60c ■ SEPT. 1967

Radio-Electronics

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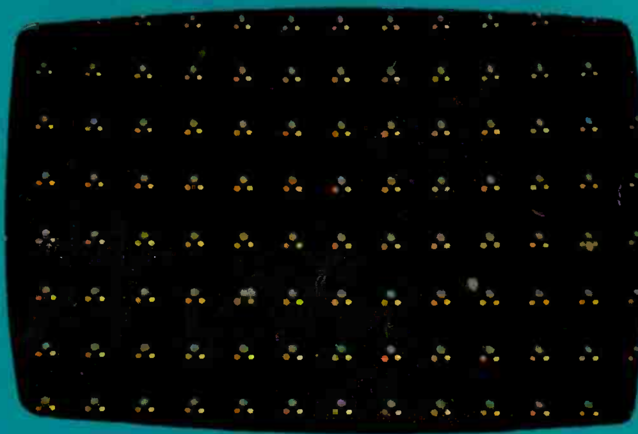
HUGO GERNSBACK, Editor-in-chief

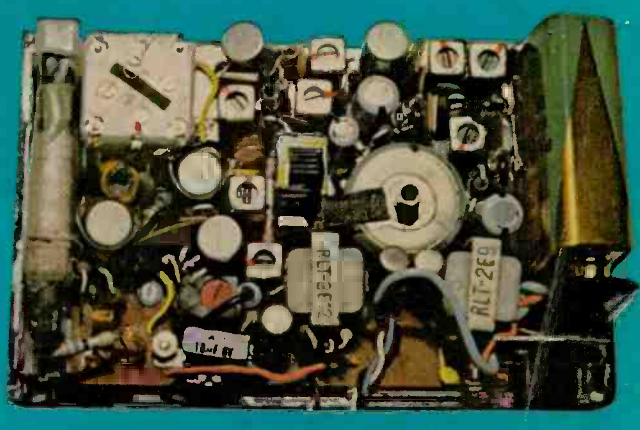
A GERNSBACK PUBLICATION

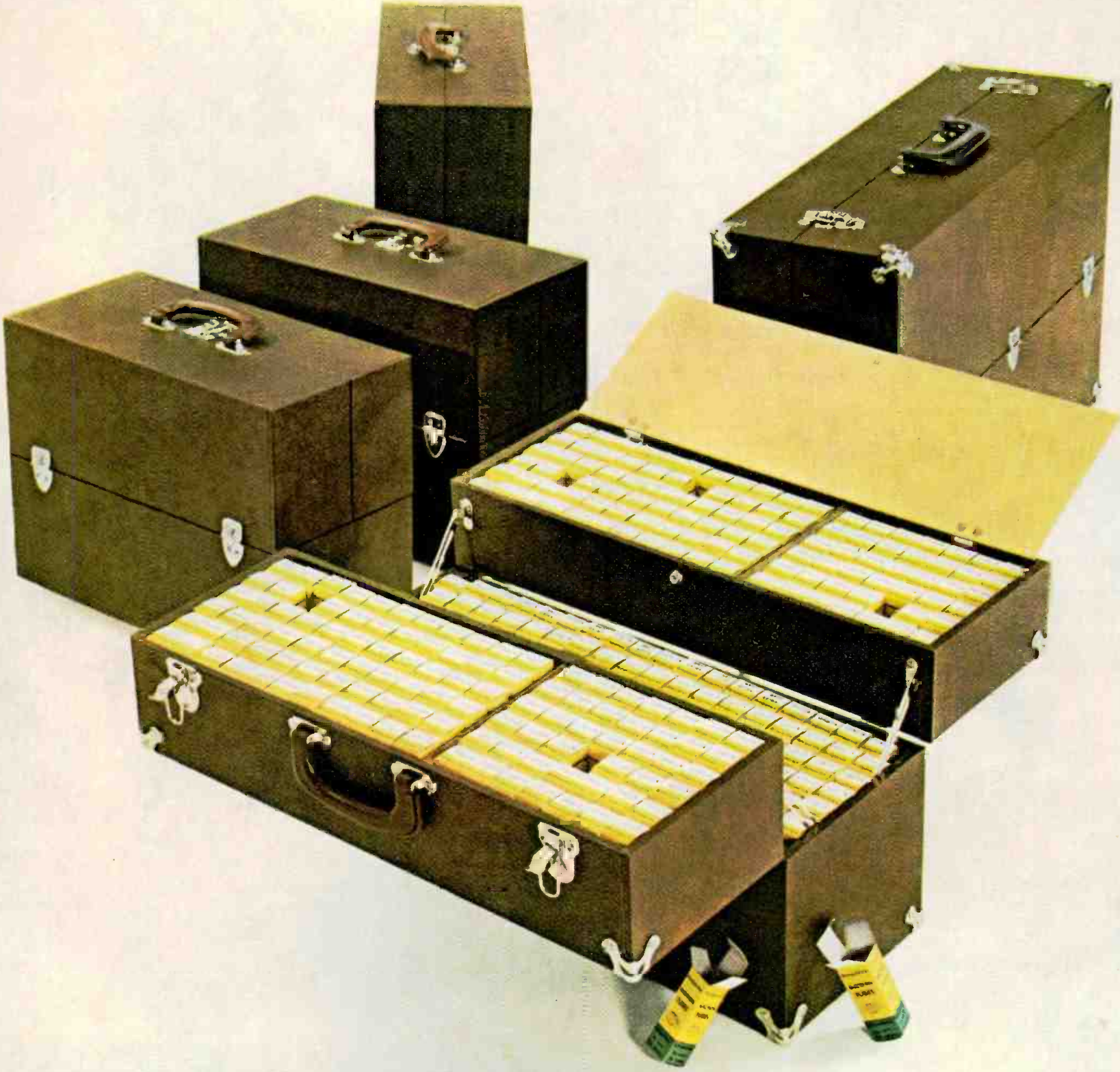
ABC's of Color TV



Creative Servicing

Transistor Servicing





One out of every five professional servicemen has switched to Amperex TV replacement tubes

It takes a lot of quality to change the buying habits of 20% of the most knowledgeable technicians in the business. These servicemen are following the pattern set by the leading TV manufacturers, who are designing more and more of their quality lines around tubes originated by Amperex. The Amperex line of popular types is expanding all the time. Look for the green and yellow cartons at your distributor's or write: Amperex Electronic Corp., Hicksville, L. I., N.Y. 11802.

Amperex

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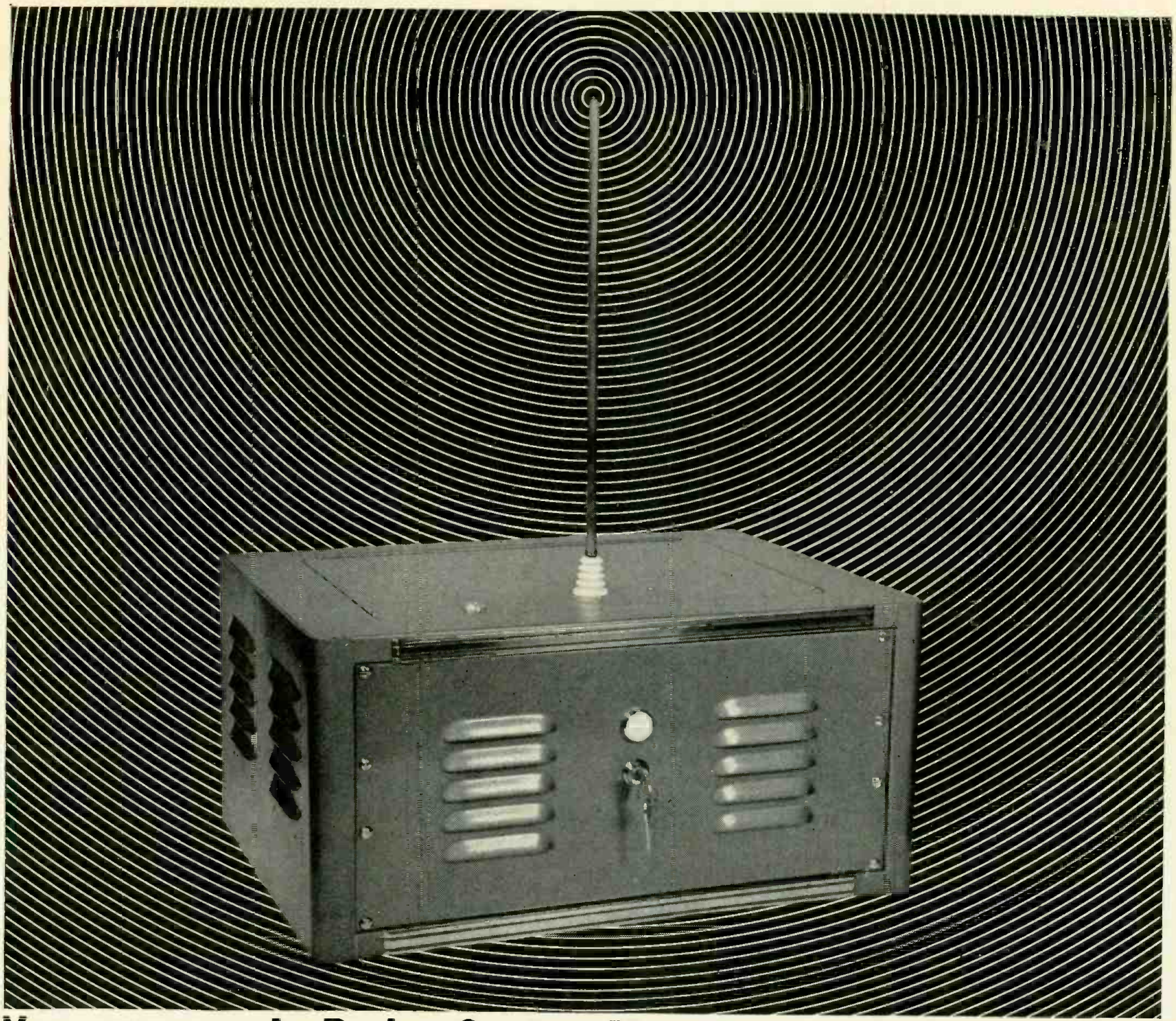

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FROM THE EDITOR

Brainwaves and Electronics

Combining two branches of science is hardly new, and the results are often startling. Yet, despite the knowledge we have of body science and electronic science, there is one combination of the two whose development seems unduly slow.

A close friend of mine is quadriplegic. A double case of polio—bulbar and spinal—a few years ago—left both arms mostly and both legs totally paralyzed. The polio bug "eats up" random sections of the motor nerves running from the brain to muscles. When the bug severs nerves like this, the muscles at the ends of those nerves no longer receive the brainwaves that tell them to function. Paralysis results.

The impulses or brainwaves that make muscles work are electrical. The waves are strong enough to be seen on an oscilloscope, heard on a set of headphones, or carried by wires and made to operate servomotors. These characteristics are put to work in some recently developed artificial arms.

For example, the stump of an arm-amputee still contains the ends of certain nerves that originate at the brain. These are the nerves that formerly reached all the way to the forearm, wrist, and fingers. Impulses traveling down these nerves formerly caused the forearm, wrist and fingers to work. Neurologists can find these nerves in the stump and attach electrical sensors to them.

The nerve impulses from the sensors are fed to a tiny servo computer. The amputee can, with the motor section of his brain, go through the brain-motions of, let's say, making a fist, which takes impulses in several nerves. These brain waves travel down the several nerves to the stump as electrical impulses and are picked up by the sensors. The impulses are gathered into the tiny computer and fed to appropriate motors in the artificial limb. This electromechanical arm makes a fist, driven by the wearer's will to make a fist.

This can't help my friend, though. His nerves are severed somewhere in his spinal column. Consequently, there are no nerve ends to tap onto. Anyway, he is not an amputee, nor would he want to become one, so prosthetic limbs are out. However, he could use his own limbs. Tests with an electromyograph—a machine that measures the ability of a muscle to function—show that though there has been considerable atrophy of muscle tissue, my friend still has muscle capability in his legs.

He is in the predicament of thousands who are crippled by polio and other nerve-damaging diseases or birth defects. His brain still functions excellently. His muscles could still work. What keeps him from walking or using his arms is the "open wiring" in his spinal cord. The electrical brainwaves for his motor actions can't reach the muscles where they can do some good. Because of the atrophy from disuse, and because a certain amount of muscular damage was done during the acute stages of his polio, my friend's muscles probably need stronger brainwave impulses than yours or mine do, so amplification might be needed.

Medical and electronic science, working together, should develop an answer for this. My friend's motor brainwaves could be tapped off at the top of his spinal column or directly at his brain, amplified as much as necessary, processed by computer if need be, and fed to appropriate muscles in his arms and legs.

What about cases where brain damage has occurred and motor impulses from the brain are missing? Motor brainwaves from a normal person could be recorded on tape and then "played back" into the muscles of the handicapped person. Any number of central means could be devised, including balance sensors, speed regulators, and so on.

No one today has the whole answer, and it will be a while in coming. But, I'll not be surprised, one day a few years from now, to see my friend come walking in like anyone else.

Forest H Belt

Radio-Electronics

September 1967 VOL. XXXVIII No. 9
Over 55 Years of Electronics Publishing

EDITORIAL

TELEVISION AND RADIO

AUDIO / HI-FI / STEREO

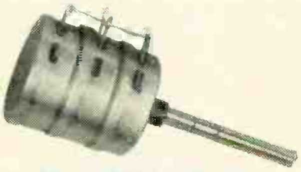
TEST INSTRUMENTS

GENERAL ELECTRONICS

THE DEPARTMENTS

p 51—DEBUG TRANSISTORS

p 58—COULD BE WORSE



p 36—IMPEDANCE VS VOLUME

p 43—KILL THAT SQUEAK

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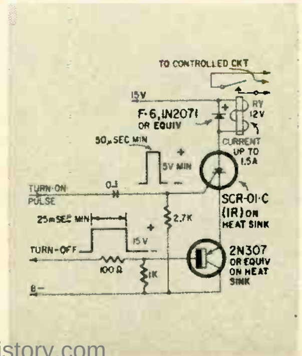

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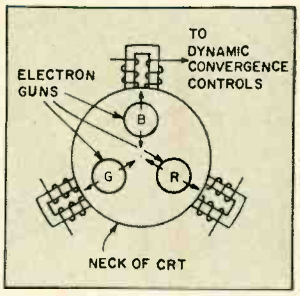

p 32—New self-teaching technique lets you learn color TV at your own rate of speed and is error-proof.

HIGH-FREQUENCY WASH

p 62—Ultrasonic cleaners are easier to fix than a TV set. Here's how they work and what can go wrong with them.

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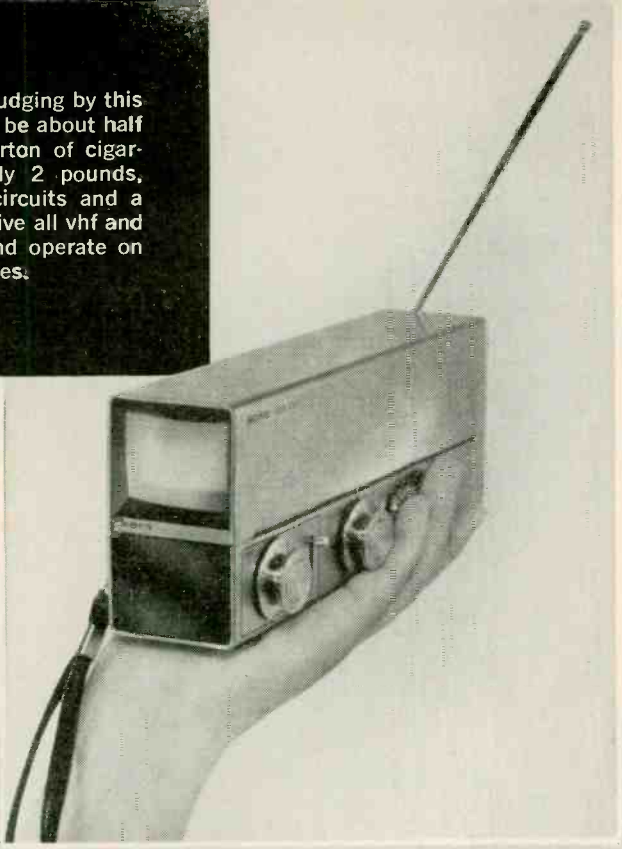
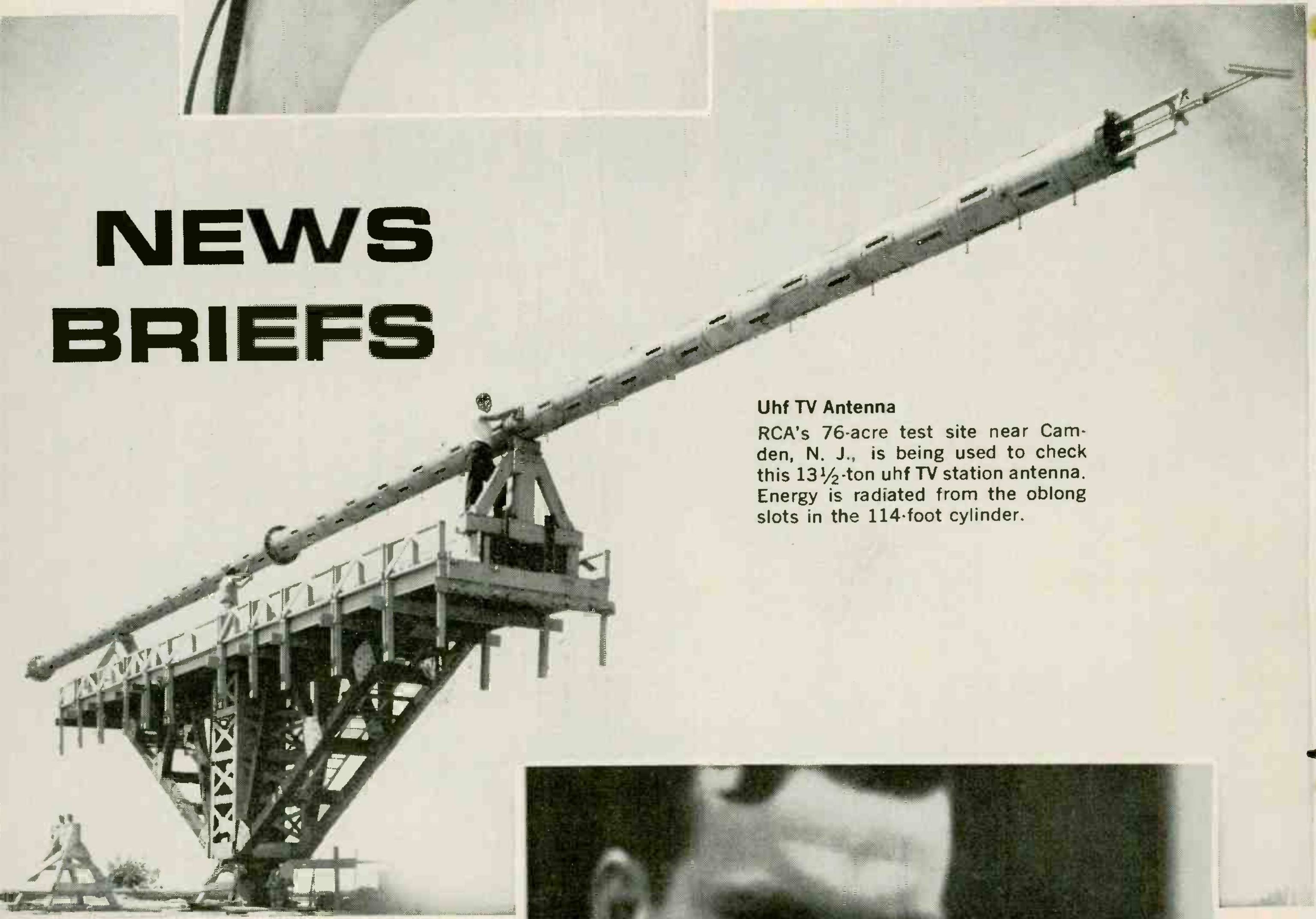


Pocketable TV

Future TV sets, judging by this Sony model, will be about half the size of a carton of cigarettes, weigh only 2 pounds, use integrated circuits and a 1 inch CRT, receive all vhf and uhf channels, and operate on ac line or batteries.

World's Smallest Detector

Germanium-immersed infrared detector (tiny black area in center of white circle) is dwarfed by the bee's eye. Detector is .04-inch in diameter. Produced by Barnes Engineering Co., Stamford, Conn., for spacecraft instruments to study Earth.



Uhf TV Antenna

RCA's 76-acre test site near Camden, N. J., is being used to check this 13½-ton uhf TV station antenna. Energy is radiated from the oblong slots in the 114-foot cylinder.

Lineless Telephone

Bell Telephone Laboratories' experimental telephone—shown with case removed—contains a transmitter, receiver, ringer elements, antenna system, signaling circuit board and rechargeable batteries. Provides simultaneous 2-way conversation (not push-to-talk) as well as dialing and ringing. Range is 100 to 1,500 feet from a fixed station.

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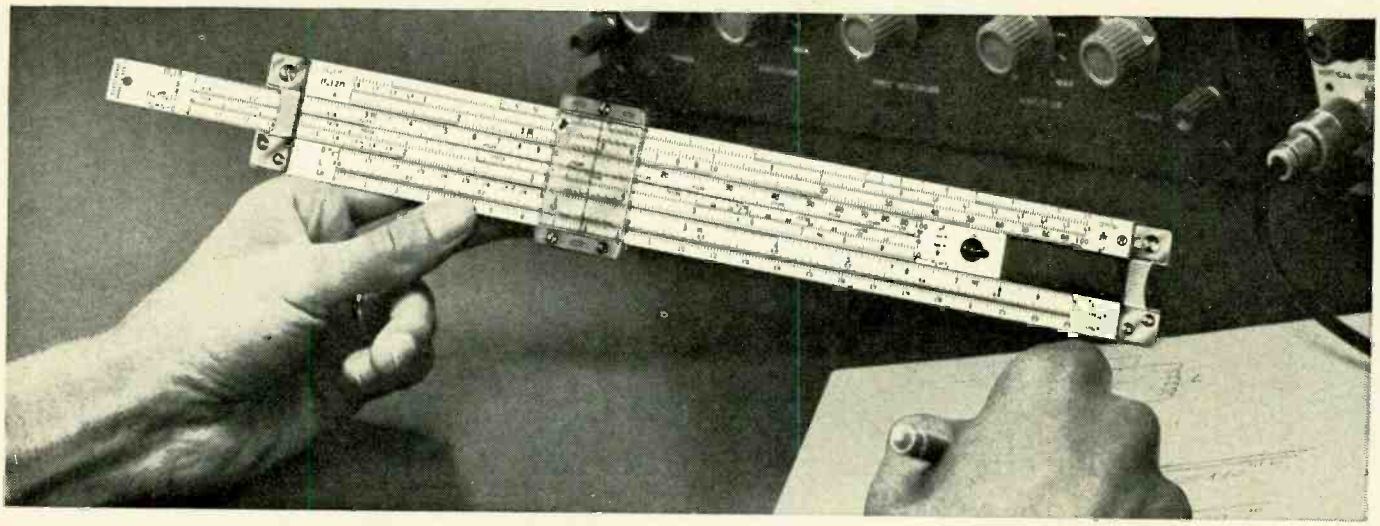

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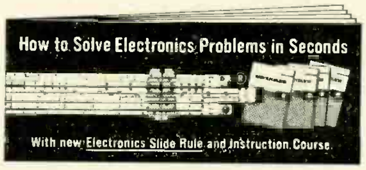

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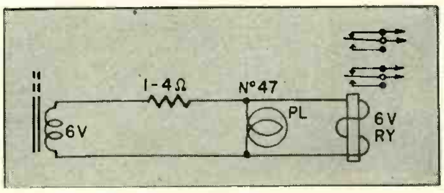
Correspondence

TWIN SLAVE

Dear Editor:

I have just read the article "Twin 200 Watt-Second Solid-State Strobe Slaves" by E. F. Rice in March RADIO-ELECTRONICS. I would like to make one suggestion for improved safety. The 3pdt switch to discharge capacitors when power is turned off will leave the capacitors charged if the fuse blows or if the power cord is unplugged with the switch left on. If S1 were replaced with an spst switch and a relay, the capacitors will always be discharged except while power is actually applied to the unit. The relay can have dpdt (or dpst normally closed) contacts, with a 6.3-volt ac or 117-volt ac coil.



The spst switch is connected in place of S1-a. The normally closed contacts of the relay are connected in place of S1-b and S1-c (see sketch). The relay coil is connected, depending on its voltage rating, to the 6-volt transformer winding or across the primary of the power transformer.

W. J. STILES
Wentzville, Mo.

APRIL FOOL

Dear Editor:

I have a DUD service department, ready to service any and all DUDS (Digital Unit Diagnosis System). All have had five or more years of digital computer service as prerequisite for employment in my service shop.

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JAMES T. DINSMORE
Fort Worth, Texas

[Four large manufacturers wrote for more information on our April Fool story, and two, like you Mr. Dinsmore,

continued on page 12

Radio-Electronics

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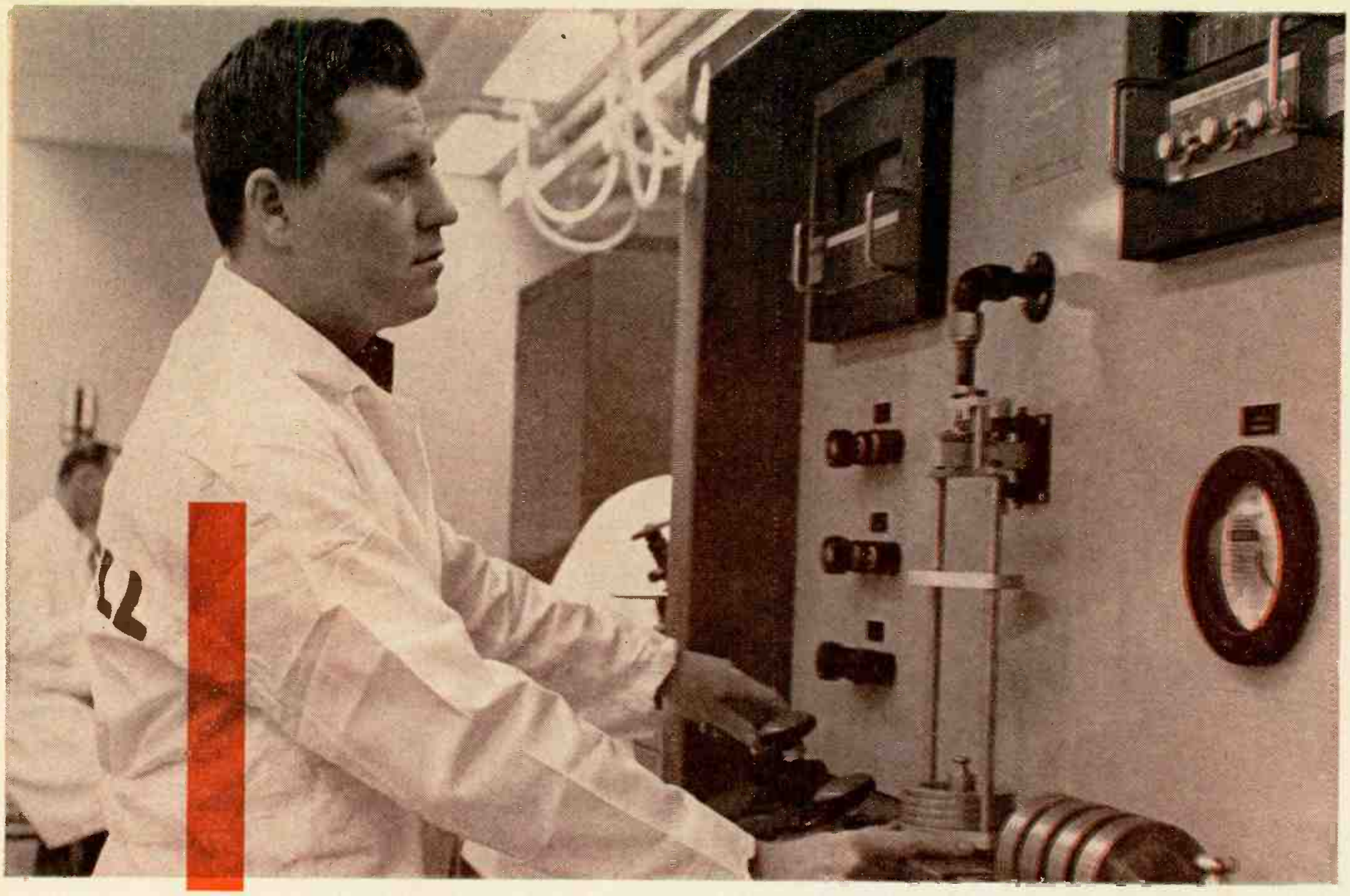

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L. V. Lynch, Louisville, Ky., was a factory worker with American Tobacco Co., now he's an Electronics Technician with the same firm. "I don't see how the NRI way of teaching could be improved."

G. L. Roberts, Champaign, Ill., is Senior Technician at the U. of Illinois Coordinated Science Laboratory. In two years he received five pay raises. Says Roberts, "I attribute my present position to NRI training."

Don House, Lubbock, Tex., went into his own Servicing business six months after completing NRI training. This former clothes salesman just bought a new house and reports, "I look forward to making twice as much money as I would have in my former work."

Ronald L. Ritter of Eatontown, N.J., received a promotion before finishing the NRI Communication course, scoring one of the highest grades in Army proficiency tests. He works with the U.S. Army Electronics Lab, Ft. Monmouth, N.J. "Through NRI, I know I can handle a job of responsibility."

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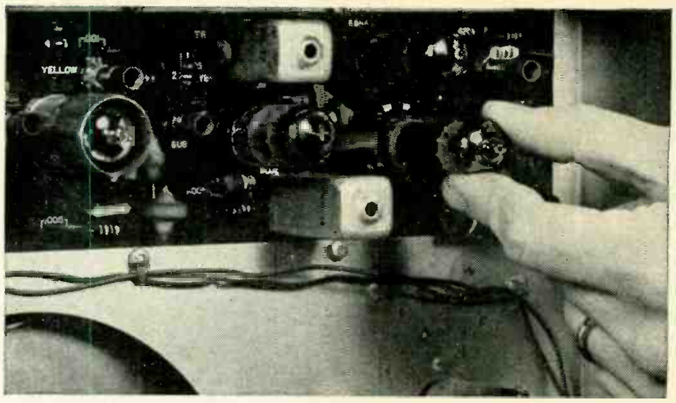

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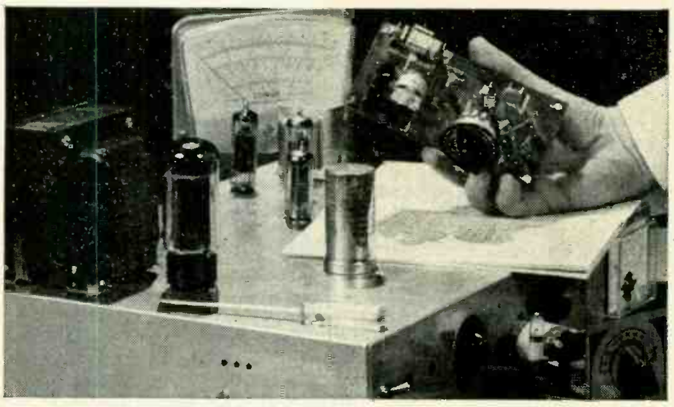

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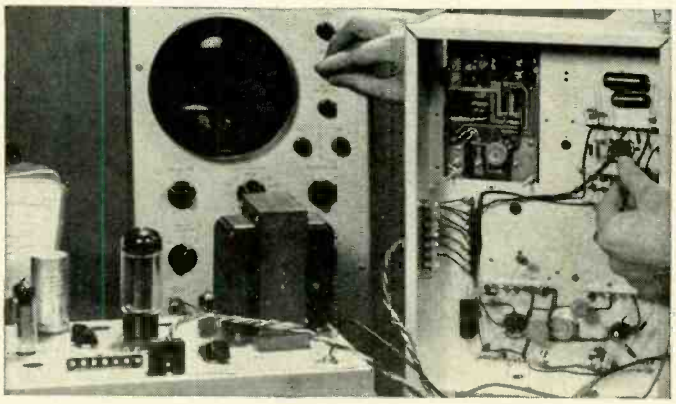

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CORRESPONDENCE continued

offered maintenance. Very good. The last laugh may be on all of us. One company is close to computerized troubleshooting, and another has an infrared device that analyzes operation by the heat patterns in a chassis.—Editor]

MIDYEAR REPORT

Dear Editor:

The article "Midyear Report on Electronics" by Larry Allen in your June 1967 issue is most interesting and informative. However, I take issue with the statement "Citizens band is slowing down, but commmercial two-way radio is making up for it."

LEO G. SANDS

New York City

MORE ON BAFFLES

Dear Editor:

James F. Novak, in "Baffle: Speaker–Air Interface" in the June issue, correctly points out that the range of low-frequency response in an infinite baffle or closed-box speaker system is determined exclusively by the bass resonant frequency, and that the level of bass response is determined by the Q. He then concludes with the familiar saw: "A large box allows *more* and *cleaner* bass than a small box."

The bass resonant frequency of an acoustic suspension speaker can be made as low as the designer wants it to be. The Q can also be adjusted to whatever value the designer thinks proper. There is nothing in the small size of the box which imposes special limitations (outside of efficiency).

In short, the range and level of bass response in a properly designed acoustic suspension system is exactly the same as in a properly designed infinite baffle system using the same size woofer. Further, the substitution of air springiness for mechanical suspension stiffness reduces bass harmonic distortion radically, usually by 75% to 90%.

ROY F. ALLISON

END

Acoustic Research, Inc.
Cambridge, Mass.

CORRECTION

There are two errors in "Build Your Own Shortwave Receiver," in our August 1967 issue. On the schematic, one side of C22, the cathode of D1, and the sleeve of J2 are shown connected together. This common connection should also be tied to the ground bus. On page 58, middle column, second paragraph, the second sentence should read: "For 80-meter coverage, the full 80-turn coil is required." END

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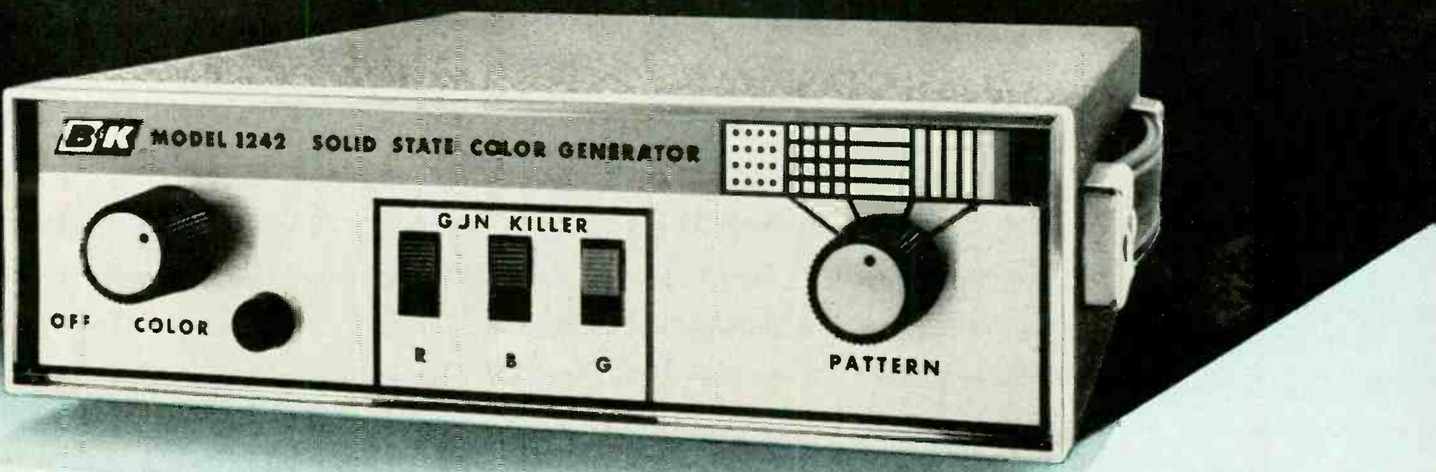

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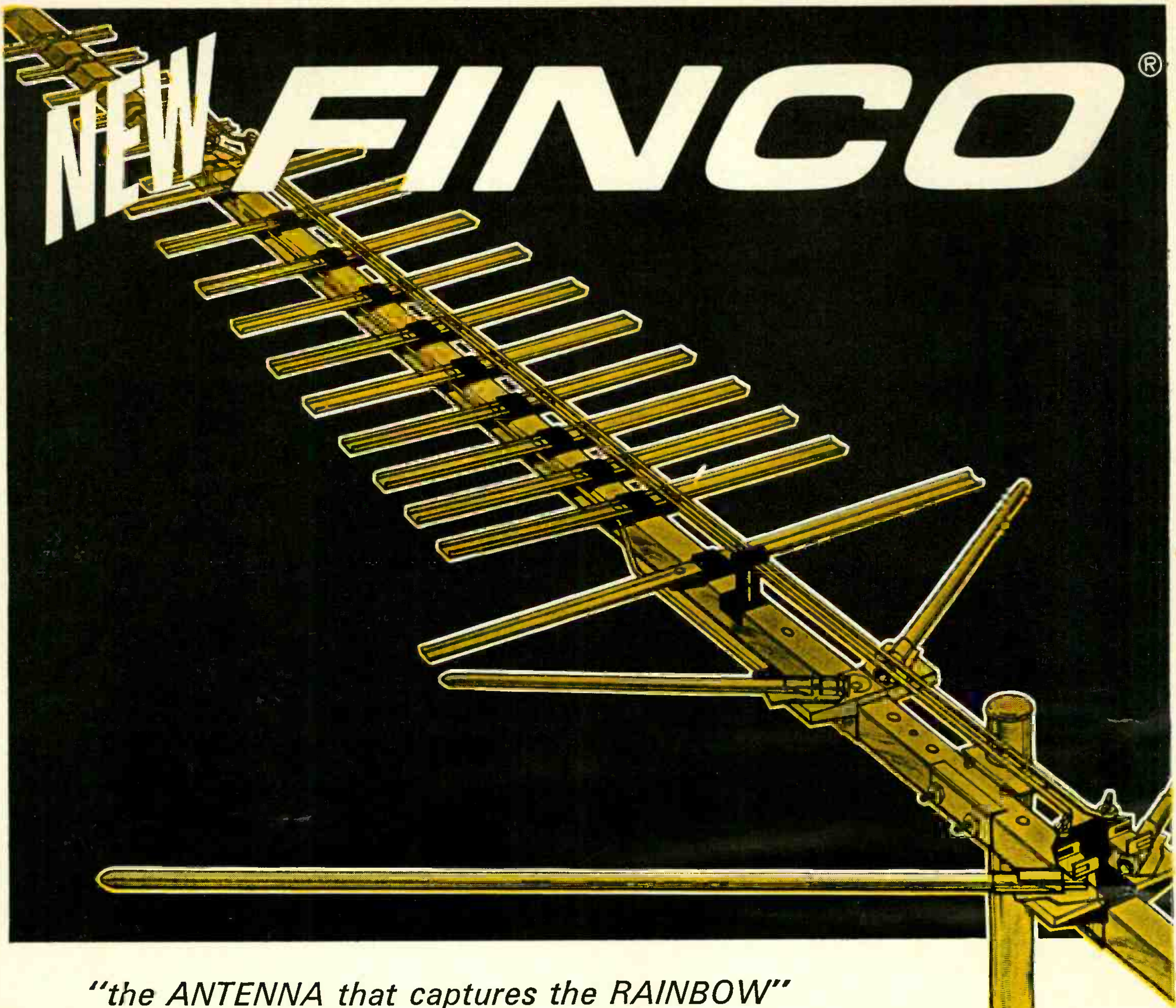

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NEW BOOKS

AUDIO SYSTEMS, by Julian L. Bernstein. *John Wiley & Sons, Inc., 605 Third Ave., New York, N.Y. 10016. 5½ x 8½ in., 110 pp. Paper, $4.50*

A thorough study of audio systems, written somewhat in textbook form. Includes examples with solutions as a part of each chapter; then provides a number of problems but doesn't give answers for them. Takes up the nature of audio signals and noise, measurement units, attenuators, mixing systems, amplifiers, recording, and equalizers. Also studies the electromechanical devices used in audio systems. Enough mathematics to explain the principles, but nothing beyond ordinary algebra. The reading isn't light, but shouldn't be difficult for a high-school graduate.

DESIGNING TRANSISTOR I.F. AMPLIFIERS and TRANSISTOR BANDPASS AMPLIFIERS, by W. T. Hetterscheid. *Springer-Verlag, New York, Inc., 175 Fifth Ave., New York, N.Y. 10010. 6¼ x 9¼ in., 358 pp. and 314 pp. Cloth, $12.00 and $11.40*

This pair of books is part of the "Philips Technical Library" series by this publisher. Both are designed as engineering texts, as the title of the first implies. They go well into the calculus of design, but, as is sometimes the case with well-written books, the nonengineer can learn a lot between formulas. Well supported, too, with design curves and charts. Two good books for advanced study.

THE TREASURE HUNTER'S MANUAL, by Carl von Mueller. *The Gold Bug, Box 588, Alamo, Calif. 94507. 5½ x 8½ in., 336 pp. Paper, $6.00*

Not technical, but a lot of our readers express interest in treasure-hunting devices, and this book deals with practically every facet of treasure-hunting. It discusses tools and instruments for treasure-hunting, but doesn't give any technical data on them. Even if you aren't a treasure-hunter, you might enjoy the tales of treasure-and-how-it-got-there that pepper the book.

TRANSISTOR CIRCUIT ANALYSIS AND DESIGN, by Franklin C. Fitchen. *D. Van Nostrand Co., 120 Alexander St., Princeton, N.J. 08540. 6½ x 9½ in., 426 pp. Cloth, $8.50*

Second edition of a book published first in 1960. Covers most of the latest types of transistors, beginning with semiconductor physics and devices, and continuing through advanced pulse and switching circuits. Covers applications of transistors and consumer devices as well as communications and computer units. Although well loaded with mathematics, the text doesn't depend entirely on them for understanding. Each chapter is accompanied by a group of related problems for the reader to work out; answers are provided for only a few of them. END

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40 1927/1967 Fortieth Anniversary

In the Shop . . . With Jack

By JACK DARR

"I've checked every part in that circuit and it still doesn't work!" Does that sound familiar? It certainly does to me, for it's about the most common complaint in my Clinic mail.

One, if you have checked every part in this circuit and it won't work, what about the possibility that the trouble isn't in *this* circuit at all? Two, the statement may be false! It should be: "I've checked every part in the circuit *that I can think of*, and it still won't work." Consider this; if you *have* checked "every part" and replaced the bad ones, it *would* work! This is simple logic, something that we forget to use at too-frequent intervals.

Let us look at a typical case, using the regular guinea pig (my wife's husband).

He examines a fairly new Zenith color TV, and finds only a thin white line across the tube. First diagnosis is easy; no vertical sweep. Well, everyone knows that this defect is caused by a bad capacitor somewhere in the vertical oscillator, if new tubes won't cure it. (Or is it? Let's see.)

Checking tubes, voltages, etc., plus moving the height and linearity controls (in case one of them had developed a dirty spot under the slider) do no good at all. Quick check of yoke and output transformer shows okay. Low-voltage supply okay. Bench job.

Humming a gay tune, he sets the chassis on the bench, without even connecting the extension cables, and starts checking capacitors very nonchalantly. Snap job. Ho-hum. But 15 minutes later, he has checked all seven capacitors and found them perfect, checked all "associated resistors," plus the controls. Not an easy job, now.

He's got one symptom, now, though. The plate voltage on the triode section of the 6BA11 "oscillator" half comes up to normal when first turned on, but drops very rapidly to about 6–8 volts as the tube warms up. Well, he knows what causes this—a leaky coupling capacitor. Hmm. Coupling capacitor perfect, grid voltage zero. Since he had jumpered the heater voltage to the control grid of the 6HE5 output tube, and produced a 6- to 8-inch raster, the trouble *was* in the oscillator (input) section, but where?

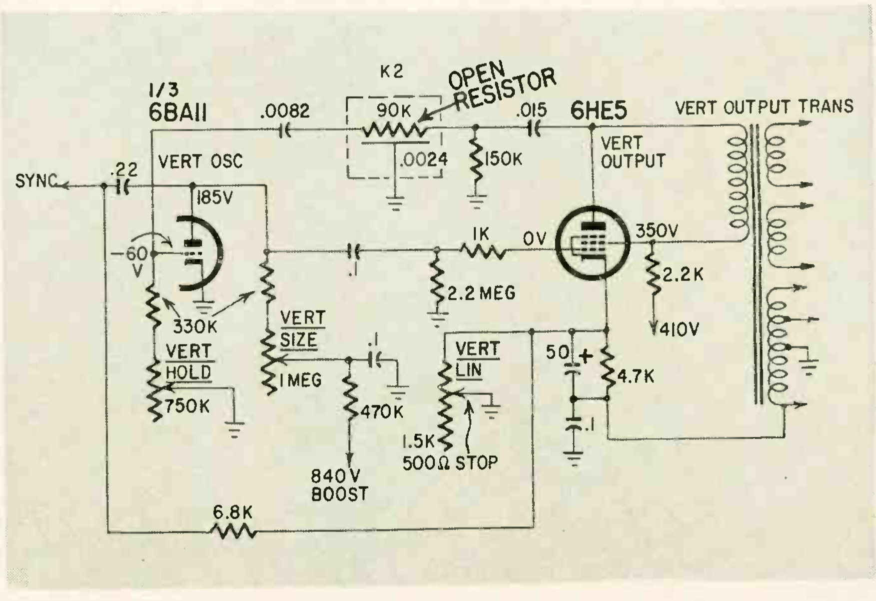
All the parts in the feedback loop were checked. All capacitors good, no leakage at all. He'd even unhooked the little PC integrator unit and checked it for capacitor leakage to ground; fine. (The diagram shows the complete circuit, or all we need of it.)

Rechecking the grid voltage of the 6BA11 triode, he now notices that there is a very small negative voltage

continued on page 26

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, 154 West 14th Street, New York 10011.



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Prices & specifications subject to change without notice. CL-301 on it. He hasn't used the scope up to now, for the circuit obviously was not oscillating, and there were no waveforms to look at! So now, up with the LO-CAP probe and see what's going on. After all, this is a multivibrator, and about the only way you can *keep* an MVB circuit from oscillating is take a hammer to one of the tubes.

Oh, ho! A very tiny "ripple" on the grid. Turning up the scope gain, he finds an odd pattern; instead of the 60-Hz sawteeth, a "sinewave-looking" sort of waveform, but fast; about 600 Hz at least! (By turning the height control wide open, he gets a small raster.

Now, he takes the obvious next step in the process; he goes and gets a cup of coffee. Returning, he sits and stares at the set. It's trying very hard to tell him something. Finally, it dawns on him—if the oscillator is running *fast*, there must be an *open* part in the frequency-determining circuit!

All the capacitors in the feedback loop had been checked for capacitance as well as leakage, so that wasn't it. What was left. Oh, ho. He sees one. Unhooking the little PC integrator in the feedback loop, he checks it for *continuity*; previous check had been only for capacitor leakage. Whee! It's open! This one is supposed to have 90K of series resistance with .0024 μF of capacitance! The C is pretty close, but there's no R at all; it's almost completely open! Replacing the integrator cures the trouble!

Now, let us use perfect 20-20 hindsight to see what stuck our guinea pig for so long. One, he'd frozen on the idea that this *had* to be capacitor trouble, because it is in a very large percentage of similar cases. Two, he wasn't *thinking* clearly about possible causes of this kind of trouble if the capacitors were okay, as they were. With the feedback loop open, the oscillator couldn't work at its normal frequency, but it was trying as hard as it could. With one of the components out, it had to work at a much higher frequency, with, of course, a much reduced amplitude.

The first thought, after the capacitor test failed, was a "tube trouble." Incorrect bias (positive) caused the tube to draw so much current through the very-high-value plate resistors that the plate voltage fell to almost zero. Well, in itself, this was true; however, it was not due to a shorted coupling capacitor, but simply to the fact that the grid had gone to zero bias, and, *in this tube and circuit*, that was enough to kill the plate voltage!

The conclusions to be drawn from this are: One, suspect *everything* in the circuit, no matter how unusual you think it might be for this particular part to fail. Two, if "checking every part in the circuit" doesn't produce a cure, look somewhere else! It is entirely possible that this circuit is *not* the cause of the trouble you see. Three, don't sit there and fight it: go get a cuppa coffee!

Selective color loss

I get good color on channel 4, but not on channel 5, 8, or 11, all in the same town. I've tried substituting tubes in the color circuits, burst amplifier, phase detector, and so on, but no luck. I use coax lead-in with a balun at the set. To get all channels I had to add a small trimmer capacitor across the antenna terminals. What's wrong?—A.P., Dallas, Tex.

I believe you're working in the wrong section. If you do get color on even *one* station, your color section must be okay, since it is common to all channels! This type of trouble can only be caused by something which is *changed* for different channels. The tuner, for example. Check your oscillator settings to make sure that you're on the right side of the color carrier, etc.

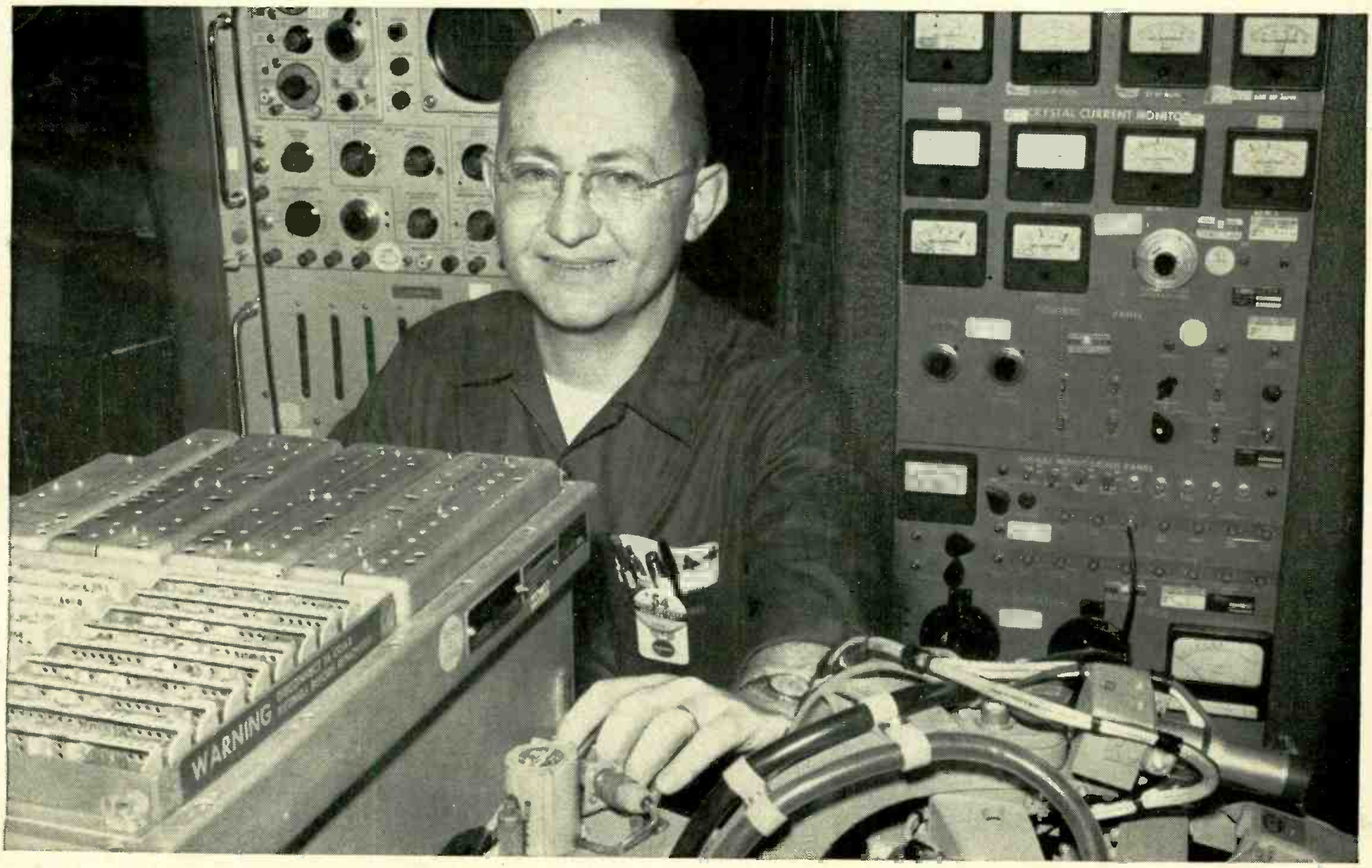
I would also, very definitely, check your antenna and lead-in system. Try taking it off entirely and substituting rabbit ears for a test. See if you can get color with this kind of setup, even if it is terribly snowy. If so, then your present antenna system has a "suckout" or trap effect in it *somewhere* that is attenuating the color signal on all channels except 4.

Car radio overload

I have a 1962 Chevrolet auto radio for repair, and the complaint is blurring and distortion when the customer gets too near to the radio station. Is there anything that can be done about this?—L.P.G., Secaucus, N. J.

The first step, which you may have already taken, is to make sure that his antenna trimmer is adjusted properly, for maximum volume at about 1,400 kHz. If this doesn't cure it, then you may have to modify the front end of the radio slightly.

The basic trouble is overloading of the rf transistor by the strong signal. Take the antenna coil out of the set, and, very carefully, unwind two turns from the *secondary*. This will cut down on the level of rf signal, and should reduce the distortion. END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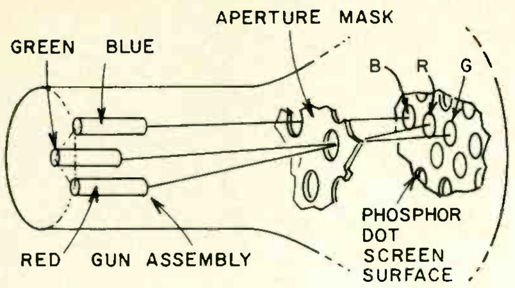


Fig. 1—The aperture mask guides the beams.

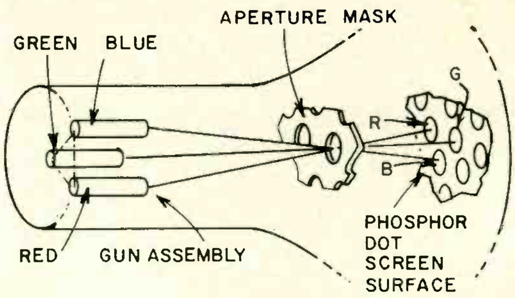


Fig. 2—If one beam doesn't track with the others, it can pass through the wrong hole in the mask.

Learn Color the Programed Way

You'll find this an easy system for picking up the fundamentals painlessly **By GLENN M. RAWLINGS**

Do you hate to study? Do you have trouble remembering what you've read? Maybe you'll find this question-and-answer technique easier to follow. Just begin by reading BLOCK 1.

1

As you can see in Fig. 1, the neck of a color picture tube contains three electron guns. They are focused through an aperture mask so the electron beam from each gun strikes only a particular group of phosphor dots on the screen surface. Unlike black-and-white TV, where only one type of phosphor material is used, three types are required for color. Each phosphor emits either red, blue or green light when struck by an electron beam. The phosphor dots are arranged in a triangular pattern. Normally, the beam from one of the guns strikes only the red dots, another the green, and the third strikes only the blue dots. If any two of the guns are turned off, the screen should then be a solid-color display of either red. blue or green; obviously this depends on which gun is on. This proper gun–dot relationship is called *purity*.

In practice you can't obtain an *absolutely* pure screen. By careful adjustment, though, you'll get nearly perfect purity. In general, there are two purity adjustments: Whole-screen purity is adjusted by moving a double ring-magnet assembly around the neck of the tube. Purity near the outer edges of the screen is accomplished by moving the deflection yoke forward or backward on the neck of the picture tube. Both these adjustments magnetically affect the electron beams of all three guns; each beam then strikes only its own color phosphor dots on the screen surface. Important point: *purity adjustments affect all three beams simultaneously. So will a stray magnetic field near the CRT.*

Question: Which of the following would have the most effect on the screen purity of a color receiver?

- ☐ Adjustment of the i.f. strip. Go to **Block 20.**
- ☐ Received signal strength. Go to **Block 8.**
- ☐ A stray magnetic field near the area of the picture tube. Go to **Block 7.**

2

Not correct. Return to BLOCK 12 and restudy.

3

Wrong. Go back to BLOCK 7, restudy and select another answer.

4

Would you believe . . . *false!* Go back to BLOCK 11 for the correct answer.

5

Through the process of elimination, you have chosen the correct answer. This same procedure should be used for all servicing.

The color picture tube can reproduce black-and-white images only under certain conditions. When no signal is being received, the screen (or raster) will seem white (assuming the color circuits are operating properly). This is so because all three guns are turned on. Your eye mixes the colored light into white.

The light values between black and white are called gray-scale values.

As shown in Figs. 1 and 2, there are three different color phosphor dots on the screen surface. To produce a correct gray scale, the amount of light emitted from each phosphor dot must be equal to the others. Since there is a considerable difference in the efficiency of the phosphors, a different beam intensity is required for equal light emission. For example, to produce a white screen, the green gun may contribute only about 25%; the red and blue guns contribute the remaining 75%.

In order for the various light levels in a monochrome picture to appear as proper values of gray, a definite relationship of the three beam currents must be maintained. The primary adjustments for setting this relationship are the screen and background controls.

Question: In a color tube producing a white raster, the beam currents from each gun are different. Why?

☐ To compensate for losses in beam energy due to their striking the aperture mask. Go to **Block 14.**
☐ To compensate for the difference in emission efficiency of the red, blue and green phosphor materials. Go to **Block 21.**
☐ Because of improper adjustments to the screen controls. Go to **Block 16.**

6 No. Return to BLOCK 15 and try again.

7 Your answer is right. A stray magnetic field would put a steady deflection force on the beams, causing them to strike improper phosphor dots. The symptom of this unwanted field usually is a colored patch on some area of the screen. Degaussing the picture tube will eliminate the problem.

As previously mentioned, the purity adjustments affect all three guns simultaneously. The next adjustments to be mentioned control beam deflection of each gun separately.

Even though you get correct purity, it is possible for one, two or all three of the beams to be passing through the wrong holes in the aperture mask. Notice in Fig. 2 that the blue beam is actually passing through a different hole in the mask than the other two. Although it is striking the proper color, the blue beam isn't positioned properly with respect to the other beams.

For proper color pictures, the beams must be converged, or aligned, so that all three pass through the same hole at the same time. This is called *convergence*. If the beams do not converge properly, a color fringe will appear around the edge of objects on a b-w picture.

To make convergence adjustments, you *must* use a dot or crosshatch pattern to see what effect you're having on the beams. The convergence controls interact; if you adjust one, you'll have to adjust the others.

During *static* convergence adjustments, the beams are first made to overlay each other in the center of the screen. When the beams are deflected toward screen edges, they travel farther and pass through the mask at a different angle than before. Because of this, *dynamic* convergence voltages are applied to coils around the neck of the tube (Fig. 3). These coils create fields which deflect the electron beams slightly. Thus proper convergence is maintained during the entire scanning process.

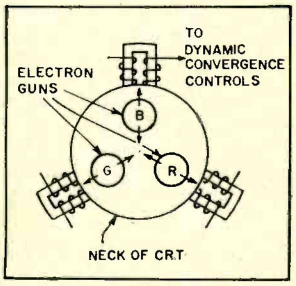


Fig. 3—If you could look into the neck of the tricolor CRT from behind the screen, this is what you'd see. Electron beams from the three guns are deflected dynamically by magnetic fields produced by the coils.

Question: Which of the following best describes a convergence problem?

☐ The raster is not a pure, solid color. Go to **Block 3.**
☐ When viewing a black-and-white picture, you see a fringe of green on the edge of objects in the scene. Go to **Block 12.**
☐ In a black-and-white picture, areas of low brightness seem to be more purple than black. Go to **Block 18.**

8 Your answer is *wrong!* Return to BLOCK 1.

9 Wrong. While it is true that some technicians have a permanent "crosshatch" burned on their eyeballs from long convergence sessions, this is not the answer. Return to BLOCK 17.

10 Wrong. Return to BLOCK 17 and reread.

11 Your answer is correct. When proper, the delay causes black-and-white (luminance) and color (chrominance) signals to overlap each other at the picture tube. Troubles in the delay line can cause symptoms such as ghosts or a complete loss of picture.

As previously mentioned, the 3.58-MHz local oscillator is synchronized to the transmitted color burst signal. This *phase-locked* signal is then "mixed" in the color demodulator tubes and compared with the transmitted color sideband information. The instantaneous color-demodulator-tube plate voltage represents picture-tube beam intensity for a given color at a specific time. In practice, only red and blue sidebands are mixed in the demodulator tubes. Green is produced by comparing the blue and red demodulated signals against the reference luminance signal. Luminance (or Y) contains all three colors—red, green and blue. This reestablishes a definite relationship which existed at the transmission of these signals. A process called *matrixing* produces the proper amounts of red, blue and green by algebraic summation of the various signals.

Question: The 3.58-MHz crystal controlled (local) oscillator is synchronized to the color sideband signal.

☐ **True.** Go to **Block 4.**
☐ **False.** Go to **Block 17.**

12 Your answer is correct!

As a rule of thumb, before any purity or convergence adjustments are made to a color receiver, the raster should be centered. All linearity, height, width and drive controls should be properly adjusted. The agc should be correctly set and the picture tube completely degaussed. The high-voltage power supply should be checked for the correct voltage. This value should not vary beyond 5% as the brightness and contrast controls are moved over their normal operating range.

By now you should have some idea of the construction and makeup of the three-gun color tube and its ability to produce a pure screen of either red, blue or green. But what about the time and position on the screen that these colors should appear? And how are colors that are not specifically red, blue or green obtained? Let's answer the second question first. You've seen that the CRT screen surface is composed of thousands of phosphor-dot sections. These dots are so small that for all practical purposes the human eye cannot resolve one from another—even though they are of different colors.

As you have probably guessed, there must be a means of synchronizing the color beams to the transmitted signal, to produce the correct picture. The circuits needed for color are shown as shaded blocks in Fig. 4; the unshaded blocks are common to all television receivers.

At the front end or tuner of the color receiver, the following signals are received: picture carrier (including sync pulses), brightness (or Y) information, color burst (3.58 MHz), color sideband information and the sound carrier (4.5 MHz).

During color processing by the various amplifiers and demodulators, a slight delay is imposed upon the color signals before they reach the picture tube. Because of this effect, it is necessary to delay the brightness (Y) signal with an electronic delay line. Thus all video signals reach the CRT at the same instant.

The 3.58-MHz color burst signal is removed from the carrier and used to synchronize the local crystal oscillator in the receiver.

Question: The purpose of the delay line in the color receiver is:

- ☐ To prevent the chrominance (color) signals from reaching the picture tube before the luminance (Y or brightness) signal gets there. Go to **Block 2.**
- ☐ To prevent the luminance (Y or brightness) signal from reaching the picture tube before the chrominance (color) signal gets there. Go to **Block 11.**
- ☐ To delay the transmitted 3.58-MHz burst signal in order to synchronize the local crystal oscillator. Go to **Block 19.**

13 Best to overlook alignment of these circuits until more data are obtained. Never attempt alignment without proper equipment. Your answer is wrong. Return to BLOCK 15 and select another answer.

14 Hold on now. Better go back to BLOCK 5 and try again.

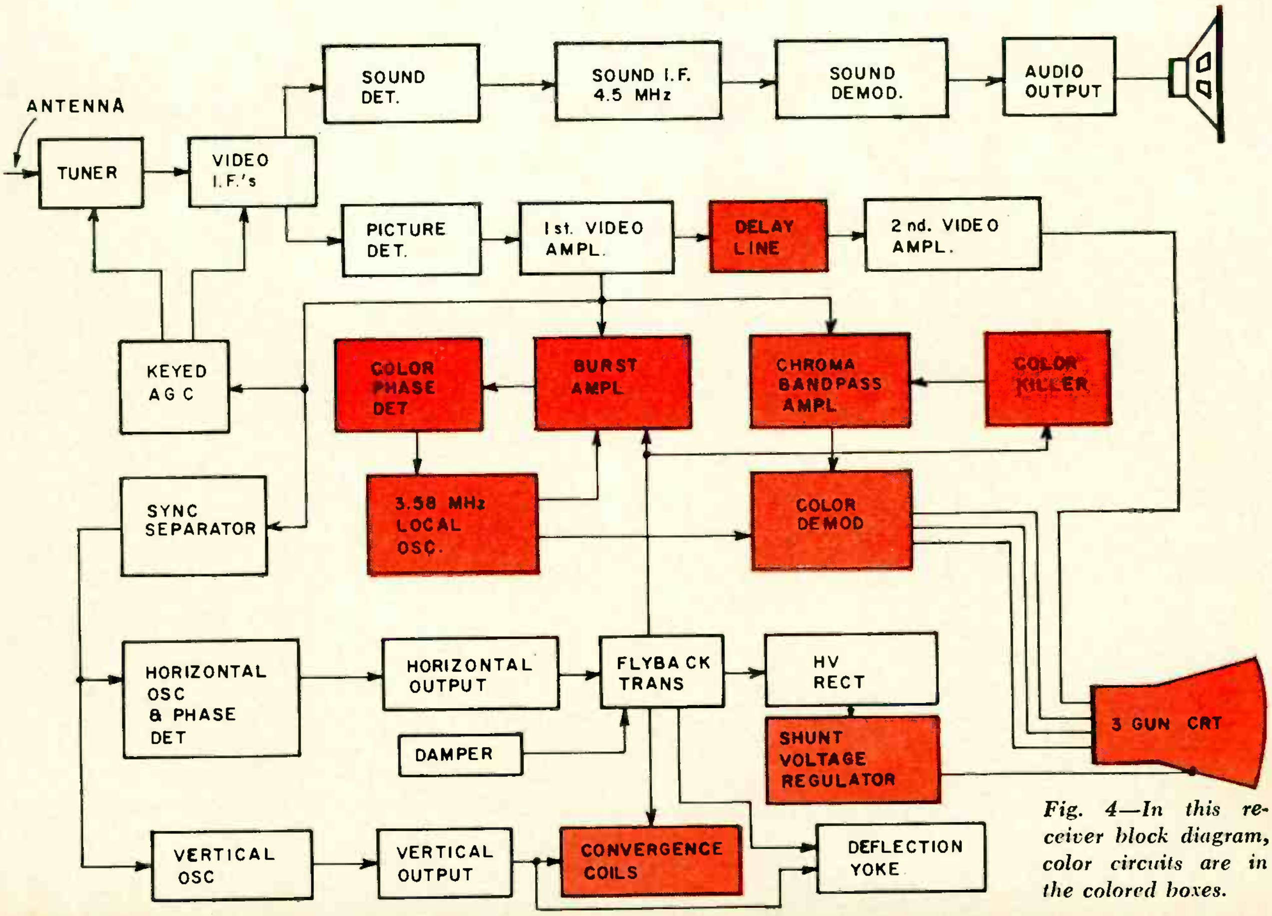


Fig. 4—In this receiver block diagram, color circuits are in the colored boxes.

15

Your answer is correct.

Color television is a lot like black and white; you can diagnose many troubles by a careful examination of the picture. For instance, a herringbone pattern in a color picture can be caused by the beat between the 3.58-MHz color signal and the 4.5-MHz sound signal.

Other troubles and causes: displaced colors (or color fringing)—a sign of misconvergence. Running colors or bars of colors moving vertically through the picture—loss of sync to the 3.58-MHz local oscillator. Missing, weak or wrong colors can be caused by demodulator troubles, chroma amplifier problems, or a number of other things.

Before suspecting improper color operation, you should first verify correct b-w.

Question: When servicing a color set, generally the first thing to do is:

- ☐ Check the alignment of the i.f. and color circuits. Go to **Block 13.**
- ☐ Disconnect and use an ohmmeter on all paper capacitors in the receiver. Go to **Block 6.**
- ☐ Sit down, carefully study the symptoms, then logically take corrective steps to eliminate the problem. Go to **Block 5.**

16

Wrong. Return to BLOCK 5 and reread the question.

17

Your answer is correct. The 3.58-MHz crystal oscillator is synchronized to the transmitted color burst signal.

Referring once again to Fig. 4, the burst amplifier amplifies the incoming 3.58-MHz signal and the color phase detector compares this burst with the locally generated 3.58-MHz signal. If the local oscillator drifts (compared to the incoming burst), the phase detector sends an error signal to the oscillator.

The chroma bandpass amplifier separates the color signals and has a variable gain adjustment for color control.

The color-killer circuit normally disables the chroma bandpass amplifier as long as no burst is being received. Hence no color appears on the screen during b-w programs. When a color program is received, the 3.58-MHz burst cuts off the color killer.

The convergence coils, as previously mentioned, are around the CRT neck and have adjustable current controls associated with them.

To keep convergence voltages stable despite variations in the high-voltage power supply, that supply uses a shunt voltage regulator circuit (see Fig.5). This regulator circuit has a vacuum tube in parallel with the output. Since the tube's control-grid voltage changes with the loading on the high-voltage supply, the result is a constant output voltage to the picture tube.

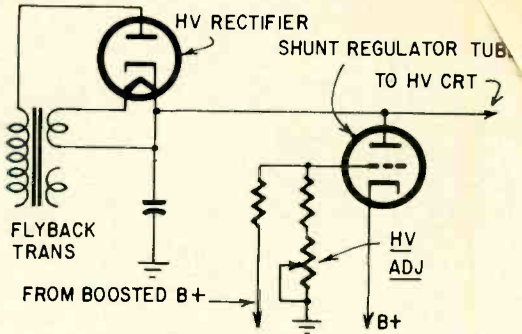


Fig. 5—Shunt regulator stabilizes high voltage.

Question: For what primary reason is the high-voltage power supply regulated in a color set?

- ☐ To keep the high voltage constant while making convergence adjustments. Go to **Block 10.**
- ☐ To keep the red, blue and green beams converged at the aperture mask, regardless of the variations in high-voltage loading. Go to **Block 15.**
- ☐ To keep from burning a permanent "crosshatch" pattern on the screen. Go to **Block 9.**

18

Sorry about that! Return to BLOCK 7 and try again. (The symptom you selected is caused by improper gray-scale adjustments, to be mentioned later.)

19

Wrong! The delay line does not affect the local oscillator. Return to BLOCK 12 and select another answer.

20

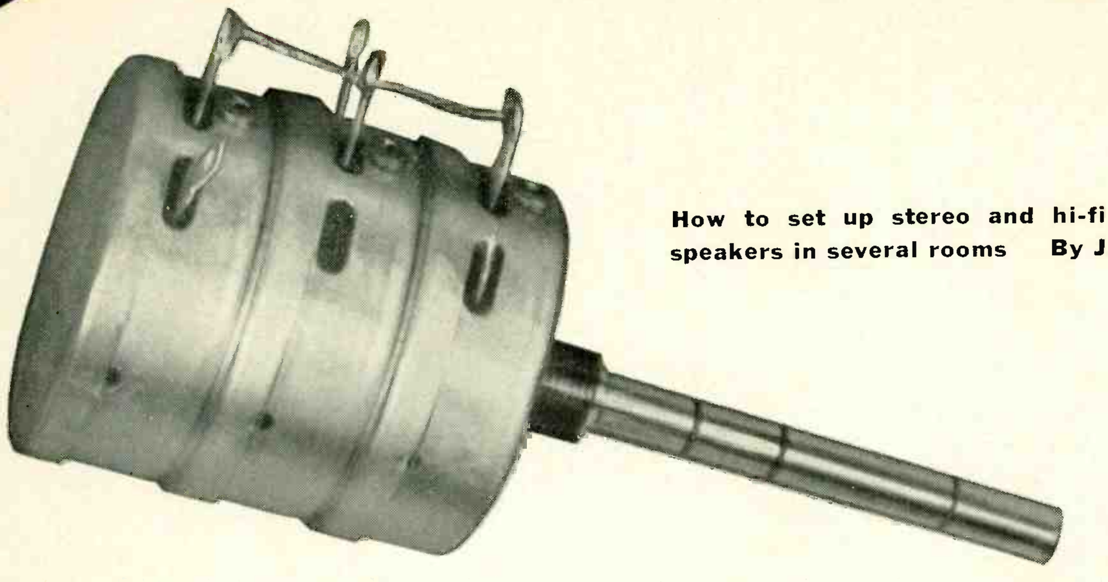
Sorry about that. You had better go back and reread BLOCK 1 again. Select another answer.

21

Your answer is absolutely right.

Sometimes when troubleshooting a color set, the problem may not be in the set at all, but rather in the antenna or lead-in system. This is a possibility that should not be overlooked. A perfectly good b-w picture might be obtained with an antenna incapable of receiving the wider bandwidth of a color transmission—especially in rural areas. The antenna should have a flat response over all the channels received. Make sure the lead-in is in good condition, whether it is twinlead or coax.

We haven't intended to give you specific instructions for making adjustments or corrections to a color receiver. Rather we hoped to enlarge or refresh your knowledge of color technology. Hope you had some fun at the same time. END



How to set up stereo and hi-fi systems with speakers in several rooms **By JAMES A. FRED**

KNOW YOUR L- AND T-PADS

FREQUENTLY, IT IS NECESSARY TO VARY the volume of a loudspeaker independently of the amplifier, as in the case of a remote speaker in a bedroom. To achieve attenuation and to avoid the introduction of distortion, a "pad" can be used. A pad is an attenuator that does not change the circuit impedance as attenuation is varied.

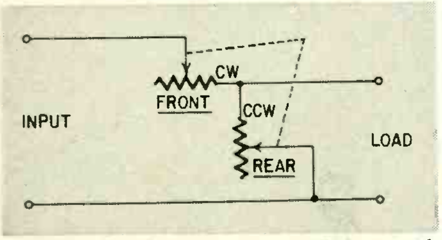


Fig. 1—Diagram of a variable L-pad.

The L-pad

The L-pad is less expensive to build than the T-pad, since only two resistance sections are ganged together. The resistance element in the front section is called the series leg; the back element is called the shunt leg. The L-pad (Fig. 1), consisting of two sections, maintains the circuit impedance independent of attenuation at only one pair of terminals.

To analyze the operation of an L-pad, refer to Table I, "Rotational Measurements for a 16-Ohm L-Pad." As an example, let us use a 16-ohm speaker connected to a 16-ohm L-pad and an amplifier. (The data in this table are actual measurements made on production L-pads.) Notice that the resistance of the series leg is the same as the characteristic impedance of the L-pad, while the resistance of the shunt is eight times as much. At the counterclockwise end, or 0° of rotation, series resistance is 16.29 ohms, shunt resistance 0.2 ohm, impedance 16 ohms, and attenuation 38.2 dB. At 50% or 150° of rotation, series resistance is 7.76 ohms, shunt resistance 18.5 ohms, impedance 16.35

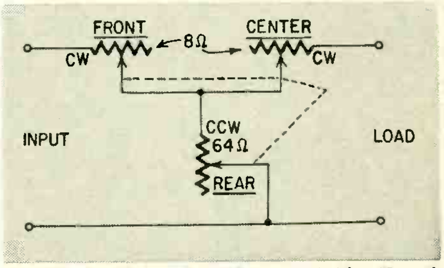


Fig. 3—A typical 8-ohm variable T-pad.

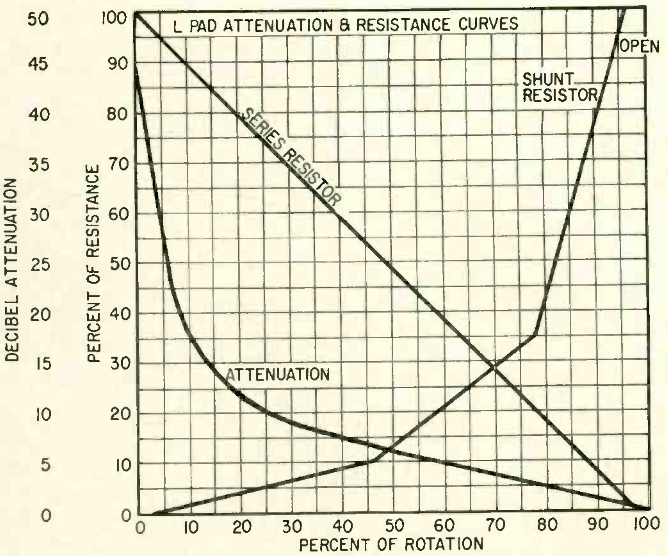


Fig. 2—How attenuation of L-pad changes as shaft is rotated.

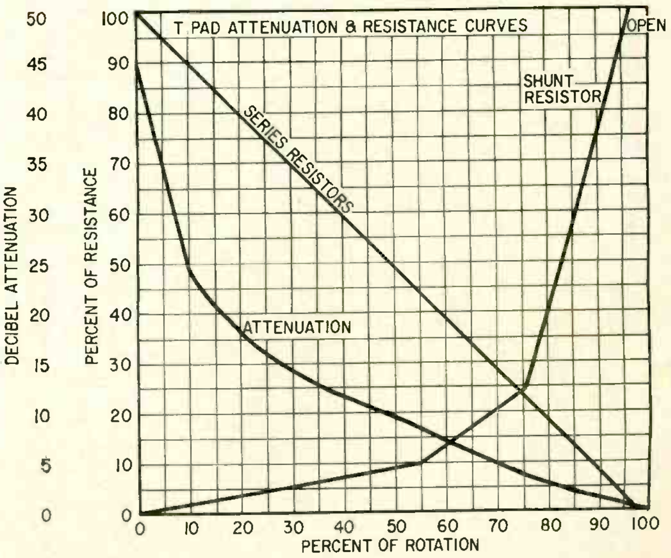


Fig. 4—Typical attenuation curves for a variable T-pad.

ohms, and attenuation 5.4 dB. At 100% or 293° of rotation, series resistance is 0.19 ohm, shunt resistance is infinite, impedance is 16.19 ohms, and attenuation is practically zero. As the L-pad is rotated from one end to the other, the impedance stays essentially the same.

The graph of Fig. 2, "L-Pad Attenuation and Resistance Curves," can be used to approximate the necessary resistance values for the resistance legs. Notice that the series leg is linear, while the shunt resistor is a tapered winding in three linear sections. This tapered winding gives the L-pad a more nearly linear attenuation. Total resistance of the shunt leg will be eight times that of the series leg. The series resistance will be the same as the rated impedance of the L-pad. Total attenuation is 45 dB. Since the threshold of audibility usually is assumed to be −60 dB, you will still be able to hear a signal even with the L-pad turned to the counterclockwise end of rotation. If it becomes necessary to cut the sound out completely, a switch must be used to open up the line. If so, it would be best to have the switch substitute a fixed resistor of the same value as the L-pad, to maintain proper loading in the circuit.

L-pads can be used as described to control the volume of loudspeakers, but T-pads are generally preferred for this purpose, as explained in the following section.

The T-pad

Where it is important that an attenuator and the amount of attenuation have no effect on circuit impedance, a T-pad is used. The T-pad (see photo and Fig. 3) consists of three control sections ganged together and operated by a single shaft. The front and middle elements have resistance values equal to the impedances they are to be matched to, and are referred to as the legs. The resistance of the rear element, or shunt leg, is usually eight times the value of either of the series legs.

Table II, "Rotational Measurements For an 8-Ohm T-Pad," shows how the T pad operates. When the control is at the ccw end of rotation, the input series resistance is 8.26 ohms, output series resistance 8.09 ohms, impedance 8.26 ohms, and attenuation 53.5 dB. At 50% or 150° rotation, the input series resistance is 3.93 ohms, output series resistance 3.92 ohms, impedance 7.87 ohms, and attenuation 9.65 dB. At full clockwise rotation, the input series resistance is .036 ohm, output series resistance .029 ohm, impedance 8.06 ohms, and attenuation practically zero. From one end of rotation to the other, the T-pad impedance stayed at essentially 8 ohms.

The graph of Fig. 4, "T-Pad Attenuation and Resistance Curves," can be used to approximate the resistance necessary for the resistance legs. For example, let us say that we need a 16-ohm T-pad. From the curves, we find that the series leg will be a 16-ohm linear-wound element, and that two will be needed.

The shunt element will be eight times this value, or 128 ohms, made in three linear sections. The first section of the shunt element should be 10% of the overall resistance, or about 13 ohms in the first 55% of rotation. The second section should be 15% of the overall resistance, or 20 ohms in the next 21% of rotation. The third section of the shunt winding should be 75% of the overall resistance, or 95 ohms in the next 21% of rotation. The shunt coil is open for the last 3% of its rotation.

Those who are content to accept the preceding explanation on faith alone can stop here, and will probably be satisfied to buy and use L- and T-pads as always in the past. For those who are mathematically minded, we will proceed a little deeper into the subject.

The attenuation of a resistance pad is expressed as a number of decibels (dB), where the dB expresses the ratio between two different amounts of power

TABLE I.

Rotational Measurements For a 16-Ohm L Pad.

Degrees of Rotation	Series Resis.	Shunt Resis.	Impedance	Decibels Atten.
0	16.29	0.20	16.00	38.2
10	15.74	0.26	16.00	35.9
20	15.18	1.45	16.51	21.6
30	14.49	2.41	16.58	17.7
40	13.94	3.52	16.83	14.9
50	13.39	4.62	16.98	13.0
60	12.84	5.73	17.06	11.6
70	12.30	6.67	17.00	10.3
80	11.74	7.72	16.94	9.7
90	11.06	8.62	16.66	9.1
100	10.51	9.72	16.56	8.4
110	9.86	10.83	16.42	7.9
120	9.41	11.71	16.17	7.5
130	8.87	12.82	15.99	7.0
140	8.31	14.73	15.99	6.4
150	7.76	18.50	16.35	5.4
160	7.10	22.17	16.40	4.7
170	6.54	25.94	16.44	4.2
180	5.98	29.75	16.60	3.8
190	5.44	33.56	16.25	3.4
200	4.90	37.39	16.11	3.1
210	4.38	41.20	15.90	2.9
220	3.80	44.47	15.56	2.7
230	3.27	52.34	15.52	2.3
240	2.80	65.50	15.66	1.9
250	2.32	83.10	15.62	1.5
260	1.61	99.30	15.37	1.3
270	1.01	115.5	15.06	1.2
280 (hop-off)	0.41	125.3	14.56	1.0
290	0.16	inf.	16.16	0.09
293	0.19	inf.	16.19	0.09

KNOW YOUR L- AND T-PADS

at two points—input and output, in this case.

$$\text{decibels} = 10 \text{ Log} \frac{P1}{P2} = 20 \text{ Log} \frac{V1}{V2} = 20 \text{ Log} \frac{R1}{R2}$$

Strictly speaking, dB's can be used to express voltage or current ratios only when the two points in question have the same impedance value. However, when matching stereo controls in actual practice, input and output impedances are ignored. It is mainly in speaker matching, in the telephone industry, and in the broadcast industry that impedances are so critically matched.

Let us go back to the impedance of the T-pad and draw an equivalent-circuit diagram (Fig. 5), but with a load. As you can see, the first series leg (8.26 ohms) is in series with the shunt leg (.034 ohms), which is in parallel with the second series coil (8.09 ohms), which is in series with the 8-ohm load impedance. Working it out in simple arithmetic, we have 16.09 ohms in parallel with .034 ohm, which gives us .03 ohm. The 8.26 ohms and .03 ohm added together give us approximately 8 ohms, the nominal impedance of this T-pad.

TABLE II.
Rotational Measurements For an 8-Ohm T Pad.

Degrees of Rotation	Series in Resis.	Shunt Resis.	Series out Resis.	Impedance	Decibels Atten.
0	8.26	.034	8.09	8.26	53.5
10	7.98	.0826	7.98	8.08	45.8
20	7.68	.480	7.68	8.14	30.6
30	7.40	.910	7.38	8.26	25.1
40	7.09	1.35	7.04	8.33	21.7
50	6.80	1.78	6.78	8.39	19.4
60	6.53	2.22	6.53	8.46	17.6
70	6.23	2.66	6.22	8.47	16.05
80	5.92	3.02	5.91	8.40	15.00
90	5.63	3.47	5.61	8.40	13.85
100	5.33	3.90	5.38	8.35	12.9
110	5.03	4.27	5.02	8.25	12.15
120	4.79	4.72	4.78	8.23	11.4
130	4.49	5.10	4.50	8.16	10.8
140	4.24	5.51	4.22	8.04	10.2
150	3.93	5.87	3.92	7.87	9.65
160	3.69	6.30	3.63	7.78	9.10
170	3.37	6.87	3.32	7.65	8.45
180	3.09	8.53	3.10	7.90	7.25
190	2.80	10.20	2.80	8.05	6.30
200	2.50	11.95	2.50	8.08	5.20
210	2.20	13.63	2.20	8.03	4.90
220	1.95	15.00	1.90	7.91	4.45
230	1.65	18.09	1.65	7.94	3.70
240	1.40	27.08	1.35	8.35	2.80
250	1.10	36.10	1.11	8.39	1.95
260	.806	45.18	.858	8.20	1.60
270	.507	54.2	.57	7.91	1.30
280	.231	63.1	.28	7.57	1.05
285 (hop-off)	.083	63.3	.107	7.27	1.05
290	.0307	inf.	.0286	8.05	.065
293	.036	inf.	.029	8.06	.065

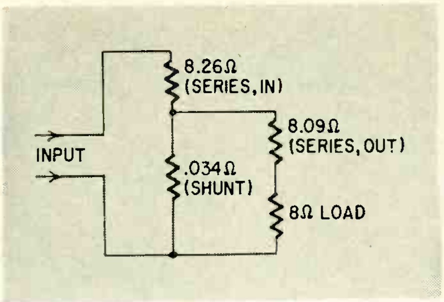


Fig. 5—Equivalent circuit of a T-pad and its load set up for the maximum loss.

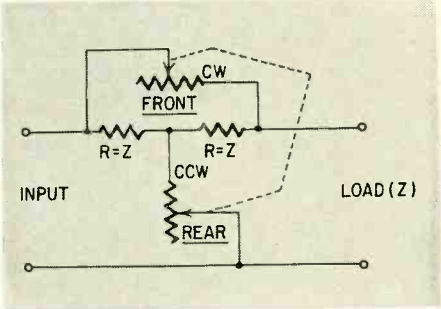


Fig. 6—A variable bridge-T attenuator has only two elements which change value. ("Front" and "rear" labels are reversed.)

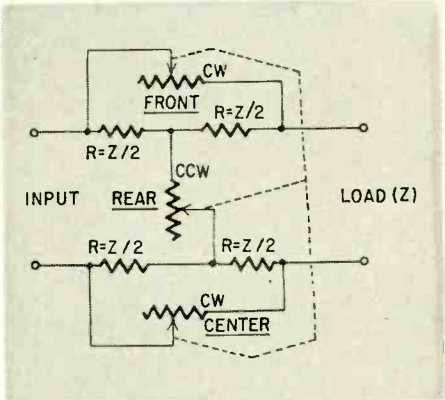


Fig. 7—Variable bridge-H attenuator has three variable and four fixed resistors.

An equivalent-circuit diagram of the L-pad can be drawn and analyzed the same way.

This article is limited to L- and T-pads, because these are the ones most readily available to technicians and experimenters. There are other types.

Instead of T-pads, some companies supply variable bridged-T pads; these require only two variable sections plus two fixed resistors. This is less expensive and, in many cases, a bridged-T pad (Fig. 6) will work adequately in place of a straight 3-section T-pad.

Another type usually available on request is the bridged-H pad (Fig. 7). This pad consists of a conventional T-pad with four fixed resistors connected as shown. The resistors help to give a more linear attenuation curve. END

Creative Electronic Servicing

Think logically before you troubleshoot and you'll solve the problem faster

By LARRY ALLEN

CAUSE-TO-EFFECT REASONING. TUBE changing. Parts substitution. Hit-and-miss. Cut-and-try. Localizing. Signal tracing. Parts checking. Sectionalizing. Signal injection. Half-section analysis. Divide and test.

All these terms are familiar. Each represents an approach to the problem of finding the cause of trouble in a faulty piece of electronics gear. There are two more terms I'd like to add: psychology and creativity.

You may already have a pretty good idea how psychology applies to troubleshooting. My dictionary calls *psychology* the science of the mind—why people think and act as they do. Your most powerful troubleshooting tool is your mind; it sorts and classifies whatever trouble clues you track down and figures out what is causing them.

If your mind tracks down and processes the clues logically, you are a good troubleshooter. If you jump around from clue to clue, in no logical order, chances are you run into tough dogs more often than you should.

So . . . what about creativity? *Creativity*, according to the dictionary, has to do with inventiveness. In just those terms, then, we can say that creative troubleshooting is finding (inventing) new ways to locate faults in electronic equipment.

What thoughts run through your mind when you first walk up to a repair job on your bench—say, a television receiver? If you have a paper handy right now, jot down what your first step is.

You will use at least three of your senses: *sight*, to see if the raster or picture comes on or if the tubes light, and to watch for smoke or other visual signs of trouble; *hearing*, to verify if the sound section works or has too much hum, or if the horizontal oscillator is working, or if the telltale crackling is there when the high voltage first comes on; and *smell*, to decide if anything is overheating, or sniff ozone caused by corona.

In all these cases, sensory stimuli (as psychology manuals call them) are being sent to your brain in hopes it can

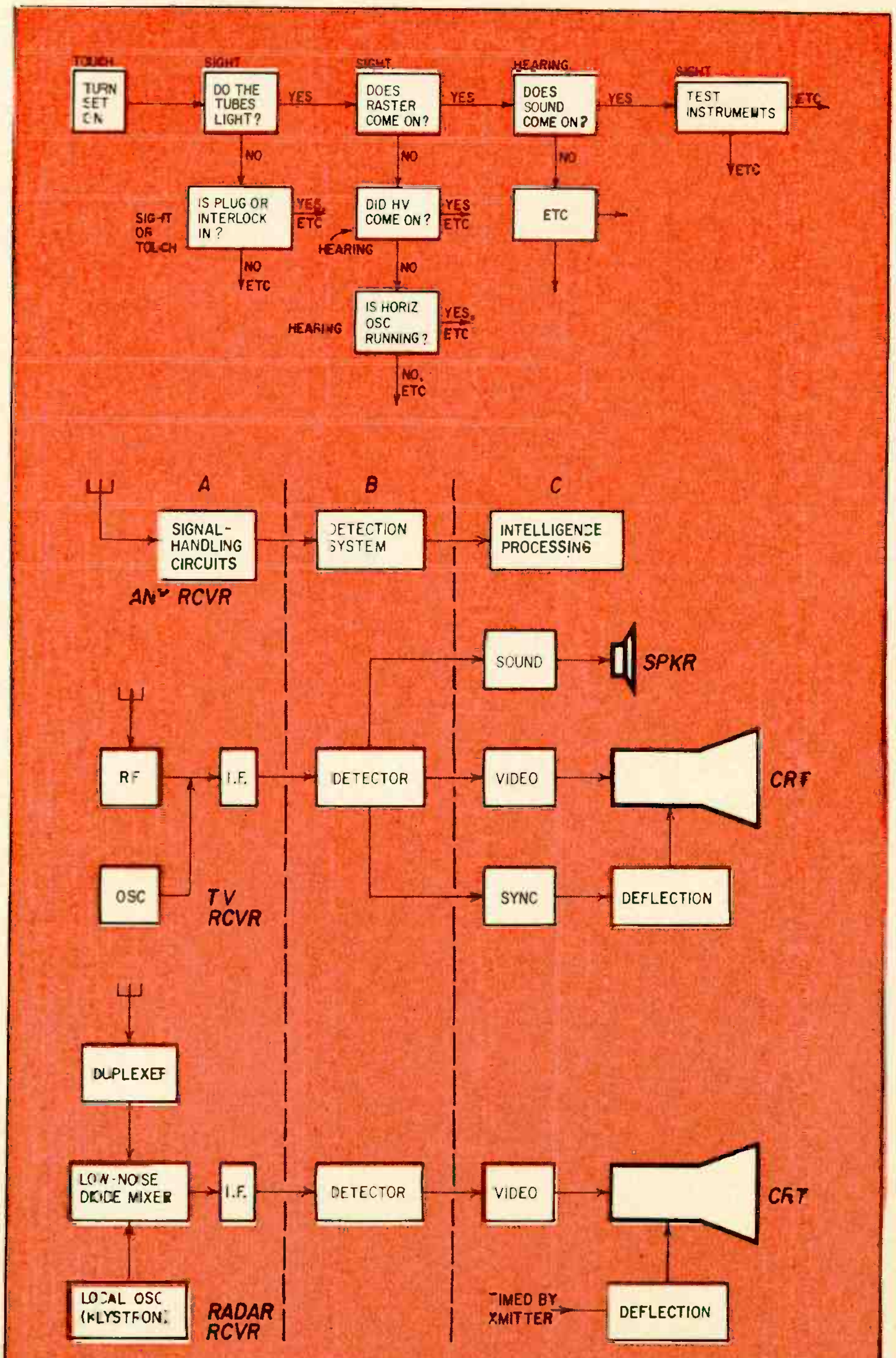


Fig. 2—You can break any receiver down into sections, to find the trouble easily.

decipher their meanings. All the information from the four senses funnels into the computer you think of as your brain; the output is some conclusion about the information.

Now, about the psychology of that conclusion. Here is how a conclusion is synthesized (another psych-book term) in one example. You *sniff:* no smell of burning, so on to the next sense. You *listen:* no station sound, but you can hear the horizontal oscillator start and the high voltage charge up the aquadag on the CRT, so your brain registers that something is blocking station sound. You *feel:* the volume-control knob is all the way down and turning it up brings on station sound. Your brain registers that the set's stimuli to smell and hearing are normal.

Finally you *look:* the screen is black. Brain says, aha! Here is a major clue. Conclusion, then: The trouble in this set is something that prevents a raster in spite of the high voltage you already know is present (you heard it crackle into existence).

Then you go on to other stimuli or combinations of them. You probe with your senses for other clues. When your senses have reached their limits, you employ extensions of them. Meters, scopes, probes, and other instruments give your brain—via your senses, even with the instruments—a clue to where the real trouble lies.

For most effective troubleshooting, the thought process or psychology of your actions should follow a logical pattern. This pattern can be broken down a little further. It can be thought of as *yes* and *no* responses to questions your brain is asking through your senses. Take a look at the brief example in Fig. 1. When you reach the point where your senses can't tell you any more (and this point is reached quickly, for the brain sorts clues rapidly), then test instruments provide the next clues for your brain to process.

From this you can see that troubleshooting can be broken down psychologically into fairly simple steps or decisions. Many of them take only split fractions of a second. To the experienced technician these decisions seem second-nature and are made almost without conscious thought. The many conclusions are drawn so automatically, quickly and unnoticeably that the uninitiated, watching an old-timer work, is almost always totally unaware so many decisions are even being made. An apprentice often doesn't even learn about this logical—psychological reasoning that is so important a part of competent troubleshooting. He gets the idea that the old-timer's speed is all the result of experience.

Now let me get back to creativity, and how it applies to troubleshooting. An interesting thing about the creative approach to servicing is that it is useful to newcomer and old-timer alike. Learned thoroughly and used properly, creative methods do not depend on experience. You do not have to memorize hundreds of case histories. You can troubleshoot a set using the creative approach without ever having serviced that particular complaint or set before.

One warning! No system of servicing—creative or otherwise—is a substitute for knowing the operation of the system or equipment you are servicing. You *must* learn the operation of basic circuits and their interrelationships, and then you can apply creative techniques to servicing any possible combination of these circuits. That is why no electronic equipment will be beyond your ability.

Creativity equals inventiveness. That doesn't mean you have to redesign or reinvent the circuit to service it properly. It means you should practice inventiveness in your approach to servicing the circuit.

Creativity begins when you decide what question to ask of the set, section or circuit. Take the yes–no approach, for example. In the troubleshooting situation cited earlier, you smelled, listened, looked, and felt. Each time, you made an answer. If you looked to see if a tube was lit, you decided either yes it was or no it wasn't. If you smelled to see if the power transformer was smoking, you decided it was or wasn't. If you felt to see if it was too hot, either it was or it wasn't. You have to analyze the circuit to ask the right question.

If the yes–no system will work when you ask questions with your senses, it will also work when you ask them with test instruments. If you're checking with a voltmeter at the plate of a tube, you're asking: Is voltage there? Answer, yes or no. If yes, is it low? Yes or no. If no, then is it high? Yes or no. You ask and answer this series of questions in the time it takes to touch the probe to the tube pin. The instrument lets you see

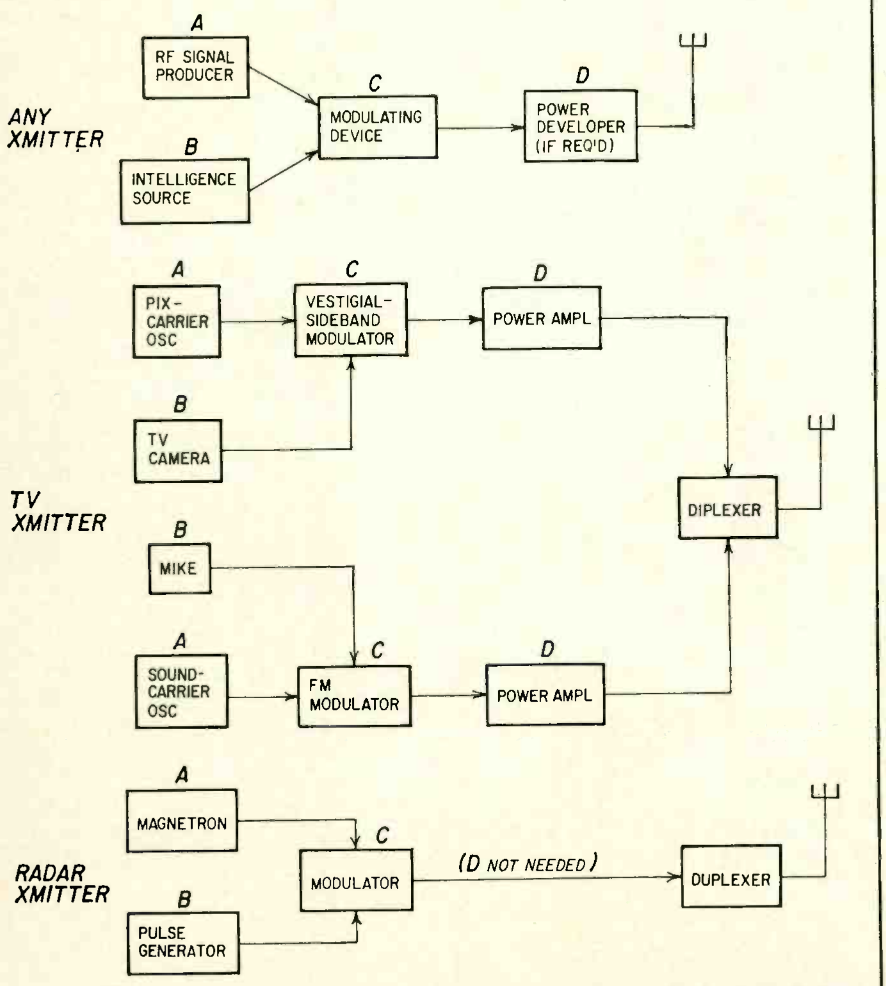


Fig. 3—A transmitter also works in stages, no matter what kind of rig it is.

something you couldn't observe with your unaided senses.

Suppose you're signal-tracing an audio section by the injection method. You touch the generator output probe to the audio amplifier plate and listen. Is there sound at the speaker? Yes or no. If no, go on to the next point nearer the speaker. If yes, move back toward the detector or audio input point. You're using instruments to supplement your senses. And you're employing creativity to select the questions you ask of the circuit. In any overall servicing process, you can put creativity to work on section stage, circuit, part.

If you still don't understand how creativity fits in, here are some long sentences that may clarify it for you: *Creativity* is involved when you decide just what troubleshooting technique you will use in a particular set or with a particular complaint. *Creativity* is being used when you adapt a single principle of troubleshooting to fit the many servicing situations or the various equipments you encounter. *Creativity* means putting clues together to draw a conclusion: Which system is at fault, which section is at fault, which stage is at fault, which circuit is at fault, and finally which part is at fault. *Creativity* is in the picture when you are deciding what to do about the fault: Do you align, repair or replace? Do you order an exact replacement or can you substitute? And so on.

Now let's move back to psychology—the thought processes of creative servicing. The best place to start servicing any equipment is by visualizing it as a whole system, made up of main sections. Fig. 2 shows how a receiver is sectionalized and how this division applies to a TV receiver and to a radar receiver. The identical main sections exist in a CB receiver, a satellite receiver, a microwave relay receiver, transistor radio, and in any other kind of receiver that you can imagine.

Fig. 3 shows the same principle of breaking into sections as it is applied to transmitters. You can easily see how it applies to TV and radar transmitters. The same principles apply to other transmitters, no matter what their primary purpose.

Understanding the basic premise, you can move on to the next step in creative troubleshooting: breaking the section down into stages. Fig. 4 shows the fundamentals. We're taking the A section of both receivers in Fig. 2 and breaking down only that section. You can see how nearly alike these sections are in a radar receiver and a television receiver. If you apply creative thinking to your troubleshooting, you'll find you can service the one just as easily as the other.

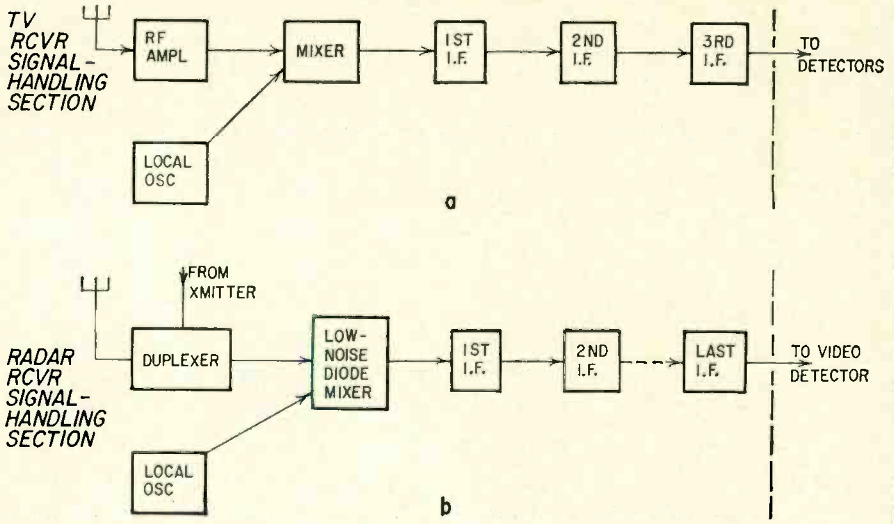


Fig. 4—Though you may know only TV, chances are you could service radar.

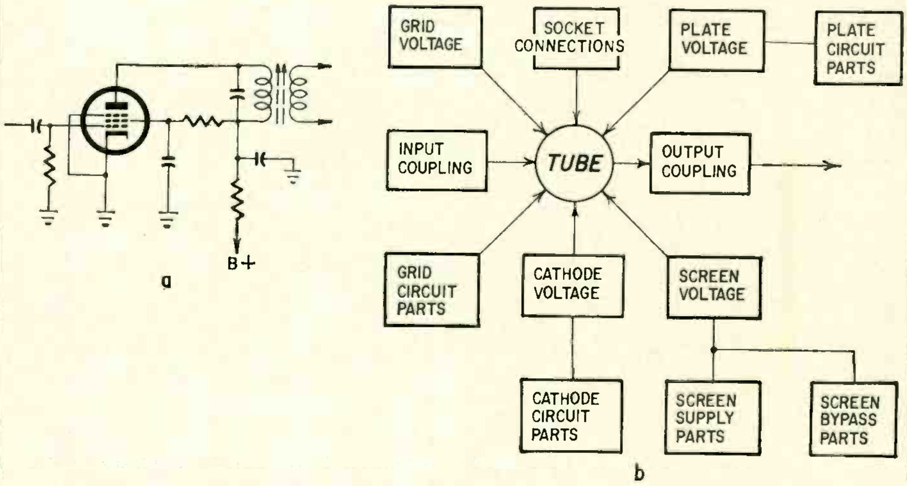


Fig. 5—Once you've found the defective stage, break it down into components.

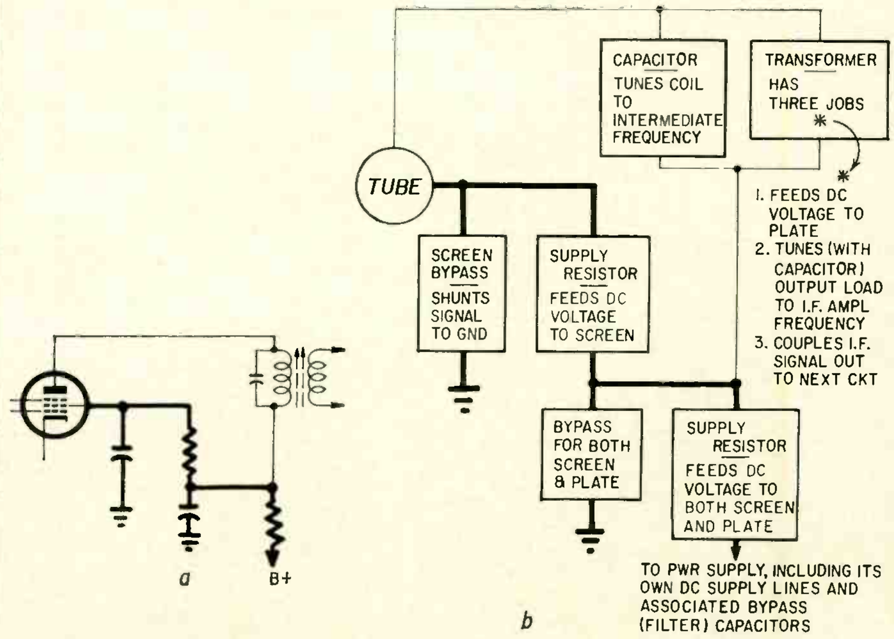


Fig. 6—Keep in mind the functions that each device is supposed to perform.

Creative Electronic Servicing

Creative troubleshooting now has brought you to the logical breakdown of sections into stages. What do you do with the stages? Ask them questions just as you did the sections. Is the signal getting through the mixer? Yes or no. Is the signal reaching the third i.f.? Yes or no. On each answer you base your next logical step. Good psychology (thinking).

Suppose the signal is being blocked at the fifth i.f. stage in the radar receiver. Fig. 5 shows, in blocks that are equivalent to the schematic, how you can break down the i.f. stage in your next psychologically correct step of troubleshooting. The blocks represent the factors you must examine. You can apply your creative practice of asking the yes–no question about each factor.

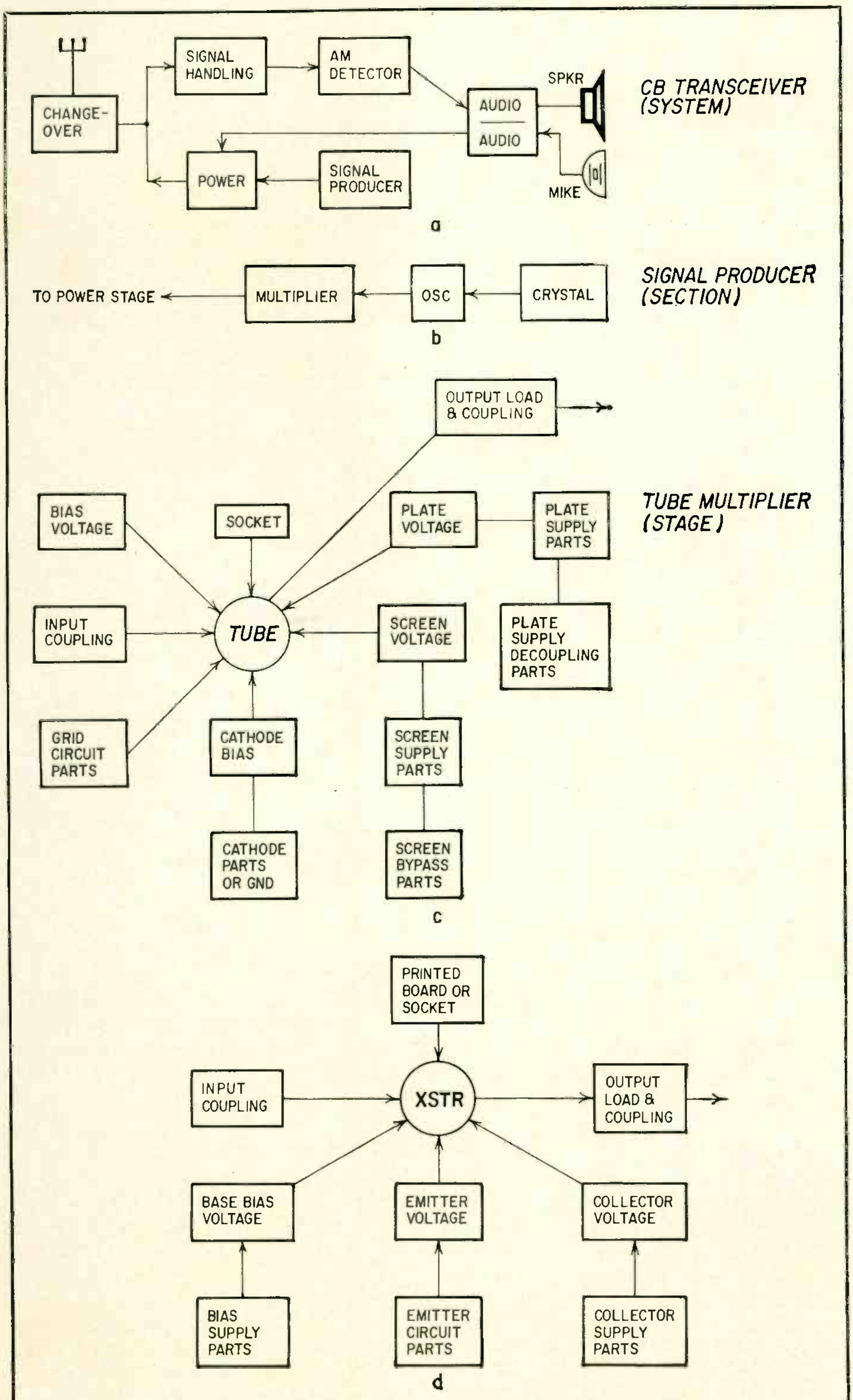


Fig. 7—Your troubleshooting steps should take you over (a) the complete system, (b) the section at fault, and (c or d) the stage containing trouble.

Next in your line of psychologically correct troubleshooting procedures is a breakdown of the stage into circuits. You noticed Fig. 5-b was already broken down into circuit segments: grid, cathode, screen, plate, and socket. Fig. 6-a shows schematically both the screen and plate circuits in this stage, with the screen circuit in heavy lines. The circuits and the components have several functions; Fig. 6-b labels them.

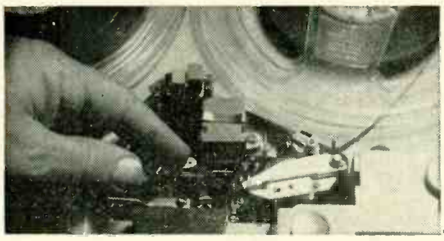
Will the creative servicing method we've been using apply here? Most emphatically, yes. Each component has a function, sometimes more than one. Consider the transformer as a good example. You must ask: Is it feeding dc voltage to the plate of the tube? Is it tuning to the correct frequency? Is its tuning too broad? Is it coupling the i.f. signal to the next stage? Each question has a yes or no answer, and can then be followed with: why?

With that *why?*, the next step in our creative troubleshooting procedure has been reached. You either replace the faulty part or you test it further.

Let's run through this logical procedure once more—this time with a CB transceiver. Fig. 7 shows the several steps in breaking it down into psychologically manageable sections, stages, circuits, parts. It's easy. Try breaking down something you've been asked to troubleshoot. You'll find you can reduce the most complicated electronic gear to easily understood proportions.

When I began defining creativity for you, I pointed out that it means inventiveness. You can be as inventive about your servicing techniques as you like. Most useful will be a method that applies to almost every situation and kind of equipment. If you find yourself changing methods to fit various types of equipment, you haven't yet found the one most versatile.

One final point about being the top-notch troubleshooter that creative methods of servicing qualify you to be. Neither creative servicing nor psychological reasoning can fix a set for you. Mechanical and muscular movements are still needed. You have to take sections apart, sometimes, to reach the parts that are causing trouble. It often takes digging. Once you have mastered a psychologically sound approach to servicing, one that is creative enough to be applied to any kind of electronic equipment you're asked to service, the difference between you and the true expert will be in how well and how confidently you dig in. END



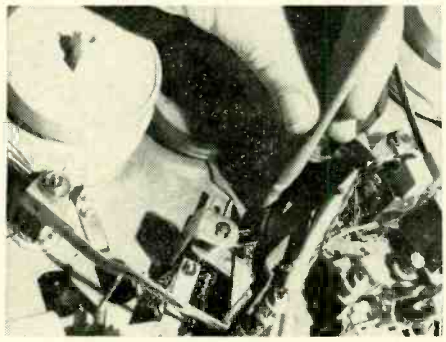
WHAT KIND OF NOISE ANNOYS A TAPE?

Squeaks, rattles and bangs make difficult listening, no matter where they are in a tape deck

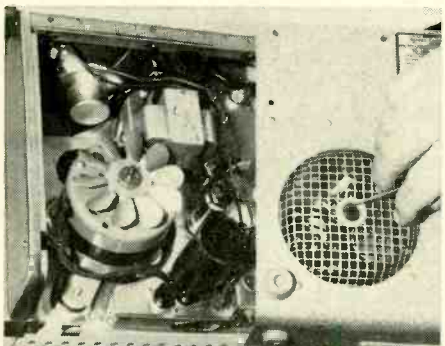
By GLEN F. STILLWELL

WHAT A BOTHER, WHEN YOU FLIP THE play switch of your tape machine and get set to hear some good music, to hear instead a lot of sound—hum, squeals, rattles, squeaks, clicks, sighs, moans, and what-have-you—you didn't bargain for. It's enough to drive a tape listener to distraction.

Mostly these are mechanical noises that develop in tape machines, and about which there is very little in the books. You can sometimes hear them being picked up by the microphone, so that they are part of that tape no matter what machine it might be played on and no matter how good that machine might be.



You can use a sheet of sandpaper to smooth out any high spots that may develop on the flywheel of a tape deck.



Fan and fan-cage screen can be a source of rattle. Bent fan blade can scrape, or the fan shaft may extend and rub screen.

The electronic technician and the recording buff should both know what to do about these annoying defects. In more than a decade of using, testing, repairing, and experimenting with tape recorders, I've run into some real noisemakers. So I'll pass some of them along to you.

I'll skip experiences with earlier machines that are not around anymore and deal with present-day models. As a matter-of-fact, the latter, with their complicated controls and accessories, are the big offenders in the unusual-noise department. One of the first troublemakers I ever encountered was a recorder that developed a strange squeak that was finally traced to a faulty counter.

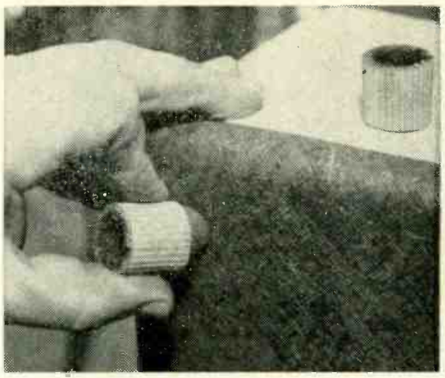
To locate the source of noise in a recorder, you must first decide in what part of the machine the noise is originating. A noise in the speaker is often difficult to locate because it may be being picked up far back and amplified. Poor shielding, faulty connections and a microphonic tube are a few of the things that can cause this kind of noise. Best start out your troubleshooting by checking all tubes. An intermittent howl I once heard in an extremely compact recorder originated in one of the tubes—easy to correct, hard to find.

Tape or deck trouble?

When the noise shows up in the speaker, you also have to suspect the playback head and the tape. If the tape is suspected of "printing through" (thin tape), the solution is obvious—new tape. However, if there is a bleeding from one track to another, realignment of the magnetic head may be the answer to the problem.

On the other hand, faulty linkages and noisy mechanical action are so often the cause of noise that little more need be said about electronic faults. At the outset, in troubleshooting mechanical-movement noises, check for vibrations by applying finger pressure to various areas of the recorder case and deck. You can determine this way whether the recorder is properly put together and all screws tightened.

Intermittent clicking or squeaking noises often develop in older recorders as a result of hardened rubber-faced driving wheels. Spotty wear of this kind can be caused by the user's too-rapid tape-speed shifting. The wheel may look satisfactory, but an undetected flat spot, even though very slight, can be an awful noisemaker.



Sections of garden hose can be pushed over hardened rubber feet to absorb noise.

Tilting the machine to different positions is one way to check for unusual noises.

When you have to replace defective rubber-faced wheels, it is generally advisable also to renew drive pinions and belts to make sure that the noise is completely eliminated. In a Telefunken recorder that had this trouble, the pinion had been redesigned to improve quietness of operation.

An initial step in troubleshooting is to remove all protective covers and then replace the control knobs so that mechanical linkages and their movements can be observed in actual operation. A model 400 Norelco recorder developed a high-level, continuous scuffing sound that could not be found until the case was opened up and the mechanism ob-

continued on page 93

Build This Transistor Characteristic Plotter

A construction project to display curve families on your scope screen By JOHN H. FASAL*

A CURVE OF COLLECTOR CURRENT VS collector voltage with constant base current is useful when you are designing transistor circuits. Applying manufacturer's data to characteristic curves assures proper use of a transistor. You can determine the limits of thermal dissipation and transient operation as well as correct values for current transfer and saturation. In addition the rapid display of a set of curves is an excellent way to match transistor pairs.

Devices for plotting transistor characteristics are commercially available. However, they're expensive. An electromechanical version costs less but does most of the work of a design-engineer's model.

Operating principles

The basic schematic of an electromechanical plotter is shown in Fig. 1. A fluctuating dc voltage from a full-wave rectifier is applied between collector and emitter of transistor Q. This voltage is fed to the horizontal input of a scope. The voltage drop across resistor R_E in the emitter circuit is proportional to emitter current. This drop drives the vertical amplifier of the scope. The horizontal beam deflection is proportional to the instantaneous emitter–collector voltage while vertical deflection is proportional to the emitter current. This value is practically equal to the collector current. The base is biased by i_b obtained from a constant-current source consisting of a 6-volt NiCad battery, adjustable voltage divider R_D and series resistor R_S.

This circuit causes the scope beam to trace the V_{EC}–I_C characteristic of the transistor. Circuit nonlinearities may introduce some errors; these must be avoided.

Series resistor R_E is across the scope vertical input. The voltage drop across R_E—which is what the scope displays—is caused by a current which reduces emitter–collector voltage. This V_{EC} reduction has no relation to the driving voltage. So, to minimize this nonlinearity between driving voltage and emitter–collector voltage, the drop across R_E must be small compared with the driving voltage. This means the vertical scope amplifier has to be running at higher gain than the horizontal amplifier.

Bias current should be applied between base and emitter rather than base and ground, to avoid negative feedback across emitter resistance R_E. This feedback may become disturbing if current amplification in the transistor is high. This necessity of using a floating bias source makes the use of a line-powered constant-current source impractical. Since there's no common ground, efficient filtering is almost impossible; 120-Hz ripple would get into the sensitive base circuit and distort the scope traces.

For the same reason, the NiCad battery can't be trickle-charged during plotter operation. The charging device has to be disconnected at this time from *both* battery terminals. An OPERATE-CHARGE switch disconnects the battery from the load circuit so that battery discharge is avoided even if the line is disconnected.

A third precaution must be taken to assure constant-current base bias. Base current is determined, not only by applied dc voltage and series resistor R_B, but also by base resistance r_b. This value is determined by collector current and transistor Beta. R_B has to be high compared to r_b to stabilize base current.

It's desirable to display several curves simultaneously on the CRT, each

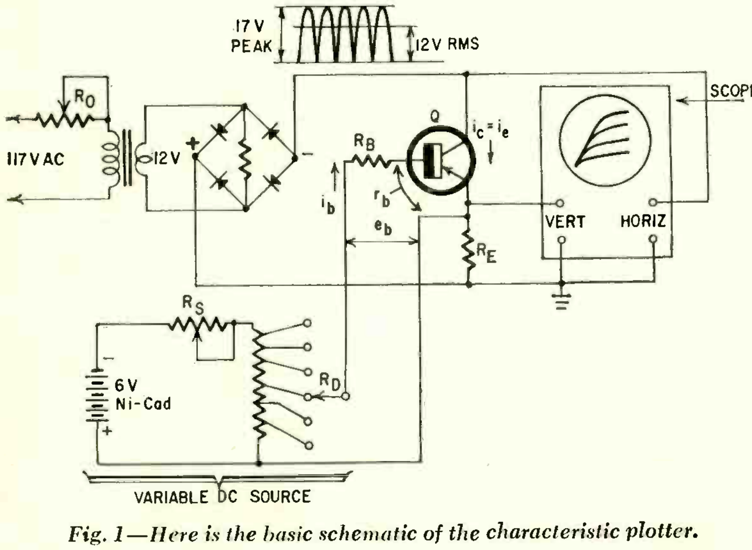


Fig. 1—Here is the basic schematic of the characteristic plotter.

Parts List

R1—pot, 5,000 ohms, 5 watts
R2—see text
R3—68K, ½ watt
R4—200 ohms, ½ watt, 5%
R5—pot, 10K, ½ watt
R6, R7, R8, R9, R10, R11—pot, 250 ohms, 2 watts, WW, (CTS series 115, type 117 or equivalent; Federated Purchaser, Inc., 155 U.S. Highway 22, Springfield, N.J. 07081. Stock No. 117R-251A. $1.25 each.)
R12—see text
D1, D2, D3, D4, D5—silicon diode, at least 150 mA, 100 piv
T1—117V pri to 12V sec, at least 150 mA
T2—117V pri to 12V sec, at least 2 amps
S1, S2—spst toggle switch
S3—spdt slide switch
S4—spdt toggle switch
S5—rotary switch, 4 poles, 3 circuits, nonshorting
S6—pushbutton, NC
S7-a, S7-b, S7-c, S7-d, S7-e, S7-f—reed switch (Gordos MR600 or MR606 or equivalent. MR600—Newark 60F3407, $1.00; MR-606—Newark 60F3408, $1.05.)
J1, J2, J3, J4, J5, J6—pin jacks
Magnets—Alnico V, ⅛ x ⅛ x ¾ inch, (Permag S5B-559 or equivalent) and ¼ x ¼ x 1⅛ inches, (Permag S5B560 or equivalent) Available from Permag Corp., 88-06 Van Wyck Expressway, Jamaica, N. Y. 11418; $2.50 for both.
Motor—600-rpm synchronous-clock type (Haydon or equivalent)
Transistor sockets (3), TO-5

*Assistant chief engineer. Alarms Engineering, Walter Kidde Co., Belleville, N. J.

determined by a different bias value. Due to CRT persistence, bias voltages can be changed rapidly so that five or six curves can be traced and will appear almost at the same time. It works out that a set of curves must be traced in about ⅕ sec. The time available for horizontal sweep is about 1/60 sec. With rectified 60-Hz ac, a square wave is produced that can be used to sweep four times (two times up and two times down). This produces four superimposed traces. These four traces for each curve are more than sufficient to create the impression of persistence.

The sweep system

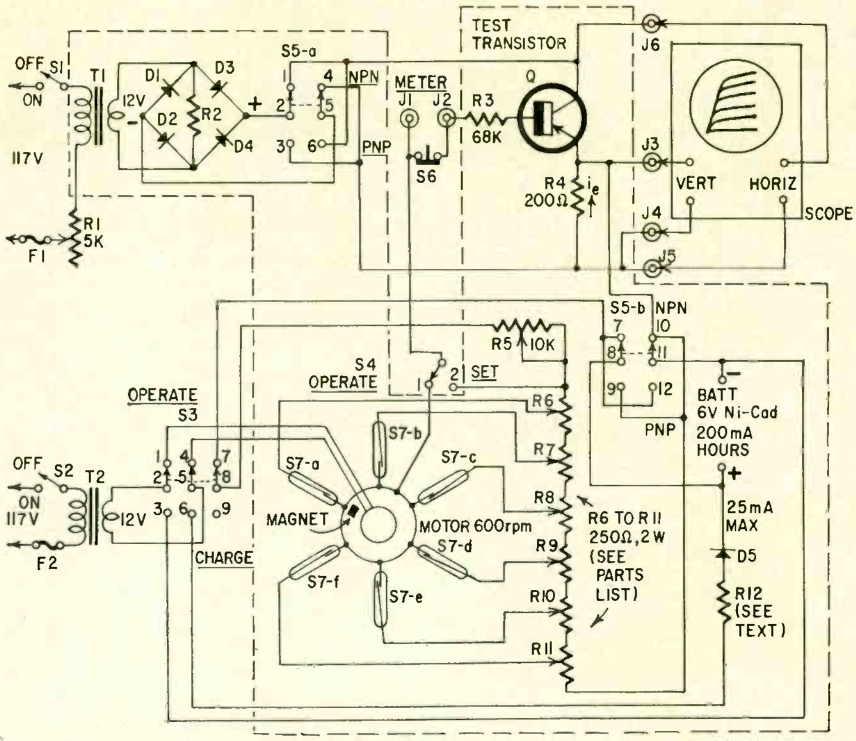
Commercial plotting instruments often use a complicated sweep generator and an electronic switching device to vary bias current. This version is simpler, using a rectified sine wave as sweep. Bias is switched by a simple rotating magnet that activates a set of reed switches.

Fig. 2 is the plotter schematic. R1 varies the amplitude of the voltage through T1, to adjust sweep length of the curve. R2, in parallel with this secondary, corrects sine-wave distortion caused by R1. The value of R2 must be determined by experiment with a scope connected to T1 secondary and a resistor box in parallel with both.

The output of the rectifier bridge D1–D4 is connected to polarity-reversal switch S5, which permits changing two things at once. One is the polarity of the sweep applied between emitter and collector of the transistor; the other is the polarity of the dc biasing voltage from the 6-volt NiCad battery.

This change in polarity is necessary to switch from pnp to npn mode. The scope horizontal deflection plates are controlled by the sweep voltage, and the vertical deflection follows the voltage drop across resistor R_E (R4 in Fig. 2). This resistor is a shunt for emitter-current measurement.

Transformer T2 with independent switch S2 and fuse F2, serves two purposes: It provides energy to charge the NiCad cells if switch S3 is in the CHARGE position. If S3 is on OPERATE, T2 powers the motor driving the rotating magnet. This magnet activates the six reed switches which change the bias currents. A third set of contacts on S3 disconnects the voltage divider from the battery circuit if the plotter is not in operation. The voltage divider itself consists of an adjustable series resistor R5 (10,000 ohms) and potentiometers R6–R11 (250 ohms each). Each resistor center point is connected with the base of the transistor through the closed reed switch (S7-a–S7-f), spdt switch S4, normally closed pushbutton switch S6 and series resistor R3. Bias current can be meas-



ALL PARTS WITHIN THE DASHED LINE ON THE PRINTED BOARD

Fig. 2—Complete schematic diagram for wiring the curve tracer.

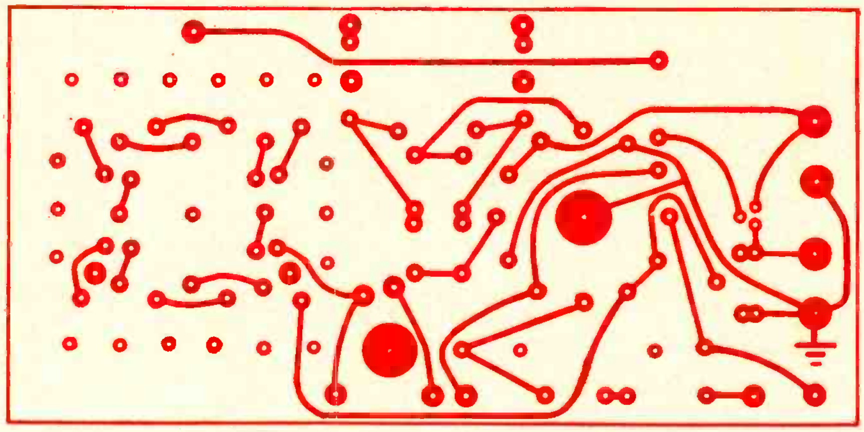
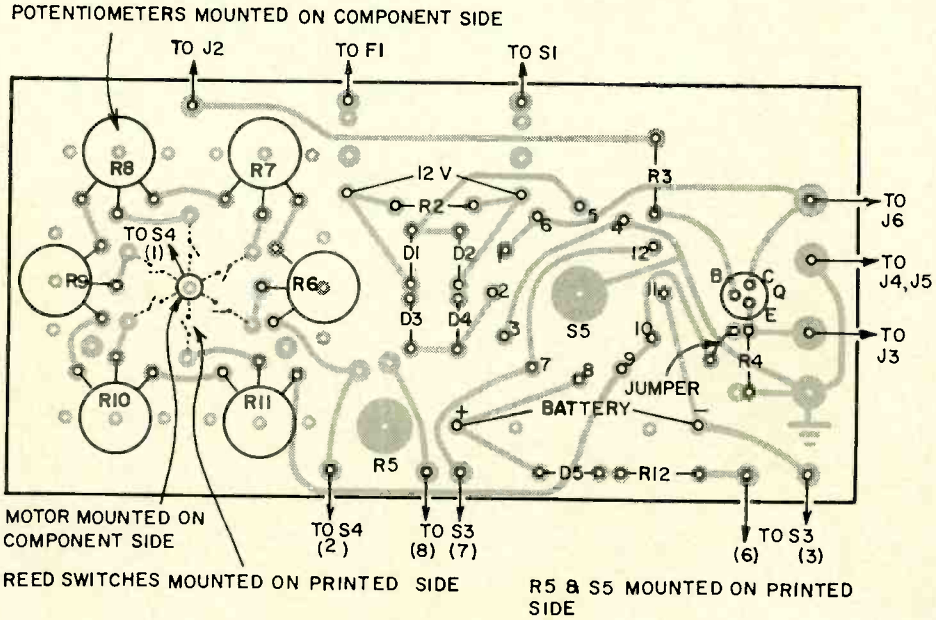


Fig. 3-a—Make a photocopy exactly twice this size and you have the pattern for laying out the PC board. b—(below)—Here's where the parts are mounted on the PC board.



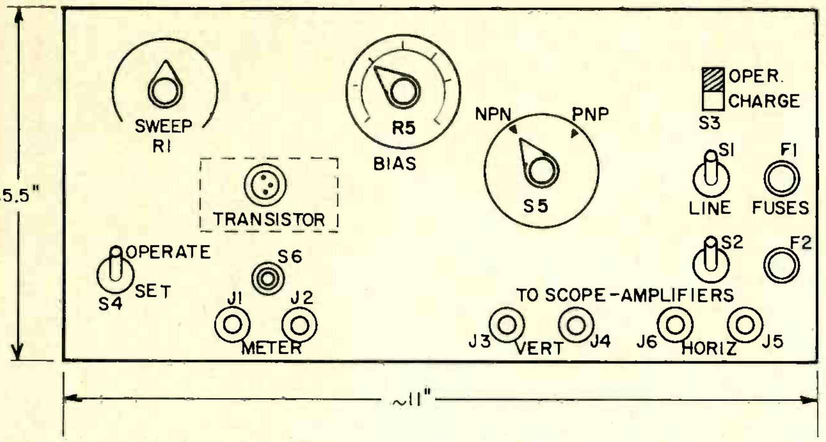


Fig. 4—Suggested front-panel layout. Note second transistor socket on panel, wired in paralled with one on board. Use plug (made from third transistor socket) and cable between sockets on panel and the printed circuit board.

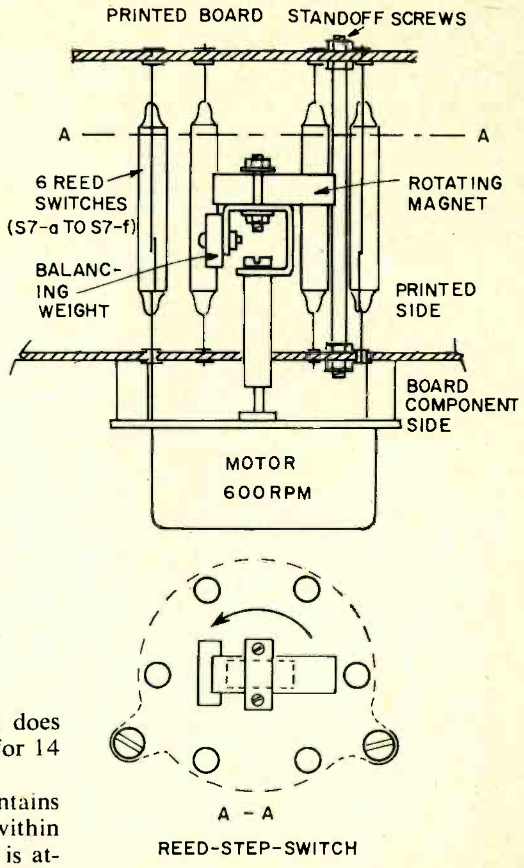


Fig. 5—(at right)–Small printed board is mounted on standoffs behind the main board. Reed switches go between boards. Motor is mounted on front of main board. T1 and T2 are on front and rear of the main board, respectively.

ured by connecting a microammeter at test points J1 and J2 and by opening S6.

Switch S4 has two positions: In OPERATE it connects to the reed switch assembly, which is one of the arms of pots R6 to R11; in SET it connects to the highest obtainable bias, which is controlled by R5.

The value of limiting resistor R12 is chosen so that charging current does not exceed 25 mA (to be applied for 14 hours for full charge).

A printed circuit (Fig. 3) contains all components shown in Fig. 2 within the dotted line. The printed board is attached to the front panel with standoffs. Rotary switch S5 and pot R5 are mounted on the printed board; their shafts are passed through the front panel, where the knobs are mounted. Front-panel layout is shown in Fig. 4, and the following parts are mounted on it: switches S1, S2, S3, S4 and S6; fuses F1 and F2; terminals J1–J6; line rheostat R1, and a transistor socket. This panel-mounted socket is connected with short leads and a plug to an identical socket on the printed board.

It's convenient to connect front-

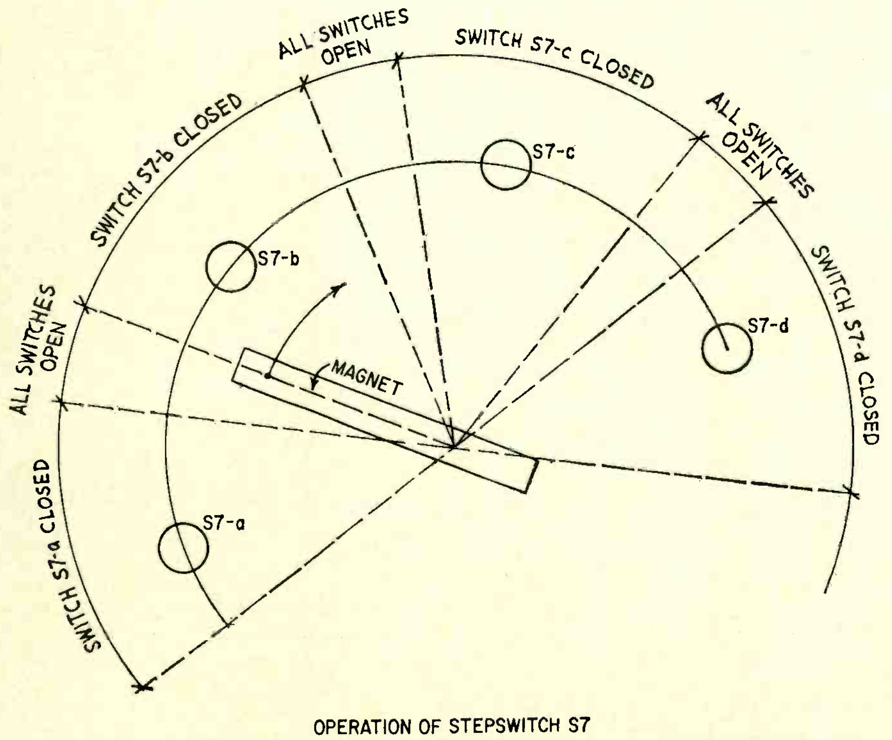


Fig. 6—As the motor turns, the magnet rotates, closing the reed switches one by one.

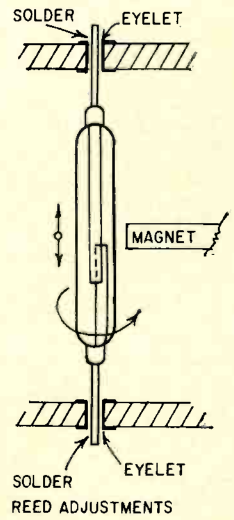


Fig. 7—Position for proper operation.

panel components with the printed-board terminals by a wiring harness.

To sweep through the reed switches in 1/10 sec, the motor speed must be 600 rpm. Synchronous clock motors of this speed are readily available. The torque necessary to rotate the magnet is not high if the rotating magnet is well balanced. Of course, the torque has to be high enough to overcome the interaction between magnet and reeds. A torque of at least 100–150 inch-ounces—referring to 1 rpm—is advisable.

The motor is mounted on ½-inch standoffs on the component side of the board. The hole in the printed board for the motor shaft should be at least ½ inch in diameter. The magnet is ¼ x ¼ x ½ inch. Fig. 5 shows how to mount the magnet on a bracket attached to the motor shaft. It's necessary to attach a piece of nonmagnetic material to the lighter end of the bracket as a counterbalance to the magnet.

One end of each of the six reed switches is soldered to an eyelet on the printed board, so the switches form a circle around the motor-shaft hole. A second, smaller printed board is used for soldering the other ends of the reed switches. This smaller board is mounted on two standoffs. A ¼-inch hole in the center of the small board allows motor-shaft adjustments. Each reed switch is about 1½ inches long and should have a sensitivity of at least 50 ampere-turns.

It is very important that the rotating permanent magnet be adjusted to activate only one switch at a time. This means that the magnet should always release one switch before closing the next. Fig. 6 illustrates reed switch layout and magnet triggering.

Switch alignment

You'll have to position each reed switch carefully before soldering, rotating the magnet while you do so. Magnetic force must attract the longer reed and close the switch. Be sure the axis of the rotating magnet is well centered within the reed-switch circle. Fig. 7 shows how to adjust each reed switch for best triggering.

Reed-switch make-and-break intervals can be controlled another way—slip an open magnetic ring over the glass tube of the switch. After adjustment, glue the ring to the tube with a drop of cement. You should adjust the reeds as follows: Use a screwdriver to turn the motor shaft and thereby rotate the magnet. Turn each reed switch until it is triggered by the magnet each time around. Make sure all switches are activated consecutively. Finally, adjust the counterbalance for minimum vibration of the magnet during rotation.

Make preliminary adjustments before you install the printed board in the cabinet. First, the batteries must be charged and the value of resistor R12 determined for the correct charging rate. Connect a decade resistor box in series with a milliammeter on the 100-mA range. This combination should be substituted for R12 in the circuit. Set S3 in CHARGE position and adjust the decade box for a 15–25-mA meter reading. Install for R12 a 1-watt resistor of the value found by the box test. A discharged battery will take about 14 hours to charge fully. At the end of this time its open-circuit terminal voltage should be 7 volts.

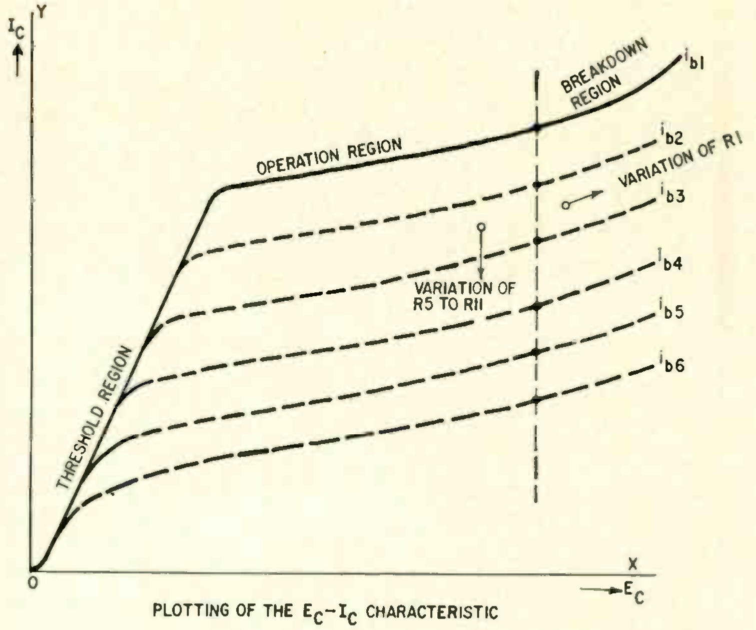


Fig. 8—Plotting of the E_c-I_c characteristic on the CRT screen.

(A) *Display of a single curve representing the highest bias setting:*

1. Disconnect T2 by throwing S2 OFF. (The motor has to be stopped to display a single curve only.)
2. Throw S3 to OPERATE. This disconnects the charging circuit from the battery and connects the battery to the pot.
3. Turn bias pots R6 to R11 and R5 to midrange.
4. Set polarity switch S5 to the PNP or NPN position corresponding to the transistor type to be tested.
5. Insert the transistor into the socket.
6. Connect the horizontal and vertical outputs of the plotter to the scope.
7. Put switch S4 in the SET position. (This produces a fixed base bias adjustable by R5.)
8. Set the scope sweep selector to EXTERNAL position and the scope vertical and horizontal sensitivities for 1 volt/inch and 0.5 volt/inch, respectively.
9. Energize transformer T1 by throwing S1 to the ON position.
10. Slowly increase the sweep voltage by decreasing resistor R1 and correct, if necessary, the horizontal and vertical sensitivities until one characteristic curve appears sharp and well centered on the screen.

A typical pnp curve is shown in Fig. 8. If the curve appears rotated by 180° the transistor is an npn. Fig. 9 shows how the curve display changes with various scope gain settings.

If the curve doesn't appear as in Figs. 8 and 9, several things may be wrong. If the curve is a straight line only, the vertical sweep voltage may be too small. Try decreasing R1 and adjusting scope vertical gain. If the flat part of the curve is too short, try increasing horizontal gain.

If you find double-tracing or loops in the curve, there's probably noise in the bias circuit. The cure is to shorten connections and keep ac line connections away from sensitive parts of the circuit. You may have to shield some portions. Check resistor R2 for a sine waveform of the sweep.

If the steep part of the curve is too short, the vertical scope amplification may be too low, or there may be insufficient bias voltage. Try increasing vertical gain or reducing resistor R5 (or both).

If the slopes of the steep and flat parts of the curve are too large, and the breakdown region is too extended, the horizontal gain is too low or the sweep voltage is too high. Try readjusting horizontal amplifier gain and rheostat R1.

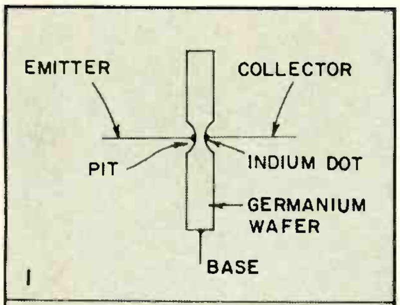
(B) *Display of a family of six*

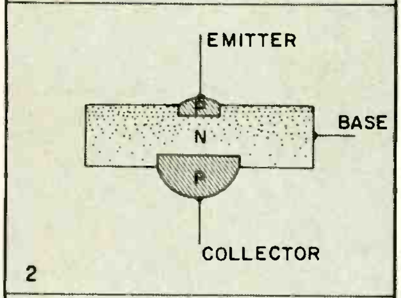
continued on page 88

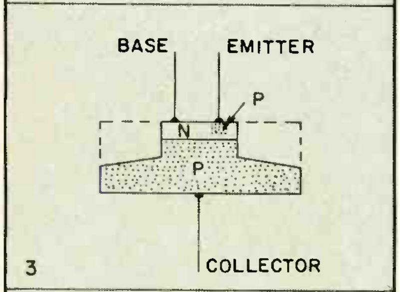
MAT·MOST·MOSFET·UFET·FET:
UNDERSTANDING SOLID-STATE TALK

Names and abbreviations for the semiconductor family

By **RUFUS P. TURNER**







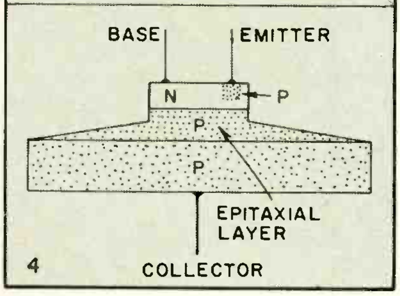


Fig. 1—First improved junction transistor was the surface-barrier type.

Fig. 2—With the drift transistor came an increase in upper-frequency limit.

Fig. 3—To overcome low voltage limit, the mesa transistor was developed.

Fig. 4—Still higher voltage-handling was built into the epitaxial mesa.

A QUICK GLANCE THROUGH TODAY'S technical literature leaves the impression that the electronics field has as many abbreviations and acronyms as Washington does. And indeed there are quite a few—some bewildering. Consider, for example, MAT, MOST, MOSFET, FET, UFET, and IGFET!

A great many of these creations are in the family of transistors and related devices. But it was not always so. In the beginning, in the midst of a vacuum-tube population explosion, there was only *a* transistor—a point-contact thing that resembled a germanium diode with two whiskers instead of one. If the transistor had remained as it was, manufacturers might have varied its characteristics all over the lot but just assigned type numbers like those of tubes—or perhaps even simpler ones.

But along came another kind of transistor, more rugged and stable and easier to make. This *junction* transistor was dubbed NPN and PNP according to the order in which the negative and positive layers were placed in the semiconductor sandwich. This not only introduced two three-letter symbols, but required that the first transistor also have its own distinguishing initials (PC for point-contact). The letters game was under way.

How early terms grew

Two limitations of early transistors were low input impedance and low operating frequency. The junction transistor didn't improve matters much when it first appeared. Overcoming these shortcomings has spawned many types of transistors, eventually requiring the descriptive acronyms which name them.

First, the *surface barrier transistor* raised the top frequency capability to 50 MHz and beyond. This new device had a thin base layer and smooth subminature electrodes, formed through a revolutionary process: Tiny pits were etched in the germanium substrate by electrolysis. Fine jets of metallic (indium) salt solution, carrying direct current, were sprayed against opposite faces of the semiconductor wafer. When the wall between the pit floors was thin enough, the dc polarity was reversed, causing a tiny dot of the metal (Fig. 1) to be plated at the bottom of each pit, forming emitter and collector. The term *surface barrier transistor* is a good mouthful; so, with typical American zest for abbreviating, we quickly cut that down to SBT. With that step, the family of acronyms grew to PC, NPN, PNP and SBT.

MAT and MADT (SBDT)

Later work showed that operation of the SBT could be improved further by alloying the tiny electrodes to some extent into the semiconductor base. That was done by heating the structure after the indium dots had been deposited deep in the SBT pits. The result was the *microalloy transistor* (MAT).

Still further work in this SBT family showed that reliability could be increased and parameters controlled more closely by diffusing a base-doping impurity into the semiconductor wafer of the MAT before depositing the electrode dots. The result: the *microalloy diffused transistor* (MADT). This type has also been called *surface barrier diffused transistor* (SBDT).

Progressively, the SBT, MAT and MADT (SBDT) offered higher top-frequency operation (important in vhf radio and high-speed computers) than that available with either the PC, NPN or PNP. However, voltage ratings were still low.

The next device to raise the high-frequency limit was the drift transistor. In this alloy-junction unit (Fig. 2), the concentration of impurity in the wafer (base) is graduated, being highest in the region of the emitter. The internal drift field created by this distribution speeds up the transistor's internal currents. Faster action inside the device increases the maximum frequency at which it will operate efficiently.

Hills and plains

To achieve higher voltage-handling ability to go with improved high-frequency operation, designers evolved a somewhat hill-shaped device which then became immensely popular. The odd appearance results from restricting the junction region to a small swelling atop a much larger semiconductor wafer. The wafer also acts as collector. The *post-alloy-diffused transistor* (PADT) is one result of this odd conformation.

The starting point of the PADT is the collector—a wafer of P-type semiconductor large enough to handle the desired voltage. First, a thin N layer is diffused into the top of the wafer and becomes the base. Next, a small P region is diffused or alloyed into the thin base and becomes the emitter, and a small pellet of N material is alloyed into the base for contact. Finally, the unneeded part of the wafer is etched away, leaving the emitter and base in the swelling, and the collector occupying most of the remaining wafer.

The SBT, MAT, MADT and PADT all used a thin base region in a comparatively thick wafer, thus avoiding the fragility of the extremely thin wafer a PNP or NPN would require for high frequencies. But still other higher-frequency units came forth. Fig. 3, for example, shows the cross-section of another transistor in which an extremely thin base layer is deposited in a thick, therefore mechanically rugged, substrate. The starting point is a wafer of P-type semiconductor of the thickness indicated by dashed lines. First, a very thin N layer is diffused into the top of the wafer to form the base. Next, a small P region is alloyed into the N-type base to make the emitter. Finally, most of the wafer structure is etched away, leaving the base and emitter in a little plateau. The Spanish word for hill or table —*mesa*—names this transistor.

The mesa transistor may be improved (Fig. 4) by forming a thin, high-resistivity layer in the original P material before the N-type base is diffused in. This resistive layer divides the collector into two parts. Because its atoms integrate neatly into the crystalline structure of the collector, the resistive layer is termed *epitaxial*. This layer permits higher-voltage operation of the *epitaxial mesa* transistor. What it does is allow heavy doping in the main part of the collector, for low saturation voltage, without reducing the voltage-handling ability of the entire collector.

We drop from the hills to the plains when we move from the mesa transistor to one which is processed completely in a flat wafer, hence called *planar*. The starting point is a wafer of N-type silicon, the bulk of which will become the collector. First, a coat of silicon oxide is formed on the top face. Next, a circular trough is etched out of the oxide; through this "hole," a large P-type base region is diffused and spreads into the wafer (Fig. 5). Then, a concentric disk-shaped area of the oxide is etched away, and an N-type emitter region diffused into the wafer through that bared space. Finally, ring- and disk-shaped contacts are deposited, as shown. The emitter–base and collector–base junctions would be exposed on the top face of the wafer and subject to contamination and short circuit if they were not protected by the oxide layer. The latter is said to *passivate* the planar transistor.

The advantages of the epitaxial layer in the mesa transistor are available also for the planar. Fig. 6 shows this layer added to the planar structure previously described. The result is the *planar epitaxial passivated* (PEP) transistor. (Incidentally, we also have PEP diodes.)

The field-effect family

The devices just described—SBT, MAT, MADT, PADT, mesa, epitaxial mesa, planar, PEP—improved high-frequency operation of the transistor, and the latter ones in the group also raised operating voltages. None, however, accomplished anything in the direction of increasing input impedance; low input impedance had been a limiting factor in many applications. The first device with high input impedance was the *field-effect transistor* (FET).

Fig. 7 shows the basic FET. An N-type silicon bar (the *channel*) has contacts (*source* and *drain*) attached to opposite ends, and P regions (*gate* electrodes) diffused a shallow depth into opposite faces. The source acts like the cathode of a tube, the drain like the plate, and the gate like the control grid.

A depletion region inside the channel surrounds the gate electrodes, as shown in Fig. 7-a. If negative bias voltage applied to the gate is increased, the depletion regions expand toward each other, narrowing the channel and reducing current flow from drain to source. At some high value of bias, the regions meet (Fig. 7-b), closing the channel completely and cutting off the current. Thus, the gate acts like the negative-biased grid of a triode tube. The gate, as a reverse-biased PN junction, is responsible for the FET high input impedance.

The channel may be N-type and the gates negative-biased P-type (as shown in Fig. 7). Conversely, the channel may be P-type material and the gates N-type, in which case positive bias is necessary. Separate acronyms are sometimes used to show which is which: NFET or PFET. The term *unipolar field-effect transistor* (UFET or UNIFET) also is sometimes used, to denote that the current carriers passing through the channel are of one type—holes or electrons, depending on the type of channel material used. (Conversely, conventional transistors are called *bipolar*, to indicate that their operation depends upon emission into the semiconductor of carriers of the opposite type. There is no such

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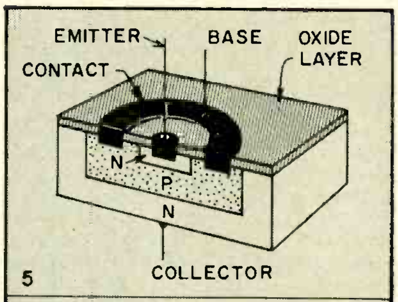
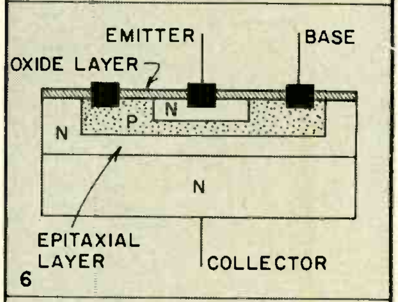




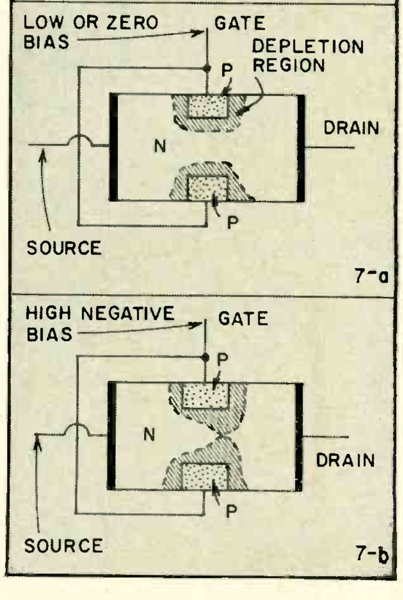


Fig. 5—Planar transistor is so-called because it's shaped like a plain.

Fig. 6—Planar epitaxial passivated transistor, a further improvement.

Fig. 7-a—Basic field-effect transistor uses gate field as control. b—With high gate field, current flow from source to drain is small.

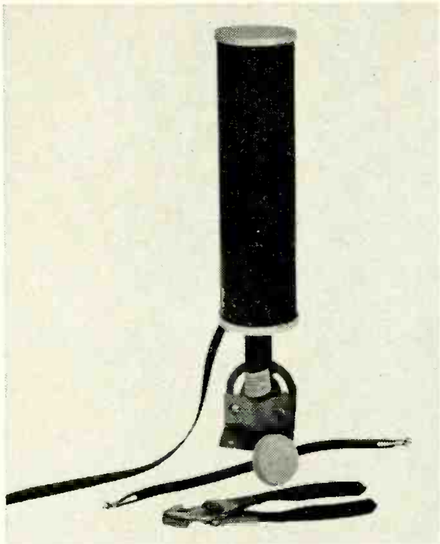
ANTENNA REPORT

LAST FALL AN unusual antenna—the *Americus SkyProbe*—was introduced in Lewisburg, Ohio, by its developers, UniScience Laboratories. As reported in R-E's July 1967 News Briefs, the SkyProbe was demonstrated by being dropped 139 feet into a metal-cased water well and connected to a TV receiver with 300-ohm lead-in. A Dayton, Ohio, newspaper reported that the antenna produced good pictures on the TV from stations 20 to 50 miles distant.

We wrote Dr. John Eagle, head of UniScience, who replied that his antenna is "not a diapole [sic] but can receive both color and uhf beneath the earth's surface." He further claimed that classic theories of TV and radar reception are "incorrect or incomplete," and that neither antenna size nor height is a "controlling factor" in reception.

On May 7, 1967, *The New York Times* carried an advertisement by a New York City department store, offering the SkyProbe antenna for $12.99. The ad stated: "SkyProbe revolutionary outdoor TV antenna gives clear, sharp reception from every direction. . . . It's a brand new concept that utilizes basic radar techniques to give you clear, sharp reception from any angle." Perhaps the most interesting line in the ad read: "This *solid-state* outdoor antenna is only 18" . . ." (emphasis supplied). We found these same claims in an ad in the *Cincinnati Post & Times Star* during October 1966, and in literature sent to us by UniScience.

A RADIO-ELECTRONICS staffer purchased a SkyProbe from the store, paying the advertised price. The name of the magazine was not mentioned. Several of us then compared the performance of the SkyProbe with existing antennas at four locations. The experiments were performed using the signals received from New York City TV stations on channels 2, 4, 5, 7, 9, 11 and 13.



The SkyProbe (top) R-E purchased had two lead-ins (one for TV, one for FM). "Impelator" (see text) is next to pliers.

An R-E staffer took the SkyProbe to his home in Plainfield, N.J.—about 25 miles from the TV transmitters atop the Empire State Building in Manhattan. At this location, an outdoor antenna is essential for good TV reception. The SkyProbe produced only marginal results when compared with the existing outdoor antenna—a stacked dipole–reflector–director combination which had been installed some years before.

Our next test was in the Rockaway Beach section of Queens, at a site with a clear shot at the TV transmitter site 14 air miles distant. Normally the portable TV with built-in antenna used at that location picks up a good picture with a few ghosts now and then on all vhf channels. When the SkyProbe was substituted for the built-in telescoping antenna, there was a barely noticeable improvement in picture quality on channel 5, and a slight impairment of quality on channels 7 and 11. Otherwise reception was the same.

Next the SkyProbe was placed on the window sill facing toward the transmitter site—a practice suggested in the ad. There was no noticeable change in signal quality except on channels 5 and 13, which got worse.

Similar experiments were carried out on the 16th floor of an apartment building in Lower Manhattan. Although this site is only 1.6 miles (line-of-sight) from the TV transmitters, nearby buildings cause severe ghosting when indoor antennas are used. The SkyProbe was compared with rabbit ears. There was no noticeable difference in performance between the two, whether the SkyProbe was placed atop the TV set or on the window sill—which faced away from the TV transmitter site.

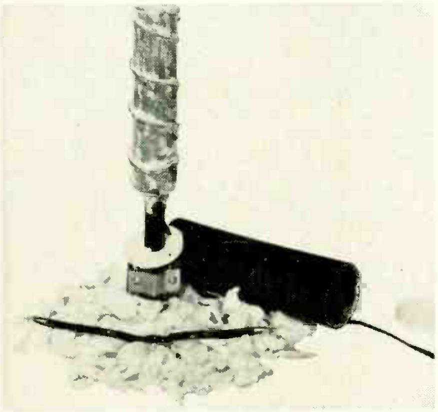
Finally, we brought a portable TV to the R-E editorial offices on 14th Street, just one air mile from the Empire State Building. Again, we tried the SkyProbe and compared it with rabbit ears. Ghosts from the nearby buildings caused poor pictures on nearly all channels, and this condition was not noticeably improved by the SkyProbe—whether located inside the office or on the window sill facing toward the transmitter location.

Antenna prices

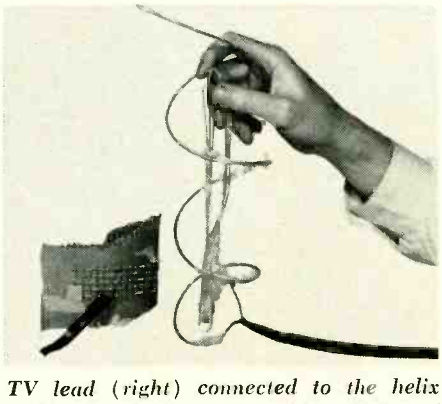
We found rabbit-ear TV antennas at discount houses, parts distributors and department stores, at prices ranging from $1.50 to $4.50. These were simple rabbit ears—with nothing to switch or change in the circuit. We used the same type of antenna in our experiments.

Finally, we took the SkyProbe apart to find out what was inside it. The photos show what we found. Once we had removed the plastic outer sheath, we found a spiral of aluminum wire—about No. 8—wound on a cardboard tube. Foam-type plastic filled all empty space within the sheath. Inside the cardboard tube we found another black plastic tube, and inside this we found No. 12 aluminum wire, bunched together. The spiral was connected to one side of the 300-ohm lead, while the bunched wire was connected to the other. A second piece of 300-ohm lead, marked "radio" (for FM) was found to terminate (one side of the line only) in a piece of wire mesh measuring 1 by 3 inches. This mesh seemed capacitively coupled to the spiral.

Along with the SkyProbe, our purchase included what was called an "im-



Under the plastic sheath, a wire helix.



TV lead (right) connected to the helix and to bunched-up wire within. FM lead and mesh capacitive coupler are at left.

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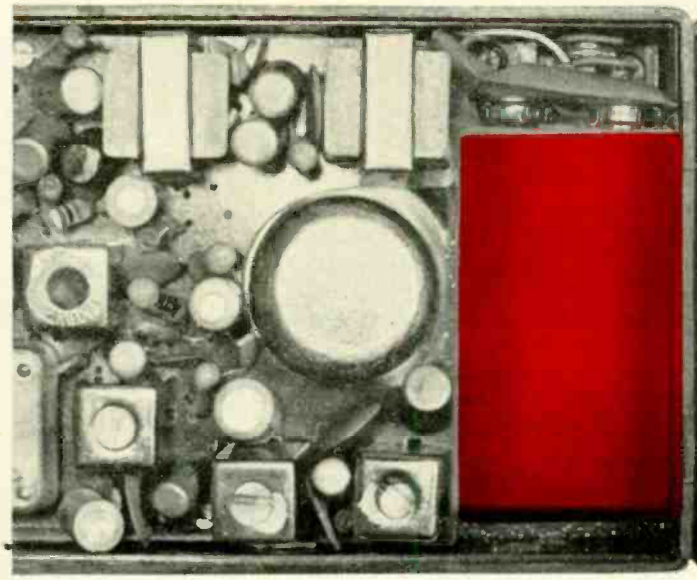


Be Brave! Take On Transistor Radios!

If you're turning away people with little squawkboxes, you're losing your share of a booming business By HOMER L. DAVIDSON

DON'T LOOK AT THAT SMALL POCKET transistor set and say, "We don't fix them." Why let *Joe's Radio Repair* down the street have the job?

Time is the important factor in repairing transistor radios. If the repair runs over half the cost of the radio, most customers will not have them fixed. I don't blame them. Do you?

Most of the trouble with that small transistor radio is the owner himself. He has left the batteries in too long, dropped the radio, or tried to fix it himself. Yes, wear and tear does enter into the picture, but only about 20% of the time.

Break transistor radio repair jobs down into sections and components and, with a little experience, you're in business and making money.

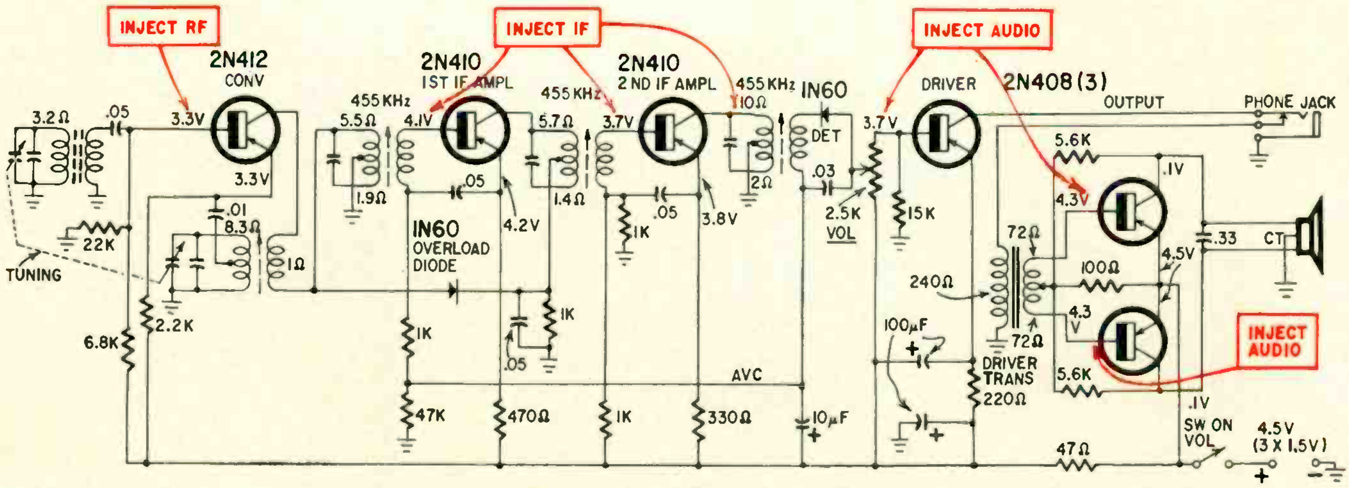
Test equipment? It isn't elaborate or costly: a harmonic generator for audio, i.f. and rf signal injection; a volt-ohmmeter to check voltage and resistance; and a low-voltage supply with a milliammeter, to supply voltage to the radio and measure current drain. Basic equipment *with* knowledge beats elaborate equipment and no knowledge.

Before we begin, let's look at the trouble listed on the repair ticket. When you take the set, write down *everything* the customer says is wrong with the radio. Be complete. Some customers resent too many questions, but you are trying to save time to make money.

On the repair ticket it states that the radio is dead, intermittent, was dropped by the owner, had a new battery only last week, or will just pick up the local stations. You will rarely read that the owner tried to repair it himself. Yet, it happens. Remember, most of the trouble is what the owner has done.

He has let the batteries run down, or put them in backwards. Or, since the earphone was plugged in, the speaker doesn't work. He, or his son or daughter, dropped the radio—which was supposed to have an unbreakable case. The owner tried to fix the radio himself after it was dropped and the printed circuit board was partly broken. He decided on soldering the joints (with acid-core solder) and what a mess! He thought he could improve the reception by turning those small screws, which happen to be i.f. adjustments. Of course, he didn't have a small screwdriver, so the i.f. can is torn and has to be replaced.

Enough about the customer. Let's start finding the trouble in a dead transistor radio. The radio has a new battery in it—that was the first thing the customer thought of. A weak battery will cause low volume, no sound, squealing, or motorboating. Check for correct battery polarity. You can check batteries with a battery checker or with a volt-ohmmeter. The radio's switch should be



Circuit of a fairly typical six-transistor radio. Note center-tapped speaker and lack of output transformer. Diagram also shows where to inject what kind of signal as an aid to troubleshooting. All the necessary signals can come from a single generator.

Be Brave! Take On Transistor Radios!

Service pocket sets

on. If a 1½-volt battery drops to 1 volt, discard it.

Generally, you'll hear hiss in the speaker if the audio and some of the i.f. section is working. Run the volume control up and down. A scratchy or rushing sound indicates that at least part of the amplifying section is working. But *this* radio is dead. Clip the dc power supply in place of the batteries. Set the correct battery voltage and then switch the meter to current. If the current reads above, let's say 30 mA, you have a shorted transistor, or leaky filter capacitor. The average current drain of different sizes of radios is shown below:

5-transistor	radio		5 to 11 mA
6	"	"	5 to 20 mA
7	"	"	10 to 25 mA
8	"	"	10 to 25 mA

Testing by signal injection

If you still have no sound and the current drain is fairly normal, inject an audio signal from the harmonic generator to the center terminal of the volume control. You can also place a screwdriver there or touch it with your finger and listen for a click or hum in the speaker. Another simple method is to hold a soldering gun near the first audio transistor. The 60-Hz field from the soldering gun will make a hum in the speaker. *By starting at the volume control, you have divided the transistor circuit in two and can go either way to find the trouble.*

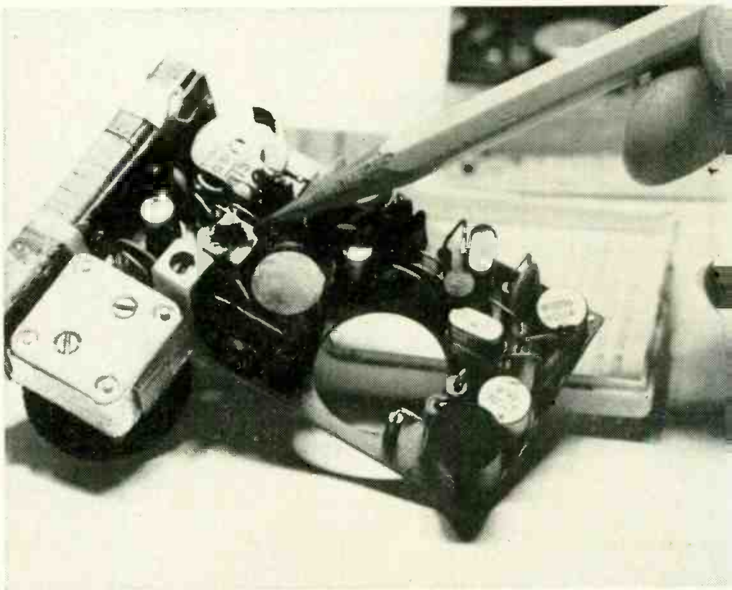
Proceed to the base of each audio transistor with the audio signal and through to the speaker until you can hear the tone. Many times the earphone jack gets jammed and opens the connection to the speaker. An open speaker is unlikely, but it does happen occasionally when the voice coil is center-tapped. In this case there is low volume and distorted sound. A bad transistor or defective bias will also cause distortion, so check voltages. Speaker trouble is generally caused by rattling and dented cones.

Let's assume you have audio at the speaker when the signal is injected at the volume control. Proceed by inserting an i.f. signal at the base of each i.f. transistor, working back toward the mixer, until you hear the tone. A defective i.f. transformer will generally show up as a loss of gain, or no signal at all, or very broad tuning during alignment.

If the i.f.'s seem okay, inject an rf signal at the base of the converter transistor, then at the antenna. The small antennas give a lot of trouble. They are usually mounted on a separate fiber board and then soldered to the circuit board. The connections often break, making reception erratic.

The alignment of most transistor radios can be touched up with the harmonic generator. Inject an i.f. signal into the base of the converter stage and adjust each i.f. transformer for loudest tone. Set the harmonic generator for as low a reading as possible, with the tuning capacitor plates full open. Tune in a station around 1,000 kHz and adjust the oscillator section trimmer while you rock the variable capacitor shaft backward and forward through the 1,000 kHz station. Inject an rf harmonic signal into the antenna, set the tuning capacitor to 1,600 kHz on the dial and peak the rf trimmer. Check stations around the high and low ends of the band. Readjust the oscillator and rf trimmers as needed to get correct dial readings and good sensitivity. (I know of a technician who uses his fluorescent bench light to align radios. He simply

Instruments for transistor-radio fixing: A broadband signal generator, a volt-ohm-milliammeter and a battery eliminator.



The customer admitted trying to improve reception by tightening those little screws. But he didn't use the right tool!

at a profit with a few well-known troubleshooting techniques.

holds the radio close to the light and uses it as a noise generator.)

Intermittents

When the repair ticket says the radio is intermittent, you can safely bet that the board is broken or parts have come loose. One customer said, "I just press on the case and my radio quits." Dropping the radio is one of the greatest hazards and, generally, something gives. A broken board is quite easy to see. The best thing to do is to order a new board and replace all the components, but what customer is going to wait a month for the board when he wants the radio fixed today? Excuse me —I should have said *right now!*

A PC board isn't too hard to fix. On direct lines, run a heavy piece of bare copper wire across the break and solder it in place. Do this in a couple of places to make the board rigid. I still use hookup wire to solder around the other breaks. The solder supports often break off where they fasten to the plastic case. Solder eyelets or larger washers in place to make a solid mount.

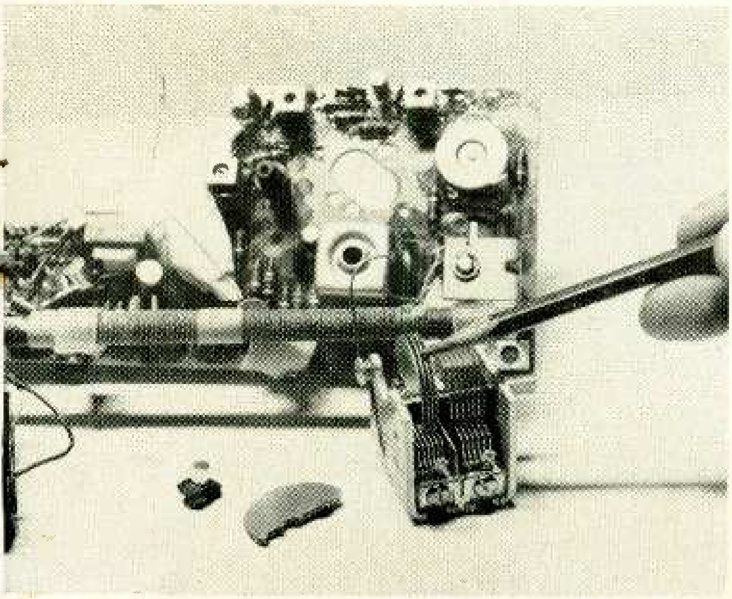
Larger components, such as output and interstage transformers, the tuning capacitor and the volume control, can become loosened when the set is dropped. Pressing on the board shows the set is intermittent. This is especially true of the variable capacitor, where connections stick through the board and are soldered to the printed circuit. Hit these joints with a good hot iron, because the contact may be had above the soldered connection, where you cannot see it.

A customer brought in a small radio that used up a battery in 4 to 5 days. For 2 weeks it would play perfectly. Then the same thing would happen. Upon checking the radio, I found that when the radio was turned off, I could still hear a small sound from the speaker on local stations. A small wire from the switch was being pressed against a sharp junction on the board, shorting across the on-off switch. When the contact was made, the radio was on all the time, but the volume was down.

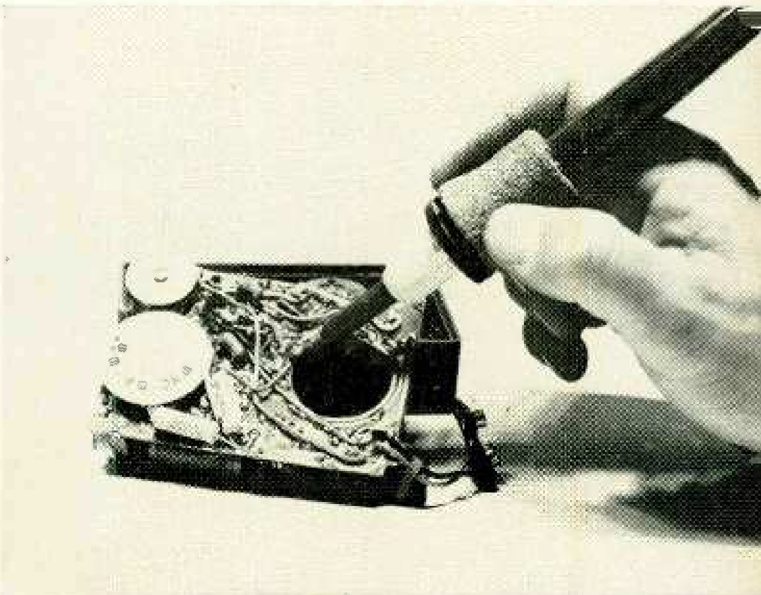
When you replace a transistor or i.f. transformer, heat the connection and pull the solder downward. This will leave only a small portion soldered, or none. Keep working the component back and forth when doing this. You can clean the holes with a toothpick or sharp pencil. (Pick up a couple extra toothpicks during your coffee break.) I always like to let the radio play when I solder any connections. That way I know that I've made a good joint. Also, if I get careless and solder runs onto the next lug, I know it at once. Have the milliammeter in series with the battery when you do any soldering with the radio on. A short will show as heavy current drain.

Many technicians stay away from printed circuits of any kind. Become one who doesn't, for they are here to stay. Learn all you can about printed circuits and get experience in repairing them. You can make money at it. Trouble is my bread and butter. In the radio and TV business, every minute of the day you are taking care of your customer's electronic troubles.

Why learn transistor radio servicing? One of our customers—Mr. Jones —has eight of them in his household. We repair them and make money doing it. Oh, yes . . . I almost forgot: Mr. Jones also has two automobiles with a radio in each, two TV sets, one small table radio, and I just sold him a big stereo set last Christmas. END

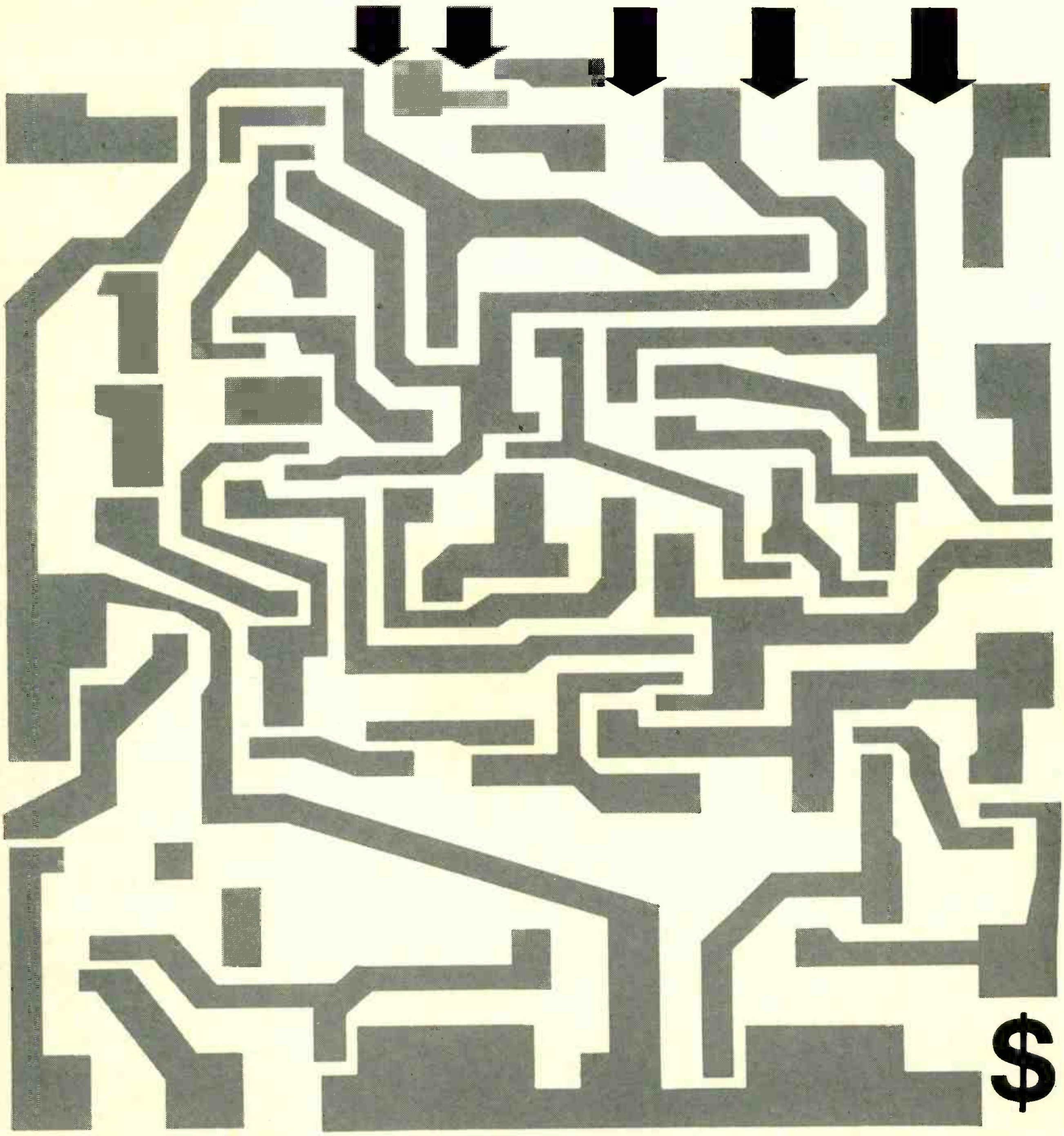


This receiver was dropped, and batteries fell against the tuning capacitor, amputating three plates. Cure—a new capacitor.



Another case of a drop breaking the circuit board; opens were bridged with insulated wire to correct the trouble.

There's more than one road to success.



An integrated circuit enlarged several thousand times

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IT CAN'T BE ALL BAD

By PHIL PRINDLE

AS SOON AS I UNLOCKED THE DOOR OF MY SHOP I knew it was going to be one of those days. The phone was ringing already!

"Good morning, Ernie's TV Repair," I greeted the caller as cheerfully as possible. Early morning isn't my best time of day and I hadn't had my second cup of coffee. It was Mrs. Stumpp. She lives about five miles out of town, has six kids that are really terrors and never pays her previous bill until her set breaks down again.

Glumly I assured her that I'd be out as soon as Charlie showed up to watch the shop. Charlie's my part-time helper, a crackerjack technician but decidedly not the punctual type.

While waiting for Charlie to make his appearance I checked my answering service to see what other house calls were in store.

Mrs. Whitaker was one. I'd told her six months ago the picture tube was going. No doubt by this time it was gone for good. Better take one along just in case.

One call was from the school. They wanted me there before noon because six teachers were planning to have their classes watch Mr. Dan the Mathemagics Man at 1:30. I hoped I'd be magician enough to have the set fixed by then!

And finally a call from a Miss Marner. Hmmmmm, might be interesting. Bachelor that I am, I'm always willing to check out new material providing it's over twenty-one and under forty! I decided to leave that call for last—just in case it was a complicated job.

Drat that Charlie—where the heck was he this morning?

I had just decided to get some bench work done while I waited for Charlie to come in, when a customer walked in with a portable phonograph. "Can you fix this?" she asked. "The turntable goes around but there's no sound!"

"We'll try," I smiled, "We'll try." Then my smile faded. "Where did you get this?"

"Oh, I bought it down at the discount store a couple of years ago. They had a big sale."

"Ummmm," I said as I searched for a brand name. Just as I thought. One of those import jobs where it's impossible to find a circuit diagram and if you're lucky enough to find the trouble it's almost certain you can't get a replacement part.

"We'll look it over," I told the customer after explaining the possible difficulties. "We'll call you and let you know what we find."

I'll leave that one for Charlie, I decided, if he ever gets here.

I turned back to the workbench to recheck a color set that had been giving us trouble for a couple of days. It had trouble in the color-sync stage. We'd checked the sync-phase detector and the reference oscillator, and had tried to find the trouble with a scope, but so far no luck. Just as I was really getting somewhere a client came in with a bunch of tubes to check—one of these do-it-yourselfers who would no doubt end up by bringing the set in anyway. Especially since all the tubes checked out okay.

Fortunately, Charlie finally showed up. He'd had a flat on the way. I told him to keep working on the color set and to check out the phonograph.

Storm clouds were gathering as I hopped into my truck. Looks like rain, I thought, reminding myself I had better get a new windshield wiper blade—no sense driving the truck into a ditch to go with the other troubles I'd had today.

I bee-lined for the school, which seemed to be the most urgent call. Mrs. Stumpp and her six kids would just have to go without TV for another hour.

At the school, a secretary led me to the set where I spent forty-five minutes checking it and finding nothing wrong. Then the principal appeared.

"We had some vandalism here over the weekend," he said. "Now that I think of it, the antenna looks bent."

Fifteen minutes later we had located the custodian, who provided a ladder. Sure enough, some mischievous student with a grudge against the school had not only bent the antenna but had disconnected the lead-in. I had service restored in five minutes—in time, I hoped, for the kids to see Mr. Mathemagician.

Grabbing a quick sandwich at the lunch counter on the edge of town, I drove out to Mrs. Stumpp's house. Sure enough there sat four of her six children staring at the dark screen. Unfortunately, one of her school-age boys was home with a cold. He opened the door and greeted me with, "What took ya so long? I missed all the cartoons!"

I ignored his comment and attacked the dilapidated set. The back hung loosely by one screw. It was necessary to remove a toy airplane, a handful of marbles and several wads of stale bubblegum before I coud get at the tubes. All the while, the younger children were pummeling each other and shrieking loudly. School-age boy was fingering something that looked suspiciously like a bean shooter. As I leaned over the set, "Ping!" He had zeroed in right on the back of my neck. I was muttering under my breath as I completed my investigation. The two speaker wires dangled loosely. No doubt one of the kids had pulled them loose while reaching in for the toys he had hidden there.

"That will do it, Mrs. Stumpp," I said when the wires had been secured. "Umm, about that last bill I sent. . . ."

"Guess I do owe you sumthin'," she muttered, producing two grimy one-dollar bills from her apron pocket. "Just send me another bill for today's job will ya?"

It suddenly struck me that at this rate I wasn't going to make any money today.

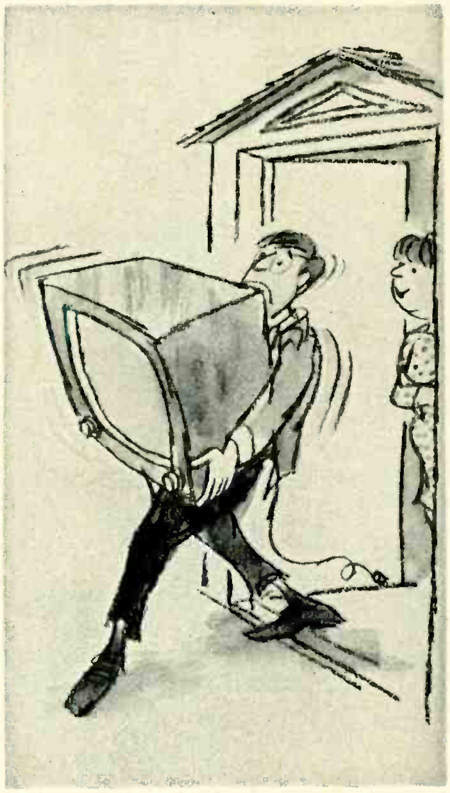
"But Mrs. Stumpp," I protested, "the last bill was for ten dollars and this house call will be seven-fifty."

"Two's all I got. And look how long it took ya to get here. I oughta get a reduced price!"

"Yeah, I missed all my cartoons!" interrupted Junior.

I had to bite my tongue to keep from telling her it was worth double time to drive out to her place and put up with her offspring. I forced a smile. "Well, thank you, Mrs. Stumpp. Just have your children keep their toys somewhere else and maybe the set will keep working for a while."

Breathing a sigh of relief to be finished with that call, I dashed back to town to check on Mrs. Whitaker's set. The picture tube, as I had suspected, was quite, quite dead.



I had to haul off her old TV for nothing.

"I can have this fixed up good as new in no time," I told her happily. No problems here, I thought.

"How much is it going to cost?" she demanded. I quoted the price of the tube and installation charge.

"Will that be one of those modern up-to-date picture tubes?"

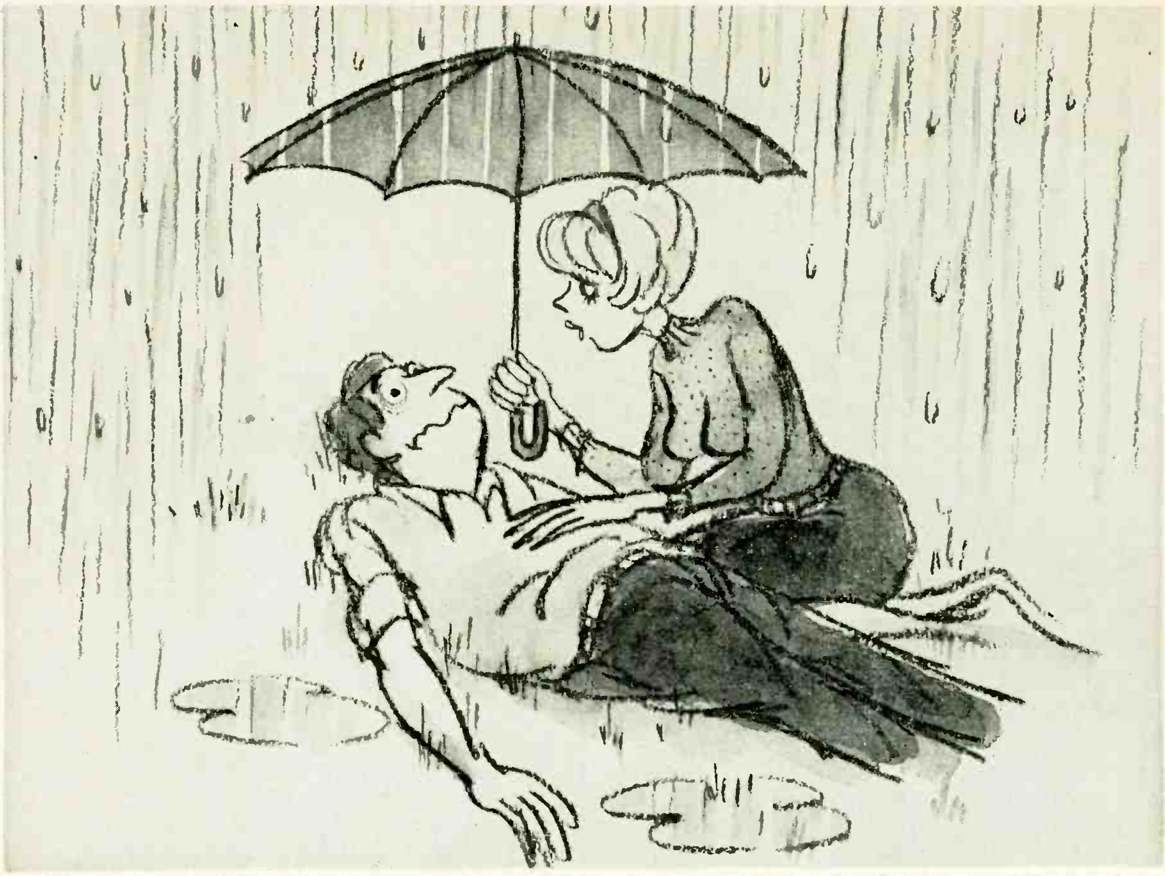
"Yes." I was a little puzzled.

"Then that'll fix it so I can get color on it!"

I explained as patiently as possible that changing the picture tube would not make a black-and-white set receive color. Mrs. Whitaker seemed to be giving the matter great thought.

"Well, in that case," she said finally, "if you'll haul off this old set for me, I'll just go downtown and get me a new color TV!"

Oh, no, I grumbled inwardly, now she wants



When I came to, I saw a lovely face near mine. "Oh you poor man," she squealed. "You're bleeding!"

me to play junk man. "Why don't you call the Goodwill or something?" I protested feebly.

"Why bother? You're right here. And I'll be sure to call you when I need someone to fix the color set."

What doesn't a guy have to do these days to keep a satisfied customer?!

Reluctantly I lugged the set out to the truck. By this time, the sky was really dark and a few large drops of rain were splattering my windshield, so I stopped at a service station for a new wiper blade. I spotted a phone and called Charlie to see if any more calls had come in. There weren't any, but he reported no progress on the color set. Instead, he'd discovered trouble in the scope and was busy trying to fix that! I told him to close up at six if I wasn't back, and headed for my last call. What a day this had been so far!

I had some difficulty finding the address Miss Marner had given. I finally located it—a cute rose-covered cottage in back of a larger house. Noting there was no antenna on the smaller house I knocked on the door.

"M-Miss Marner," I stammered as a vision of loveliness opened the door.

"Yes, come in," she invited in a soft, husky voice.

"I–I'm the TV man," I quavered, for Miss Marner was truly a dream after the nightmarish day I'd had. 36–24–36 if my eyes didn't deceive me.

"Yes, I know," she smiled. "It says 'Ernie's TV' on your shirt. Now," she said, pointing to a large box on the floor, "I'd like you to put up my antenna. I just moved here from an apartment and I can't get any reception with rabbit ears."

Suppressing a shudder at the thought of the nasty weather building up outside, I replied, "Yes, Miss" and proceeded to unwrap the antenna.

"I'll make some coffee," she suggested. "You'll be cold when you come down."

A real doll, I thought. No one else had offered me anything all day.

Since there was no ladder in sight I climbed cautiously up the rose trellis. The rain was still just a sprinkle, but the rolling of thunder made me work as quickly as possible. I was just tightening the last guy wire when *Crrrack!* a flash of lightning hit the antenna.

I regained consciousness with Miss Marner's lovely face just inches above mine. I was lying on the wet grass but she was thoughtfully holding an umbrella over us.

"You poor, poor man," she cooed as she prodded me gently to see if I had any broken bones. I let her poke while I gingerly wriggled my arms and legs and decided I was okay.

"Ooh, you're bleeding!" she squealed. I reached up to my forehead and felt a small gash.

"It's nothing," I said bravely. "But it is cold out here." Miss Marner was shivering and so was I.

"You just come right in and I'll get you some nice, hot coffee and a Band-Aid for your head."

For service like this I was happy to install antennas in the rain and even to shed a few drops of blood! It's been a heck of a day, I thought as Miss Marner assisted me into her cozy cottage. It's a good thing I called Charlie. I had a feeling I wouldn't get back to the shop by six! END

Updating the Self-Holding Relay

Semiconductors are used in the modern version of an old, old circuit

By **RONALD L. IVES**

A few years before World War I, a number of experimenters, mostly in the telephone industry, discovered how to make a relay hold itself on. Connected as in Fig. 1, if it were turned on by a short pulse, it would remain on indefinitely. Closing the pushbutton momentarily energizes the relay coil. The armature then pulls down, connecting the main supply to the coil; ergo, the relay remains closed indefinitely. You can open the contacts only by opening the supply, by a switch, relay or any other means.

The turn-on pulse can be obtained from a capacitor discharge or even from the flyback of an inductance. In a few sophisticated devices, shutoff is obtained by means of a second winding on the core. This winding is so polarized that, when energized, the magnetic field of the first coil is cancelled.

The classic circuit of Fig. 1 works on either ac or dc; more sophisticated circuits work on dc only.

Transistorized shutoff

Shortly after World War II, transistors became available, and the shutoff function of the self-holding relay could be greatly simplified. The basic circuit for transistorized shutoff is shown in Fig. 2, with constants for a specific example. Turn-off function here is performed by the transistor. Under normal conditions, its base is tied to system negative, and it is conducting. When an adequate positive bias is applied to the base, the transistor cuts off, opening the circuit through the relay coil. Note that, so long as there is a common negative, the turn-on, supply and turn-off voltages (all positive) need not come from the same source.

Turn-on and turn-off voltages can be pulses supplied through capacitors. This is usually inconvenient, however, as the pulses must have an amplitude about equal to the relay voltage. Furthermore, pulse duration must be at least as long as the response time of the relay (about 1/25 second in most instances).

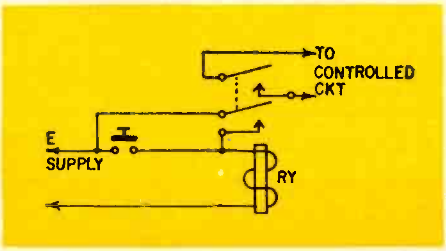


Fig. 1—The classical self-holding relay.

Operating limits are quite flexible with the circuit of Fig. 2. Relay voltage can be anything from 5 to 25, and relay current anything up to 1.5 amps. Ranges can be extended by the use of higher-voltage or higher-current transistors.

Although the 2N307 audio transistor is quite rugged, resisting thermal and other abuse, you won't get dependable operation for long unless the transistor is equipped with an adequate heat sink. With negative-ground systems, this requirement can be met by bolting the transistor to a metal chassis. When the transistor is not at chassis potential, a heat sink consisting of a sheet of copper, 3 x 3 x 7/16 inch, is usually adequate. Allow plenty of room around it for convectional cooling.

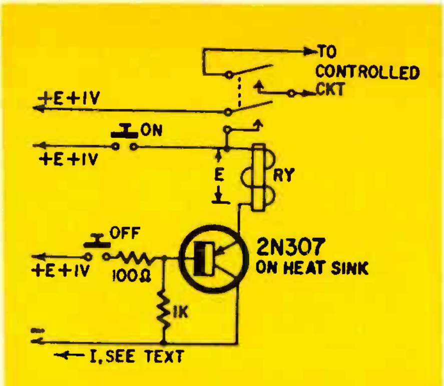


Fig. 2—Transistor substitutes for a normally closed switch. A positive pulse applied to the base opens it.

SCR turn-on

Within the last year or so, the silicon controlled rectifier, which is practically a solid-state thyratron, has become available at reasonable prices. The SCR is a rectifier that doesn't conduct until triggered; once triggered, it conducts until it's shut off. The circuit of a relay arranged for SCR turn-on and transistor shutoff is shown in Fig. 3. It operates as follows: When the power supply is turned on, the SCR, which has not been triggered, does not conduct, and the relay is not actuated. The transistor, whose base is tied to system minus, is capable of conducting whenever energized.

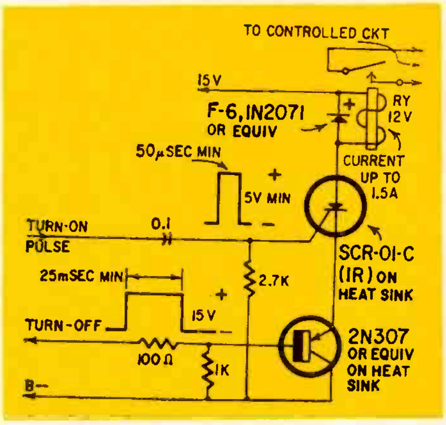


Fig. 3—Newest version uses SCR turn-on.

When the SCR is triggered, by a pulse of approximately +5 volts lasting about 50 μsec. the entire circuit conducts and the relay operates. As the SCR, once triggered, remains conducting until it is turned off by a supply interruption, the relay is held on.

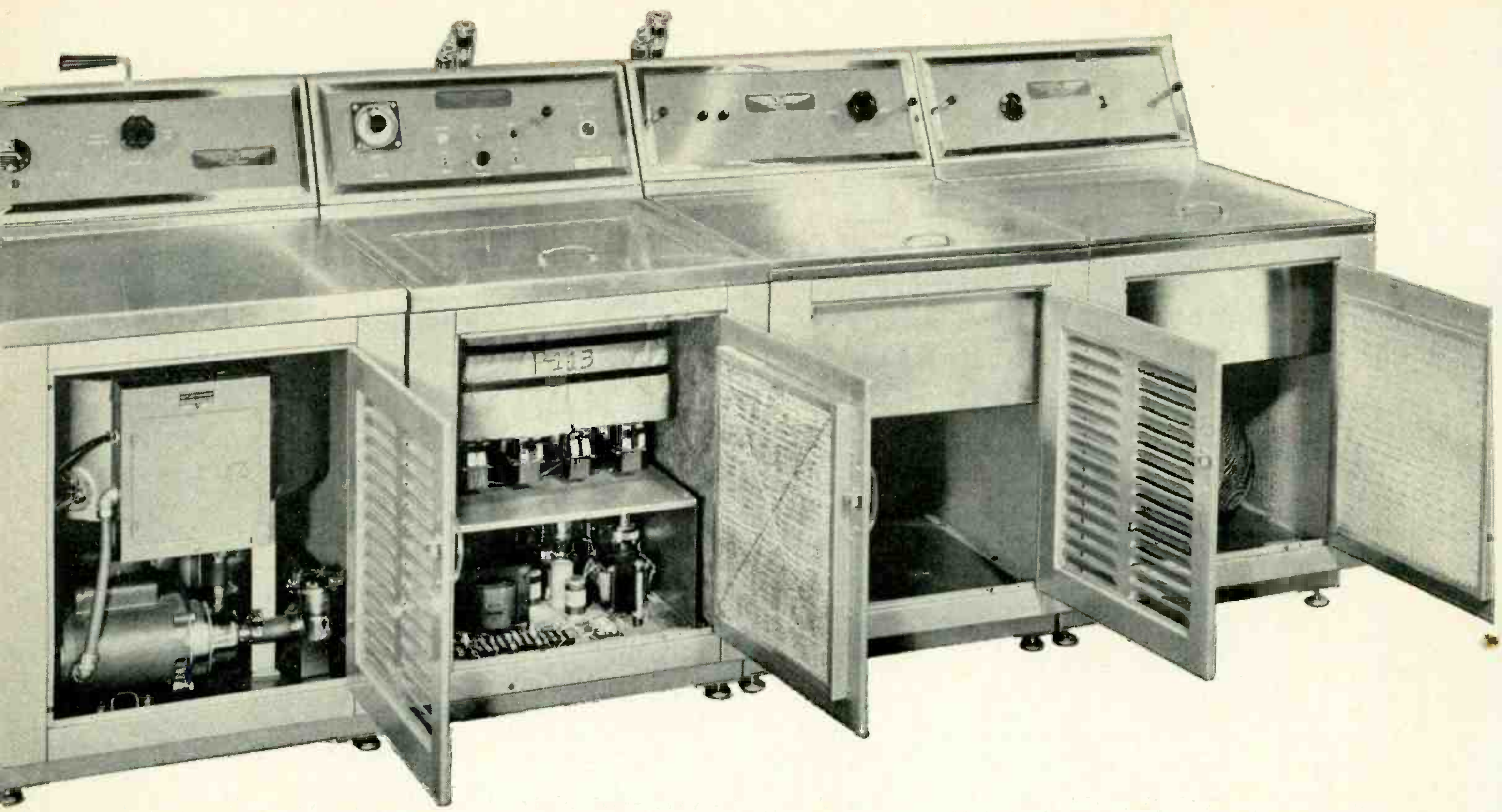
The controlled circuit is turned off by putting a positive bias on the base of the transistor. This cuts off the transistor, interrupting the supply, so that the SCR stops conducting and the relay releases. The shutoff pulse must have sufficient amplitude to cut off the transistor completely. In the circuit of Fig. 3, 15 volts is required. If a lesser value is used, the relay will release momentarily (the SCR is still conducting), and then be actuated again at the end of the pulse.

Turn-on and turn-off potential can be obtained from the main supply, or from any other convenient source, so long as all sources have a common negative.

Performance and service life

The circuits outlined here are excellent performers, needing a minimum of maintenance. As far as can be determined, the service life of the circuit depends chiefly on the life of the relay, provided the solid-state devices are not overvolted and have adequate heat sinks.

The oldest direct-relay device I know of (Fig. 1) recently quit after 23 years of service. (The relay wore out.) One of the first relay-transistor circuits I built (Fig. 2) is still working perfectly after 5½ years of commercial service. It's reasonable to assume that a silicon controlled rectifier, if operated within its ratings and not mistreated, should last indefinitely. END



Servicing Ultrasonic Cleaners

A useful sideline for electronics technicians By R. C. ROETGER

THE ELECTRONIC SERVICE TECHNICIAN who wishes to expand his activities will find servicing ultrasonic cleaners a profitable field which does not require vast learning of new techniques. Because many plants do not have sufficient electronic equipment to warrant a full-time electronics expert, they are frequently faced with the necessity of calling on a "factory man." This involves, not only the high charge for such service, but also often costly production delays. These factors make a strong case for having a technician available locally.

If a service technician understands audio-oscillator principles and is well versed in audio-amplifier maintenance, he has 90% of the required know-how already. True, the frequencies involved in ultrasonics are above the audible range but basic audio principles still apply. It only remains for the technician to become acquainted with the general configuration of commercial cleaners so that he will have some idea of where to look for what. Such information is important mostly when no service manual is available. The troubleshooting hints at the end of this article are based on practical experience and should help you if you are a newcomer, until you develop your own methods.

The first time a technician opens a cleaner he may be somewhat disconcerted by the conglomeration of pipes, valves, heaters and so forth. There is no need to worry, however, for these are plumbing components, and have nothing to do with generating ultrasonic power.

All ultrasonic cleaners include a minimum of three sections:

1. The generator produces the ultrasonic energy—at a frequency of 20 to 50 kHz.

2. The transducer converts the electrical energy to mechanical movement and agitates the cleaning liquid. The transducer is mounted on or made integral with the bottom of the ultrasonic cleaning tank.

3. The control equipment starts and stops the cleaner. In more elaborate equipment, it also controls liquid temperature, cleaning time and filtering.

Other items may include electric heaters and thermostats to maintain the cleaning liquid at a desired temperature, timers which automatically determine the length of the cleaning period, spray rinses that wash off dirt loosened by ultrasonic action, and a system for filtering the cleaning liquid.

Most of the work to be done by the electronic technician will be on the generator and transducer. On the other hand, there are some accessory items which he may handle profitably, depending upon his ability and facilities.

Ultrasonic generators

Ultrasonic generators are either high-power oscillators with the output taken off directly or low-power ones coupled to an amplifier which drives the transducer.

With a knowledge of tube types, the technician looking into his first cleaner can spot the oscillator and amplifier. But he may have trouble finding a dc plate supply. Why? There is none. This type of generator can use ac on the tube plates. Ultrasonic power is generated only during the half-cycle when the plates are positive. The stage may be either single-ended or push-pull, equivalent in efficiency to a half- or full-wave rectifier.

The major differences among manufacturers are the methods of producing ultrasonic oscillations. The most common systems use either a tapped oscillator coil or a feedback transformer. Sometimes there is a power amplifier driven by a tertiary winding on the oscillator transformer. Fig. 1 shows some typical commercial units with tubes. At least one manufacturer produces a solid-state generator, with 32 transistors in push-pull parallel and a full-wave silicon rectifier.

Transducers

Transducers used in commercial cleaners are of the magnetostrictive or piezoelectric type. If the cleaning tank is small, say a quart or so, the transducer will be of the single-element type. Larger tanks holding many gallons are driven by a number of transducer elements in parallel or series-parallel. The specific makeup of elements vary with the particular manufacturer. In magnetostrictive types, an element usually consists of a core and a winding. Crystal transducer elements are generally blocks about 3 x 3 x 5 inches or slightly larger. Magnetostriction transducers are polarized by either permanent magnets or dc from a small solid-state rectifier.

Controls

A pair of toggle switches is usually all that is required to control small, simple cleaners. One of them controls filament power; the other, through a relay, controls plate power. Large elaborate units will require controls for various accessories. Fig. 2 illustrates a typical control circuit for a high-power cleaner. It is shown not so much to indicate a particular setup as to acquaint the technician with a typical sequence diagram. Points to remember about these diagrams are:

- Relay contacts are seldom shown near the actuating coil.
- Transformer secondaries are not always shown near the primary.
- Electronic components are not identified on the equipment but can be located by the wire or terminal-strip number.
- Control equipment is usually operated on 117 volts ac, even though the main equipment uses a higher voltage.

Troubleshooting

Once trouble is encountered and the technician has made the usual voltage and resistance checks, replaced tubes with available spares, or improvised bench-test setups to check high-power output tubes, it then becomes necessary to have some specific troubleshooting hints to ease the job.

Other than complete failure, or failure of auxiliary equipment, the most common complaint is the loss of cleaning efficiency. Although this can be caused by cleaning-liquid faults (dirty, too cold, etc.), a plant or operator problem, other causes may be defective transducers or low generator output.

When it is suspected that the transducer or generator is the source of trouble, here's what to do:

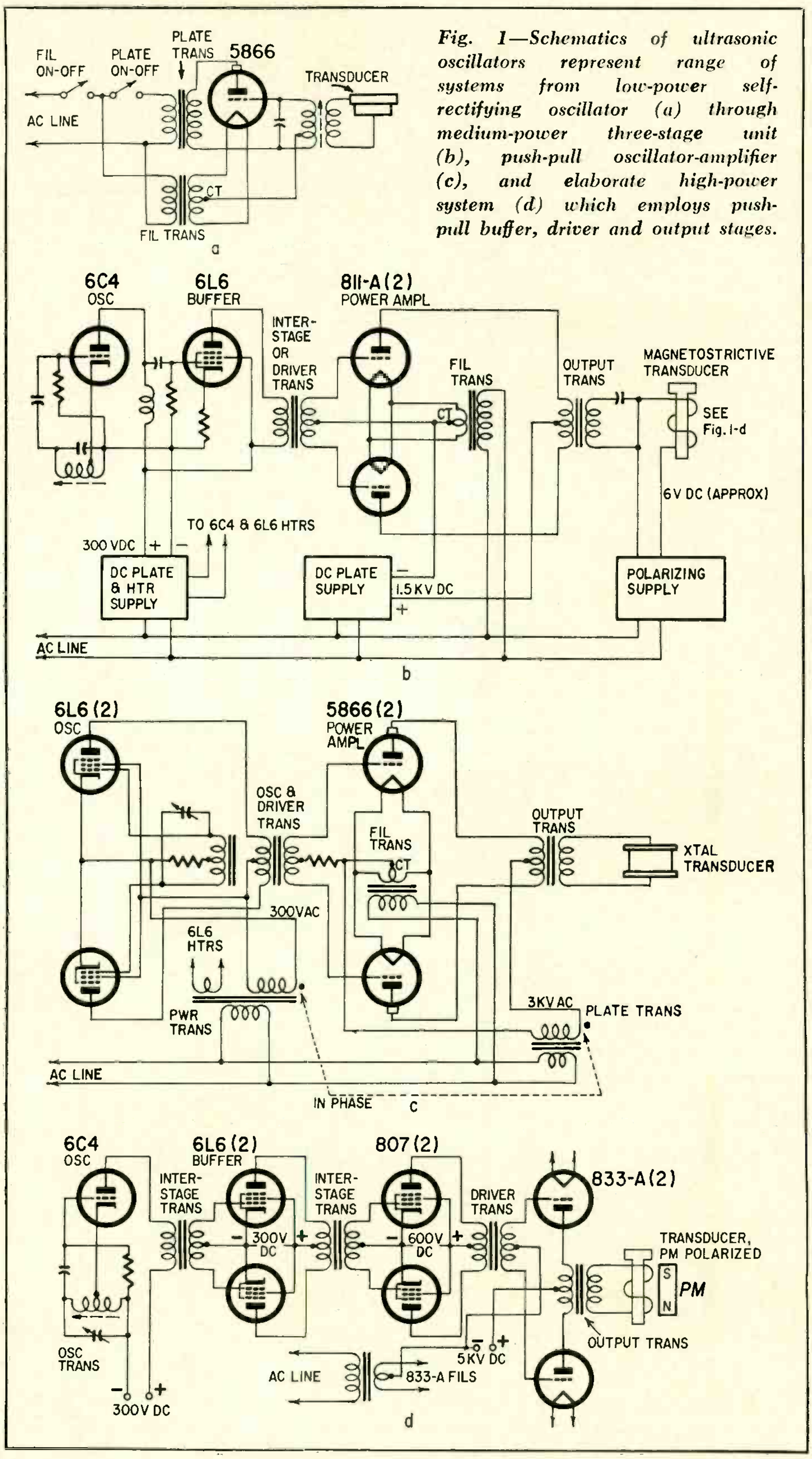


Fig. 1—Schematics of ultrasonic oscillators represent range of systems from low-power self-rectifying oscillator (a) through medium-power three-stage unit (b), push-pull oscillator-amplifier (c), and elaborate high-power system (d) which employs push-pull buffer, driver and output stages.

Nickel, iron, chromium, cobalt and other ferromagnetic materials change dimensions when in a magnetic field. This effect—called magnetostriction—varies with material and strength of the field.

In ultrasonic transducers, the most-often-used magnetostrictive effect is the change in length along the axis of the external field. In an oscillating field, the material expands and contracts at the frequency of oscillation. A magnetostrictive transducer is generally made of tin tubes, rods or laminations formed into a core as the driving coil.

Piezoelectric transducers are quartz or ceramic crystals which vibrate at the exciting frequency. The amplitude of the vibrations is greatest at the resonant frequency of the crystal.

Servicing Ultrasonic Cleaners

1. Rotate the oscillator tuning control to determine if it is set for maximum agitation in the tank. If the cleaner has a tuning meter, compare the reading with the manufacturer's specifications. A normal meter reading with poor agitation suggests transducer trouble; a low or very high reading is indicative of generator trouble.

2. Isolate the transducer elements and check. In many transducers a damaged element will not knock out the entire unit. In wound types, look for opens, shorts or a short to the core (grounding). Compare winding resistance of all elements to detect shorted turns. If available, a bridge should be used for this measurement. A check for opens, shorts, or grounds should also be made in crystal transducers. An open will be indicated by the absence of a capacitive kick with the vom on the R × 100K range.

3. Check for loss of polarizing voltage (when used) on magnetostriction transducers. Rotating the polarizing control (if any) should cause a change in the output plate current.

4. Using the ac scale of the vom and a .05-μF 600-volt capacitor in series with the probe, measure the signal on the grid(s) of the output stage and compare it with the manufacturer's data or handbook values. If it is too low, work back toward the oscillator until the loss of gain is located.

5. In push-pull-parallel solid-state generators look for defective transistors. These can often be detected by their burned emitter resistors.

6. Make certain the cleaning liquid is at the correct temperature; a faulty thermostat might be cutting off the heat.

Complete equipment failure usually makes it easier for the technician. The following "cookbook" approach has been found to be practical in such cases:

1. Check all fuses.

2. Check door and cover safety interlocks.

3. Check the time-delay relay if filaments are on but plate voltage is not.

4. Check coax cable between generator and transducer for a short or open.

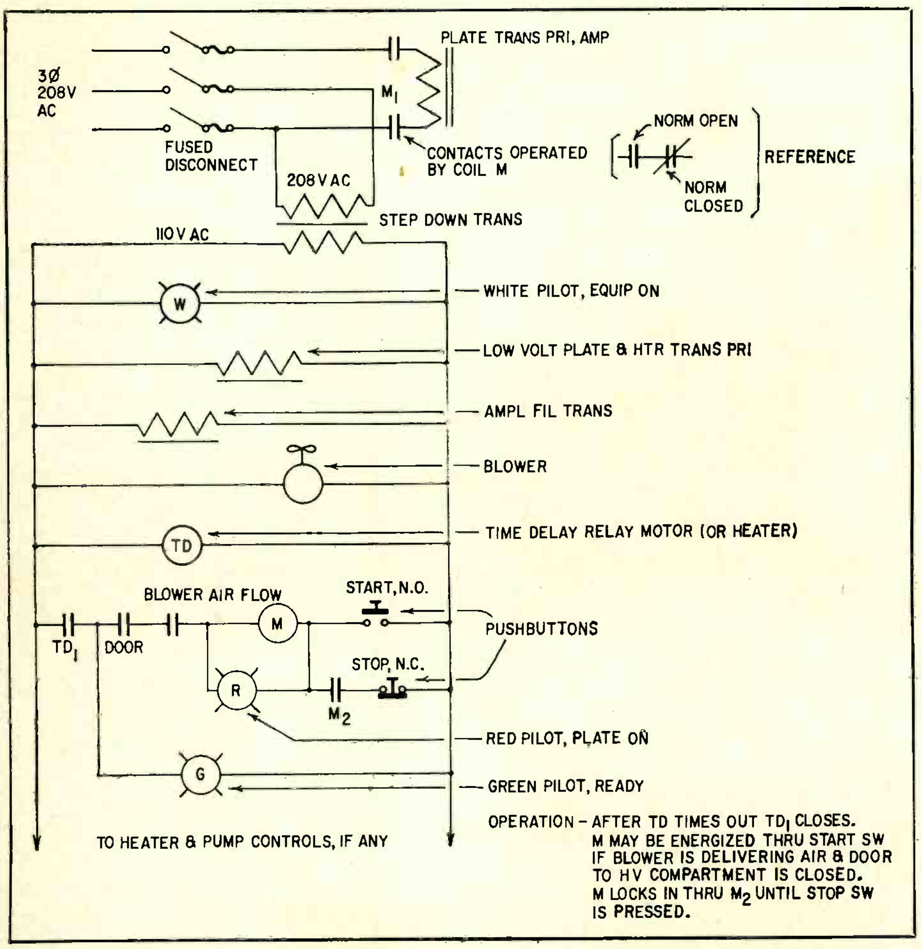


Fig. 2—Sequence diagram shows order in which power is applied to ultrasonic cleaner.

5. Check the transducer when loss of efficiency is the symptom.

6. See that the oscillator is not detuned. Tinkering with the oscillator or a defective component could cause the frequency to be outside the response range of the transducer, or may even cause complete failure to oscillate.

7. If a thermostat is used to hold the generator off until the cleaning liquid reaches a certain temperature, check it.

8. Check any air-flow interlock switches used in connection with the oscillator. If a multichassis, self-rectifying unit has been dismantled for any reason, make sure the polarity phase of the interconnecting ac lines has not been reversed.

Normally the electronics man will not be asked to work on the accessory equipment. Nevertheless, some knowledge of the related problems may prove useful. Some common troubles:

Liquid not heating or heating insufficiently:
Cause—Defective thermostat or defective heating elements.
Remedy—Isolate heating elements and check for opens. Defective elements must be replaced. Some thermostats may be repaired if the trouble is confined to the contacts.

No circulation:
Cause—Clogged filter, stuck valve, or faulty pump.
Remedy—If pump motor is not running, check for applied voltage and a tripped protective device. (If pump motor is running, a plumbing problem is suggested.) A faulty motor may be repairable economically.

Inoperative solenoid valve:
Cause—Mechanical binding or open coil.
Remedy—Replace coil.

Power-tube cooling fan inoperative:
Cause—Defective motor winding or bad bearing.
Remedy—Replace fan.

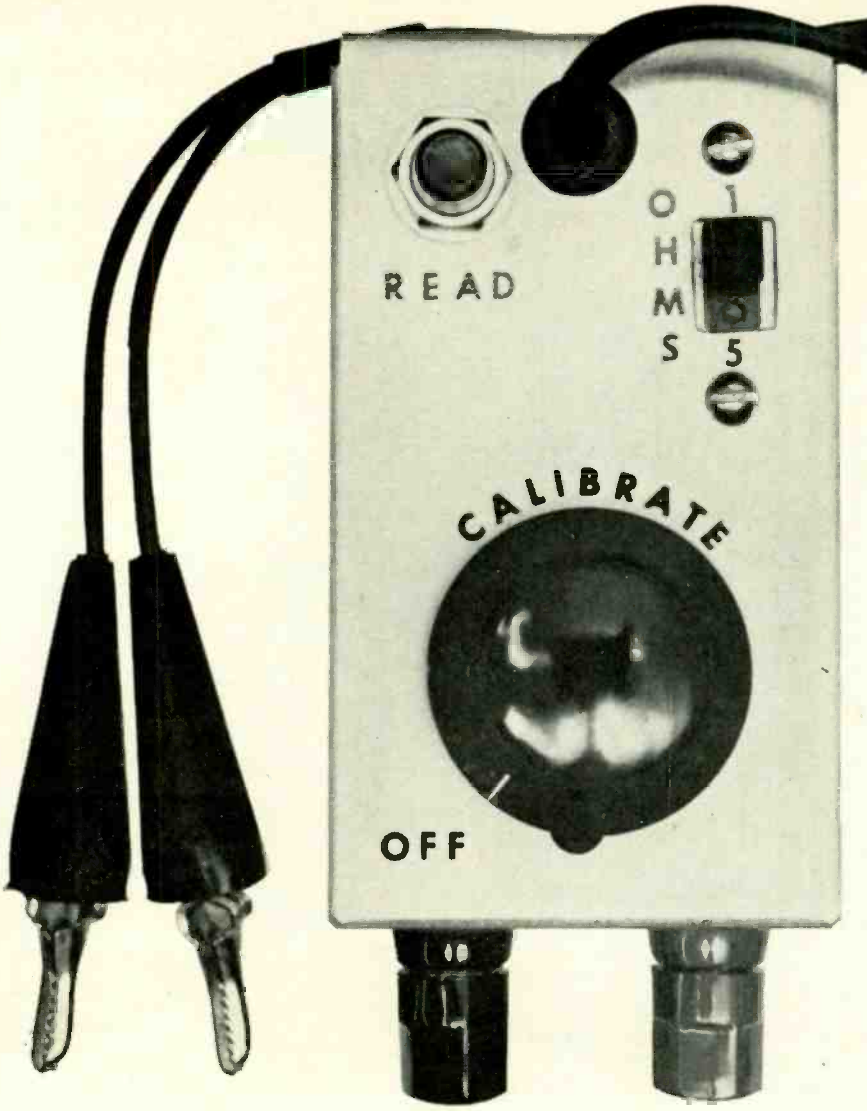
Precautions

The high voltages employed in the output stage of modern generators are dangerous. Be especially careful when measuring or working around them.

Respect the ultrasonic-frequency output voltage even on transistorized generators operating with less than 50 volts bias.

Avoid physical contact with the cleaning liquid unless you are sure it will not harm the skin.

Avoid breathing vapors from the liquid. If possible, work with plain water in the tank. END



THE OHM SPLITTER

Use almost any vom to measure fractions of an ohm accurately with this adapter

By J. T. McCORMICK

IN THESE DAYS OF TRANSISTOR IGNITION systems and powerful amplifiers working at low voltage, it is sometimes necessary to get the lowdown on a resistor whose value is less than 1 ohm. This inexpensive ohm-splitting gadget will let you spread 1 ohm clear across the face of your multimeter.

Unlike the R × 1 range of the usual ohmmeter, the gadget's accuracy is independent of battery condition. Moreover, you read fractions of an ohm directly on the dc scale—just as you do volts and amperes.

The Ohm Splitter can be used with any vom or multimeter that has a 50-, 60- or 100-μA current range. It can have its own meter if frequent use justifies the expense. The percent accuracy of the meter has no bearing on the accuracy of resistance measurement, but linearity does. The meter should have good linearity.

The gadget uses the principle that any part of a series-connected dc circuit carries exactly the same current as any other part. Fig. 1 shows the idea. R_s is a 1-ohm resistor used as a standard.

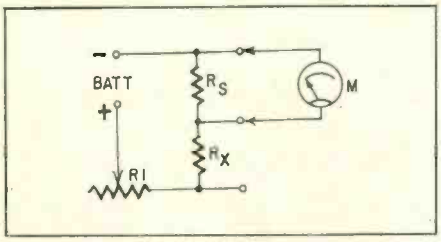


Fig. 1 —Principle of Ohm Splitter is to adjust current through standard and unknown for known voltage drop across standard, then transfer meter to unknown.

R_x's value is unknown, but presumably less than R_s. The meter's resistance is much more than 100 times R_s, consequently the error caused by meter loading is less than 1%. Current in the circuit is adjusted with R1 until the meter stands at full scale (or at the "50" mark if the scale has 60 divisions). We call this full-scale reading (actually the voltage drop across R_s) 1 ohm. The meter is now disconnected from R_s and connected across R_x. The drop across R_x is in direct proportion to its resistance and, since the current values in R_x and in R_s are the same, the meter reading directly indicates the value of R_x in parts of an ohm. If the meter has 50 (or 60) scale divisions, each division indicates .02 ohm.

(Somehow the situation seems funny: we use a micro*ammeter* to measure a fraction of a *volt* and call it a fraction of an *ohm*. Isn't electronics grand?)

To give the necessary range of adjustment without burning, the rheostat of Fig. 1 is replaced by a cheap transistor in the actual gadget. The full circuit is shown in Fig. 2. R1 controls the transistor's bias. R2 limits base current to avoid the possibility of burning R1. R3 and R4 are resistance standards. R4 adds a second range (5 ohms) to make the gadget more useful. S2 is the range switch. S3, as you can see, painlessly switches the meter from standard to unknown by the push of a button. D limits meter voltage to less than 1 volt in case the button is pushed with no R_x connected.

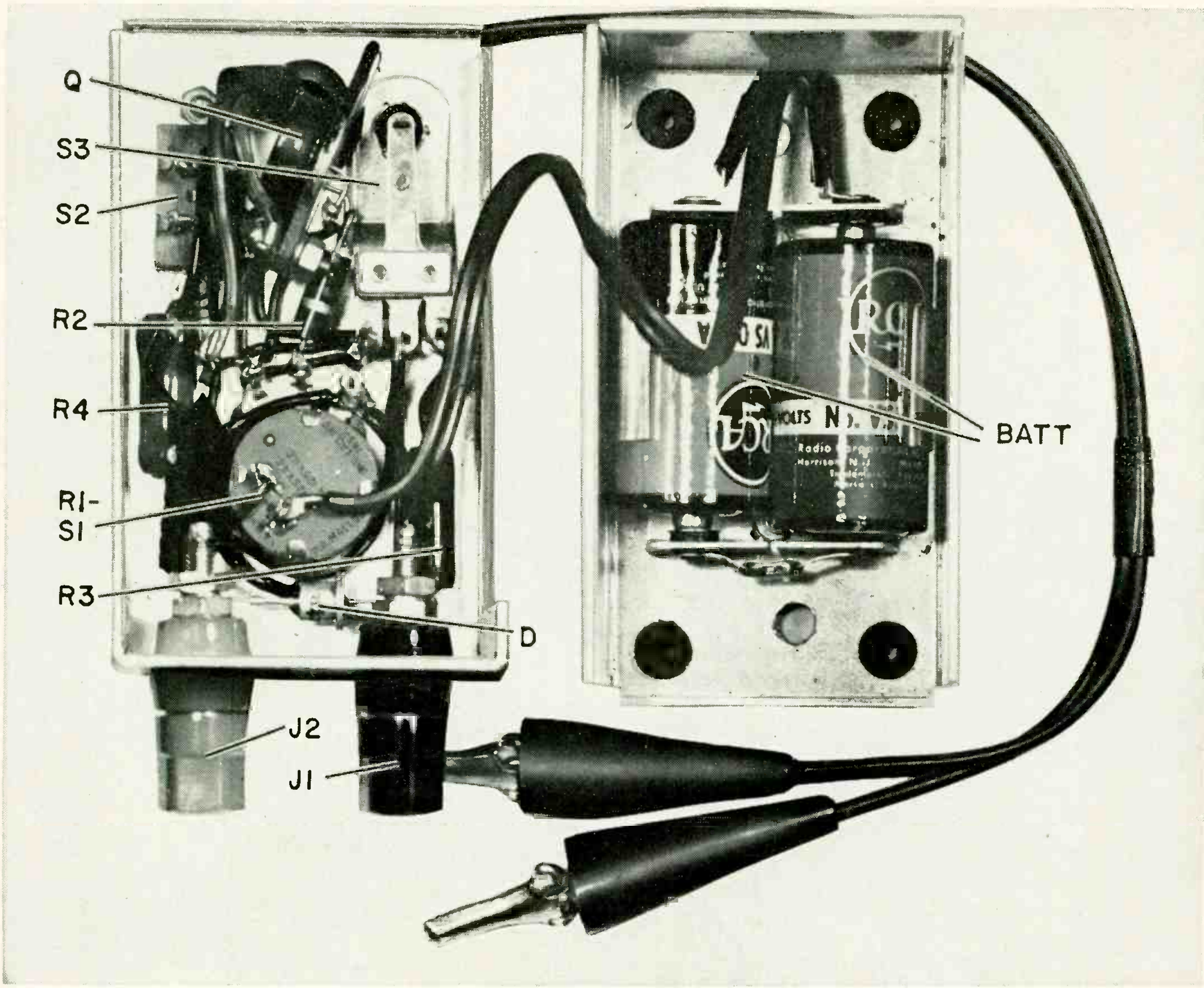
That's really the whole story. The Ohm Splitter can be built to suit your taste, but some remarks about the components may be helpful.

Q can be almost any "bargain" germanium power transistor, even a rather leaky one. It dissipates only a fraction of a watt and needs no heat sink. D, too, can be of the "bargain" variety, but don't use a miniature diode. Current can be quite heavy, depending on the setting of R1.

Ordinary lamp cord can be used for test leads. Attach these leads permanently; the uncertain resistance of plugs and jacks cannot be tolerated. Any means of connecting the meter is acceptable. Five-way binding posts will take any meter.

I know of at least one multimeter which has a resistance of 6,000 ohms on its 60-μA range. This means a 300-mA load on the Ohm Splitter's battery when using the 1-ohm range. Use C-size cells or alkaline cells if you are likely to use such a meter.

Wirewound resistors are specified because they are readily obtainable. Incidentally, I used a 10% wirewound for



Solder connections must be good, especially in series circuit including S1, Q, the battery, R3 and R4, and the clips.

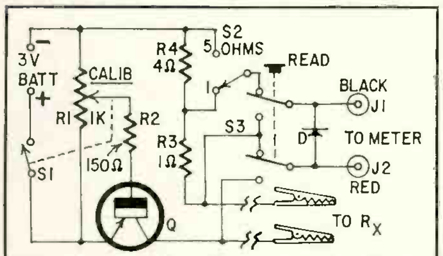


Fig. 2—Circuit of the entire Ohm Splitter. Transistor and diode can be almost any kind. See the parts list for data.

PARTS LIST

BATT—3-volt battery (2 C-cells)
D—500-mA silicon diode, any voltage
J1—black 5-way binding post
J2—red 5-way binding post
Q—germanium power transistor (1-watt dissipation or higher)
R1—pot, 1,000 ohms, with spst switch
R2—150 ohms, ½ W, 10%
R3—1 ohm, low-wattage wirewound, 5%
R4—4 ohms, low-wattage wirewound, 5%
S1—spst switch on R1
S2—spdt slide switch
S3—dpdt pushbutton switch
Case (author used 2¼ x 2¼ x 4-inch aluminum box), 2 crocodile clips, 2-cell battery holder, knob, etc.

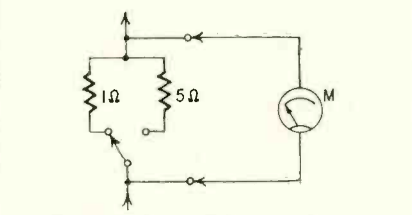
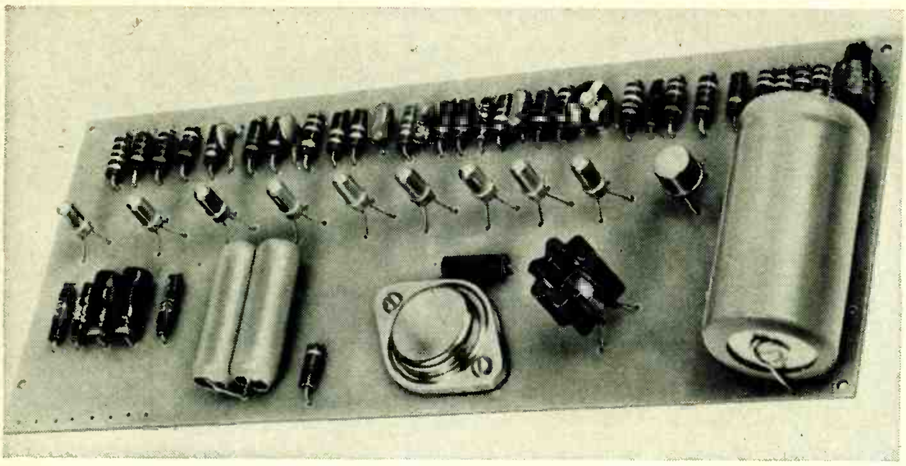


Fig. 3—DON'T try this circuit arrangement: It puts the unpredictable contact resistance of the switch into the circuit.

Since the indicating meter acts as a millivoltmeter, a higher range but lower resistance will often work better. For example: a 1-mA, 100-mV movement (meter resistance 100 ohms) reads full scale at 100 mA with the unknown terminals shorted, and, of course, less than that for any readable value of unknown. What is required for this instrument is a low-resistance meter, rather than a small-current type.

R4, and had to pad it with a foot of No. 32 wire rolled up in a piece of tape to bring it more nearly into line. If you want to use 1% resistors, ½-watt rating will do. Burstein-Applebee lists them in the 1-ohm value—but not the 4-ohm. Solder four 1-ohmers in series for R4; don't be tempted to use the idea of Fig. 3. The resistance of the switch would be included in your standard—and you would have no standard. The resistance of a switch cannot be assumed to be zero, nor expected to remain at a particular value.

The resistance of the test leads is the first thing to measure with the Ohm Splitter. Clip the ends together, calibrate, and push the button. This resistance must be subtracted from all future measurements. I shortened my leads to .02 ohm, so that it is necessary to subtract only one scale division. When using the 5-ohm range (where each scale division equals 0.1 ohm), lead resistance can usually be ignored. END



A CLASS-D HI-FI AMPLIFIER

A practical circuit using pulse-width modulation

By I. QUEEN

SWITCHING AMPLIFIERS HAVE BEEN DEscribed several times in recent publications. A build-it-yourself amplifier of this kind was covered in a series of articles by Norman Crowhurst which began in RADIO-ELECTRONICS for July 1965. The response of the amplifier was quite limited and I wondered what could be done to broaden it for hi-fi use. I found my answer during a trip to England. I came across the Sinclair X-20 switching-type hi-fi amplifier. This mode of operation is also called class D and pulse-width modulation. This is a description of that unit.

The X-20 uses 12 transistors, is mounted on a printed-board measuring 8¼ x 3¼ x 1 inches, and weighs less than 4½ oz. It has less than 0.1% total harmonic distortion at 10 watts. Though it is capable of 40 watts peak music power, Sinclair specifies it at 20 watts of average music power.

The X-20 was available without power supply or volume and tone controls. We mounted the X-20 in an aluminum chassis (10 x 5 x 3 inches) and added the tone and volume controls and power supply. Fig. 1 shows the simple supply we used, and Fig. 2 the controls.

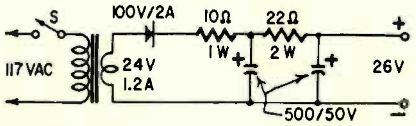


Fig. 1—Power supply for the amplifier.

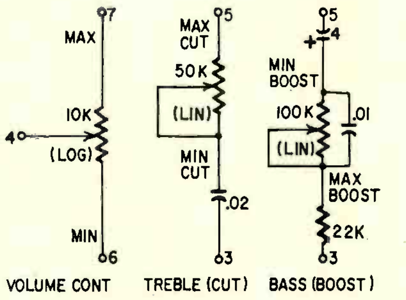


Fig. 2—Amplifier controls. Either or both tone controls can be used.

The schematic of the X-20 is shown in Fig. 3. The operation is as follows:

Q1 is a preamplifier stage which can handle as little as 1 mV (into 5,000 ohms). The preamp stage is followed by high-gain stages Q2 and Q3, after the external volume control. Q4 and Q5 form a free-running multivibrator at about 75 kHz. The output of Q5 is a square wave. It is fed into Q6, a feedback integrator—note the capacitor between collector and base. After integration, the waveform becomes triangular, and is fed into Q8 and Q9. Q7 (a transistor with collector left open so it acts as a diode) conducts only when the applied signal exceeds the negative bias at its emitter—that is, its anode in this hookup.

C7 and Q8 differentiate the square waves, converting them to pulses. Negative peaks drive Q8 to conduction, blocking Q9. Positive peaks will block Q8, thus permitting Q9 to conduct. Due to the large amplification of Q8 and Q9, the transistors are overloaded by these pulses, and their tops are flattened. The output becomes a symmetrical square wave, assuming there is no audio signal being fed into the amplifier.

When audio is applied, signals from Q3 are fed through R8 and C12. Q7, acting as a diode, mixes them with the pulses from Q6. When the speech signal is positive-going, it adds to the positive pulse, increasing and widening it. At the same time, the positive-going speech signal will reduce and narrow the negative pulse, when it is present. Of course, when the audio wave goes negative, the opposite will happen (see Fig. 4). During a complete audio cycle, the output waveform from Q9 will look like Fig. 4-a, then like 4-b, back to 4-a, then to 4-c, then finally back to 4-a. The pulses, varying in width according to the audio-rate signal being fed to the amplifier, are reduced in amplitude by R20 and R21, then fed to the base of Q10.

Transistor Q10 acts as a control de-

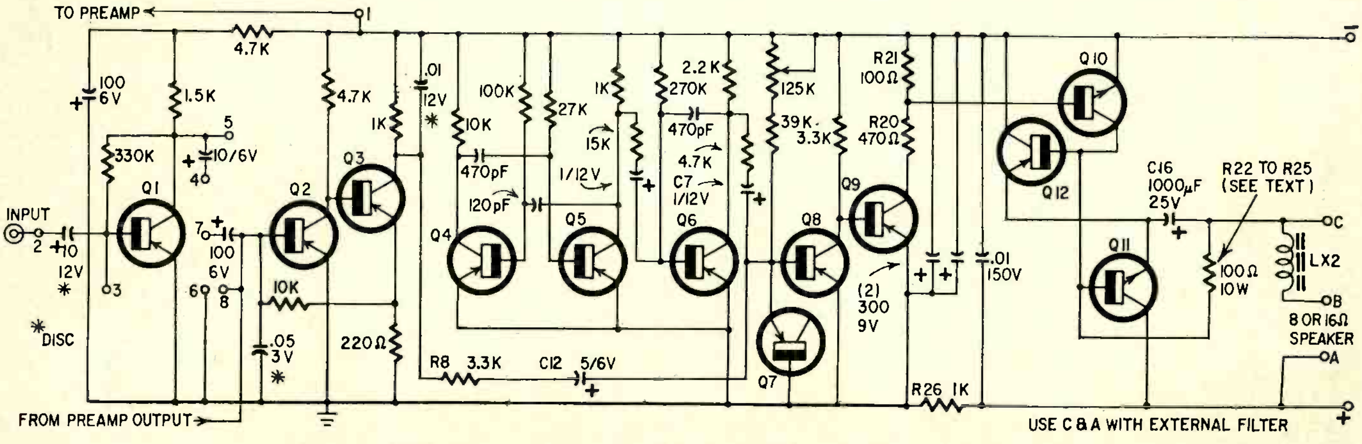


Fig. 3—Schematic of the Sinclair X-20 pulse-width modulated amplifier.

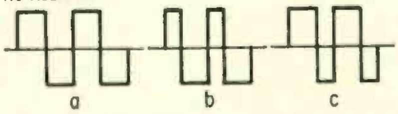


Fig. 4—Amplifier output waveforms. Pulse width—above and below baseline—varies with instantaneous polarity and frequency of the audio signal. a—No audio input, b—the negative audio half-cycle, c—the positive half-cycle.

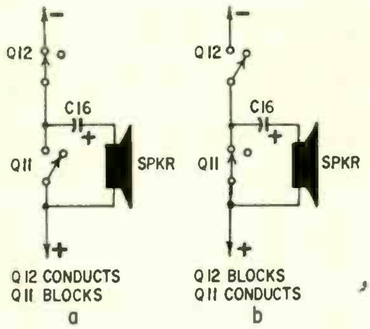


Fig. 5—Basic output circuit with Q11 and Q12 represented by switches.

vice, whose resistance varies with its base bias. When the base goes more positive (than its emitter) Q10 conducts. The transistor blocks when the base goes more negative, of course.

The two-transistor output stage, Q11 and Q12, is in series across the power supply. When the control transistor conducts, the bases of both output transistors are in effect connected to negative. Therefore, Q12 conducts, while Q11 blocks. On the other hand, when the control transistor is blocked, the bases of the output transistors return to positive, through resistors R22, R23, R24, R25 (shown as a 100-ohm, 10-watt unit) and the speaker. Q11 conducts, and Q12 is cut off.

What effect does this have on the speaker? Fig. 5 shows. For the moment, assume there is no audio to the amplifier. Q10 will have equal on-off intervals at the high switching frequency of 75 kHz. Q11 and Q12 are represented by switches. In Fig. 5-a, C16 will charge through the speaker. In 5-b, it discharges and current goes through the speaker in the opposite direction.

When audio is applied to the input of the amplifier, conditions change. The negative and positive pulse widths are no longer equal. One output transistor will conduct for a longer period than the other. During the next half-cycle, the second transistor will conduct longer. And so on. This pulse width varies at the audio rate of the input signal, which becomes audible in the speaker. END

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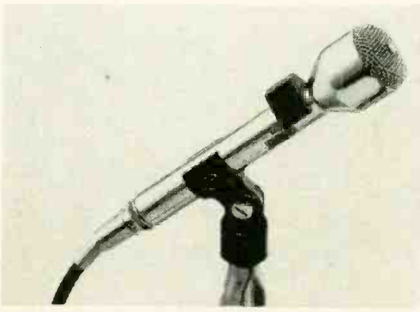

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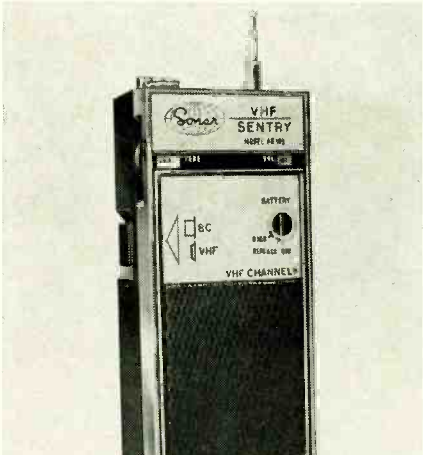

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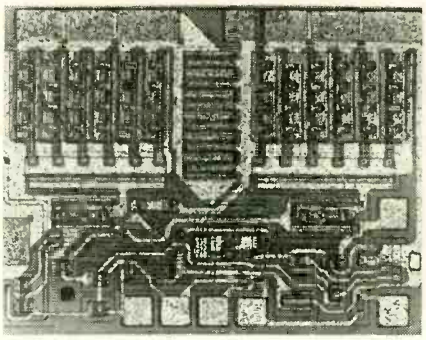

from 20–20,000 Hz. Housed in a 10-pin low-profile metal can. Input impedance, 10 ohms; output impedance, 0.2 ohms. Voltage gain adjustable to 9, 18 or 36. Output voltage sensitivity to power-supply variations, 40 mV/V. Drain current, 11 mA dc with a 16-V power supply at zero signal input.—**Motorola Semiconductor**

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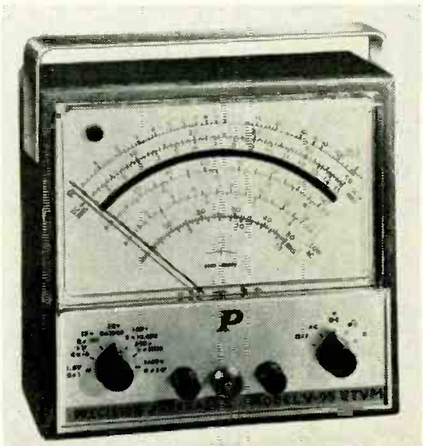

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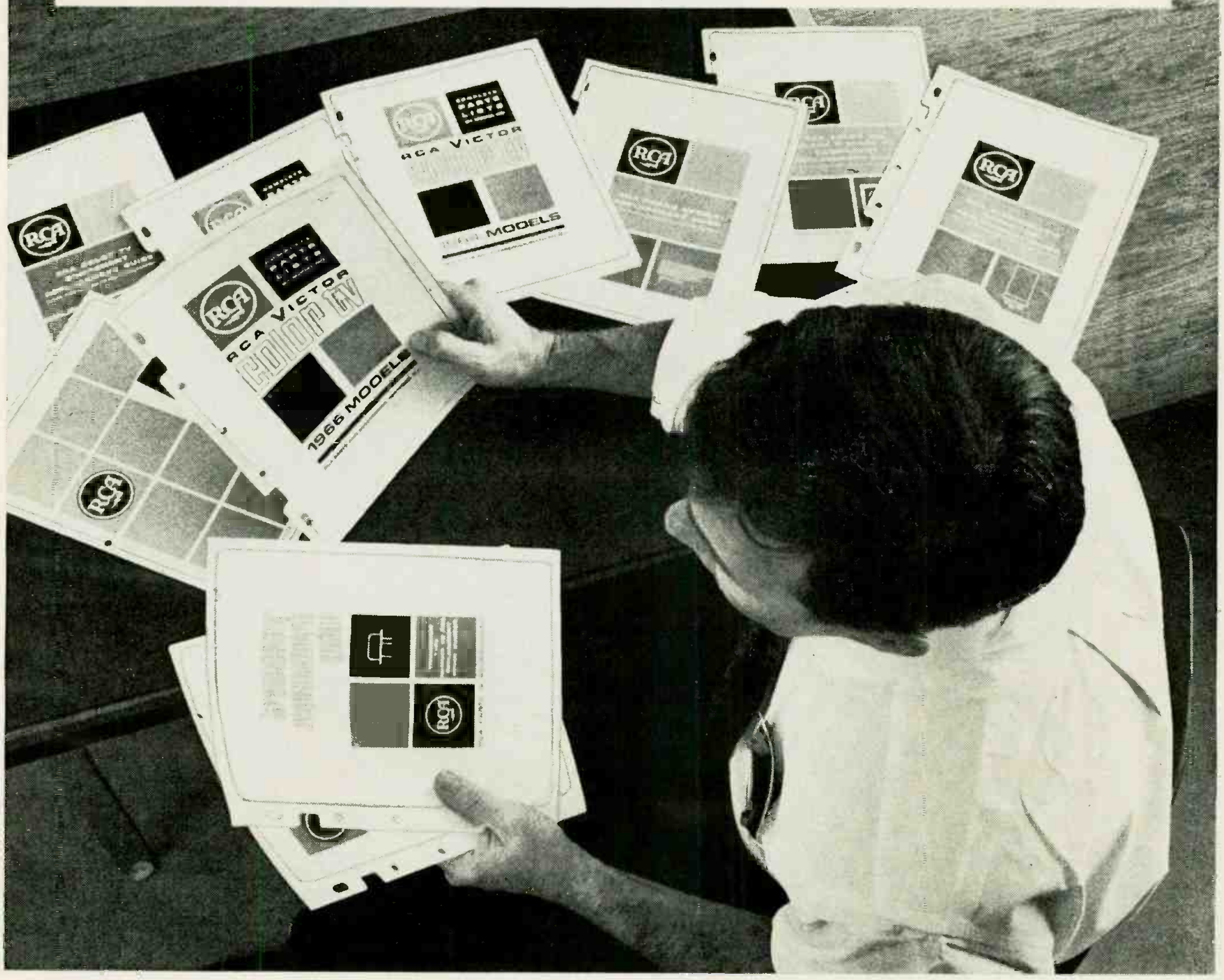

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MCP-198—DIODE REPLACEMENT GUIDE
MCP-199—TRANSISTOR REPLACEMENT GUIDE
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scales to eliminate parallax, specially calibrated scales for reading low-voltage measurements during transistor analysis in the 0.5-, 1-, 1.5- and 5-V ranges, and simplified peak-to-peak and dB scales. Accessory high-voltage and rf probes available at $12.95 and $7.95, respectively. $79.95—**Precision Apparatus**

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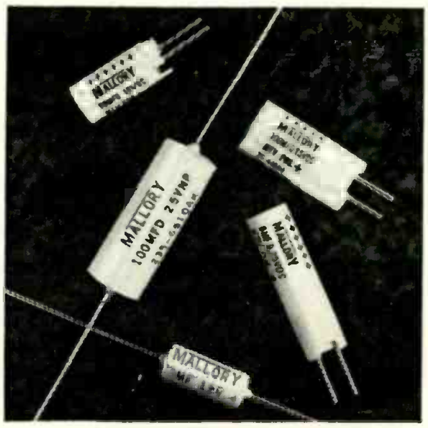

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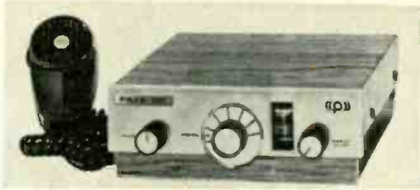

trol, automatic deep noise clipping, provision for *Pace Selective Call* system. $129.95—**Pace Communications Corp.**

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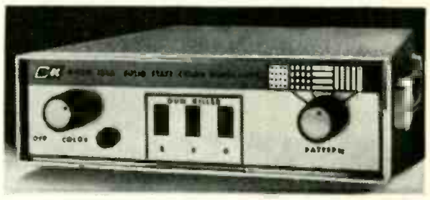

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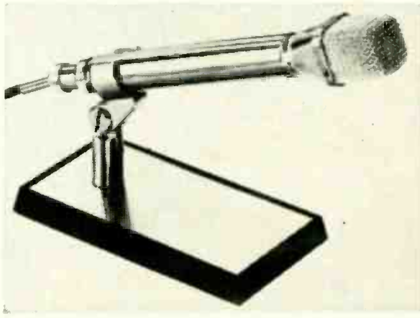

CARDIOID DYNAMIC MIKE, *model M0264.* For recording, PA. Includes desk stand, 20-ft cable. Response, 100–14,000 Hz. Impedance, 50K. 7¾ in. long x 1⅛ in. diam.—**Olson**

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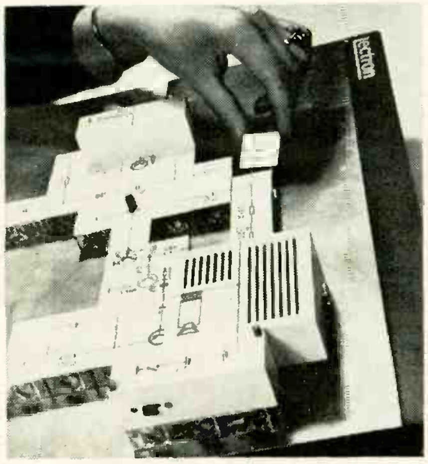

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COMPLETE CATALOG FOR OPTICS, SCIENCE AND MATH. *No. 674.* 147 illustrated pages. Describes more than 3,800 items.—**Edmund Scientific Co.**

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TEST EQUIPMENT CATALOG. *No. 67D.* 8 pp. Describes color-bar generators, CRT testers, oscilloscopes, probes, radio analyzers, signal generators, sweep generators, transistor testers, tube testers, video scanners, vom's, vtvm's.—**Hickok Electrical Instrument Co.**

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CATALOG OF GOLD LINE UHF CONNECTORS, ADAPTERS, AND SPECIAL ACCESSORIES FOR HAMS AND CB'ERS. Illustrated, 6 pp. Accessories featured include the *Signal Hunter* direction-finding antenna, coaxial switches, automobile alternator and generator filters, a lightning arrester and a *CB Matcher* antenna matching network that insures a VSWR of 1.1:1 for full power.—**Gold Line Connector, Inc.**

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MICROPHONE CATALOG, *SAH-115, A Microphone For Every Purpose.* 12 pp. Lists Sonotone's complete line of dynamic and ceramic mikes. Includes microphone parts and accessories. —**Sonotone Corp.**

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1967 CATALOG. 31 pp. Illustrated. Specs, graphs and descriptions of *MIL-T-27B* military transformers and commercial-industrial transformers.—**Microtran Co., Inc.**

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NICKEL-CADMIUM BATTERY DATA CATALOG, *No. BA-189.* 8 pages. Includes commercial nickel-cadmium sealed cells, commercial and military aircraft batteries, special-purpose batteries and nickel-cadmium space battery. Section on *PCA-131* nickel-cadmium battery charger/analyzer. Specs.—**Sonotone** END

Circle 71 on reader's service card

continued from page 49

emitter action in unipolar FET's, since the gates are reverse-biased and serve only to set up a transverse electric field in the channel.) And the term JFET (*junction field-effect transistor*) may be found in some data.

Higher input impedance than that afforded by the conventional FET is provided by the device shown in Fig. 8. Separate N regions are diffused (for source and drain electrodes) into a P-type substrate. An oxide layer is formed on the top face of the substrate, and a metallic gate electrode is deposited on top of the oxide. From its configuration, this type of field-effect device is termed *metal-oxide semiconductor* (MOS), *metal-oxide-semiconductor . transistor* (MOST), or *metal-oxide-semiconductor field-effect transistor* (MOSFET). It is also sometimes called an *insulated-gate field-effect transistor* (IGFET) from the fact that the oxide layer insulates the gate electrode from the substrate.

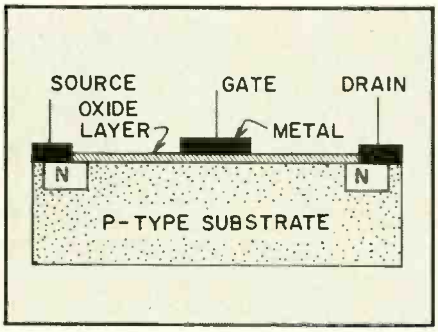


Fig. 8—The basic insulated-gate FET.

The extremely high input impedance of the MOST results from its almost zero leakage current from the gate, because of the oxide insulation. The dc stability of the MOST is less than that of the FET, possibly also because of the oxide layer, but the MOST is a good rf device.

Other acronyms

One of the newest solid-state acronyms is RGT—for *Resonant Gate Transistor*. The heart of each RGT is a tiny solid-gold tuning fork, which makes it possible to tune IC's without bulky coils. A silicon wafer the size of a quarter holds 500 RGT's.

In addition to acronyms and abbreviations which describe the transistors themselves, another one seen on transistor and diode data sheets is JEDEC. This one stands for *Joint Electronic Device Engineering Council*, and its presence means that the component has been registered by that group and given an identifying number.

Outside of the transistor–diode corner of the electronics world, there are of course many other acronyms—MASER, LASER, RADAR, SONAR, SOFAR, and many more—but that is another story. . . . END

ANTENNA REPORT

continued from page 50

pelator for set attachment between vhf and uhf lugs" (quoted from slip of paper found with the device). As shown in the photo, the "impelator" appeared to be a plaster disc with two short pieces of 300-ohm lead coming from each side of it. When we broke the plaster, we discovered that the 300-ohm line was a single intact piece, with no components of any kind attached. There was no apparent purpose for the plaster, and the line apparently served merely as a jumper.

To summarize: Despite advertising claims, the SkyProbe antenna is *not* solid-state; it contains no transistors or diodes. Inside the plastic sheath we found nothing but wire, plastic foam and cardboard. The SkyProbe seems to work about as well as ordinary rabbit ears—except that it is not essentially directional, and thus cannot null out ghosts. (We oriented our reference rabbit-ears for best pictures.) Furthermore, the SkyProbe does not appear to perform as well as an outdoor directional antenna.

The SkyProbe sold in New York City for $12.99. In Cincinnati the price was $8.57. Each figure is several times the price of rabbit ears, which we found comparable in performance.
—Thomas R. Haskett.

[*As we were preparing the above report, we received the following letter and photos.—Editor*]

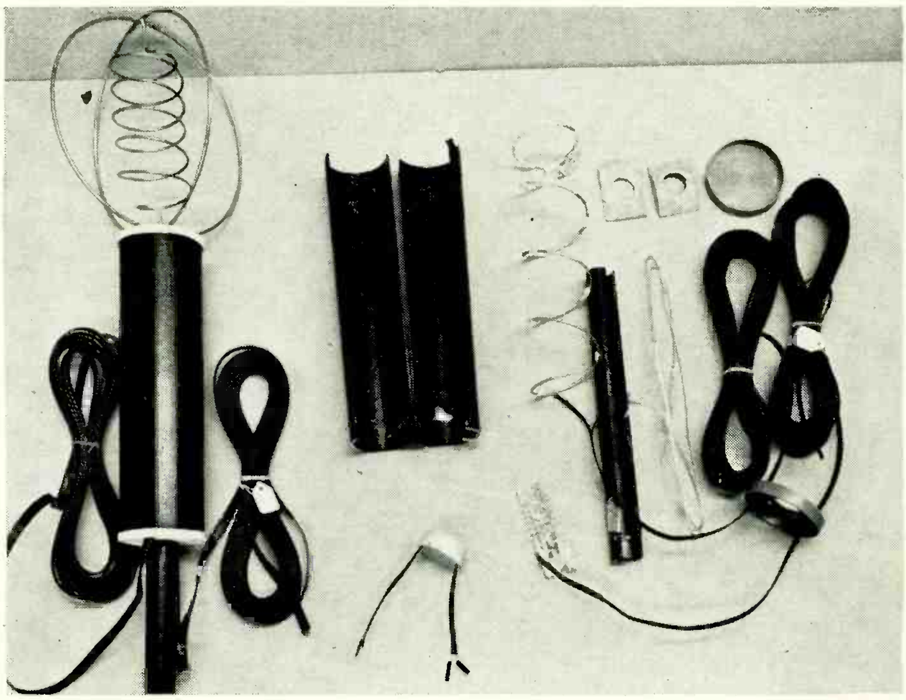
Dear Editor:

In your July 1967 News Briefs you told of a demonstration of a new antenna, the *Americus SkyProbe*, developed by John M. Eagle of UniScience Laboratories, Inc.

Being very much interested in new antenna developments, especially the new Air Force Subminiature Integrated Antenna (SIA, which was also mentioned in the July News Briefs), in our broadcast and CATV activities, we ordered an Americus SkyProbe antenna from UniScience Laboratories. We received three antennas: SkyProbe model D-19, SkyProbe model D-19A, and a MiniProbe (advertised for local reception only). The accompanying photo shows, on the left, the assembled D-19A with the fancy hardware on one end. Our costs for these antennas (presumably net prices) were $5.99, $7.47 and $3.50, respectively.

A cursory test of these antennas was all it took to convince us that the most elaborate of the three was almost as effective as a set of rabbit-ears. Most, if not all, reception came from the lead-in wire rather than the antenna.

An Abraham & Straus advertisement in *The New York Times* of Sunday, May 7, 1967, intrigued us. It described the SkyProbe model D-19, priced at $12.99, and said: "This *solid-state* outdoor antenna is only 18", yet gives *amazing* black and white, color and AM/FM reception. It's a brand new concept that *utilizes basic radar techniques* to give you clear, sharp reception." (Emphasis added.) We decided to dis-



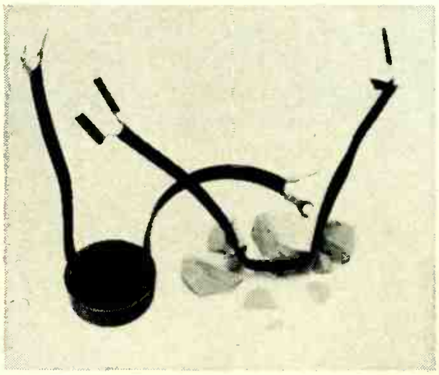
Reader Sellars bought D-19A SkyProbe (assembled left) and D-19 (disassembled right).

Circle 127 on reader's service card ➔

assemble the D-19 to see what was inside. The photo shows the results.

There was no evidence of any transistors, diodes or anything else which could be called "solid-state" devices. We found nothing resembling any "basic radar techniques" except for the wire itself which, I guess, *is* basic to any radar unit.

The crowning blow of all, however, was the small, round device with two short lead-in wires in the lower center of the photograph. It was described as the "fantastic new Americus Impelator to replace all other jumper systems." It is to be used to connect the uhf to the vhf antenna terminals on the receiver so that one antenna could serve both terminals. Normally such a device would be a matching transformer. After the photograph was made we broke the device open. The last photograph shows the results. It proved to be a solid piece of epoxy material with *one piece* of lead-in wire running into it and directly back out—nothing else! Indeed, it was "fantastic"!



The "Impelator" purchased by reader Sellars turned out to be an antenna-terminal jumper—just as R-E's did.

My reason for writing this letter is not to take you or your fine magazine to task. I felt that you would want to have the results of our investigation and to know that this antenna is in no way related to the SIA. It is merely a hunk of junk worth perhaps $1.00 at the most. In my opinion UniScience is perpetrating a hoax and cheating the unsuspecting public.

By means of copies of this letter and photographs I am also informing the National and two local Better Business Bureaus as well as the Federal Trade Commission, and two consumer magazines so they may take whatever action they deem appropriate.

LACY S. SELLARS
Jefferson Standard Broadcasting Co.
Charlotte, N. C.

END

Build This Transistor Characteristic Plotter

continued from page 47

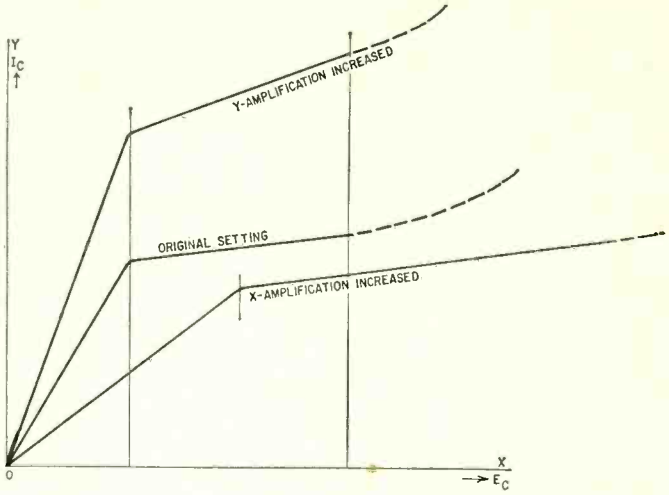


Fig. 9—The scope amplification affects the slope of the curves.

curves from six different bias values.

Put S4 in OPERATE position. Adjust pots R6 through R11 for 6 different bias values. Turn the rotating magnet with a screwdriver and observe the scope. Each time the magnet closes a reed switch, the bias will change and another curve will appear on the screen (compare with Fig. 8). If all switches are correctly operating and the bias values are set correspondingly higher, six different characteristics will appear on the screen at almost equal distances from each other.

Throw S3 to OPERATE and close S2. The motor will start to rotate, and the set of six curves should appear simultaneously on the screen.

Again you may find a few malfunctions. A single missing curve is probably the result of reed-switch failure or improper operation. Readjust the failing switch.

If a curve jumps on the screen, one switch is probably closing before the preceding switch has opened. Readjust the incorect switches by observing action while slowly turning the magnet by hand.

If the curves have different values of intensity or brightness, the closing times of the reed switches are unequal. Try centering the axis of the rotating magnet with respect to the reed switches. Check reed switch adjustments.

If only five characteristics are visible, the sixth is probably lost in the bottom of the trace. This indicates that bias on R11 is lower than threshold voltage. Increase bias by readjusting R11 and R5 or both. Readjust the vertical amplifier of the scope if necessary.

Excessive flicking of the display indicates that transfer time is too long or the motor speed is too slow. The remedy is to reduce transfer time by decreasing the gap between the rotating magnet and the reed switches and by readjusting the reed switches. Be sure the motor speed is not less than 600 rpm.

Calibration

Displaying a family of characteristic curves is an excellent way to match and compare transistors. However, the advantage of plotting characteristics can best be realized by calibrating the scope screen in terms of transistor parameters. What you need is a grid which will fit over the CRT face, so you can read values of voltage and current through the transistor.

Here's a simple method of calibration: Obtain a sheet of clear plastic as large as the CRT face. Draw on the sheet 25 to 50 horizontal and vertical parallel lines at equal distances from each other. Display a set of transistor characteristics on the screen. Adjust centering so the curve origin starts at a lower-left grid intersection (if pnp transistor—put the origin in the upper right-hand corner for npn).

Don't touch the scope gain controls, but disconnect horizontal and vertical inputs from the plotter and center the trace. Inject an undistorted ac signal into the horizontal and then into the vertical amplifier in turn. (In each case the unused input must be grounded.) Adjust the input-signal amplitude (not scope gain) until the trace fills about three-quarters of the screen both horizontally and vertically.

Measure the rms values of the two injected voltages. Multiply these rms voltages by 2.28 to find the peak-to-peak values. The beam deflections are proportional. For easier grid reading, change the input voltages so the distances between the parallel grid lines correspond to convenient voltage values (for instance, 0.1 volt, 50 mV, etc.)

Record these voltages for later reference.

Since the vertical deflections have to be calibrated in current, not voltage, each voltage value must be divided by 200 (the value of R4) to obtain the corresponding value of current. (Assume that 10 vertical divisions correspond to 1 volt p-p. That's equal to 0.355 volt rms. Each vertical division is then 0.1 volt divided by 200, or 0.5 mA of current.)

Display the set of curves again, with origin at the same intersection as before. Readjust, if necessary, the sweep voltage with R1, to fit the family of curves well into the screen area.

Connect a microammeter (250–500 μA full scale) to jacks J1 and J2. Stop the motor by throwing switch S2 to OFF. Turn the rotating magnet by hand until it faces reed switch S7-a. Push S6 and read bias current. Adjust pot R6 for a convenient bias-current reading. The curve should be near the original position on the screen.

Repeat this bias setting for each curve in turn. Place the magnet in positions facing reed switches S7-b to S7-f, and adjust the pots R7 to R11 for equal increases in bias currents (for instance 480, 400, 320, 240, 160 and 80 steps of 80 μA each). Record these settings for later reference.

The preceding calibration method is useful for many transistors, if you adapt the array to the characteristics of each transistor. Do this by adjusting the sweep voltage only (R1). Under these conditions, as long as the vertical and horizontal gain and bias settings are not changed, the calibration remains valid.

Any change in gain or bias current requires new calibration.

After you've finished calibrating the instrument, mount the front panel and PC board in the cabinet. Pot R5 is the only front-panel control affecting calibration. Because of this, it's advisable to provide a dial with exact graduation. This permits precise recalibration (Fig. 4). The positions of all other switches and controls should be well designated.

Don't forget to make notes of scope gain-control settings, since they affect the calibration. In any case you can check for correct calibration by taking voltmeter readings at the scope inputs and microammeter readings on jacks J1 and J2 (after pressing the pushbutton). END

PRACTICAL HINTS FOR CB SERVICE are yours in an article on CB talk troubles. Without proper modulation, a CB transceiver is useless. Keep your customers happy with correctly adjusted talk power, and keep your cash register full.

TOUGH DOGS— the benchman's nemesis—can be solved if you're willing to take them on fearlessly. Find out about some peculiar radio and TV receiver troubles, and how they were corrected. Read both these up-to-the-minute servicing articles in the **October issue**.

NEW SEMICONDUCTORS, MICROCIRCUITS & TUBES

TWO NEW TUBES FOR 2-WAY RADIO

The Amperex 8603 is a beam power tetrode specifically designed to have the lowest possible IM distortion when used as a linear rf power amplifier in SSB transceivers and mobile marine and aircraft equipment operating up to 75 MHz. It can deliver 43 watts PEP with third-order IM distortion better than 40 dB down under CCS operation. Under ICAS, 56 watts output may be obtained with slightly higher distortion.

The 8647 is designed for use as an rf power amplifier, oscillator and frequency multiplier up to 250 MHz and is recommended for class-C FM service. At 175 MHz typical CCS, ICAS and PTTS (1 minute on, 4 minutes off) ratings are 33, 40 and 49 watts, respectively. These outputs can be obtained with about 2.5 watts of rf drive power.

Designed for use in transistorized mobile equipment, both these Amperex

Circle 133 on reader's service card

tubes feature zirconium-coated molybdenum anodes and instant-heating cathodes. The tubes have a special base in which the anode pin is brought out separately from the normal pin circle to simplify under-chassis input and output circuit shielding.

LOW-COST PLASTIC FET'S

The MPF103, -104 and -105 make up a series of three new Motorola n-channel junction field-effect transistors for general-purpose audio and switching applications. The low price—50 cents each in 1,000 up quantities—is expected to lead to their wide acceptance in operational amplifiers and in the input stages of audio amplifiers and other consumer and industrial products where high input impedance is desirable.

Major characteristics:

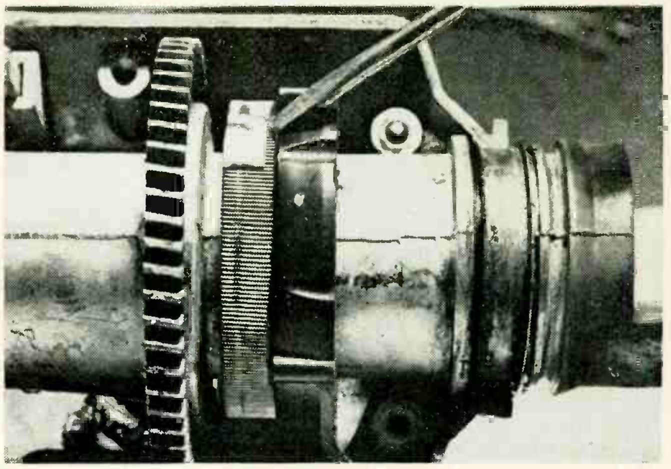
Characterstics	*MPF 103*	*MPF 104*	*MPF 105*
Forward transfer admittance (μmhos)	3,000	4,000	4,500
Max gate-source cutoff volts (dc)	−6	−7	−8
Zero-gate-voltage drain current (mA)	1–5	2–9	4–16
Min gate-source breakdown volts	−25	−25	−25
Max input cap (pF)	7	7	7
Max output admittance (μmhos)	50	50	50
Max reverse transfer cap (pF)	3	3	3

END

TECHNOTES

ROTATOR MOTOR REPAIR

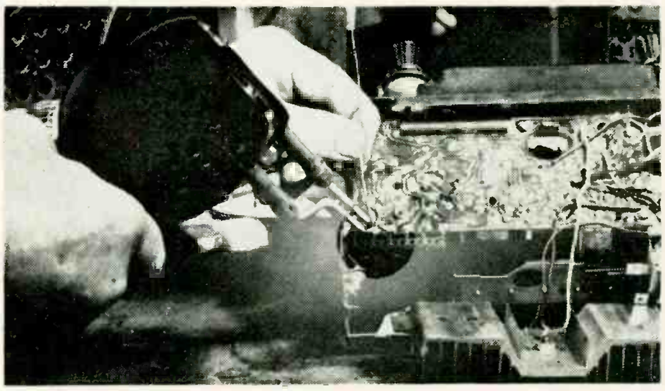
The antenna rotator had quit—and of course stopped in the wrong direction for good TV reception. I took the rotator down and disassembled the motor. The small direc-



tion-indicator rheostat had opened where the wiper blade slides on it. This was Sunday, the rotator had to be repaired, and naturally I didn't have an extra rheostat on hand. I laid a small copper strip inside the rheostat and soldered it to the copper turns. This completed the circuit, and the rotator has been working ever since.—*Homer L. Davidson*

1965 DELCO/CHEVROLET RADIOS

An intermittent oscillator trimmer capacitor in early 1965 Chevrolet auto radios can cause intermittent reception, frequency drift and cutting-out at the low end of the dial. This can be checked by using a pencil or blunt tool to push gently on the oscillator adjustment screw—usually sealed with red paint.



It is quite a job to change this capacitor because it is mounted under the circuit board. First, loosen the board from the chassis. Unsolder the tuning unit and pry the soldered terminals away from the soldered connections. Apply heat to the trimmer capacitor terminals and suck the molten solder off the board. Clean out all trimmer terminal holes before inserting the replacement unit. Solder all terminals, button up the chassis and then realign the front end.—*David Mark*

END

WHAT KIND OF NOISE ANNOYS A TAPE?

(continued from page 43)

inner surface of a drive belt was hitting one of the tube shields.

In a similar category is the loose motor fan with blades that strike a projection on the housing. The early 1500 series Wollensak had a fan-shaft projection that caused no end of noise when the recorder was not properly positioned. Fortunately the trouble was easily spotted. In the case of most such noises, the sound is telegraphed to other areas and you may spend hours trying to locate the source.

Such was the case when the takeup reel on a Sony was rubbing against a high spot on the cover. Similarly a high spot on the brake of a Uher recorder had me scratching my head for more than an hour. These puzzlers are at their worst when the offending noise comes and goes. Invariably it is on hand at demonstration time or when you are using the microphone and want recording-studio quietness.

Linkage vibration at odd times is another hard-to-locate source of noise. For this reason, when the recorder is an old one, time in locating a noise can actually be saved by getting the machine into operation and simply watching it for a while. Look for broken tiny tension springs and for missing or displaced pads or cushions.

Portable recorders that develop what sounds like excessive hum may need an additional end-play washer on the motor shaft. Test for this by tilting the instrument this way and that while it is in operation. The rubber feet on some recorders may harden and won't absorb normal motor vibration. This can be corrected easily by pushing sections of garden hose over the worn feet. Also, in extreme cases, a felt pad under the instrument will silence the noise. END

50 Years Ago

In Gernsback Publications

From September, 1917

Electrical Experimenter

U.S. Blows Up Tesla Radio Tower
Spy Aerials

The Marvels of Radio-Activity

The Franklin Experimental Club

The Present Status of the Audion

RADIO SHACK Wharfedale SPEAKER RIOT!

Giant Special Purchase!
The Audio Buy of the Year!

Another Radio Shack exclusive — the speaker kit riot of the century! We're offering the "guts" of a WHARFEDALE speaker system in kit form, including woofer, tweeter, all network parts, and detailed instructions for installation in your existing cabinet or for building an enclosure. This same speaker was nationally advertised by the manufacturer at *$122.50* in a cabinet.

YOU PAY ONLY 49.95

Wharfedale features: heavy-duty 12½" long-throw die-cast-chassis woofer with massive 5½-lb. Sheffield steel magnet; high-excursion cone suspension with cone resonance of 24 cps! 4" tweeter has huge 1¼-lb. magnet and die-cast basket! Wool cloth suspension! The professional 2-section LCR crossover network includes an aluminum-clad series capacitor for tweeter, variable potentiometer to let you custom-compensate system for room acoustics. SPECIFICATIONS: Response: 35-18,500 cps. Power (IHF per Channel): 8 watts (Min.), 30 Watts (Max.). Impedance: 8 ohms. Acoustic Control: treble, continuously variable. Crossover Point: 1000 cps. #40-922

COMPANION SPECIAL PURCHASE FROM EMI

High Compliance 4" Speaker Value!

3.99 EACH

4 to 12:	3.77
13 to 24:	3.69

British acoustic suspension speaker for custom hi-fi replacement in compact enclosures, or as an extension. Cone is suspended by cloth surround that provides cone excursion *never before possible* in a speaker this size. Massive ceramic magnet develops over 13,000 Gauss! 15 watt music power; 50-15,000 cps response; 8 ohms. #40-1908.

3 BLAZING WATTS OF TRANSCEIVER POWER!

NEW!

- *4-Crystal 2-Channel Operation!*
- *Call Alert! Range Gain!*
- *Center-Loaded Antenna!*
- *Separate Mike and Speaker!*

79.95 NO MONEY DOWN

NEW FOR '68 — the fabulous Realistic TRC-99. Has 19 solid state devices on military quality PC boards; RF stage; center loaded 57" telescopic whip for the ultimate in performance. *Plus* call alert; separate ceramic mike and speaker; exclusive lock-to-talk switch; battery condition meter; and a die cast case that can really take it! AGC and ANL; squelch; dual channel operation WITH ALL 4 CRYSTALS for channel 5 and 11 — plug-in, of course, so it's really a 23-channel transceiver! 6 side facilities for external speaker, beep tone, channel, external mike, external antenna and 12 VDC power supply. Optional 12V battery pack available. #21-107.

TRC-66/ALSO NEW FOR '68!

A step down in power and cost, the dual-channel TRC-66 is similar to the "99" but is rated at 1½ watts and includes crystals for Ch. 11 only. #21-105

59.95

NEW! MICRONTA 6½" VTVM

39.95

Factory Wired & Tested!

- *Easy-to-Read 2-Color Scale!*
- *Response: 30 cps to 10 MC!*

Features zero-center scale for alignment of FM/TV detector circuits; high-input impedance; precision resistors for accurate readings. AC Volts: RMS: 0.1 to 1500 V. (7 ranges); DC Volts: 0.1 to 1500 V. (7 ranges). Peak-to-peak 4-4000 V. (7 ranges); Output —20 db — +65 db (7 ranges). Resistance: 0.2Ω to 1000 meg-ohms (7 ranges). 117 VAC, 50/60 cy. With leads and instruction manual. Size: 7½ x 6¾ x 8⅛". #22-025

50,000 OHMS/VOLT 26-RANGE MULTITESTER

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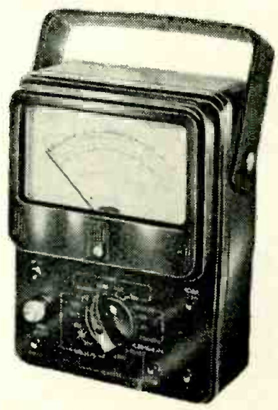


- *4" Meter w/Mirrored Scale!*
- *1% Precision Resistors!*
- *Meter Protection Circuit!*

DC Volts: 0-0.5-2.5-10-50-250-1000V at 50,000 Ω/volts. AC: 0-2.5-10-50-250-100V at 12,500 Ω/volts. DC current 2μ a-2.5-250ma — 1.10 amps. DC resistance: Rx 1/10/100/1000. Center reading scale 90/900/9000/90,000 Ω. DB: —20 to +64 in 5 ranges. Batteries, leads, instructions included. 7 x 5½ x 2⅝". #22-150

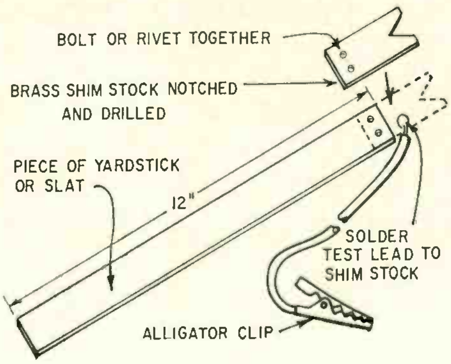
Circle 139 on reader's service card

TRY THIS ONE

SHORTING STICK FOR TV HIGH VOLTAGE

If you are tired of being belted by high-voltage discharge—especially in color sets—when you change the voltage-regulator tube or high-voltage rectifier, you'll find this gadget a valuable addition to your tool kit. It is very inexpensive and goes together in minutes.

Start with a flat (or round) piece of insulated material (I used a 12-inch piece of a broken yardstick). Next, get a small piece of brass shim stock from your auto supply house. Cut a "V" in the shim stock and then bolt or rivet it to the stick so about 2 inches protrudes from the end. Solder an 18-inch piece of test lead to the brass and add an alligator clip as in the drawing.



To use, clip the test lead to the chassis and, using the stick as a handle, slide the strip under the rubber insulator on the CRT high-voltage anode lead. The brass strip touches the anode connector and the residual charge drains off to ground. You can then put your hand in the cage and remove the tubes without getting smacked.

—John H. Larry

END

Solution to R-E Puzzler for August 1967

1 superheterodyne	13 arrester
2 lithium	14 electrode
3 antinodes	15 detent
4 etchant	16 germanium
5 spaghetti	17 analyzer
6 conduit	18 duodiode
7 connection	19 ceramic
8 kilovoltmeter	20 dielectric
9 doublet	21 getter
10 raster	22 soldering
11 element	23 prototype
12 friction	24 joint

25 radiogoniometer

Deduct 4 points for each part you missed.

Your rating:

60-64 Walk.	76-84 Double.
68-72 Single.	88-96 Triple.

100 OHM RUN! Congratulations!

By Edmund A. Braun

SCHOOL DIRECTORY

MARKET CENTER

GENERAL

WANTED

AUDIO — HI-FI

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HI-FIDELITY COMPONENTS, Ham Marine and Communication equipment at considerable savings. If you want to save money write us for our low prices on all your needs. **AIREX RADIO CORP.,** 132 (RE) Nassau St., New York, N.Y. 10038

LIKE MUSIC WITHOUT COMMERCIALS? Completely wired 67 KHz SCA (background music) adapter Model SCA-2 for $34.95. Five tuned circuits, two silicon transistor amplifier and ratio detector. Four connections to your FM receiver. Instructions included—No adjustments. Operates on 6 to 12 Volts DC. Size: 2½ x 3 x ¾ inches. Dealer inquiries invited. Available installed in a nationally advertised six tube AM-FM radio for $59.95. Also available installed in a nationally advertised ten transistor AM-FM portable for $79.95. Texas residents add 2% sales tax. **KENZAC CO.,** P.O. Box 66251, Houston, Texas 77006

NEW HAMMOND REVERBERATION Mechanisms —$4. **CAL'S,** Box 234, Dearborn, Michigan 48121

INVENTIONS & PATENTS

INVENTIONS-IDEAS developed: Cash/Royalty sales. Member: **UNITED STATES CHAMBER COMMERCE,** Raymond Lee, 130-U W. 42nd, New York City 10036

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BARGAINS in Canadian Electronic equipment and surplus. Send $1.00 for giant catalogs. **ETCO,** Box 741, Dept. R, Montreal, Canada

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Payment must accompany all ads except those placed by accredited advertising agencies. 10% discount on 12 consecutive insertions, if paid in advance. Misleading or objectionable ads not accepted. Copy for October issue must reach us before August 10th.
WORD COUNT: Include name and address. Name of city (Des Moines) or state (New York) counts as one word each. Zone or Zip Code numbers not counted. (We reserve the right to omit Zip Code if space does not permit.) Count each abbreviation, initial, single figure or group of figures or letters as a word. Symbols or groups such as 8-10, COD, AC, etc., count as one word. Hyphenated words count as two words. Minor over-wordage will be edited to match advance payment.

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SILICON RECTIFIER SALE

IMMEDIATE DELIVERY

FULLY GTD AMERICAN MADE — NEWEST TYPE FULLY TESTED

1 AMP SILICON "TOPHAT" & EPOXY DIODES
LOW LEAKAGE FULL LEAD LENGTH

PIV/RMS 50/35 .05 ea.	PIV/RMS 100/70 .07 ea.	PIV/RMS 200/140 .10 ea.	PIV/RMS 300/210 .12 ea.
PIV/RMS 400/280 .14 ea.	PIV/RMS 500/350 .19 ea.	PIV/RMS 600/420 .21 ea.	PIV/RMS 700/490 .25 ea.
PIV/RMS 800/560 .30 ea.	PIV/RMS 900/630 .40 ea.	PIV/RMS 1000/700 .50 ea.	PIV/RMS 1100/770 .70 ea.

ALL TESTS AC & DC & FWD & LOAD

SILICON POWER DIODE STUDS

D.C. AMPS	50 PIV 35 RMS	100 PIV 70 RMS	150 PIV 105 RMS	200 PIV 140 RMS
3	.08 ea	.12 ea	.16 ea	.22 ea
12	.25	.50	.65	.75
35	.65	.90	1.25	1.40
100	1.00	1.20	1.50	1.75
160	2.50	3.00	—	3.75

D.C. AMPS	300 PIV 210 RMS	400 PIV 280 RMS	500 PIV 350 RMS	600 PIV 450 RMS
3	.27 ea	.29 ea	.37 ea	.45 ea
12	.90	1.30	1.40	1.65
35	2.00	2.35	2.60	3.00
100	2.50	3.50	4.00	5.00
160	4.25	4.75	5.10	Ask

"SCR" SILICON CONTROLLED RECTIFIERS "SCR"

PRV	7 AMP	16 AMP	25 AMP	PRV	7 AMP	16 AMP	25 AMP
25	.50	.75	1.00	250	1.75	2.15	2.50
50	.60	.90	1.25	300	2.00	2.40	2.75
100	.80	1.25	1.50	400	2.40	2.75	3.25
150	.90	1.60	2.00	500	3.20	3.40	3.80
200	1.25	1.80	2.25	600	3.40	4.00	4.50

SPECIALS! SPECIALS!

Westinghouse 160 AMP, 500 PIV SILICON HI-POWER STUD RECTIFIER IN1666.
Limited quantity. $5.10 ea. 10 for $45.00

100 Different Precision Resistors
½—1—2 Watt ½%—1% TOL $1.25

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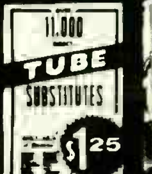

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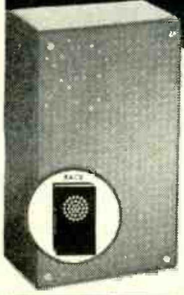

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AUDIO SWITCHING CIRCUIT

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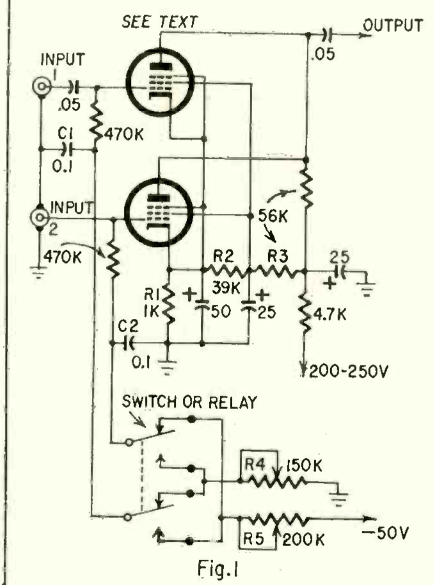


Fig.1

The circuit in Fig. 1, abstracted from *Radio und Fernsehen* (Berlin), is designed for high-impedance circuits. The tubes are EF83's but any pentode can be used with minor adjustments in the values of R1, R2 and R3 to provide normal screen and cathode voltages.

The desired signal is selected by a dpdt switch or relay connected as shown. The unwanted channel is biased to cutoff by returning its control grid to −50 volts. C1, C2, R4 and R5 are components in RC networks used to minimize switching transients and clicks.

UNUSUAL SQUELCH CIRCUIT

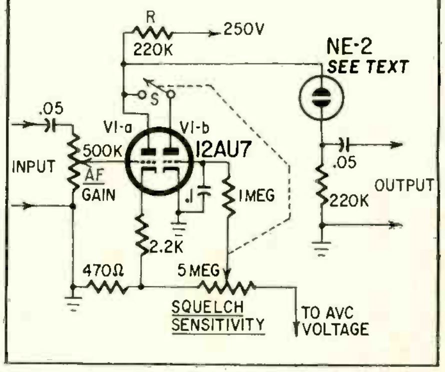
Here is a novel squelch circuit that you can add to a CB or similar monitoring receiver. It can be inserted between two audio stages in the set.

V1-a is an audio amplifier and V1-b is the squelch control tube. A neon glow lamp is the squelch element. When it is extinguished, it "opens" the circuit and prevents audio from appearing across the output terminals. When the lamp fires, it conducts and feeds the signal to the following stage. A negative avc voltage that swings from zero to at least −2 is used to switch the lamp on and off.

The neon lamp may be any convenient type with a firing voltage of 90 or less and an extinction voltage of 55 or more. When the switch is open, the 220K plate resistor maintains the plate of V1-a at a level at least 5–10 volts above the firning voltage of the glow lamp. When the switch is closed, the voltage on both plates of V1 is the difference between the supply voltage (250) and the drop across the common plate resistor (R).

If the grid of V1-b is at zero volts, the plate current is at maximum and both plates drop to around 40 volts. At this level the neon lamp is off and the set is squelched. When an incoming signal develops avc voltage, plate current in V1-b drops and both plates rise to around 100 volts. This fires the lamp and conduction continues until the plate voltage drops below the extinction voltage of the lamp.

The lamp in my circuit operated in an ambient light level of 5 to 50 foot-candles. Increasing the ambient light reduces the firing voltage; lowering the



light level increases the voltages needed to fire the lamp.

The bottom of the 5-megohm squelch control is returned to a tap on the V1-a cathode resistor. This applies a small positive voltage that bucks the negative self-bias on V1-b when the avc voltage is zero.

Within the range of 50 to 4,000 Hz, the distortion caused by the neon lamp is probably less than that caused by some more conventional squelch circuits.
—*Kendall Collins* END

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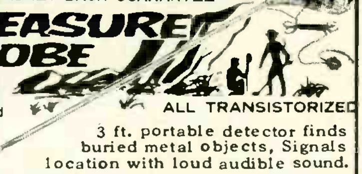

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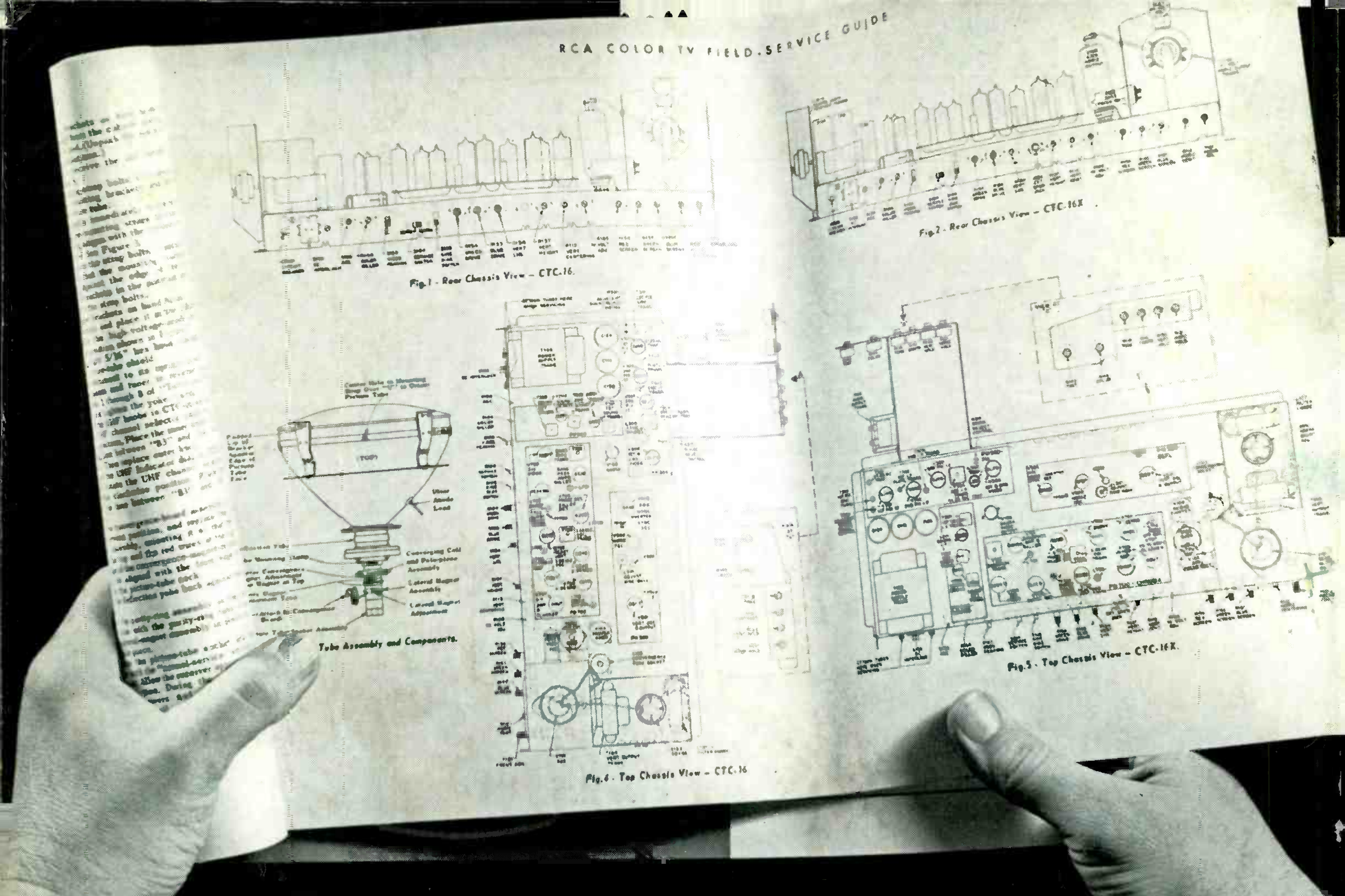

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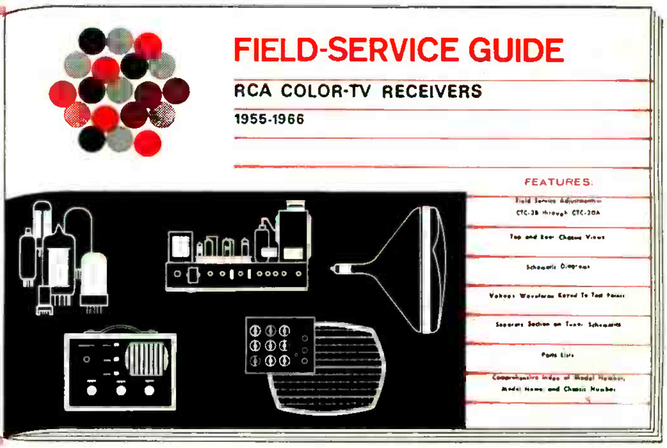

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