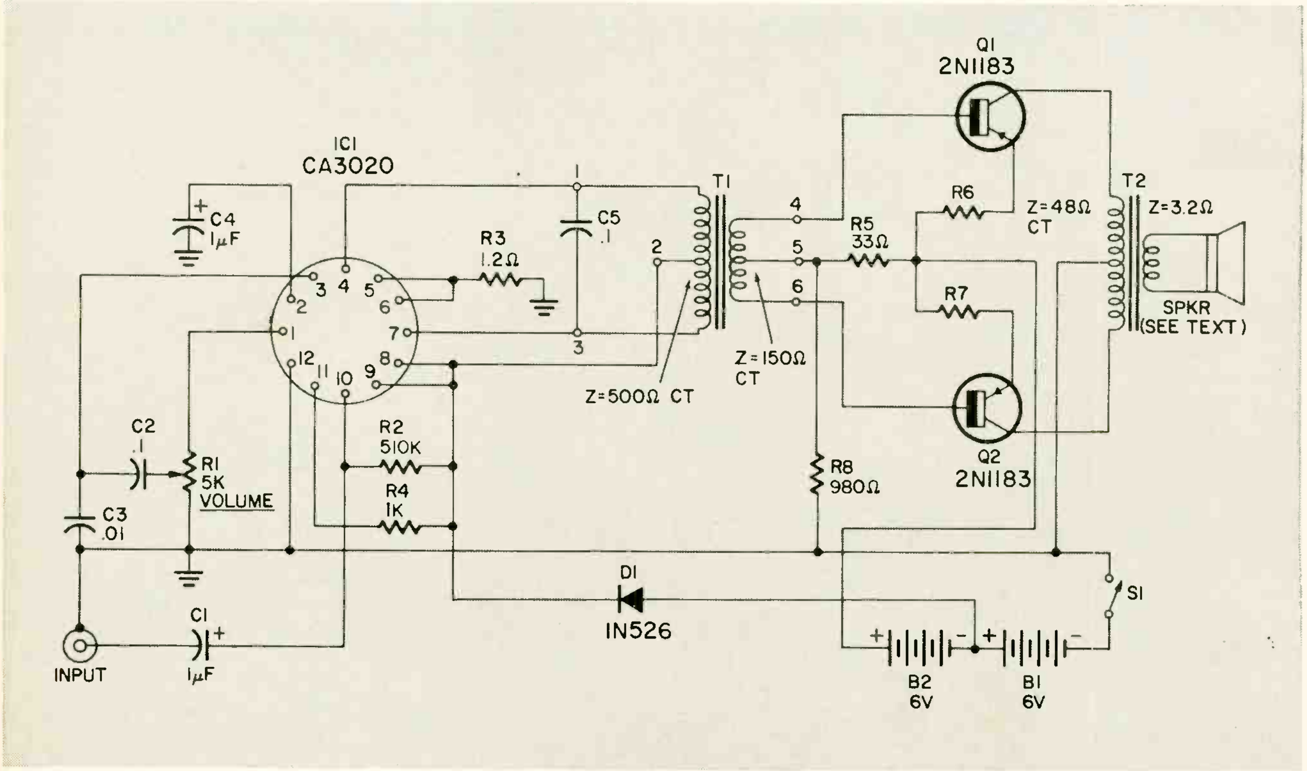


Fig. 1—The complete circuit of the IC guitar amplifier. Thanks to the IC a lot of wiring has become completely unnecessary.

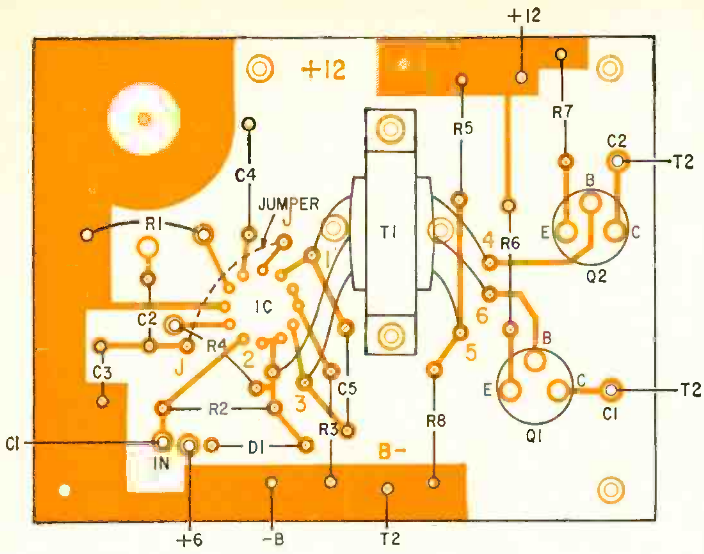


Fig. 2—Parts on the circuit board. In this view you are looking at the parts arrangement from the wiring side of the board.

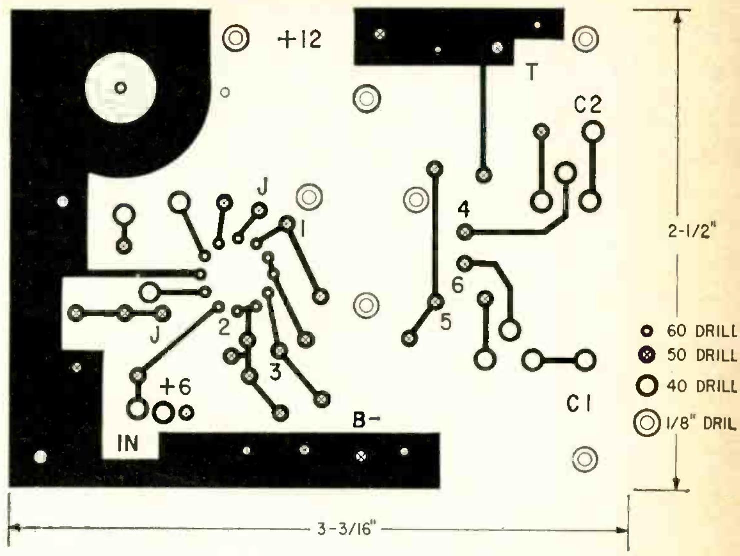


Fig. 3—Exact size drawing of the circuit board. Follow it to make yours. You can trace it or use a photographic process.

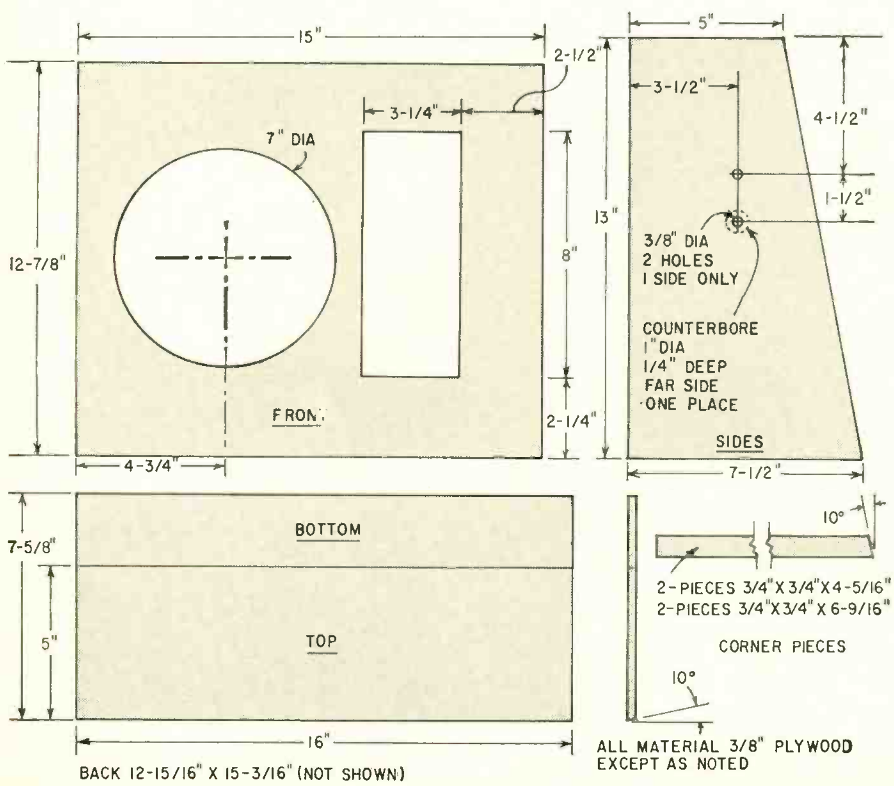
Parts List

C1, C4—1-μF, 12-volt miniature electrolytic or tantalum capacitor
C2, C5—0.1-μF, 50-volt ceramic capacitor
C-3—0.01 μF, 100-volt ceramic capacitor
R1—5000-ohm miniature potentiometer with s.p.s.t. switch
R2—510,000-ohm, ¼-watt resistor
R3—1.2-ohm, ¼-watt resistor
R4—1000-ohm, ⅛-watt resistor
R5—33-ohm, ¼-watt resistor
R6, R7—10-ohm, ¼-watt resistor
R8—960-ohm, ¼-watt resistor
T1—Transistor audio interstage transformer. Pri. 500 ohms ct, sec 150 ohms ct. (Argonne AR-163, Lafayette Radio)
T2—Transistor audio output transformer. Pri. 48 ohms ct, sec 3.2 ohms (Lafayette Radio stock No. 33 H 8578)
IC1—CA3020 integrated-circuit amplifier (RCA)
Q1, Q2—2N1183 transistor (RCA)
B1, B2—6-volt heavy-duty battery (see text)
S1—s.p.s.t switch (on R1)
MISC.—(4) ¼" spacers for No. 8 screws, 4 rubber feet, grille cloth, plywood, input jack for guitar cord

the ones listed above.

The amplifier deserves a good extended-range speaker, not just any old 8-incher. I used a Utah type D8-LA dual-cone unit. The SP8J8 is also good but the best choice is probably a speaker designed especially for guitar amplifiers.

The amplifier can be used for other purposes too; any high-impedance device such as a crystal microphone or phono cartridge will drive it. You can also drive it from the signal at the phone jack of a small transistor radio. **R-E**



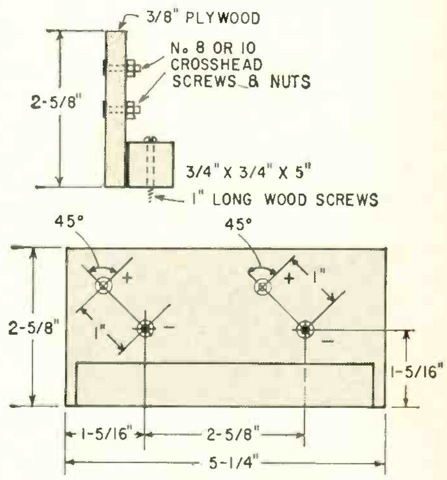


Fig. 5—You'll need a battery connector like this if you use lantern batteries with spring terminals such as the NEDA 908.

Fig. 4—Construction of the amplifier/speaker case. All parts except the corner braces are cut from ⅜" plywood.

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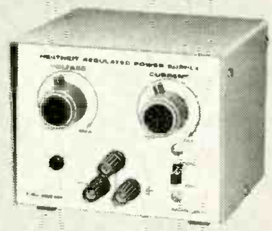

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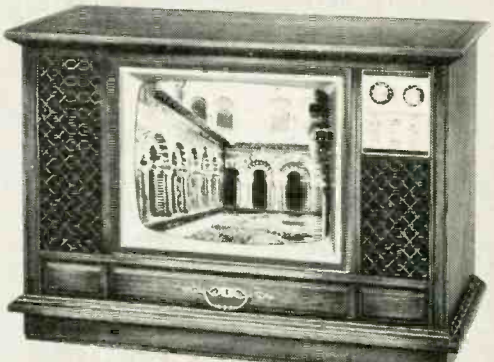

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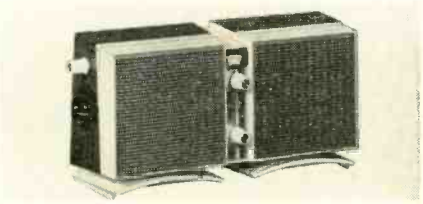

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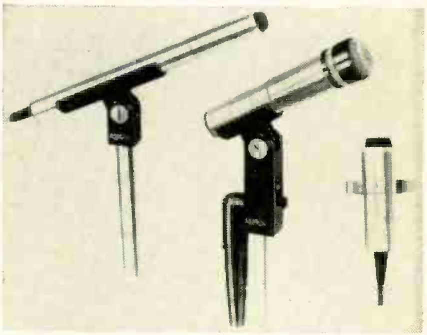

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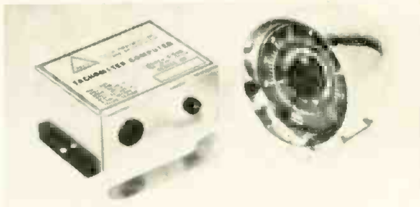
Circle 53 on reader's service card

SPEAKER SYSTEM, *Xa Series.* Employs a woofer of free-edge cone design and a high-frequency driver. Reproduction rated at 20 to 20,000 Hz. System is capable of handling from 5 to 60 watts of power and is suitable for livingroom or

concert-hall sound-reinforcement systems. Level controls and a crossover network provide adjustment of mid-range and tweeter to the acoustic environment. Comes in Contemporary, Provincial, Early American, Mediterranean and Panoramic styles.—**Wald Sound**

Circle 54 on reader's service card

COMPUTER–TACHOMETER, *Computach.* Combination computer–tachometer includes voltage and temperature stabilization to assure accuracy under all operating conditions. Zero-parallax meter is set in a chrome-plated die-cast hous-



ing. Light intensity of translucent dial with internal illumination is controlled by panel light dimmer. Unit has a 0–8000-rpm range and applies to all 2-, 3-, 4- and 6-cylinder 2-cycle and 4-, 6- and 8-cylinder 4-cycle 12-volt engines. $29.95. —**Delta Products, Inc.**

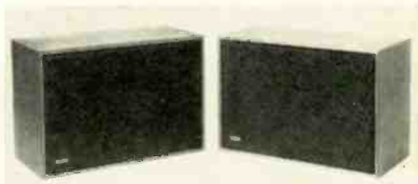
Circle 55 on reader's service card

ANTENNAS, *Color-Tracker Series*. Covers all uhf channels from 14 through 83. Units produce constant 300-ohm impedance across uhf band and form a capacitive reactance at terminal points, result-

ing in very low uhf impedance and very high vhf impedance. *Color-Tracker* antennas include the 32-element Model U-630, $29.95; 20-element Model U-620, $19.95, and 12-element Model U-610, $14.50.—**Winegard Company**

Circle 56 on reader's service card

STEREO SPEAKER SYSTEM, *Model 715* contains three elements—two 6-inch woofers and one 3½" wide-dispersion tweeter. The crossover network is a two-way L-C high-pass–low-pass filter design. Frequency response is 40 Hz to 20 kHz, ±6 dB. System measures 19" x 13" x 9¼"



and weighs 20 lb. Oiled walnut finish with dark brown grille cloth. $129 for a pair.—**Ampex Corp.**

Circle 57 on reader's service card

DIGITAL CALENDAR MOVEMENT, *#132-C*, shows month, date and hour. It consists of: mounting bracket—2 time re-set controls and a window escutcheon

This Industry Compatible Test Jig (ICTJ) Cross Reference book, and an assortment of RCA adapters, let you service almost any color TV make and model with an RCA Color TV Test Jig.

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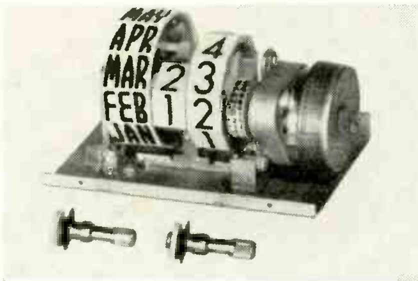
Deptford, New Jersey

62

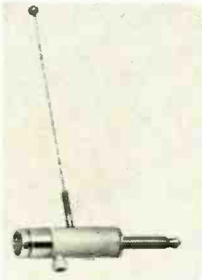
Circle 112 on reader's service card

assembly. Digits are ⅝" and can be individually reset. Size: Height 3", width 5½", depth: 3¼". UL and CSA approved motor and cord. 110–120V, 60 Hz. Designed for installation in any equipment, rack console and cabinet.—**Pennwood Numechron Co.**



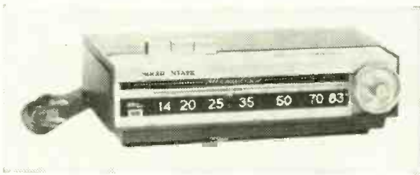
Circle 58 on reader's service card

GUITAR BROADCASTER, *Astro-Com A-1001.* Wireless broadcaster will effectively reproduce full frequency response into any good quality FM radio up to 50' away. Unit can also be used with an FM tuner patched into the microphone input of a guitar amplifier for cordless operation. Operating instructions and helpful hints are included.—**Saxton Electronics Corp.**



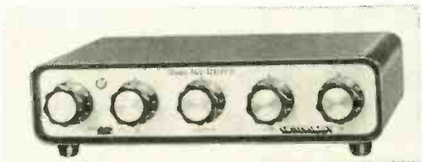
Circle 59 on reader's service card

UHF TV CONVERTER, *Model CR-880,* uses 3 transistors, 2 diodes, and a high-gain amplifier. A local distant switch enables the user to switch from local to long distance, switching on the amplifier for 30-dB signal gain. Screw terminals at the rear of the converter provide easy hookup of antenna and set leads to the converter. Three pushbutton controls for switching and selecting either uhf or vhf. $49.95.—**RMS Electronics, Inc.**



Circle 60 on reader's service card

MICROPHONE MIXER, *Model 308TR* is a solid-state, stereo–monaural audio mixer/amplifier that operates on standard



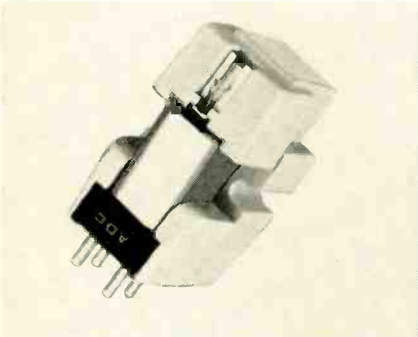
Circle 113 on reader's service card

Circle 114 on reader's service card

ac house current. It accepts up to 4 monaural input signals or 2 stereo input signals, from any combination or type of program source. It is equalized for magnetic phono cartridges. Distortion is 1% maximum (0.5% typical) at 4.0 V output. Frequency response is 20 Hz to 20 kHz with a minimum signal-to-noise ratio of 60 dB (1 mV input). Size: 3½" x 12" x 7¼".—**Switchcraft, Inc.**

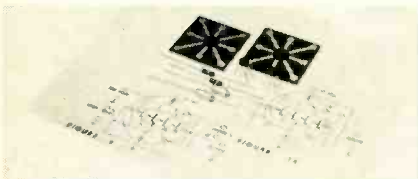
Circle 61 on reader's service card

STEREO CARTRIDGE, *ADC 550/E.* At the optimum tracking force of 1½ grams, device will track any 33⅓-rpm phonograph record, stereo or mono, uniformly. Type: induced magnet; sensitivity: 5 mV at 5.5 cm/sec recorded velocity; tracking force: ¾ to 2½ grams; frequency response: 10 Hz to 20,000 Hz ±3 dB; channel separation: 20 dB from 50 Hz to 8 kHz; recommended load impedance: 47,000 ohms. Price: $49.50.—**Audio Dynamics Corp.**



Circle 62 on reader's service card

EXPERIMENTER'S KIT, *Model IC-100.* Kit is especially designed to help the electronics student, technician, designer or experimenter gain knowledge and experience in integrated circuits. Contains five easy-to-follow experiments and many diagrams and schematics. Experiments cover gates, logic circuits, monostable multivibrator, square-wave generator and amplifiers. Includes two Fairchild μL914 integrated circuits, components and two pre-etched printed-circuit breadboards. $6.95—**Kaye Engineering**

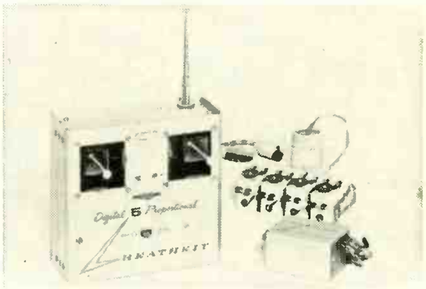


Circle 63 on reader's service card

RADIO CONTROL SYSTEM, *Model GD-47.* The complete 27-MHz system includes transmitter, receiver, 2 rechargeable batteries, 4 servos, all cables and connectors. $219.95. Transmitter, *Model GDA-47-1,* has stick type controls on 4 channels. The left stick controls rudder and throttle; the right stick controls elevator and ailerons. The fifth channel has

83

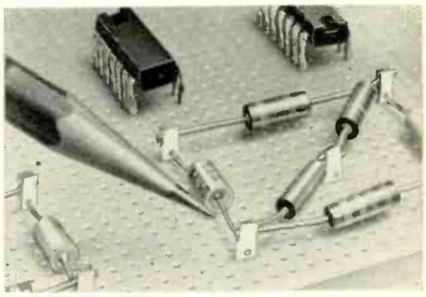
a thumb-type control and can be used for flaps or landing-gear operation. $86.50. Receiver, *Model GDA-47-2* features high sensitivity for long-range operation, noise



limiting to eliminate interference and temperature compensation $49.95. Servos, *Model GDA-47-4*, have 3 outputs delivering 3.5-lb thrust. $21.50 each.—**Heath Co.**

Circle 64 on reader's service card

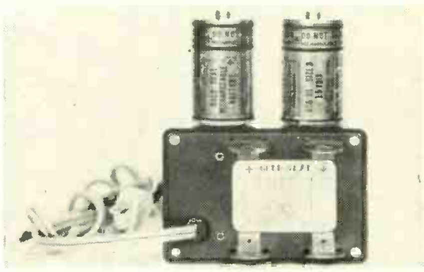
MINIATURE TERMINAL, *Micro-Klip T42-1*. Designed for use in .042" diameter circuit board holes, unit is made of beryllium copper. No staking is necessary but ends may be flared with pliers to fur-



ther secure. Insertion of terminals is made easier by the P149A hand insertion tool available for $1.50. Terminals are priced at $12.99 per thousand.—**Vector Electronic Co.**

Circle 65 on reader's service card

RECHARGEABLE CELLS AND CHARGER. Rechargeable 1.5 V alkaline D-cell has a service life of over 100 discharge cycles. Total output exceeds 100 zinc-carbon cells. *Model 201 Charger* re-



stores cells in 12 to 16 hours and will not overcharge. It charges 1 or 2 D-cells from 117 volts 60 Hz, using 3.3 watts. D-cell, $1.10 each. Charger, $4.75.—**Gold Seal Battery Co.** R-E

Circle 66 on reader's service card

End

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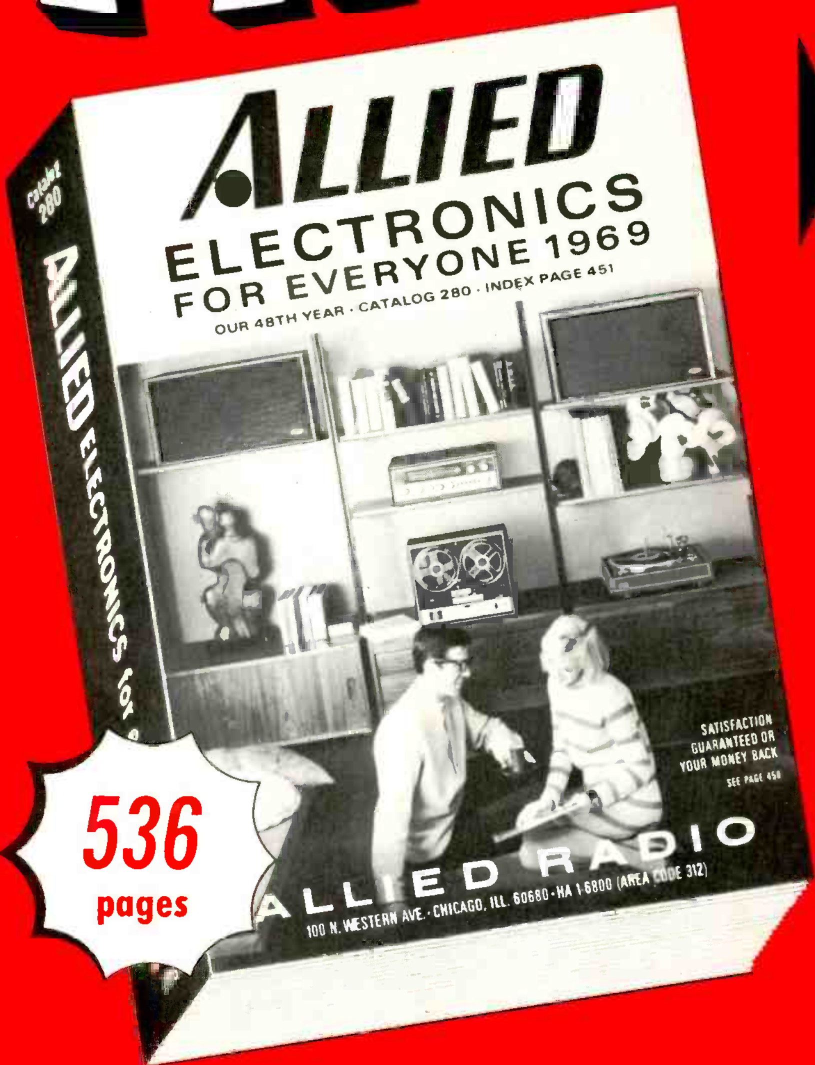

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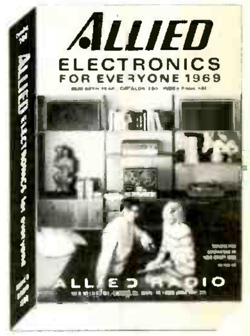

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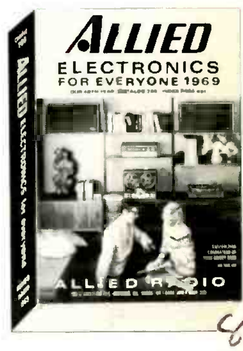

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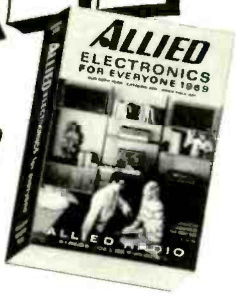

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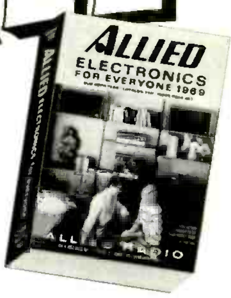

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NEW LITERATURE

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 74 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

TV & RADIO TUBES. 31-page catalog describes more than 100 tubes with specs and important features listed. Price lists, shipping information and order form are included.—**Cornell Electronics Co.**

Circle 67 on reader's service card

TV/FM RECEPTION AIDS. This 24-page guide presents the manufacturer's complete line of antennas, booster amplifiers, uhf converters, splitters, impedance matching devices, converters and other TV/FM reception products.—**Blonder-Tongue Laboratories Inc.**

Circle 68 on reader's service card

CB GEAR. 66-page catalog provides detailed data on a variety of CB equipment. Included are transceivers, antennas, coax cable, connectors, microphones, power supplies, test gear and other related items.—**CB Center of America Co.**

Circle 69 on reader's service card

APPLICATION NOTE CATALOG. 11-pages, listing the number and title, and giving a brief summary of each of more than 130 papers describing circuit and system application designs. Many are reprints of published articles by the company's engineers. Included in the index is a partial list of selection and cross-reference guides.—**Dept. TIC, Motorola Semiconductor Products Inc.**

Circle 70 on reader's service card

CLIPS AND INSULATORS. 8-page *Catalog 320* illustrates and describes every clip and insulator in the Mueller line. It also covers materials, sizes, characteristics and capacities of all clips, from miniaturized clips to the massive welding ground clamp.—**Mueller Electric Co.**

Circle 71 on reader's service card

STEREO COMPONENTS. 14 pages, fully illustrated. Catalog 268 describes 80- and 40-watt receivers in both stereo FM and AM/stereo FM models. Complete specs and important performance features are outlined for every model. Also included is the complete line of speaker systems, speakers and accessories.—**Electro-Voice Inc.**

Circle 72 on redder's service card

FET VOM *Model 601* is detailed in 2-color *Data Sheet 42068*. All technical features of this battery-operated unit are discussed.—**Triplett Electrical Instrument Co.**

Circle 73 on reader's service card

TEST EQUIPMENT. *Bulletin 2078*, 16 pages, highlights recently introduced vom *Models 208* and *209* and solid-state vom *Model 313*. Also included are operating specs and prices of equipment for TV, communications, automotive, air conditioning, refrigeration and heating servicing. —**Simpson Electric Co.** R-E

Circle 74 on reader's service card

How Fast Can You Read?

A noted publisher in Chicago reports there is a simple technique of rapid reading which should enable you to increase your reading speed and yet retain much more. Most people do not realize how much they could increase their pleasure, success and income by reading faster and more accurately.

According to this publisher, many people, regardless of their present reading skill, can use this simple technique to improve their reading ability to a remarkable degree. Whether reading stories, books, technical matter, it becomes possible to read sentences at a glance and entire pages in seconds with this method.

To acquaint the readers of this publication with the easy-to-follow rules for developing rapid reading skill, the company has printed full details of its interesting self-training method in a new booklet, "How to Read Faster and Retain More" mailed free to anyone who requests it. No obligation. Send your name, address, and zip code to: Reading, 835 Diversey Parkway, Dept. 684-019, Chicago, Ill. 60614. A postcard will do.

Circle 117 on reader's service card

Service Clinic

By JACK DARR

This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.

Ohmmeter trouble

The ohmmeter section of my EICO 214 vtvm is reading low. This seems to be only on the R × 1 and R × 10 scales; others are okay. Battery's good, for I've changed it. Where can I get a schematic of this model?—T.B., New Berlin, Wis.

Doubt if you'll need one. Your trouble's apt to be a bad multiplier resistor in the input divider of the ohmmeter section. This is just the same as the one used in the voltmeter (see the

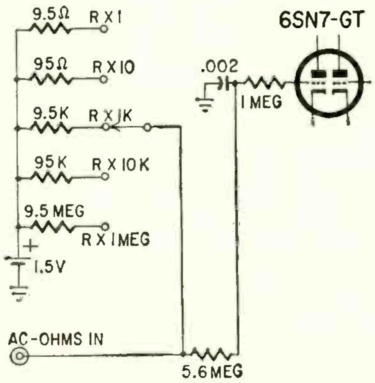


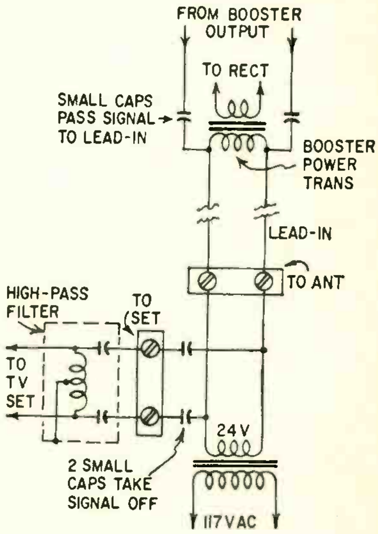
diagram). Probably something is wrong with either the 9.5- or 95-ohm resistors on the two lowest ranges. (Not to make any rash guesses, but this could have happened when *someone* tried to measure about 350 volts dc on this scale!)

You can, however, find a complete schematic of the EICO 214 in Sams *Test Equipment Schematic Manual*, TEC-1, pages 32–33, by Bob Middleton.

Filter stops booster

I put a high-pass filter in my antenna lead-in, to get rid of ignition noise. It didn't work. The antenna, with a mast-mounted preamp, works fine without the filter. I can't get anything with the filter in the circuit. Is the filter defective?—R. F. O., Columbus, Ga.

No. You've got the filter in the wrong place! Put it between the antenna-booster power supply and the TV

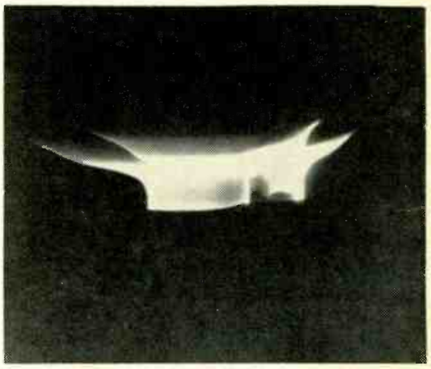


set. You must have a continuous dc path through the lead-in to the booster, for power-supply current. The average high-pass filter has series capacitors that will block the 24-volt supply.

Butterfly raster

This is the raster I get on an old Crosley TV. There's also a loud audio hum. Are you thinking what I'm thinking?—J. G., Pocahontas, Ark.

Yes, I am, and that's it—filters. There's an electrolytic open somewhere, probably one of the main filters.



The audio hum is a good clue, but a raster shaped like this (and don't ask me to *explain* it!) is almost always caused by a filter capacitor that's completely gone. (*Note*: diagnosis confirmed; it was. The input filter was open.) **R-E**

How To Buy Tools

With competition what it is today, chances are that you'll get pretty much what you pay for. The dime-store specials may be inexpensive and appear to be bargains, until you use them a few times and find that they have to be replaced. In other cases, you can buy the most expensive hand tools and find that you aren't really getting all that you pay for. A good case in point is a set of small hand tools, all chromium-plated and sold in a fitted, plush-lined carrying case. The set really looks great, makes a fine gift or presentation set, but won't work any better than the same tools from the same manufacturer, minus the case and plating, and minus about two-thirds of the price!

The best test for hand tools is experience. In time, after having bought and used many tools, you'll know what brands and types suit you best, and which are truly bargains. Until then, however, you can easily drop a bundle on the wrong tools.

What makes a good tool? Basically, what it's made of and how it's made. An inexpensive screwdriver blade, for instance, can be made of cast white metal and sold at a low price. It will truly tighten and loosen screws, but the edge won't last, and the brittle metal will give under any excess strain. The best metal for tools, considering the cost, will be steel. How tough the tool will be is a function of how it has been handled in the forming into a tool. It could have been heat-treated, oil-annealed, case-hardened or hard-surfaced. Or none of these.

To check a potential purchase these days is not the easiest thing to do, either. Many manufacturers, to reduce pilfering in shops and also make a point-of-purchase display more interesting, have gone to pouch and blister packaging. Just about all you can find out about a tool from the fancy packaging is that it's a "good" tool and its price!

If you can actually lay hands on the tool, make a quick examination. A wire cutter should have jaws that line up properly and parallel and, when the jaws are closed, the edges should mate evenly, and when you hold it to the light, no light should appear between the cutting edges.

Long-nose pliers meant for wiring should have no angular displacement at the tips of the jaws. The tool should be fairly tight, yet, when held by one leg of the grip, the other leg should drop to the open position of its own weight. If it doesn't, open and close it rapidly to determine that it's so close to such action that a drop of oil will insure it. Look at the insides of the pliers jaws. There should be fairly clean, deep-cut striations or milling, so the tool can grip a piece of wire without dropping it.

—Byron G. Wels **R-E**

Circle 120 on reader's service card

Circle 121 on reader's service card

COMING NEXT MONTH

It's hi-fi stereo tape-recording time and a large slice of the October issue is devoted to just this subject.

THERE ARE SEVEN BIG STORIES:

- What's New in Tape Recorders
  The latest tape recording equipment and what it means to you.
- Tuner Breakthroughs
  Up-to-the-minute reports on new techniques, circuits and equipment.
- What's New in Record Changers?
  There have been changes. See what they are and what they do.
- How Tapes Work
  A close-up examination of open reel, continuous cartridge and cassette tape systems.
- What Do Amplifier Specifications Mean?
  How to read an amplifier spec sheet and really understand it.
- How To Buy A Tape Recorder
  What to look for and why; before you decide which machine you want.
- Build The Compandor
  Enhance the sound of your stereo system. Easy-to-make passive unit adds amplitude where you really want it.

FOR SAFER WINTER DRIVING:

- Build A Road-Icing Alarm
  It will tell you when icy roads are likely before the ice actually appears.

PLUS THESE FEATURES:

Computerize your car lights, III
Check Color Circuit Faults
Servicing Video Tape Recorders

October Radio-Electronics

TECHNOTES

RCA CTC 22 COLOR TV CHASSIS

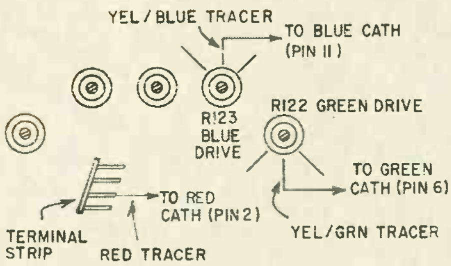
Complaint: Weak vertical and horizontal sync.
Symptoms: Brightness control acts as sync gain control. Sync unstable at reduced brightness levels; stable at high brightness.
Cause: Open C105-A, a 40-μF 350-volt electrolytic in the B+ filter circuit.—*RCA Television Service Tips*

COLOR CRT SUBSTITUTION

The 25XP22 can be used to replace the 25AP22 in General Electric KC and KD chassis. However, the 25XP22 may not match the range of the drive controls on either of these chassis.

The 25XP22 can be matched to the drive controls by interchanging the red cathode lead (from the picture tube) with the blue or green cathode lead, when necessary. The need to interchange leads can be determined only after the tube has been installed and gray-scale (color-temperature) adjustments completed.

If the complete gray-scale adjustment results in yellowish highlights, interchange the blue and red cathode leads at the drive-control bracket (see diagram). The BLUE DRIVE control now adjusts red drive, and the blue drive is fixed.



DRIVE CONTROL BRACKET (REAR VIEW)

If the screen is reddish-purple in highlight areas, swap the green and red cathode leads. The GREEN DRIVE control now sets the red drive level.

After interchanging the drive-control leads, mark the drive controls with the correct color for those who will service the set at a later date.—*G-E Service Talk*

KNIGHT KG-600B TUBE TESTER

The Knight KG-600B tube tester was indicating BAD on the gas test for all 12DQ6-B tubes tested. The meter would change to GOOD upon touching the 12DQ6-B and at the same time would put a beautiful herringbone pattern on the TV set nearby.

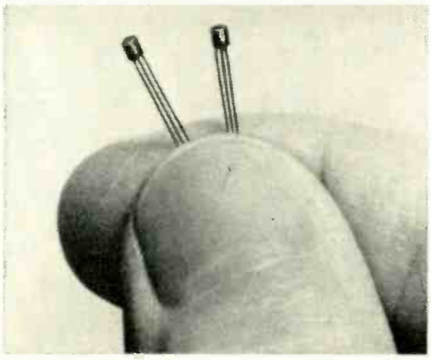
Connecting a .001-μF bypass capacitor from pin 6 of the octal socket to the meter mounting screw solved this problem.—*Stanley Bahl*

R-E

NEW IC's AND

MICROMINIATURE NPN TRANSISTORS

The A141, A142 and A143 are new microminiature npn silicon epitaxial audio transistors from Amperex. They offer low noise and high gain for such applications as wireless microphones, personal paging systems, hearing-aids and hybrid IC's where space and weight are at a premium.



Noise figure for the group is typically 1.5 to 2 dB from 30 to 15,000 Hz with a minimum h_{FE} of 80 for the A141, 140 for the A142 and 280 for the A143. Leakage current is only 10 nA and the collector saturates at only 0.1 volt, thus permitting these units to operate with very low battery voltages.

These transistors, identical in size and shape, are in 0.07" high 0.07" diameter cylindrical cans. In quantities of 100 to 999 prices are: 92¢ for the A141, 96¢ for the A192 and $1.05 for the A143. Complete specifications can be obtained from Amperex Electronic Corp., Semiconductor and Receiving Tube Div., Slatersville, R.I. 02876.

1/2-WATT HI-FREQUENCY FET'S

The U221 and U222 are medium-power n-channel junction FET's for power amplifiers to 30 MHz and vhf oscillators to 100 MHz. Packaged in TO-5 headers, these Siliconix transistors have a 50-volt breakdown which permits operation from power supplies delivering up to 28 volts. Power gain is over 30 dB at 30 MHz and power output is 0.5 watt at 100 MHz.

Unlike bipolar transistors, these

SEMICONDUCTORS

power FET's do not exhibit secondary breakdown or thermal runaway. Their high input impedance eliminates the need for complex interstage coupling networks.

Maximum and minimum gain-bandwith products are 40,000 and 15,000 μmhos for the U221, and 50,000 and 20,000 μmhos for the U222. Maximum C_{iss} for both units is 25 pF. Maximum pinchoff voltage is 8 for the U221, and 10 for the U222.

IC DECADE DIVIDER

The SM90 series decade frequency divider accepts either ac or digital input levels and produces a symmetrical output square wave at a repetition rate 1/10 that of the input. Digital clock frequencies from 0 to 40 MHz and sine waves to 35 MHz can be processed by the dividers.

The Sylvania SM90 and SM91 operate over a frequency range of −55° to −125°C and the SM92 and SM93 operate over the industrial temperature range of 0° to +75°C. The SM90 and SM92 are for uses where high-frequency operation is an essential requirement. The SM91 and SM93 are recommended for applications where low power dissipation is a primary consideration. The SM90 series is compatible with all SUHL circuits and can drive a maximum of 15 SUHL I gate loads and 10 SUHL II gate loads.

Voltage ratings:	Min.	Typ.	Max.
Dc supply			7.0
Supply surge (1 sec)			12.0
Supply operating, TA; −55° to +125°C (SM90 and SM91)	4.75	5.0	5.25
Supply operating, TA; 0°C to 75°C	4.5	5.0	5.5
Input voltage (click, inhibit, clear)			5.5
Input voltage (emitter follower)	−5.0		5.0
Output voltage			5.5

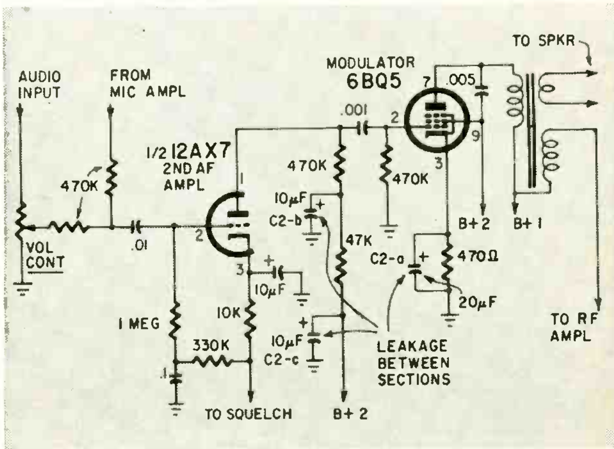
This series of IC units is available in both the TO-85 flat pack and Sylvania's ceramic dual in-line plug-in package. **R-E**

CB Troubleshooter's Casebook

Compiled by
Andrew J. Mueller*

Case 1: Intermittent squeal on transmit and/or receive.

Common to: Lafayette **HB-333**

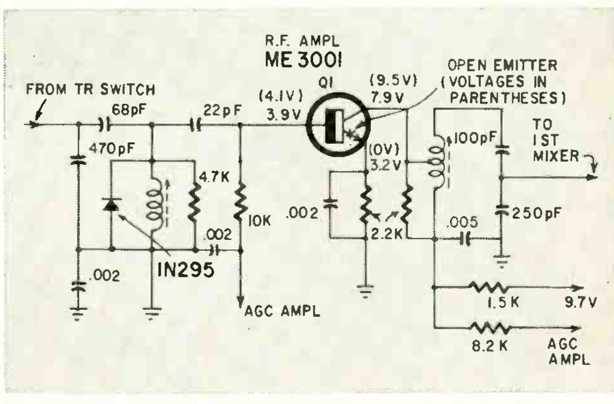


Remedy: Replace electrolytic C2

Reasoning: When C2 intermittently leaks between sections, the audio frequencies are fed between the cathode of the 6BQ5 to the plate circuit of the 12AX7. This produces an intermittent positive feedback which causes squealing on both transmit and receive.

Case 2: No receive except on very strong signals. Transmits all right.

Common to: RCA Mark 10



Remedy: Replace rf amplifier transistor Q1.

Reasoning: When Q1 opens, it disables the rf amplifier stage. This causes no reception except on very strong signals. This problem can be spotted very easily. Voltage checks reveal that there is no voltage on the emitter of Q1. Voltages in parenthesis are caused by open emitter. Check Q1 with an ohmmeter, transistor checker, or by substitution.

* Service Manager, Tel-Air Communications, Inc., Pewaukee, Wis.

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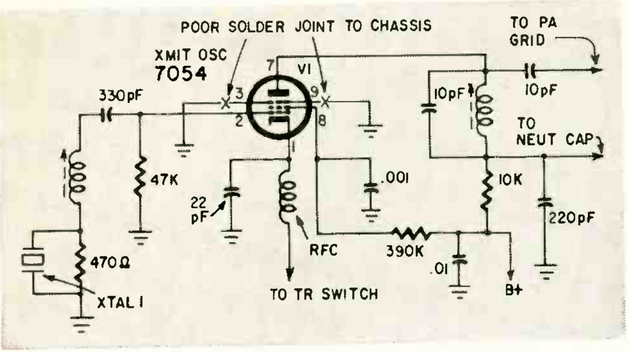
Case 3: Intermittent and off-frequency transmit. Receive okay.

Common to: Johnson **I & II**

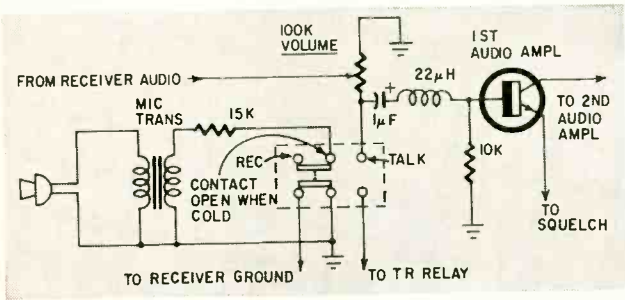


Remedy: Resolder pins 3 & 9 of V1 tube socket.

Reasoning: On some of these chassis, V1 suppressor grid tube-socket pins appear to be improperly soldered. This can produce unstable and off-frequency transmissions. It is then a good idea to have the radio checked by a licensed technician before using it.

Case 4: No modulation when cold. Receive is okay.

Common to: Sonar **J-23**

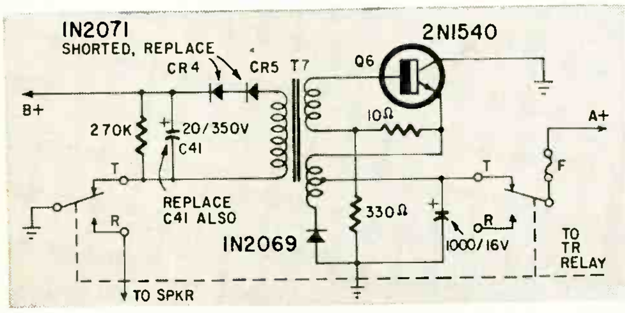


Remedy: Repair or replace microphone switch.

Reasoning: When push-to-talk (PTT) switch is cold, the contacts in the audio section do not make contact. When the switch is warm, the metal expands and contact is made. In most cases, bending the contacts will restore normal operation.

Case 5: Fuse blows on transmit. Receive is okay.

Common to: Pearce-Simpson **Sentry**



Remedy: Replace diodes CR4, CR5 and capacitor C41.

Reasoning: The diodes sometimes short due to power supply starting transients. Raw ac is then applied across C41, which acts like a very large load, causing the fuses to blow. To prevent future trouble, be sure to replace C41 as well as the diodes. **R-E**

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NEW BOOKS

ELECTRONIC HOBBYIST'S IC PROJECTS HANDBOOK, by Bob Brown & Tom Kneitel. *Tab Books, Blue Ridge Summit, Pa. 17214. 5¾ x 8¾ in., 160 pp. Cloth $6.95. Paper, $3.95*

Fifty integrated circuit projects for hobbyists, experimenters, technicians, hams and audiophiles based on popular inexpensive IC's. There's a 1-watt phono ampl and power supply, an electronic organ, a tachometer and even a miniature adding machine.

WORKING WITH THE OSCILLOSCOPE, by Albert C. W. Saunders. *Tab Books, Blue Ridge Summit, Pa. 17214. 8½ x 11 in., 104 pp. Paper, $4.95*

If you want to know how the oscilloscope works, this text will show you—and in detail. Five chapters break the scope into sections and show exactly how each section performs. Two additional chapters show how to put the scope to work for you.

TRANSISTOR CIRCUITS AND APPLICATIONS, by Laurence G. Cowles. *Prentice-Hall Inc., Englewood Cliffs, N. J. 07632. 6 x 9 in., 323 pp. Cloth, $10.95*

A practical text that provides a clear understanding of junction and field-effect transistor (FET) circuits. A full explanation of single-stage FET amplifiers with voltage gain and feedback calculations is included. Departures from the classical format present space-age circuits and applications and many experiments and practical problems.

ABOUT YOUR HEARING, by G. A. Briggs. *Herman Publishing Service Inc., 25 Huntington Ave., Boston, Mass., 02116. 5½ x 8¾ in., 132 pp. Cloth, $4.95. Paper, $3.50*

All in laymans language, the author tackles the subject of hearing, enlisting the aid of an ear surgeon and experts on audiology and related matters. General guidance on the ear and how it works, age and noise effects and reproduced sound are explored.

HOW TO USE YOUR VOM–VTVM & OSCILLOSCOPE, by Martin Clifford. *Tab Books, Blue Ridge Summit, Pa. 17214. 5½ x 8½ in., 187 pp. Paper, $3.95*

If you want to know how to get more out of these instruments this book can be your guide. It shows how the instruments work and how to apply them. Part I deals with the volt-ohm-milliammeter, Part II is devoted to the vtvm and Part III discusses the oscilloscope. Written in easy-to-understand language, the book has many drawings, schematics and troubleshooting charts.

TRANSISTOR CIRCUIT ACTION, by Henry C. Veatch. *McGraw-Hill Book Co., 330 West 42 St., New York, N.Y. 10036. 9 x 6 in., 310 pp. Cloth, $6.95*

This text helps reader understand basic transistor circuits and provides a clear method of working with them. The author intends to develop a new approach using the simplest methods. Nothing more complex than Ohm's law is used and equations are illustrated by laboratory-tested examples. Topics covered include circuit and transistor limits, static (dc) circuit conditions, the typical circuit, and more.

RCA RECEIVING TUBE MANUAL. *RCA Electronic Components, Harrison, N. J. 07029. 5¼ x 8 in., 656 pp. Paper, $1.75*

This latest revised and expanded edition contains up to date data on tube types and technology. Detailed data and application information are provided on the complete line of RCA home-entertainment type vacuum tubes plus picture tubes, voltage regulator and voltage reference tubes.

101 QUESTIONS & ANSWERS ABOUT COLOR TV, by Leo G. Sands. *Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind., 46206. 5½ x 8½ in., 64 pp. Paper, $1.75*

Here are 101 most often asked questions on color TV. They come from laymen and service technicians. Answers are supplemented with schematics and photos. Four sections cover basic theory, installation procedures and problems, servicing, and modifications of color TV receivers.

SEMICONDUCTOR HANDBOOK, by Robert Tomer. *Howard W. Sams & Co. Inc. 4300 W. 62 St., Indianapolis, Ind. 46206. 5½ x 8½ in., 288 pp. Paper, $5.25*

A comprehensive, illustrated, source book of industrial semiconductor data. Most of the data needed to understand the many types of semiconductors now on the market, their operating characteristics, circuit design procedures, and typical applications have been gathered into this volume. A general discussion of the various processes used in making transistors is included.

UNDERSTANDING AND USING YOUR OSCILLOSCOPE, edited by William A. Stocklin. *Published by Allied Radio Corp., 100 N. Western Ave., Chicago, Ill., 60680, 8½" x 5½", 128 pages, soft covers, $.75*

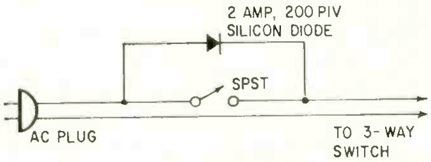
Covers one of the most useful and versatile of electronic test equipment. Clear writing style is maintained for easy understanding by students and beginners as well as the veteran technician. Includes basic oscilloscope, uses, and interpretation of waveforms and operation with associated equipment.

TRY THIS ONE

CONVERT TO A SIX-WAY LAMP

Your three-way lamp can be converted to a six-way lamp with the addition of a switch and diode. Unplug the lamp and remove the glass bulb and shade. (The harp is the device that supports the lamp shade. Some types screw onto the shell of the socket but most are on the ferrule that connects the top of the lamp base to the shell of the socket.) If a wire harp is used, slide the ferrules up and remove it as well. Using a sharp knife, carefully remove the cardboard base that may cover the lamp base.

Locate a suitable place on the base and drill a 3/8" hole for the spst dimmer switch. Install the new switch and tighten the mounting screws. Disconnect the line cord to the lamp socket inside the base, and rewire it to the switch as shown in the diagram. Solder a 2-amp, 200-piV silicon diode across the switch. Using rubber cement, re-install the cardboard base. Now reassemble the harp, lamp and shade and you're all done.



Two separate filaments in the bulbs for these lamps provide two different wattages. In the third switch position the two filaments are connected in series, adding the wattages. The three-way switch will continue to function as before, but you now have three additional wattages. The new switch directs line current to the main socket switch or through the diode. With the diode in the circuit, line voltage is rectified so that about half the power goes to bulb. Therefore, the lamp can be used at six brightness levels instead of three.—*Byron G. Wels*

R-E

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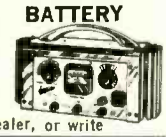

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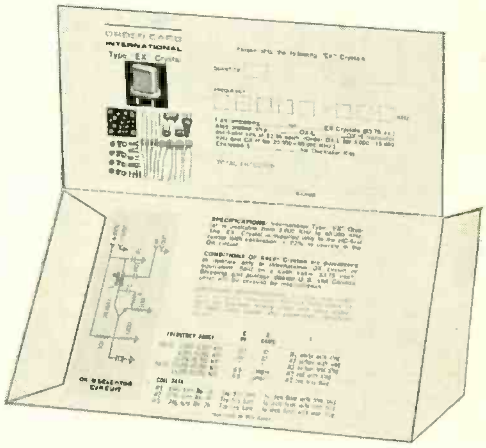

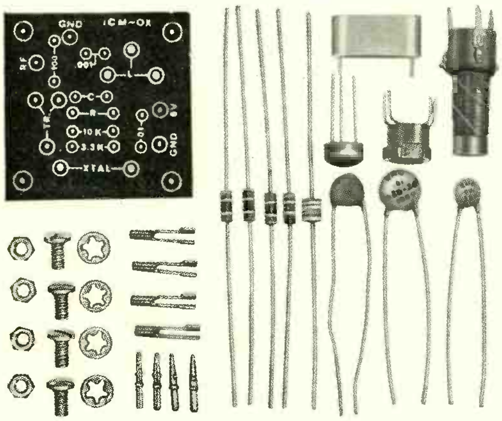

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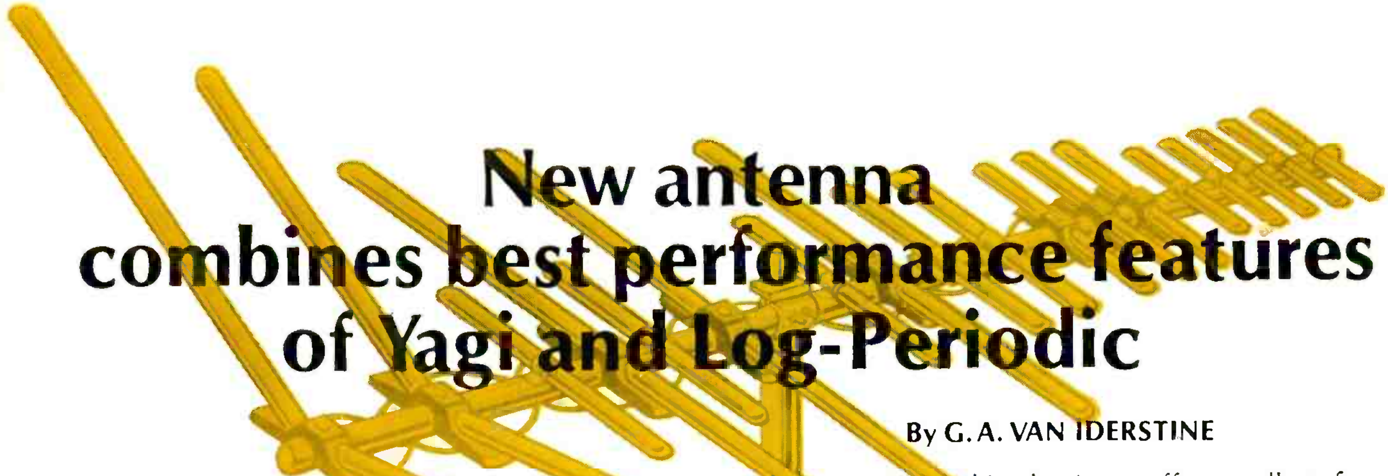
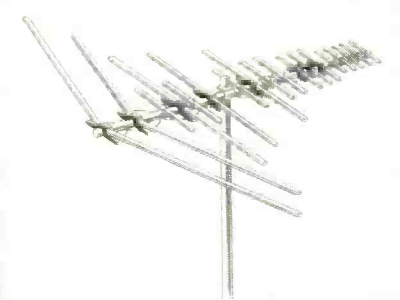


New antenna combines best performance features of Yagi and Log-Periodic

By G. A. VAN IDERSTINE

The Yagi design, developed by the Japanese inventor of that name, was for many years considered to be the best all round television antenna. However, with the advent of color TV, Yagis fell into some disfavor. While they provide excellent gain, most Yagis are not uniformly flat enough in frequency response to meet the needs of color TV.

TV engineers agree that response should be flat ±1 db per television channel to prevent color distortion. Yet some Yagis vary by more than 6 db within a single channel, causing yellows to turn greenish and reds to turn toward purple.



Gavin 82 channel V-Yagi.

The log-periodic design became popular recently because it solved the flatness problem. Log periodics do not provide as much gain as Yagis, but they produced better color pictures.

All of this set the stage for the new V-Yagi principle, developed by Gavin. The V-Yagi combines the high gain of a Yagi with the flatness of a Log-Periodic. This is done through judicious sizing and spacing of antenna elements. Like the Log-Periodic, the V-Yagi uses numerous driven elements, with each group of elements tuned for a specific channel or channels. However, the Log-Periodic's driven elements are logarithmically spaced, while the V-Yagi elements are evenly spaced. This gives the V-Yagi an advantage in size. In other words, using a given boom length and a given amount of aluminum, the V-Yagi will provide significantly more gain than the Log-Periodic.

In both the V-Yagi and the Log-Periodic design, elements serve double duty by resonating in two modes simultaneously. For example, an 85-inch element is a half wavelength long at channel 4, and 3/2 wavelengths long at channel 12.

Unfortunately, an element operating in the 3/2 wavelengths mode produces side lobes. Side lobes are objectionable in many areas, since they can pick up reflected signals which appear on the screen as "ghosts." To eliminate the side lobes, the last two elements in the V-Yagi are Veed forward. You'll notice that many Log-Periodic antenna elements are also Veed forward, for exactly the same reason.

The long Veed rear elements in the V-Yagi serve other purposes as well. For one thing, they provide gain on some channels. For another, they improve the front-to-back ratio of the antenna.

The V-Yagi principle can be used not only in VHF-only antennas, but in 82 channel antennas as well. Indeed, while many all-channel antennas are nothing more than a U antenna stuck onto the front of a V antenna, the Gavin V-Yagi units are truly integrated.

Also, many all-channel antennas attenuate the FM band, but the fully integrated V-Yagi provides excellent FM gain. Thus, it is capable of serving all home reception needs.

In addition to providing better electronic performance, the new Gavin V-Yagi antennas offer a number of mechanical advantages, including the following:

1. They are made of light, rugged aircraft aluminum. Not only does this aluminum offer excellent fatigue life, it also lightens the load for rotators.

2. The booms are round. Some people prefer square booms esthetically, but round booms reduce wind and ice loading significantly. The booms are also pre-stressed for added rigidity.

3. The elements are supported by internal Cycolac braces. Virtually unbreakable, Cycolac is one of the toughest materials known to man. It's the same polymer used in golf clubs and timber splitting wedges.

4. Insulators too are made of Cycolac.

5. Spring loaded contacts made from heavy duty rivets and resilient Cycolac maintain peak antenna performance.

6. Heavy duty plated U-bolts and saddle bracket which locks into saddle clamp. Where competitive U-bolts often rust, all Gavin steel hardware is plated irridited, and gold chromated. Double U-bolts are provided on heavier models.

Splitter separates signals to UHF and VHF antenna terminals, plus extra FM output. Supplied free with each 82 channel V-Yagi.

7. Improved saddled boom braces damp the natural resonance of the boom, minimizing vibration.

The Gavin 82 channel V-Yagi line comprises six models ranging in list price from $16.45 to $67.95.

Gavin

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