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Radio-Electronics

TELEVISI[ON]

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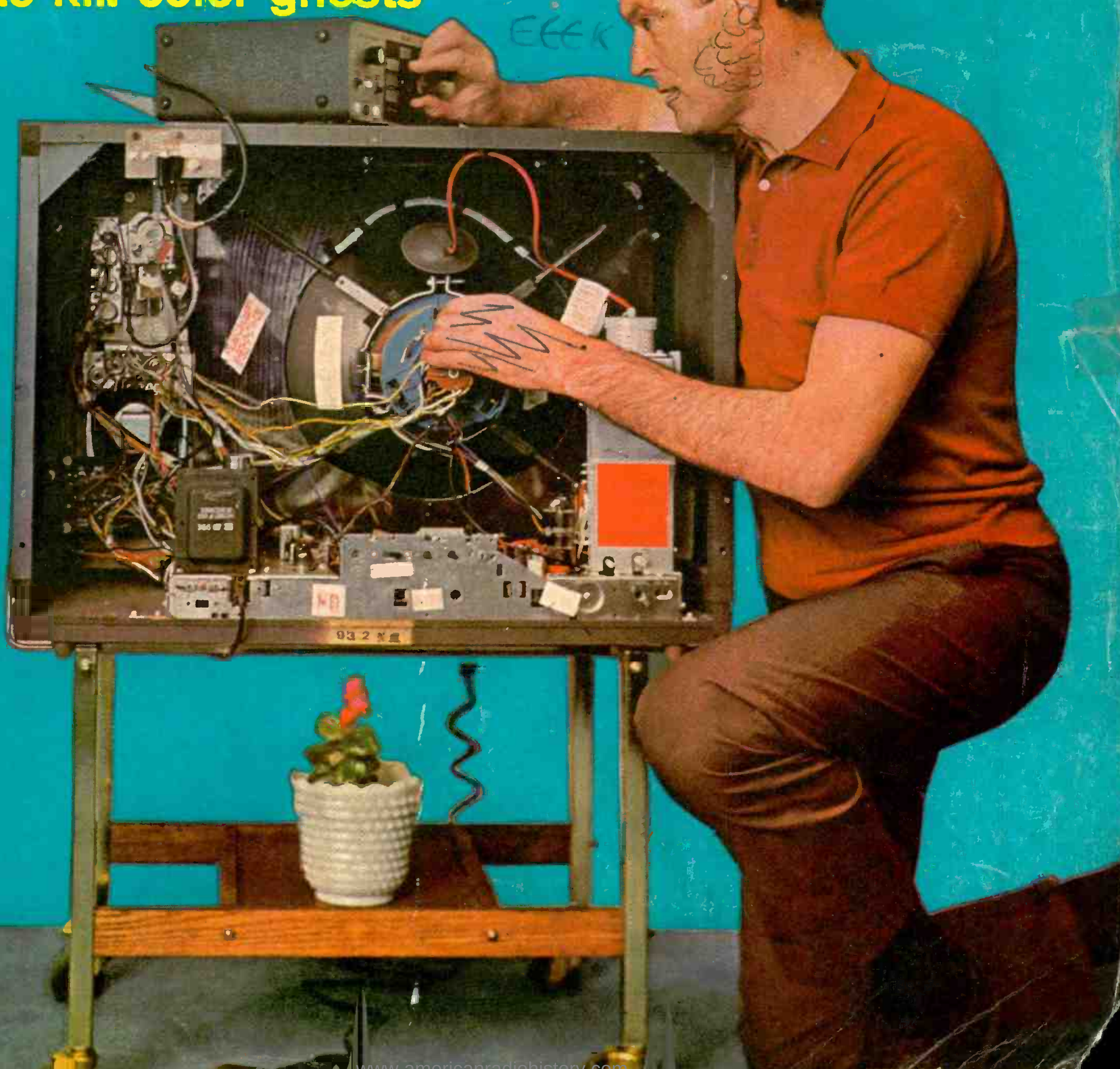
FIFTH ANNUAL COLOR TV ISSUE

How to fix intermittent color TV sets

ABC's of color purity

How to kill color ghosts



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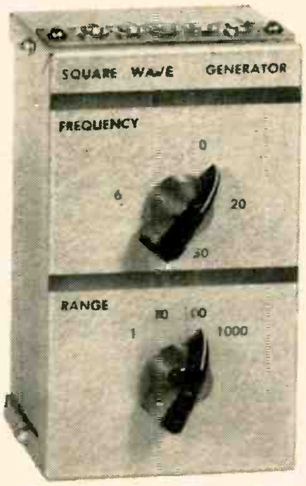

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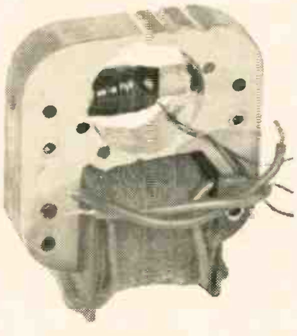

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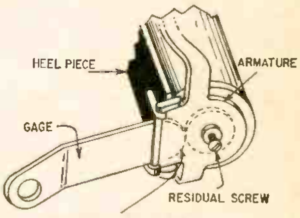
COVER FEATURE

Today's color-TV set is better than ever but requires specific skills to keep in tip-top shape. Starting on page 34 you can read about the foundation for color setup—purity adjustments. Then, on page 36, learn about the critical high-voltage regulator circuit.



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NEWS BRIEFS

ATTACHE CASE TELEPHONE

Perhaps the first fully portable radiotelephone fits inside an ordinary attaché case, yet enables the user to place a phone call from many locations where a land line isn't available.

Made by Carry Phone Corp., the new transceiver uses duplex operation, has 25 watts of output power and a receiver sensitivity of 0.3 μV, operating in the 147–174-MHz band. Normally the transceiver is in the "receive" mode, and an incoming call triggers both visual and aural alarms.

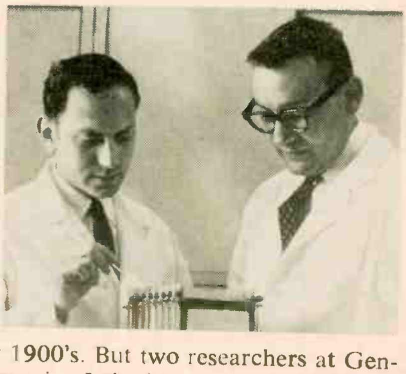
The unit can be used anywhere within range of a mobile telephone station.

TECHNICIAN DEVELOPMENT PROGRAM

One solution to the current widespread shortage of electronics technicians is to encourage new people to enter the field. Now under way is a program to channel youngsters' interests into the electronics industry.

Initiated last fall by the Consumer Products Division of the EIA, the program has been allocated $100,000 for fiscal 1967–68. Among the tactics used are color films, brochures and seminars at high schools and vocational institutions. Members of the program meet with guidance counselors and vocational officials at educational institutions. Efforts are also being made—via radio and TV announcements—to enhance the public image of consumer electronic technicians.

AIR-BREATHING BATTERY



The search goes on for a more efficient chemical battery to eventually power automobiles. Most rechargeable batteries today are lead-acid cells, a type which has nearly replaced the original iron-electrode Edison cell of the early 1900's. But two researchers at General Telephone & Electronics Labs have gone back to the iron electrode to devise a battery that promises greater efficiency per pound than conventional cells.

The battery (see photo) uses a porous iron anode together with state-of-the-art air depolarized cathodes which "breathe" atmospheric air somewhat like fuel cells. An alkaline electrolyte is used between anode and cathodes. The battery promises to remove the weight handicap which has limited battery-powered electric vehicles until now. It also would have extensive application in portable TV and radio receivers and space equipment. **R-E**

Correspondence

TRANSISTOR PLOTTER

I have just finished reading the article by Mr. John Fasal about the construction of the Transistor Characteristic Plotter (September, 1967). He has devised a very novel method of displaying a complete family of curves, but the circuit needs some modification before it will present an undistorted plot. The scope hook-up that Mr. Fasal advocates does not give collector to emitter voltage (V_{CE}) on the horizontal input. It gives V_{CE} plus the voltage drop across the emitter resistor. This gives a rather bad distortion to the plot and will make a high quality transistor appear to be quite poor. Every point on the family of curves will be shifted to the right by the product of I_C and R_E. For example, the average curves for a Motorola 2N2957 shows that when $I_C = 50$ mA and $I_B = 400$ μA, V_{CE} will be 0.8 volts. Mr. Fasal's circuit would indicate that $V_{CE} = 0.8 + 200 \times .05$ or 10.8 volts for the same values of I_C and I_B. This is due to the 200-ohm emitter resistor. This fault in the circuit can be overcome simply by reversing the scope's common and vertical connections across the emitter resistor. Now the data on the scope is correctly presented, but it is inverted about the horizontal axis and is upside down. The vertical polarity switch on the scope can be switched to put the trace on its most common position, or with a little re-orientation the graph can be read in its inverted position.

JOHN BRUCKER
Sr. Equip. Engr.
Motorola Semiconductor
Phoenix, Ariz.

ARTICLES FOR R-E

I am interested in submitting a number of articles for publication. I would appreciate full information on the required format and types of articles you are looking for.

ODO HERGENHAN
Address?

We have an author's guide to send you, Odo, but you failed to show your address in your letter. Won't you please
(continued on page 12)

Radio-Electronics

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CORRESPONDENCE
(continued from page 6)

write again? We welcome construction and service articles as well as state-of-the-art reports. Don't worry about format . . . if you will double-space your copy our editors will do the rest.

IMAGINARY NUMBERS CONTINUED

"Imaginary Numbers Are a Cinch," by Norman H. Crowhurst, was really a cinch as far as it went, but where is the rest of the article? When is the rest of it to be printed, anyway? Please don't forget or abandon it. It sure was an easy way to understand that "-1" math.

M. E. OVERSTREET
Oklahoma City, Okla.

See page 57 for Part II. Part III is scheduled for the February issue. Normally, a 2 or 3 part article will be published in consecutive issues. However, for the sake of timeliness, as well as for providing a balanced assortment of articles of interest to most, certain articles are given precedence even if it breaks into a serial type presentation.

MIXER-AMPLIFIER PROJECT

The "Build An All-Transistor Mixer-Amplifier" by Harvey Inman (August, 1967) seems to be a perfect answer for mixing signals for home movie dubbing. What is the input impedence? Can microphones with 150-ohm or 100,000-ohm impedance be used? Can I feed a record player into this unit? I enjoy your magazine very much. You always seem to come up with new ideas which are not only instructive but usually highly practical.

DR. PIERRE GRAVEL
Montreal, Canada

The input impedance to the mixer-amplifier is designed with low impedance microphones in mind in the range between 150 and 50 ohms, as are usually used in broadcast work. Exact input impedance will vary a little with the gain of the transistor used in the input stage, but it would probably be between 2000 and 3000 ohms. You can go up to a source impedance of 600 ohms. You should use a matching transformer to go higher. You can feed a phono output into the mixer-amplifier. If the cartridge puts out a voltage on the order of 1 volt or more, you can first put a 1000-ohm resistor across the input, then put 1-megohm resistor in series with the ungrounded lead from the cartridge, forming a voltage divider. This will give you a fair load for a crystal type phono cartridge and at the same time supply

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UHF SIGNAL WEAK	CS-U2 $14.95	CS-A2 $22.95	CS-B3 $49.95	CS-C3 $59.95	CS-D3 $69.95
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about the correct input signal level to the amplifier. If you use a magnetic type cartridge, you need an equalized pre-amplifier. The preamp puts out about as much signal as a crystal cartridge and it should work into the same voltage divider.

EICO CONSTRUCTION MANUAL

Would you please inform me where I could obtain the construction manual for the Eico 324 Rf Signal Generator. I wrote to the manufacturer and I didn't get an answer.

DENNETT AYLING
Merrickville, Ont. Canada

Eico has just moved to new and more modern quarters. Their new address is 283 Malta Street, Brooklyn, N. Y. 11207

AMATEUR ELECTRONICS CLUB (NOT NECESSARILY HAMS)

I am enclosing herewith a copy of our sixth newsletter which has been completely redesigned, and I hope that you will find it of interest. As we have members in the USA who joined us because of the letter you published from me (January, 1967) it is apparent that the aims of the British Amateur Electronics Club (B.A.E.C.) are of interest to all those interested in electronics as a hobby wherever they may live. I am looking forward to hearing from you in due course, and would like to thank you for the interest shown in the B.A.E.C. by publishing my letter earlier this year.

CYRIL BOGOD
Great Britain

C.B., your newsletter looks good, is very interesting and is recommended reading. Do you wish to send your newsletter to interested persons in other parts of the world? If so, what does one have to do to get on your mailing list?

SQUARE POWER . . . WITH JACK

In your solution to the problem described "In the Shop . . . With Jack", (October, 1967), I think you erred. If you step up the audio voltage to 100.5 as described, the current would be reduced to a smaller value then 0.54 amp; it would be reduced to about 0.29 amp. You used a formula $P = I^2E$. This can't be right.

W. MCDONALD
Redwood City, Calif.

You are correct, W.M., but don't blame Jack. One of the editors is eating square "PIE." **R-E**

In the Shop . . . With Jack

By JACK DARR

"HIGH-VOLTAGE TROUBLE" OR VIDEO AMPLIFIERS

RASTER BLOOMING? POOR FOCUS? NO raster at all? These symptoms can be caused by troubles in the high-voltage supply, focus rectifier, color demodulators or boosted-boost. Also, they can all have a common cause—the video amplifiers.

In the standard color TV video circuit, the video (or Y) amplifiers are direct-coupled to the picture-tube cathodes (Fig. 1). Therefore, video amplifier *plate* voltage is the CRT cathode *bias* voltage. So, the amplifier plate-current drain determines the voltage drop across the load resistor (5600 ohms) in Fig. 1. This sets the CRT cathode voltage.

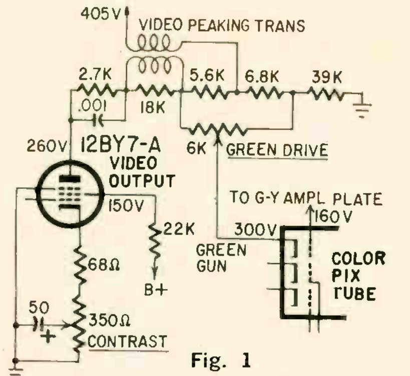

Fig. 1

Voltages shown are from a schematic; in actual sets, you'll find variations, depending on control settings. Still, it takes about a 120-volt difference, measured between the CRT cathode and grid, to cut the picture tube off.

Let's check out a typical case. An RCA CTC16XL came in with the complaint, "The brightness and contrast controls won't work. The raster won't go out." The picture tube was checked for heater–cathode shorts, and found okay. The screen controls and CRT bias were turned full on. Resetting these, with the SERVICE switch thrown to SERVICE, gave a normal action. When the switch was flipped back to NORMAL, no raster. Neither brightness nor contrast control would make the screen light up. High voltage was normal, and the high-voltage regulator action okay.

The video amplifier plate read almost 400 volts instead of the 260 shown on the schematic (Fig. 1, yet). Screen grid voltage was 250; normal, 150. Tube good, control grid about +5 volts. Brightness and contrast controls had no effect on any of these voltages.

From the voltage drops, or the *lack* of them, the tube was obviously drawing no current at all. The cathode circuit was checked, and found completely open. The contrast control was open near the ground end.

In this and many others like it, the cathode circuit goes "straight through"; there is no resistance variation. Control of contrast is done by varying the amount of degeneration in the circuit, by moving the 50-μF electrolytic from the top to the bottom of the 350-ohm resistor. We could bring the picture back, by grounding the slider of the control with a clip jumper.

With the cathode open, the 12BY7 drew no current at all and its plate voltage jumped to the supply value. This in turn put a high positive voltage on the CRT cathodes. This is the same as putting a high negative voltage on the grids, and the picture tube simply cut off.

The raster was visible when the set first came in simply because someone had turned the screen and bias controls up far enough to override the normal bias. There was no "picture" information on the screen, of course, because the video output stage was blocked—dead, as far as any signal-amplification was concerned.

For a case with an opposite reaction, take the old CTC7AA RCA chassis. This uses the same basic circuit, but without the SERVICE switch, CRT bias control, and so on. This one suddenly

(continued on page 22)

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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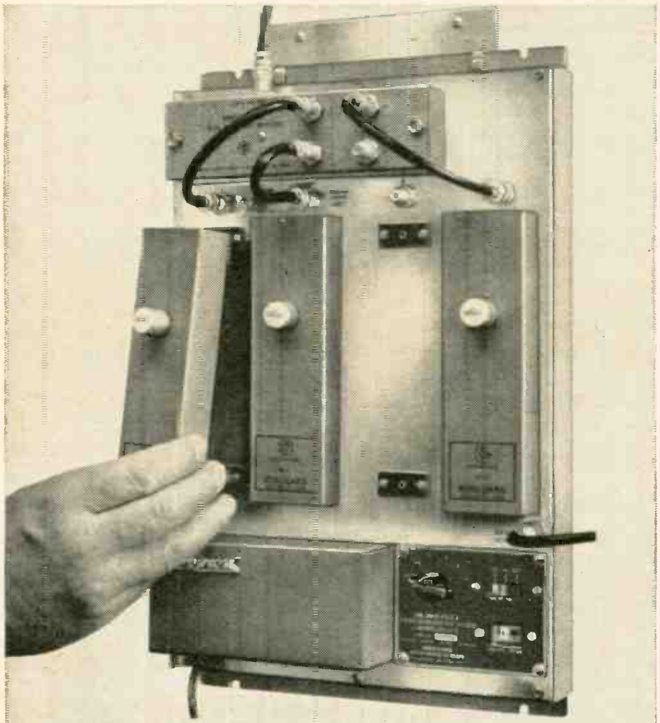

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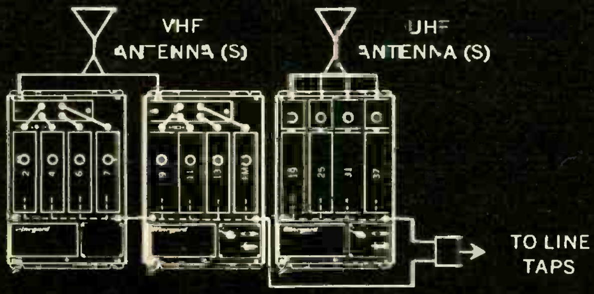

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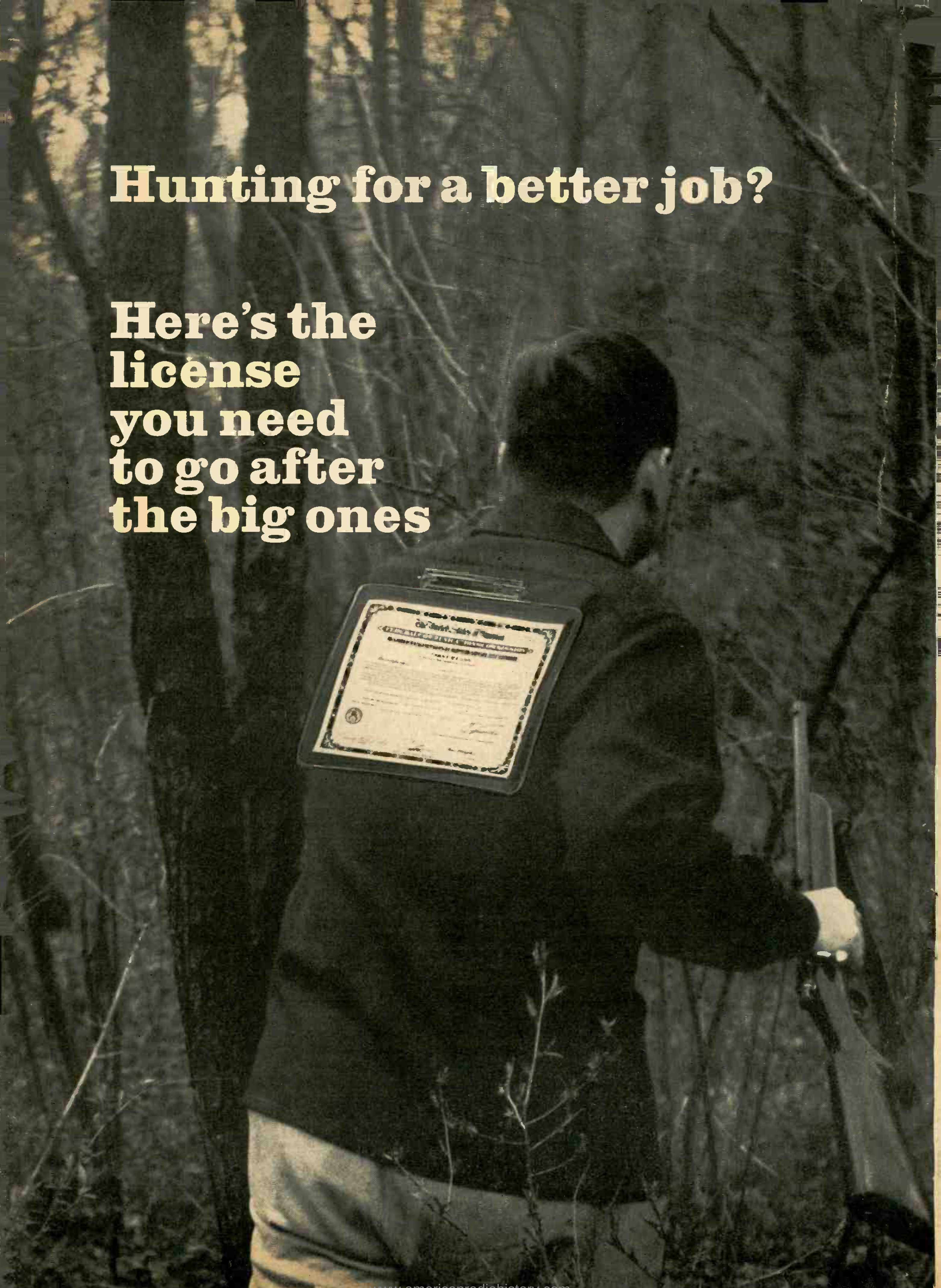

Hunting for a better job?
Here's the license you need to go after the big ones

In the Shop . . . With Jack
(continued from page 16)

went pink, lost focus and bloomed very badly.

The 12BY7 video output tube was shorted and drew *high* current; the plate voltage went down (less positive), which brought the CRT cathode voltages nearer to the control-grid voltages. In other words, closer to *zero bias*, producing maximum conduction.

In old chassis like this you can duplicate the condition by turning the brightness control full on. Note that you get a very bright, slightly bloomed and defocused picture, which is usually pinkish.

There's a good quick check for this kind of trouble. Just pull the video output tube. The normal reaction is for the raster to go out. (The plate voltage goes up, more positive, with no load, and the CRT *should* cut off. If it does not, then you've probably got a shorted CRT.) In some cases, you can bring back a one-color raster by turning up the screen control, as a quick check.

The best "final test," of course, is tube substitution. If the raster comes back, you won't have to go into the high-voltage regulator and rectifier, and so on.

If the tubes are all good, and you still have trouble, check the bias voltages on the video amplifiers. In the typical color set, you'll find blanker amplifiers and other stages connected in the same circuit as the video amplifiers. Most of these work in the grid circuits. One instance (Fig. 2): The grid circuit of the output tube is connected through the brightness control, to the grid of the blanker tube. Any trouble in *this* circuit can cause incorrect bias to be applied to the video amplifier, and away we go again.

The blanker-amplifier plate also goes to the CRT cathodes and other parts, not shown. Therefore, this tube too can affect the CRT bias if anything happens to it. The blanker grid circuit eventually winds up at the −56-volt control grid of the 6JE6 horizontal output tube. This negative voltage is actually a part of the "supply circuit" for the blanker grid! So, don't forget to check *all* these things if you run into oddball troubles in this circuit.

Remember, when you see an odd symptom such as we've described—the cause doesn't *have* to be in the high-voltage supply, the picture tube and so on. (Incidentally, remember that real CRT troubles usually show up as "one-color" symptoms; the symptoms you'll find here are very obviously "all-colors.") You will find trouble in those circuits, just as we have for the last ten years. But remember that the video amplifier(s) can show practically the same effects, with what looks like identical symptoms; no raster, etc. Video trouble is a lot easier to fix and you don't have to mess around with those high voltages!

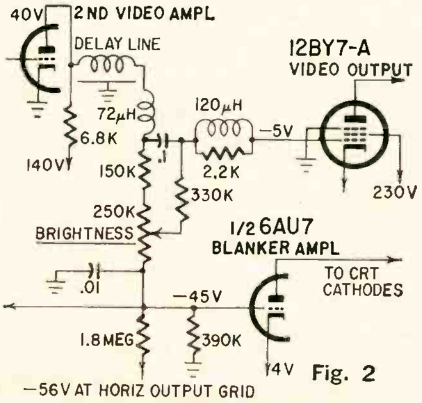


Fig. 2

TV field strength

What's the average field strength of a TV signal, at about 100 miles from the station?—B.L., Baudette, Minn.

Some time ago, I assisted in making some field-strength measurements of a channel-6 station. We used a resonant-dipole antenna and an accurate field-strength meter. At a location approximately 100 miles from the transmitter, we got a resounding 6 μV! This reading was taken with the antenna two wavelengths above ground.

However, at the same location, on a large deep-fringe area antenna, equipped with a booster, we read almost 400 μV at the TV receiver! This antenna was on a 30-foot tower and the booster stepped up the signal voltage, of course.

From a channel-5 station at the same location, we got 15 μV at the antenna. We used the channel-6 dipole, but there wouldn't be too much difference.

There are so many variables in terrain, atmospheric conditions, station antenna height and power, that there is no practical way to predict field strength at any location on a given day. There's only one sure way to find out: Go there and measure it!

Color but no screens

I've got a Zenith 24NC31Z color chassis in the shop, and the blasted screen controls won't work! I set the Service switch to "service," and the raster goes out; can't get a line at all; bias control

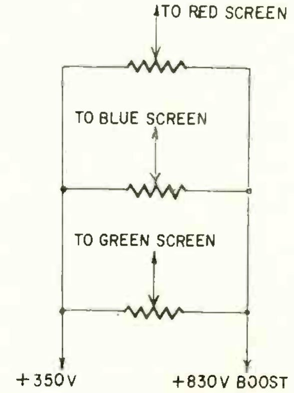

6JE6C

In the Shop . . . With Jack
(*continued from page 22*)

all the way up, etc. With a picture, the screen controls have no effect!

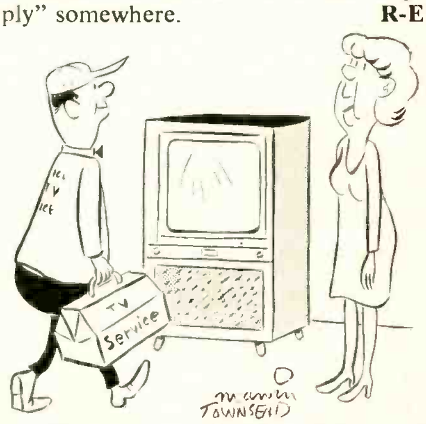
What wipes me out is that the picture is good, both in b-w and color! High voltage is okay, and all that. It beats me!—J.G., Grand Rapids, Mich.

Beats me, too! However, a crystal-ball diagnosis would seem to say that while there *must* be something open in the screen-control circuits, the screens of the CRT have very near the right voltages! They'd have to, if the set's working this well.



The diagram shows the screen supply circuit. Note that the controls are connected between B+ (350 volts) and boost (830 volts). One of these connections must be open; it is most apt to be the B+ 350-volt end, since the normal operating voltage on the three screens is up around 590–640. You couldn't get that from the B+; it'd have to come from the boost.

Because the cathode and grid bias voltages are variable, it is possible to get a raster on the tube. If your screen voltage was *low*, it wouldn't. Therefore, your screens must be (accidentally) somewhere very close to the right value. But the complete circuit from boost to B+ must be open somewhere so that the controls have no effect. Since this affects all three screen controls, it'll have to be in the "supply" somewhere. **R-E**



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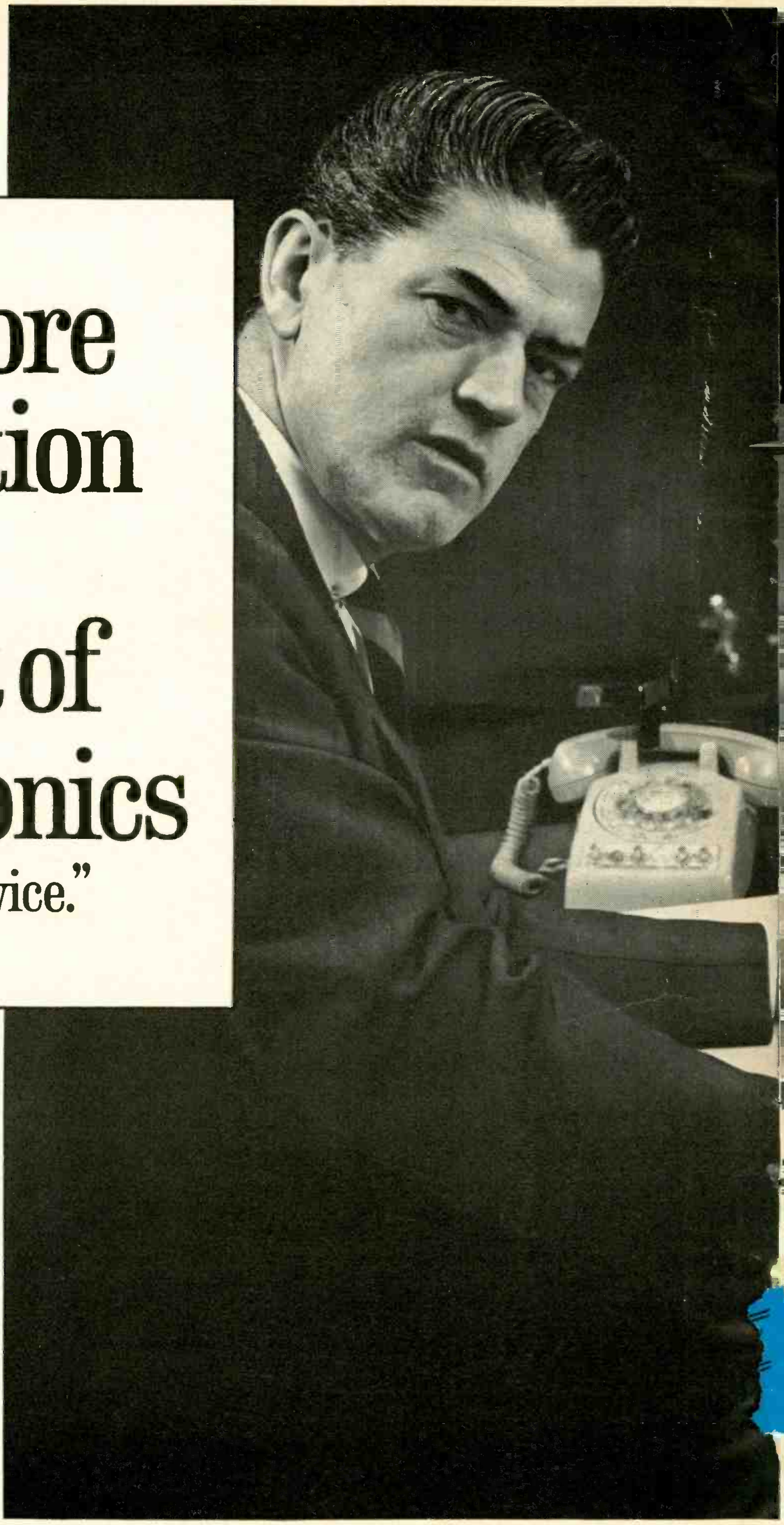

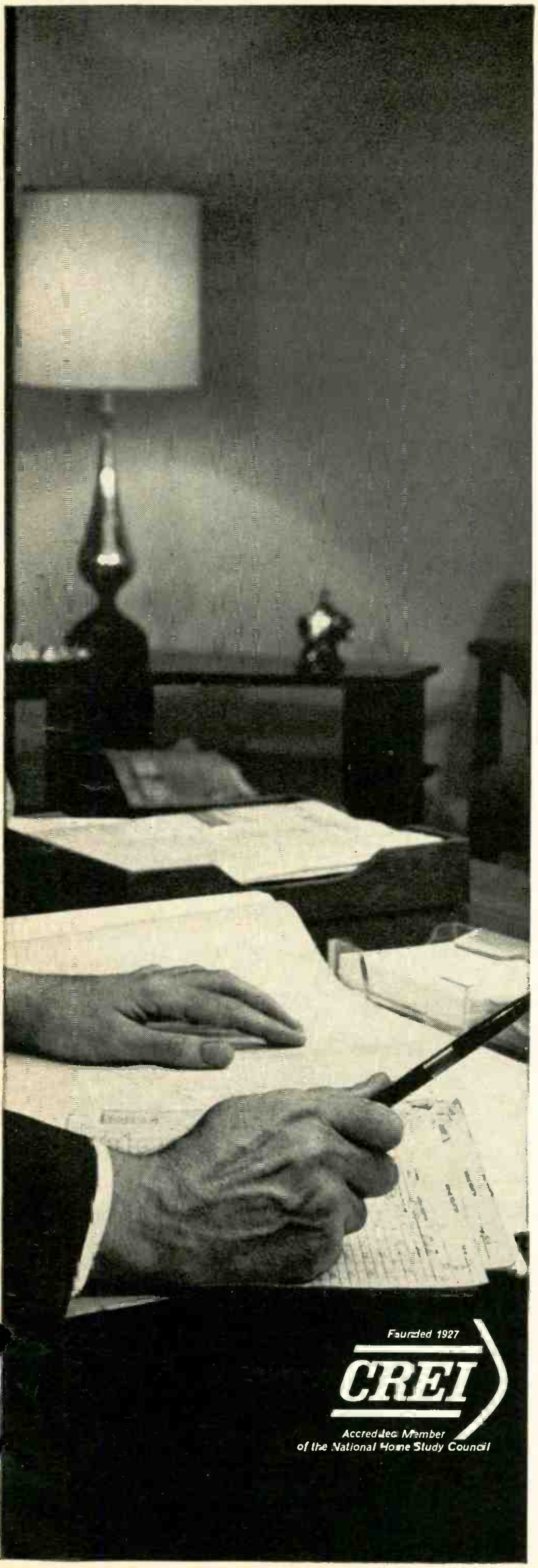

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HOW TO KILL COLOR GHOSTS

Tolerable ghosts on black-and-white TV sets can set up intolerable color problems which cause color shift and fringing By LON CANTOR

AS COLOR TV HAS COME OF AGE IT HAS put the spotlight on one of our most perplexing reception problems—multiple images. Ghosts mildly annoying in black-and-white are usually intolerable in color. And they're simple to avoid if you know how.

In general, any one or all of three things can cause ghosts: multipath reception, standing waves on the lead-in, and nonuniform frequency response somewhere in the system. All distort the signal; otherwise they are different phenomena.

Multipath reception

When signals leave the TV transmitter, they travel in all directions. In addition to a direct signal, a receiving antenna therefore often picks up a reflected signal (Fig. 1).

Since the reflected signal travels a longer distance to the receiver, it arrives a split second after the direct signal. Because TV signals travel at 186,000 miles per second, you might think that a slightly longer path would make no difference. But, remember, the horizontal oscillator is sweeping the electron beams across the face of the picture tube pretty rapidly, too. The linear velocity of the scanning spot sweeping a 23-inch picture tube, for instance, is approximately 350,000 inches per second. Therefore, a reflected signal path only 1,000 feet longer than the direct path can cause an image displacement of nearly ½ inch on the TV screen.

If the reflected signal is relatively weak, the ghost will be very faint, perhaps hardly noticeable on a b-w receiver. Your eye can tolerate a certain amount of fuzziness, if there's only a change in contrast. But color is a different story.

The most striking characteristic about color TV is color difference. A girl in a white dress against a black background (b-w) may make a pretty scene. But view that same girl in a red dress against a blue background color and you immediately notice a vividness, a near reality. This lifelike quality is what makes color TV so fascinating and entertaining.

Unfortunately, a small ghost can wreck that beautiful picture. Assume you're watching a ghosted color TV picture of a red chimney against a blue sky (Fig. 2). As you can see, the reflected signal is displaced to the right of the direct signal. Thus, the red and blue overlap at the leading and trailing edges of the chimney. These edges are a mixture of blue and red, producing a color that isn't a part of the transmitted picture. The result? The picture looks sloppy.

There is only one way to eliminate color ghosts caused by multipath reception. You need a very directional antenna, properly oriented. Fig. 3 shows the response (at one frequency) of an ordinary bidirectional dipole (A) vs that of a relatively unidirectional antenna. Notice that (B) accepts signals principally from angles between approximately 160° to 200°. In other words, A has a beamwidth of 100° while B has a narrow beamwidth —only 40°. Hence B rejects many multipath signals that A does not.

Of course, beamwidth (or lobe narrowness) depends on the type of antenna. In general, the higher the antenna gain the narrower the lobe.

There are two notable exceptions to this generalization. First some high-

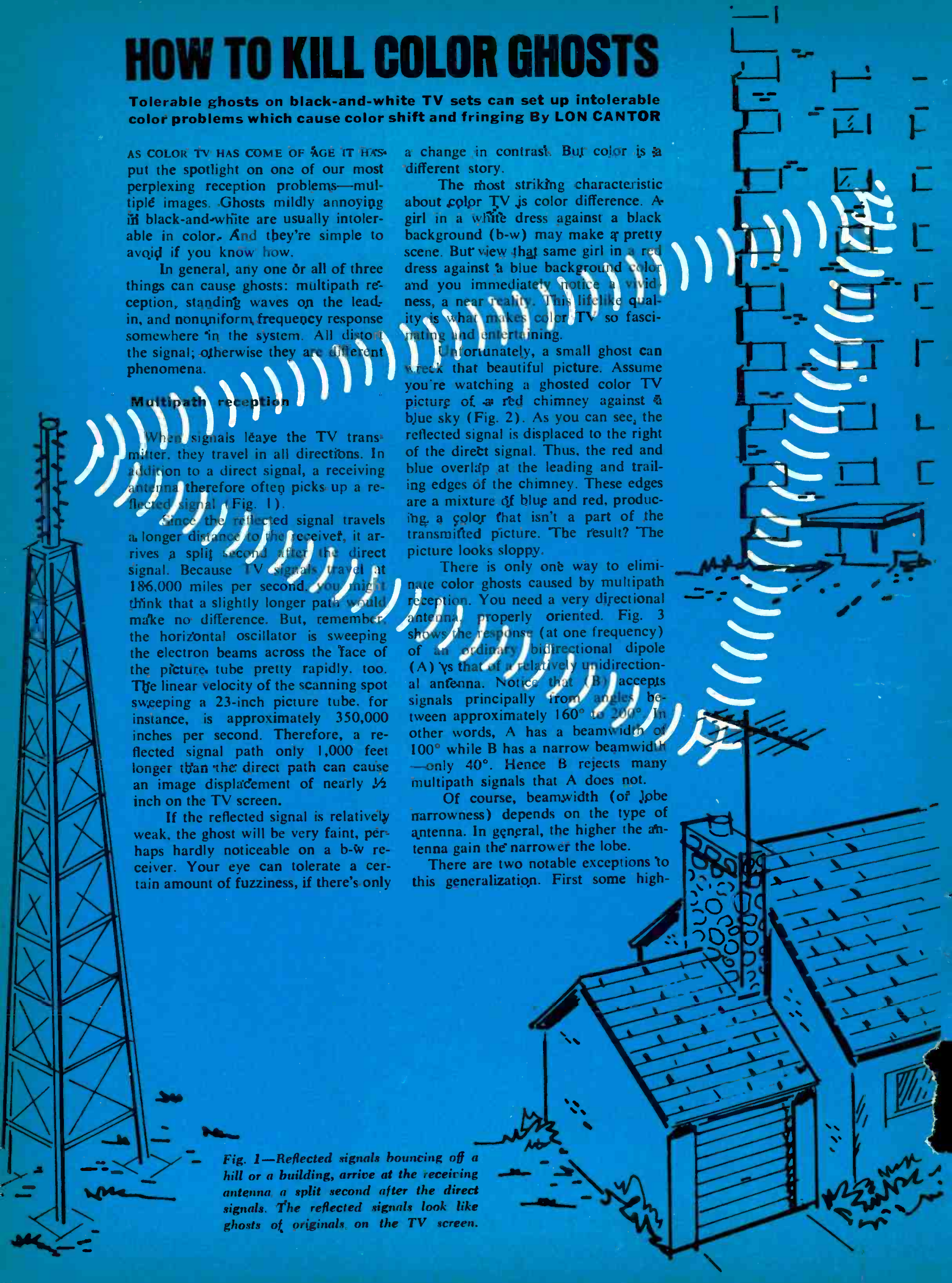


Fig. 1—Reflected signals bouncing off a hill or a building, arrive at the receiving antenna a split second after the direct signals. The reflected signals look like ghosts of originals on the TV screen.

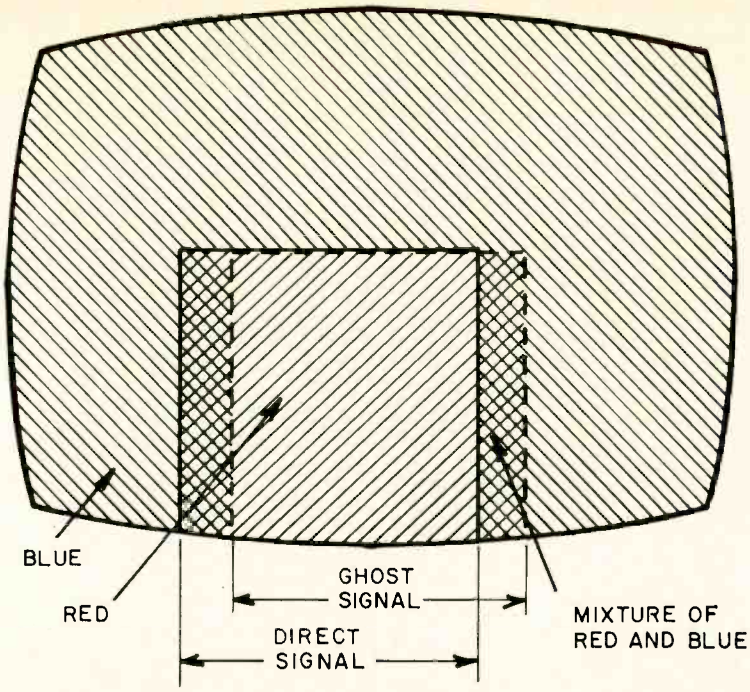


Fig. 2—In a color CRT, a ghost not only blurs the image, it produces new colors. Blurring red and blue, for instance, produces violet or purple and ruins picture.

gain antennas include very substantial side lobes. Naturally, these aren't too effective at eliminating ghosts. Second, a new type of low-gain antenna has recently been developed for metropolitan areas. Such an antenna uses two folded-dipole radiators with a special phasing harness to achieve an excellent front-to-back ratio. Because they are less expensive than high-gain antennas, they are preferred in strong-signal areas—where ghosts are most likely to be prevalent.

Really persistent ghosts can often be eliminated by stacking antennas horizontally. This simply means adding more elements side by side, to narrow the beamwidth still more. (Stacking antennas vertically increases gain, but doesn't usually reduce multipath pickup.)

Lead-in ghosts

If there's a line mismatch anywhere between the antenna and the TV set, ghosts are caused. This is easy to demonstrate: Tune in a clear color picture on a color TV receiver. Connect a 6-foot stub of lead-in to the antenna terminals. Then snip off the wire a few inches at a time. You'll see color changes and perhaps even snow and ghosts at a certain length of lead-in. You have made a trap with the lead-in stub, by cutting it to a certain length and causing standing waves.

These standing waves can also be caused by standoff insulators and staples. The point at which a standoff insulator encircles the lead-in is actually a point of mismatch; the wire pair no longer has 300 ohms of impedance. The same is true for the point at which a staple pierces the lead-in, or where the wire gets wet or coated with smog.

Remember the law that says maximum transfer of energy is possible only when impedances are matched? The signal traveling down the lead-in (called the *incident* wave, or wave leaving the source) sees mismatch points as *lumps* (points of a change in line impedance). Not all the signal energy goes through each lump; some reverses direction and becomes a *reflected* wave. (The reflected wave goes back toward the source, or antenna.)

Standing waves are produced when incident waves meet reflected waves in passing. Both move, but they always cross at the same points (Fig. 5-a). Thus, the resulting pattern, formed by addition and cancellation of signal voltages, is stationary, or standing (Fig. 5-b).

Of course, the reflected signals in standing waves eventually reach the receiver antenna terminals, but a little late. Since the time delay is short and the reflected signal is generally weak, you don't generally see a distinct ghost. (In severe cases, however, you can see ringing or multiple ghosts across the face screen.) Usually, you simply see indistinct smears.

In black-and-white pictures, these smears are almost invisible. But reflected signals are not only delayed in time, but shifted in phase. Also, the color subcarrier, unlike the sound or picture carriers, is detected in phase. Thus, the reflected signal causes a very annoying color change around the picture edges.

Uneven frequency response

When colors aren't true or shift in hue when they shouldn't, the cause is often frequency ghosting. Although nonuniform response anywhere in the system can cause such ghosts, the trouble is usually up on the roof. An antenna designed for black-and-white reception has usually been peaked for maximum gain. The "area special," in particular, is tuned to one or two spe-

continued on page 94

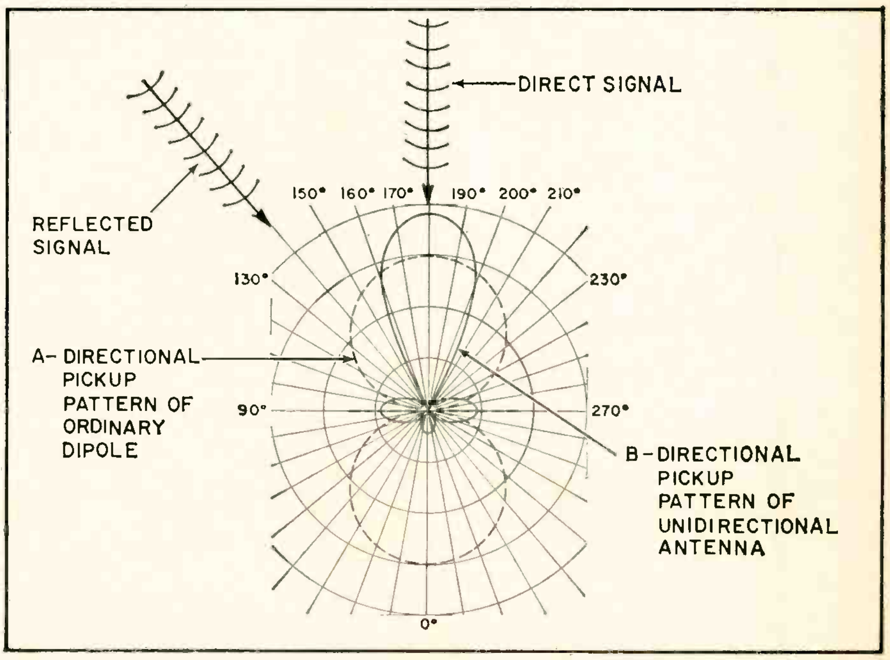
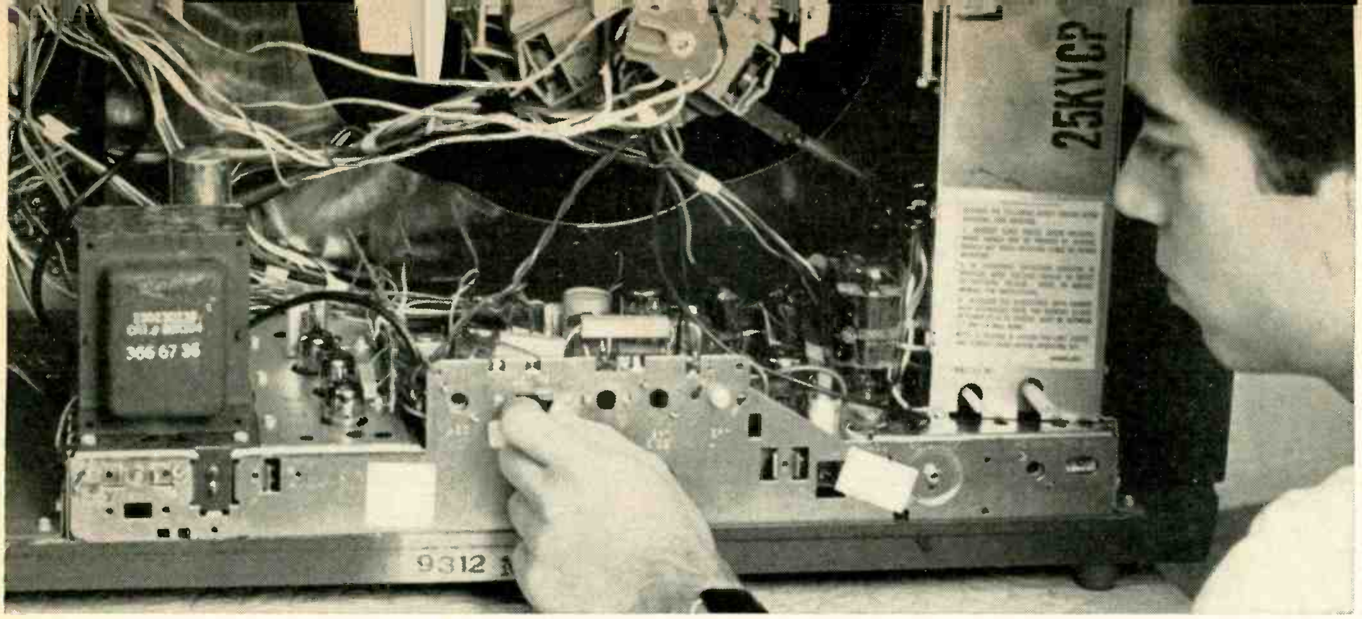


Fig. 3—The common dipole (A) isn't much good at avoiding multipath reception. Unidirectional antenna (B) is generally sensitive principally to the desired TV signal.



ABC's of Color Purity

Purity is virtuous; or, not all troubles are due to defective components

By WAYNE LEMONS

A VITAL, BASIC COLOR TV ADJUSTMENT—that's purity. It outranks convergence (though there is certainly a great deal of interaction between the two), as well as linearity, high voltage, height and width.

People may tolerate a red, green or blue outline around a picture caused by poor convergence, since it is not so noticeable on color pictures. They'll indulge a pointed head or dwarfed legs, and even overlook slight defocusing or some loss of width. But it takes a rare bird indeed to ignore his favorite girl dancer if she has one chartreuse and one pink leg. And nobody likes to have the face of his favorite comedian change from blushing pink through bruised blue or gruesome green as he moves across the screen.

The cause of these effects? Poor purity. The fellow who wrote: "I never saw a purple cow and never hope to see one . . ." could easily be in for a jolt if his new color set were not properly adjusted for best purity.

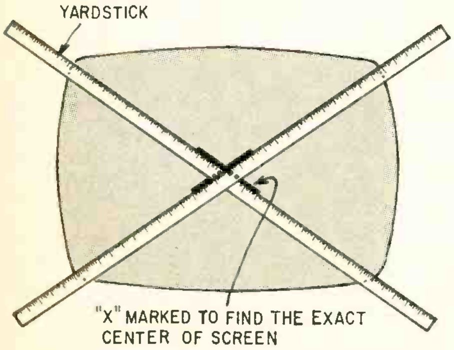


Fig. 1—You must adjust the purity tabs to center the red "fireball" on the CRT screen. Locate the screen's center with a yardstick and mark with a soft crayon.

Good purity means, of course, that with only the *red* gun on (BLUE and GREEN SCREEN controls turned down) the CRT screen is *totally* red. (Blue and green fields should also be pure but they normally will be if the red field is.)

Setup techniques

The test for purity needs a blank raster with no video. You can remove the video by pulling an i.f. tube; on some sets a third position on the service switch provides a "Purity" or "Raster" position.

Color bar/dot generators can be used to blank the screen for purity adjustments. Some generators have a position which provides only rf without modulation. If your generator has no such position you can use the dot function and just ignore the dots.

After getting a blank screen by whatever method, turn down the BLUE and GREEN SCREEN controls, leaving only RED turned on. If anywhere on the picture tube face there is any other color except red, even patches of pink, then purity adjustments are needed.

What's first? Degauss . . . degauss . . . degauss! Don't be skimpy about it. Take two or three minutes. Go over the face of the tube . . . under the chassis . . . around the sides of the chassis . . . even inside the cabinet. *Special notes:* Don't depend on automatic degaussers to demagnetize the set! They are designed to *keep* the colors pure, not to *make* them pure.

Something else: degaussing may appear to make impurities worse. That's especially true if someone has tried to set the purity earlier without first degaussing.

Once you are sure that degaussing is complete, move the degaussing coil away from the set as far as possible and then turn it off. Remember that a collapsing ac field is dc! And this dc can "set" an impurity sometimes hard to remove. So get the coil away from the set before you kill the ac.

If you still have impurity after degaussing, see if the off-color areas are near the outer edges of the raster. If so, all that may be necessary is a slight adjustment (forward or backward) of the deflection yoke to clean up the raster satisfactorily.

If this fails, however, you have to go further and do the complete purity-adjustment procedure:

1. Pull the deflection yoke back against the convergence yoke. This will

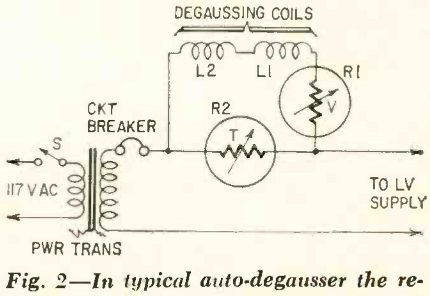


Fig. 2—In typical auto-degausser the resistance of varistor R1 rises sharply and thermistor R2's resistance drops a few seconds after the power has been applied.

leave the screen badly out of purity but there should be a rather large red "fireball" splotch somewhere near the center of the screen.

2. Adjust the purity ring tabs, by spreading them apart or pushing them closer together. Or rotate both rings until the fireball is centered. And this means as near exactly center as you can get it. Use a measuring stick and mark the exact center if necessary. (See Fig. 1—and don't think that you can't be deceived about the screen center, especially on large rectangular tubes.)
3. With the fireball centered, move the deflection yoke forward until the raster is pure. (On most sets the yoke will not be all the way against the bell of the CRT.)

That's all there is to it, *unless* you still don't have good purity. If you don't, go through the adjustments again—starting with another *thorough* degaussing.

Still impure? Check the convergence adjustments. They don't have to be perfect but if they are too far off you won't be able to get purity. Use a crosshatch and rough in both the dc (static) and dynamic adjustments. Then go through the purity adjustments again.

Changing purity problems

Moving a set may upset purity. (This is more critical, of course, on old chassis than on new ones.)

Turning a set over on its side for service will just about always upset the purity, often so severely that you can't even get color or, at best, only washed-out color. The cure: degaussing.

Any electrical device that uses a motor, transformer or other changing magnetic field can cause impurities if operated near a color set. Rotator controls, some clocks and other electrically operated equipment should not be placed on top of a color set.

The lady of the house should be cautioned not to turn off her electric vacuum cleaner under the TV set though it is perfectly okay to use the cleaner if she keeps it running.

Circuit troubles

Fig. 2 is a typical automatic degaussing circuit. The degaussing coils utilize the initial charging current of the power-supply filter capacitors to supply a strong ac magnetic field.

Before you do any setup adjustments in a color-TV set, always degauss the CRT, chassis and cabinet if it is metal.

When the set is first turned on, thermistor R2's resistance is high (about 120 ohms) and about 60 volts ac appears across the degaussing coils (L1 and L2) and the varistor (voltage-sensitive resistor R1) in series. The resistance of R1 drops and about 2 amps flows in the circuit. Current through R2 heats it, causing its resistance to drop and reduce the voltage applied to the coils and R1. The varistor's resistance increases as the thermistor's resistance decreases. Within a matter of seconds, the power in the degaussing coils drops from a maximum of 60 volts at 2 amps to around 1 volt at 0.5 mA.

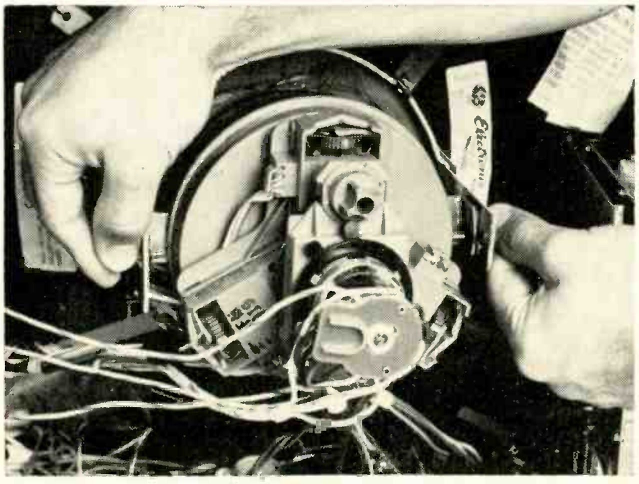
Either of these resistors can fail to reduce the automatic degaussing field sufficiently, in which case they should be replaced. The usual symptom is a weaving or bending picture which you may at first suspect as sync or filter trouble. To check, simply short across the coils or unplug them. If the bending stops, either (or both), R1 or R2 is probably defective.

On sets with automatic degaussing and bridge rectifiers in the power supply, a misleading symptom sometimes happens. The set is always impure when turned on. This impurity can be removed with an external degaussing coil; the set will then stay pure until turned off and back on again. If you have this trouble look also for insufficient width or just barely enough width. The cause is probably a defective silicon rectifier in the power supply.

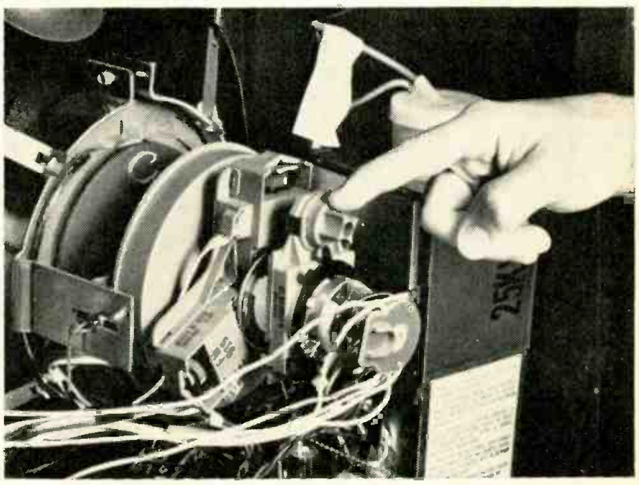
One thing you should keep in mind is the *post purity* adjustment used in some Zenith models. These sets have the purity rings in *front* of the deflection yoke. Because of this you must degauss the CRT *every time* you adjust the purity rings.

One final word—although instruction books often insist that impurity is always noticeable on black-and-white pictures, this may not be true. Sometimes impurities are only discernible by a change in tint of an object in a color picture as it changes position on the screen. So always check the red field for purity by first noting the positions of the BLUE and GREEN SCREEN controls and then turning them down. If purity is good, return the controls to their original positions. It takes just a few seconds and it can save you having to work on the set again.

Something else: Lights—especially fluorescent lights—shining on the CRT face, can make you think the purity is poor at the corner or the edges when it isn't. There is nothing quite so embarrassing as having a customer who knows nothing about electronics say: "I believe that's the light shining on the screen" and be right! **R-E**



Beginning of the purity-adjustment procedure: You must pull the deflection yoke back against the convergence yoke. The screen then becomes impure, but a red "fireball" appears.



Do not make any convergence adjustments until you are satisfied that purity adjustments have been properly made. If convergence adjustments are made, do recheck for proper purity.

High Voltage Shunt Regulators for Modern Color TV Sets

High-voltage power-supply regulation is critical . . . here's how to set it up

By BOB BARKLEY

AMONG THE CRITICAL COLOR CIRCUITS that cause major trouble, the high-voltage regulator is often overlooked. When pictures start blooming, tube and flyback failures may be next. Not only do components fail and cause trouble, regulator misadjustment can also make for poor operation.

Some technicians don't realize how critical proper adjustment is in the power-handling horizontal and high-voltage sections. The horizontal output, damper, HV rectifier and shunt regulator all carry considerable current. If these tubes are operated beyond their design limits, they'll fail before long.

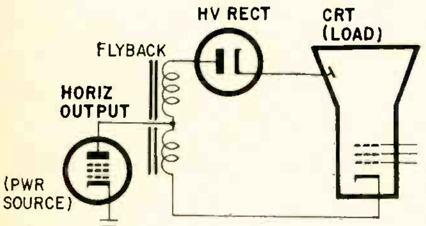


Fig. 1—In any TV receiver, the picture tube is a load across the HV supply.

To understand troubleshooting the shunt-regulator circuit better, it's important to learn why it's needed. Since regulators are seldom used in b-w receivers, a color set must therefore have a special requirement for high-voltage regulation.

HV supply for color

It does; more high voltage (than in b-w) is needed to attract the three electron beams in a color CRT. The beams must penetrate the shadow mask; this requires more "push." Also, since a color tube uses *three* electron beams (rather than one as in b-w) more power is required from the HV supply.

In a b-w set the HV power is a small fraction of the total horizontal-output stage power. Hence even appreciable changes in scene brightness (HV current drain) don't change the voltage value much, since such current changes are small compared to the total load. This means the b-w picture seldom blooms, as the HV is substantially constant.

In a color set, however, the HV power required by the three-gun CRT is much greater—a major portion of the total load. Thus changes in scene brightness (which change electron-beam current) could vary the value of high voltage and cause picture blooming.

The color HV supply is designed to furnish approximately 25 kV at about 750 μA. By Ohm's law, therefore, its internal dc impedance is approximately 33 megohms. A high-impedance supply has inherently poor voltage regulation; it's really a constant-current, variable-voltage source.

To improve regulation and hold the HV potential relatively constant, a shunt-regulator tube is used in color sets. The regulator acts as a variable load across the HV supply.

To illustrate what's been explained so far, Fig. 1 shows a simplified version of the horizontal output and HV circuit in a color set (without a regulator) The circuit can be redrawn as in Fig. 2, showing the horizontal-output stage

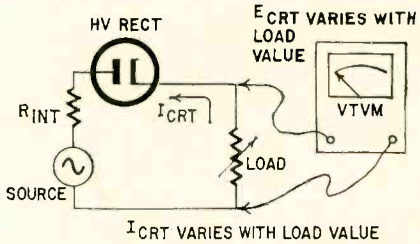


Fig. 2—Voltage output of an unregulated supply varies with resistance of load.

(and flyback) as the source of low-current high voltage, and consequent high internal resistance. The CRT has been replaced by a variable resistor constituting a load on the supply. Note that the high voltage varies with the value of this resistor. (This is another way of representing current variations.) Since the supply can furnish only a constant current value, varying the load causes the voltage across that load to change.

The solution to the problem is shown in Fig. 3; here a shunt regulator consisting of another variable resistor

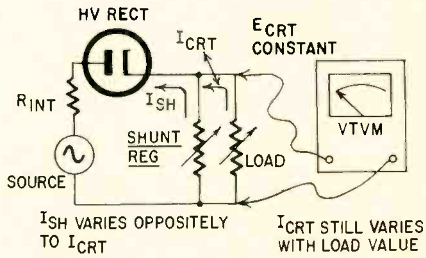


Fig. 3—Changing the shunt resistance compensates for load changes. Result is that voltage across load is constant.

has been added to the circuit. If the load resistance increases, the shunt resistance is decreased until the total resistance is the same as before the load increased. Thus the load voltage remains the same.

Another way of analyzing the situation is to consider current flow. Load (or CRT) current varies with picture (or scene) brightness. Regulator current varies oppositely, to compensate for load variation. Thus total current flow from the source (and through the HV rectifier) remains constant. *So does the high voltage at the CRT.*

The actual regulator and HV circuit is shown in Fig. 4, a partial schematic of an RCA CTC24 chassis. Regulator V102 is connected between the HV bus and the 400-volt B+ bus, which is relatively immune to changes in CRT beam current. A voltage divider (R106A, R106B, R110 and R105) is placed from the boost line to ground, and the grid of the regulator tube fed from a point in the divider.

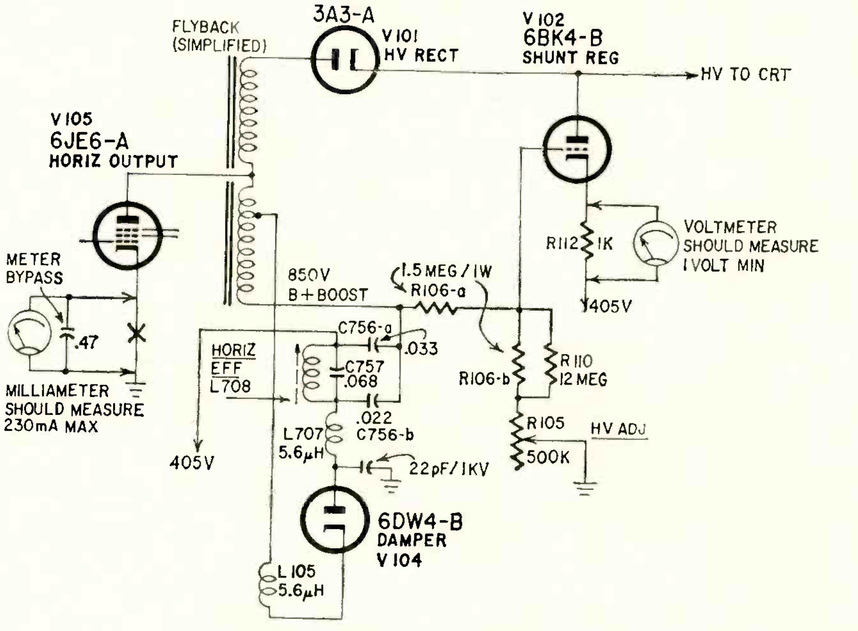


Fig. 4—Partial schematic of RCA CTC24 chassis shows test points for horizontal and HV section. Coil L708 affects current through V105; R105 controls V102.

R105 is adjusted until V102's grid is biased to cause the tube to draw slightly more current than the CRT.

Should the CRT now draw less current, the HV will rise, and so will the boost (because it's derived from the same flyback transformer). When the boost voltage rises, V102's grid voltage also rises, causing the 6BK4-B to conduct more current. This additional load on the HV supply pulls the voltage down to where it was before. Hence the output HV is regulated.

Efficiency-coil function

To shape the current waveform through the yoke properly and produce linear scanning, the entire yoke, flyback and HV circuit is designed as a parallel-resonant circuit at about five times the horizontal scanning frequency, or around 75 kHz. Because of slight component differences from chassis to chassis, an adjustment is provided to set the horizontal output tube to maximum output voltage. This adjustment is usually called HORIZONAL EFFICIENCY (L708 in Fig. 4). It allows fine adjustment of current through the horizontal output tube.

The parallel-resonant circuit formed by the HV components offers high impedance to current flow when tuned to resonance. (In other words, it offers the maximum available voltage drop across it, and maximum HV output.) This high impedance means that minimum current will flow through the horizontal output tube. And this fact makes it easy to adjust the HORIZONTAL EFFICIENCY control. The simplest way is to insert a milliammeter in series with the horizontal output tube cathode, as shown in Fig. 4, and adjust the coil for minimum current.

Setup adjustments

The secret ingredient to proper regulation is that even at *maximum* brightness the CRT current will not equal the regulator current. Regulator current is easily monitored as a voltage drop across a 1000-ohm resistor in the 6BK4-B cathode circuit, where 1 volt equals 1 mA.

Set the various controls like this:

1) **Normal-service raster switch**—Set to SERVICE.
2) **Screens**—Set for a *dim*, white line on the screen.
3) **CRT bias**—Set only to bring up the *least* dominant gun with that gun's screen set at maximum (otherwise set CRT bias *off*—counterclockwise).
4) **Customer brightness control**—Set at 75% to 90% clockwise while adjusting the screens and CRT bias.

Determine the proper value of high voltage for the chassis. (The CTC24 shown in Fig. 4 takes 24 kV.) You must set HV at this value with a black picture screen (in other words, with no current flow to the HV anode). Do this by turning the customer (front-panel) brightness completely counterclockwise. This leaves only V102 conducting, and the 6BK4 current must be a minimum value of 1 mA. Most modern circuits draw from 1 to 1.35 mA through the 6BK4 (1 to 1.35 volts across resistor R112).

The three electron guns in the CRT can then increase their current flow to 330 µA each for a bright picture. This provides more than adequate brightness for normal viewing. If beam current exceeds that through the 6BK4, the regulator loses control. This means the picture blooms. If the controls are properly adjusted, no blooming should occur.

Troubleshooting procedures

In troubleshooting a color HV circuit, the three most important measurements are:

1) **Horizontal-output current**—Dip this reading with the HORIZONTAL EFFICIENCY coil. The maximum reading for a 6JE6 is 230 mA.
2) **Shunt-regulator current**—Monitor as a voltage drop across a 1000-ohm cathode resistor with a black picture. You should have a minimum reading of 1 volt.
3) **Shunt-regulator bias voltage**—Measure this from grid to cathode of the 6BK4. This bias should be about 10 to 25 volts (*not* with respect to ground). But check the schematic of the particular chassis first. The bias is the difference between two source voltages:
   - A. *Cathode*—400-volt B+ supply.
   - B. *Grid*—850-volt boosted B+ via a resistor divider network—the HV ADJ control being one of the resistors.

The *current* through the shunt regulator must be correct and is the first place to start the troubleshooting process.

If the 6BK4 current is too low—less than 1 volt drop across the 1000-ohm cathode resistor:

(continued on page 72)

How To Fix Intermittent Color TV Sets

Learn which circuits to monitor to catch a trouble that comes and goes as it pleases

By MATTHEW MANDL

PRINTED CIRCUITS, MODULES, COMPACTRON tubes, and transistors, have all contributed to the development of color television. The old paper-envelope capacitors have been replaced with plastic-encased types that do a good job in keeping moisture out and holding the leads firmly in place. Despite all these advantages, however, the intermittent problems we have long endured with radio and black-and-white television are still with us. An elusive intermittent is aggravating, time-consuming, and costly, because there's very little that can be done to localize the trouble until the symptoms appear. If the trouble doesn't last long enough to make a good check, a set can be out of service a long time.

We've all run across cases where an intermittent—such as hum—stops as soon as test probes are applied to the suspected circuit. Even with high-impedance test equipment, enough loading often occurs to correct a critical fault temporarily. The trick here is to keep the test-equipment load constant on the suspected circuitry. Apply your vtvm, scope, and other available equipment, note the readings, and leave the probes in place. Then see which change when the trouble starts.

Another type of intermittent doesn't show up on the test bench but appears as soon as the set is put back in service. This calls for a thorough environmental check. See if the line voltage is the same in both locations; make sure the antenna is not defective; find out if the back of the set is too near a radiator, and check the wall plug for good contact.

A faulty circuit isn't too difficult to localize, though more trouble is involved to find the intermittent component. If the trouble doesn't appear often, or if it doesn't stay long enough to find the bad part, wholesale replacement of every component in the circuit may be the only answer. Many technicians swear by this procedure, claiming the cost of parts is more than offset by the extra labor it takes to pinpoint the exact part.

While this method is all right when only resistors, capacitors, and other small parts are involved, it can become time-consuming and costly where transformers and coils are involved. In color sets, particularly, it would be out of the question in cases such as the convergence board, shunt regulating and focus-rectifier sections, etc. Thus, we must first localize the offending circuitry, then try to pinpoint the exact part by using our knowledge of circuit function and proper use of test equipment. It's helpful to study typical case histories, not because you might run across the exact trouble in the near future, but to become acquainted with the procedures used to pinpoint the fault.

Contrast changes

In a Sylvania DO-6 color chassis the contrast would abruptly change to a dark level momentarily (Fig. 1), changing back to normal and staying that way for long periods of time. This receiver uses a hybrid tube–transistor arrangement in the video-amplifier section, as shown in Fig. 2. Since any stage could be involved from tuner to picture tube, it was decided that the initial tests should try to establish whether the trouble was before or after the video detector. With the set on and tuned to a station, scope leads were placed between the grid of the first video amplifier and ground. The scope HEIGHT control was adjusted to provide a full-screen view of the pattern shown in Fig. 3.

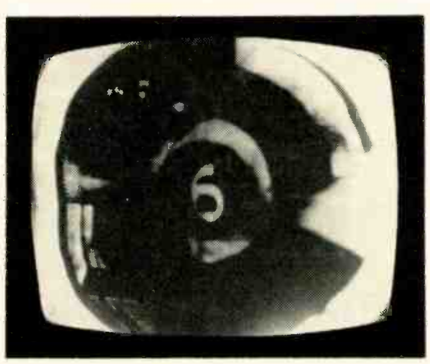


Fig. 1—A change in grid bias on the video amplifier caused this overload. A scope was used to track it down.

When the intermittent trouble occurred, there was no perceptible change in the scope pattern, so the scope leads were placed at the collector output of the second video amplifier shown in Fig. 2. Now when the intermittent occurred, the scope pattern expanded and overshot the screen face, indicating the trouble was before this test point. Next the scope leads were placed between the first video amplifier plate and ground; as an extra check a vtvm was placed between cathode and ground to observe bias changes, if any. Next time the intermittent occurred it was noticeable in the scope pattern and also in the vtvm. The cathode voltage dropped to zero, indicating either a loss of tube conduction or a short between cathode and ground.

If the tube had stopped conducting, there would have been a decrease in signal output, not an increase. Hence, the trouble was in the bias change. Because capacitors are often the worst offenders in intermittents, the 0.0056-μF capacitor in the cathode circuit was replaced and the set checked again with the test setup. During an extended test run no more trouble showed up and the set was returned to the customer. A more likely capacitor trouble is an open circuit, in which case the unbypassed 33-ohm cathode resistor would have caused some degeneration and possibly low contrast.

In an earlier version of this color receiver (DO-5 chassis) a 25-μF capacitor was included in the collector circuit of the second video amplifier. When this capacitor became leaky, similar conditions of poor quality occurred, with intermittent picture flicker.

No mention has been made regarding tube and transistor checking. When it comes to intermittent troubles, there is no use wasting time doing this, because a quick check on cold tubes and transistors (out of the circuit) means little. If the trouble symptom is present continuously and the fault is in

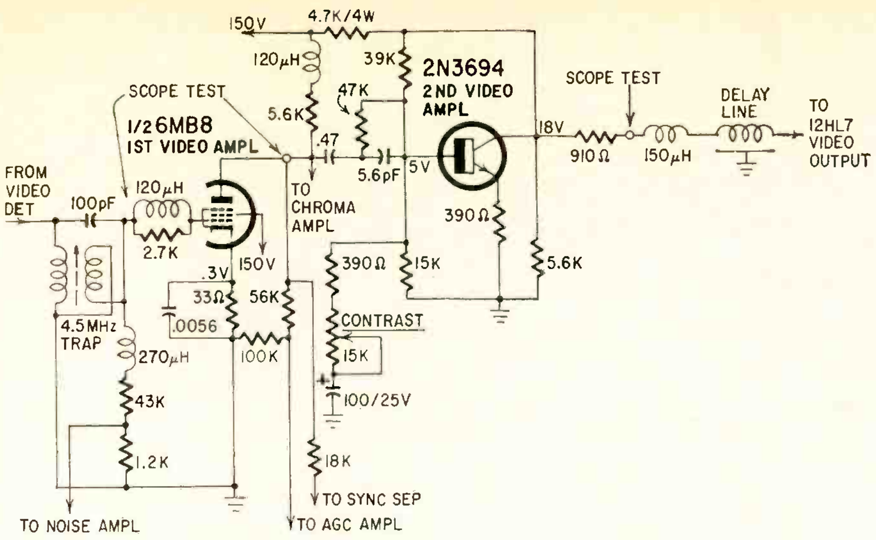


Fig. 2—Partial schematic of hybrid video amplifier used in Sylvania DO6 chassis. Overload was caused by open cathode bypass capacitor upsetting bias on the 6MB8.

a tube or transistor, the checker will show it.

Vertical jitter

In a Magnavox T922 chassis color receiver there was an intermittent vertical jitter. The raster was displaced by only a fraction of an inch, at a rapid rate and then returned to normal.

The effect appeared as a change in height because of the rapid picture shift. Close inspection of the screen during the trouble, however, showed that the vertical scan did not change, only the position. Thus, the trouble was not caused by sweep amplitude changes; the most likely cause was a change in the dc idling voltage in the vertical deflection coils. This could have been proved by placing a scope at the vertical output and observing that the peak-to-peak pattern did not change (Fig. 4).

Initially the centering control was checked with an ohmmeter and found to be operating smoothly, with no sudden resistance change as the arm was rotated. A voltmeter reading across the control, however, indicated a voltage drop and some needle flicker during the intermittent. Because the 25-µF capacitor shunted the control this capacitor was replaced and the trouble corrected. The capacitor appeared good in a checker, but obviously developed an intermittent condition when in the circuit for a time. The capacitor was developing either a partial, or a full, momentary short. Since the condition occurred so rapidly, however, the meter needle did not drop to zero during the readings. With such few components in this circuit, the capacitors could have been replaced without worrying about the cost factor, and without waiting for the trouble to show up on a meter test. It was unlikely that the capacitor at the lower end of the output transformer primary was at fault; this would have caused a change in sweep output and hence height, not vertical centering.

Intermittent focus

In an Admiral chassis there was an intermittent defocusing which happened about every two minutes or so. As shown in Fig. 5, the 5-kV focus voltage is applied to pin 9 of the picture tube through a 1.8-megohm resistor.

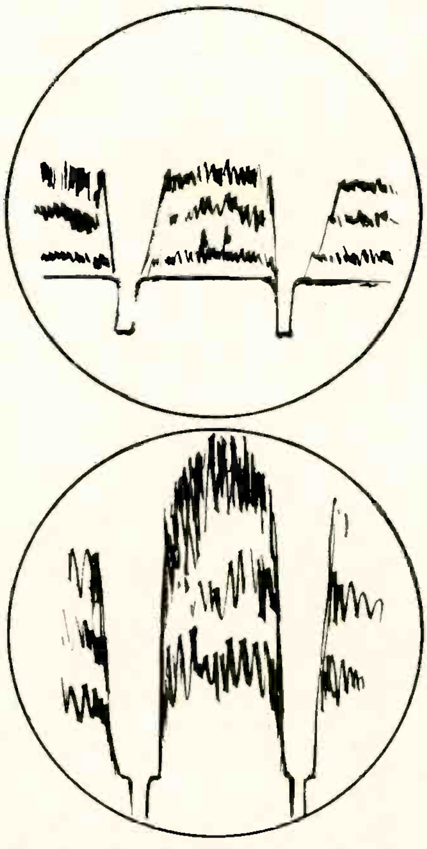


Fig. 3—Normal video output as seen on scope (top); the intermittent caused increased stage gain and increased video.

The 15-megohm FOCUS control is part of the bleeder network. The 47-megohm section is made up of 10 4.7-megohm resistors in series. A high-voltage probe placed between pin 9 of the picture tube and ground showed a voltage decrease of several thousand volts when the focus became faulty. With the receiver shut off, each resistor was checked but found to be within the specified tolerance. A new focus rectifier tube did not cure the trouble and the horizontal output system checked out all right.

A resistance change in the bleeder section appeared unlikely as the cause of the trouble, because an open circuit or a higher resistance would raise output voltage, not drop it. Replacement

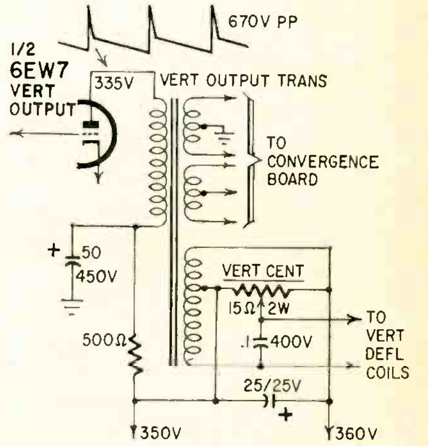


Fig. 4—Bad electrolytic shunting the centering control in this Magnavox T922 caused intermittent vertical jitter.

of the 1.8-megohm resistor was indicated, because a poor connection or an increase in resistance would decrease the focus electrode voltage. Out of curiosity, however, both connections of the resistor were resoldered to see if a poor joint was causing the trouble. Now a high-voltage probe check and screen inspection no longer showed intermittent focus and the original resistor was left in the circuit.

Miscellaneous intermittents

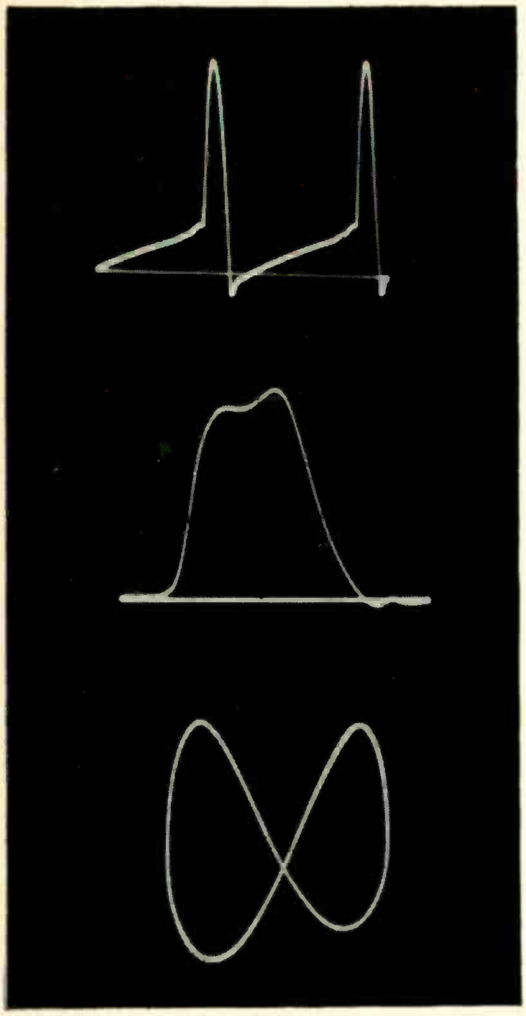
In an RCA CTC-20 color receiver a loud, intermittent noise would be heard for as long as half a minute, overriding the normal audio. After the noise stopped it wouldn't be heard again for almost an hour. Since no streaks were visible on the screen it seemed likely that the noise was not the result of high-voltage arcs, but was confined to the audio section after the detector. When the volume control was turned down completely the noise still returned with about the same volume level as before. Thus, the source was isolated to the section following the volume control, and lengthy signal

(*continued on page 63*)

YOUR SCOPE: A GUIDED TOUR

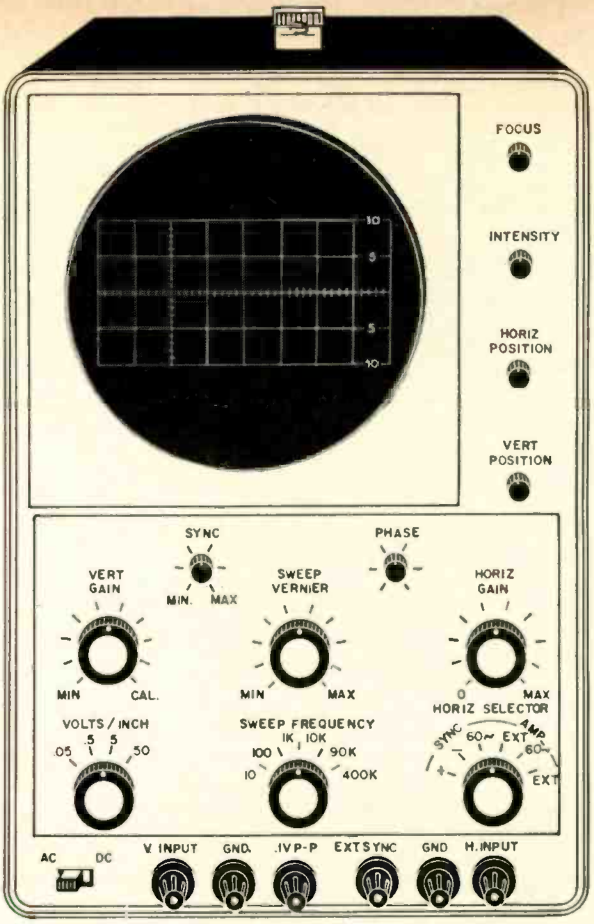
By **ROBERT G. MIDDLETON**

An oscilloscope is one of the most valuable instruments found in electronics for it lets you observe electrons at work. The scope also has more controls than any other common trouble-shooting instrument, hence often bewilders and confuses. Here are a few tips on what some of the controls do and how to use them properly for best operation. Try these on your own scope.

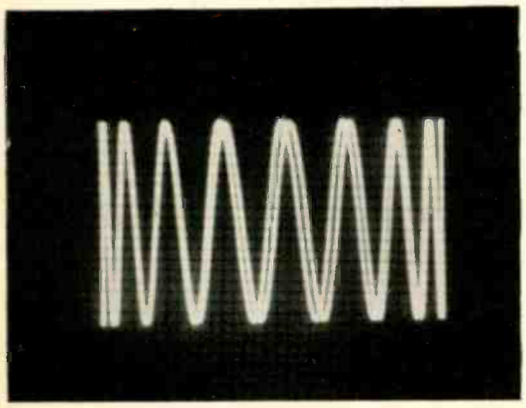


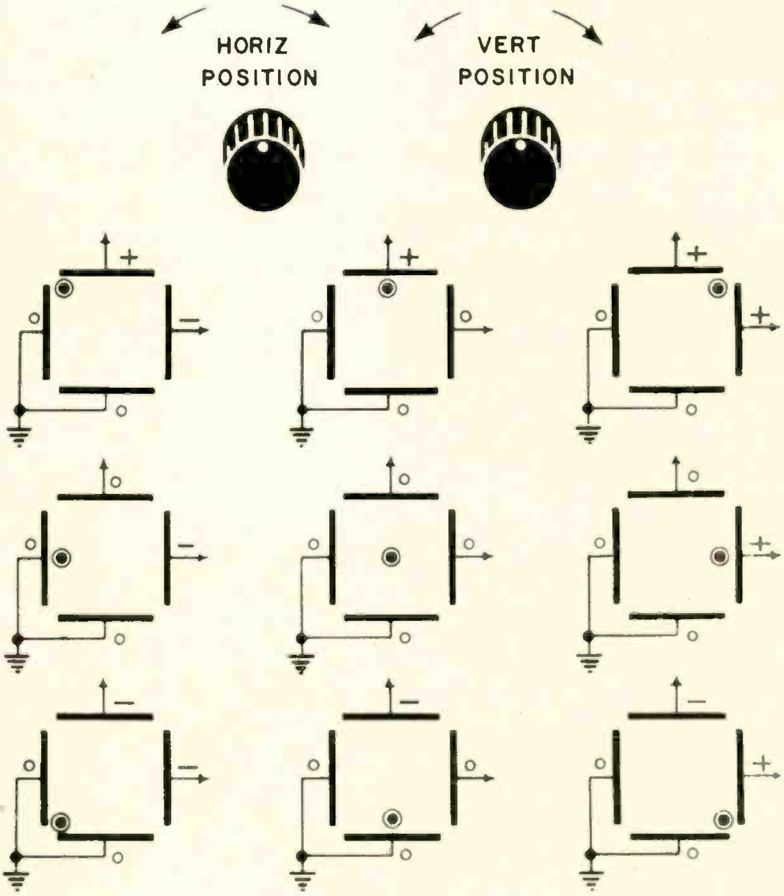
◄ Three basic types of displays:

(Top) Complex wave displayed on linear time base (sawtooth deflection). (Middle) Frequency-response curve displayed on a sine-wave time base (60-Hz ac). (Bottom) Cyclogram displayed on signal time base (circuit voltage).

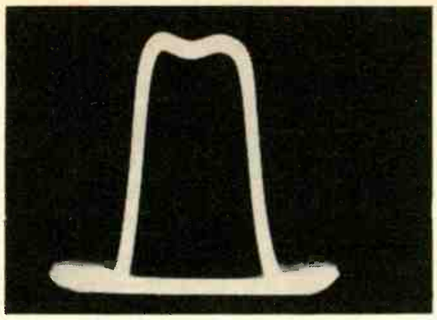


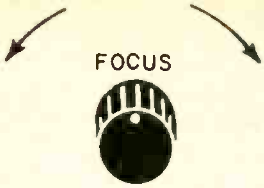
A Lissajous pattern (one form of cyclogram) obtained by feeding one sine-wave voltage to the vertical input and another to the horizontal. ▼

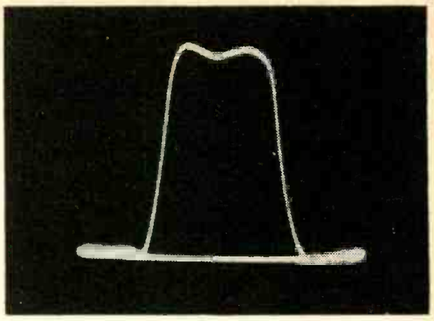




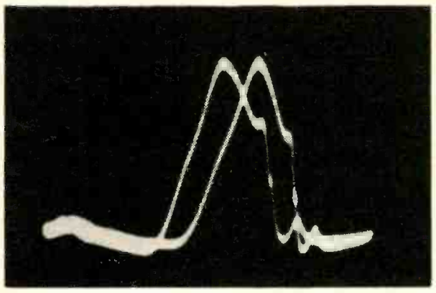
▲ The voltage (or potential) difference between deflection plates (shown as heavy black bars above) moves the electron beam (shown as black dot) across the face of the scope. These voltages are adjustable by means of the horizontal and vertical positioning (or centering) panel controls.

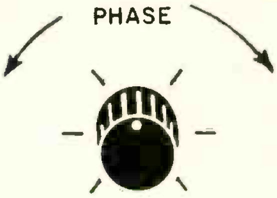


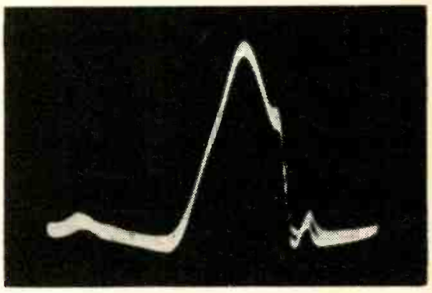




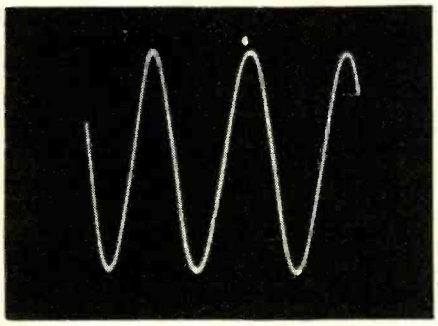
The focus control should always be set for the brightest, sharpest trace. It is most valuable when viewing complex waveforms. It interacts with astigmatism control a bit.

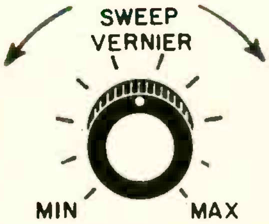


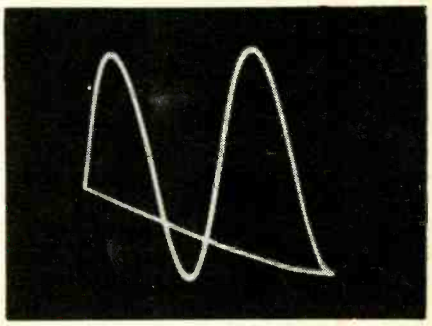




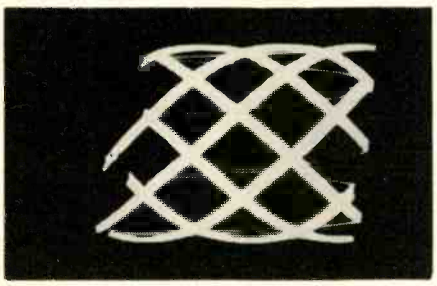
When operating with sine-wave deflection (either internal, ac, or external) you must adjust the phasing control to merge the trace and retrace (on some scopes).

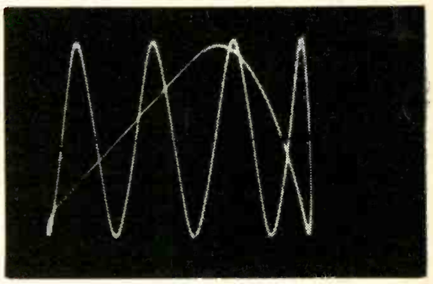




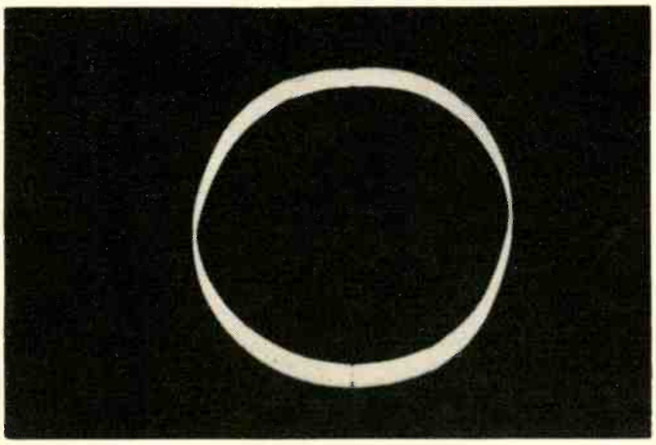


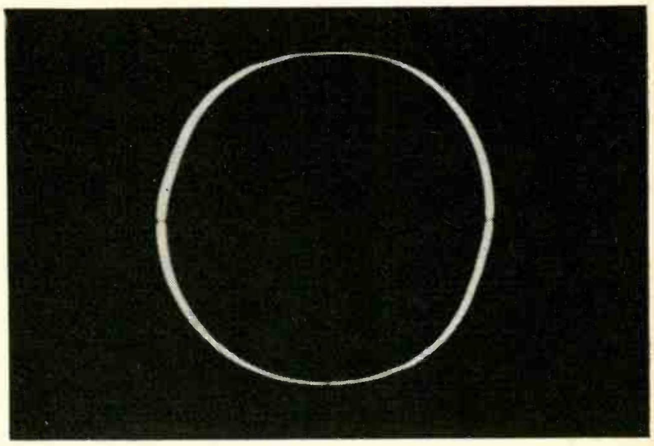
Number of cycles displayed depends on the setting of sweep frequency and vernier controls, with vernier setting exact number.





Horizontal deflection oscillator must be locked with that of signal viewed. If not waveform may not stand still (left).





The astigmatism control also affects the sharpness of the trace. It is often an internal adjustment, and is set for best focus . . . reset focus control if necessary.

R-E

New Color TV Tuning Indicator

On-screen bars pinpoint tuning

By ROBERT F. SCOTT

VARIOUS FORMS OF TV TUNING INDICATORS have been proposed or developed to aid the TV viewer in setting the fine-tuning control for best reception. However, Westinghouse is perhaps the first manufacturer to provide an "On-Screen Tuning Bar" configuration (patent pending). A display of 2 bars on the picture-tube screen serves as an indicator to show the degree of mistuning and the direction the fine-tuning control must be turned to obtain best color or monochrome reception.

To check or adjust tuning, the viewer presses a TUNING BAR on the panel. If the set is mistuned, two vertical black bars appear on the picture as shown in the photo. One bar is fixed and serves as a reference; the other appears on either side of the reference bar, in accordance with the setting of the fine-tuning control.

The "direction" of mistuning is indicated by the displacement of the movable bar (left or right) from the reference bar. The degree of mistuning can be predicted by the size of the space between the bars. The wider the space the greater the mistuning. The bars coincide with each other when the tuning is correct.

Except for the video gate circuit all of the circuits represented by the block diagram (Fig. 1) are combined on one small printed circuit board which is attached to the main color TV chassis. A push-on/off type TUNING BAR switch (Fig. 2) is located on the control panel to activate or deactivate the multivibrator circuits to turn the lines on and off, respectively.

However, the control signal portions of the circuitry are continuously activated. If the transistors in the control circuits were turned off there

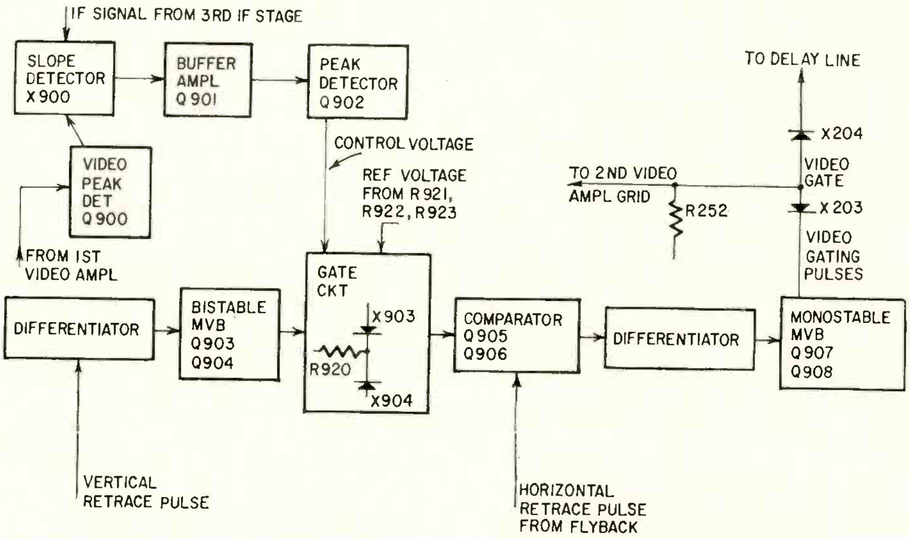


Fig. 1—Block diagram of circuits used to produce the "On-Screen Tuning Bars"—a feature in Westinghouse 1968 color TV sets. Control circuitry is on a small PC board.

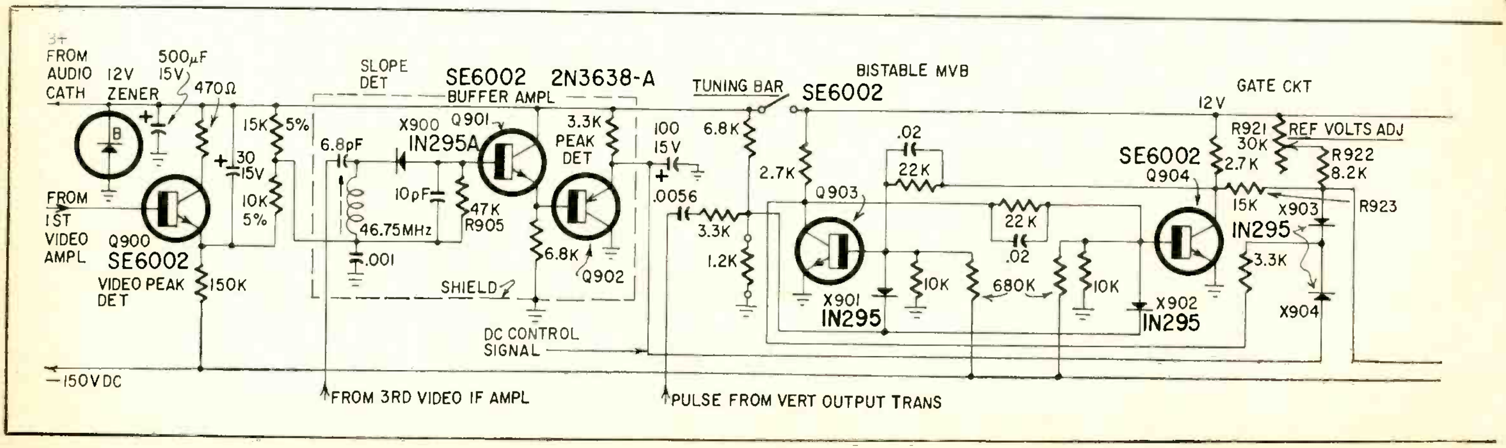
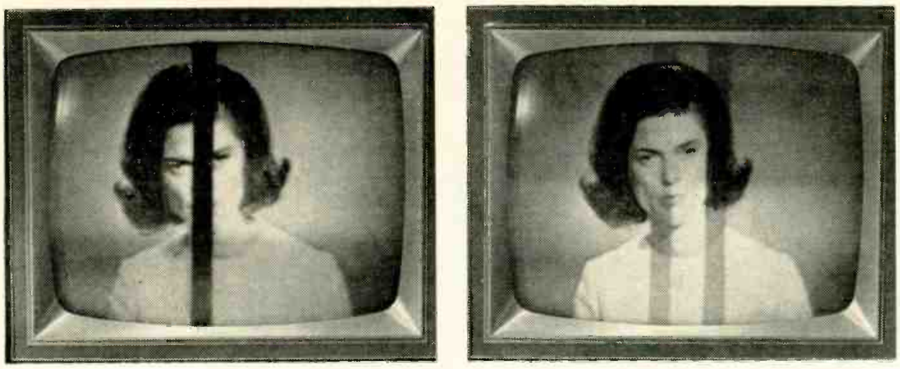


Fig. 2—Tuning-bar circuit. Two bars are produced on the CRT screen by blanking pulses generated in the monostable multivibrator. Comparator supplies the tuning-bar trigger pulses. One set of pulses is controlled by a fixed voltage; the other by a voltage that varies with fine-tuning adjustment. Circuits left of the comparator generate and gate the control voltages.



How tuning bars look on the screen. The single bar indicates optimum tuning. In right-hand photo movable bar is on the right. Fine-tuner should be rotated counterclockwise.

would be a detrimental loading on the video circuits and also a possibility of harmonic generation (tweet) in the slope detector portion.

How it works

Both lines are generated in a time-sharing system in which the reference line is generated during one picture field and the other line is generated during the next field. The required signals needed to generate the lines are a series of narrow video gating pulses of about 1 or 2 microseconds duration and are synchronized at the horizontal scan rate. Figure 3 shows the video gating pulses in time reference to the horizontal retrace pulses.

You can follow the block diagram or the schematic or both (whichever is easier for you) to get a better idea of what's taking place. Video gating pulses are generated in the monostable multivibrator Q907 and Q908. Transistor Q908 is normally in the "off" state and Q907 is normally in the "on" state. These transistors change state when a negative trigger pulse is received from the comparator. This pulse is sharpened by a differentiator network to make the triggering action more reliable.

The comparator Q905 and Q906 is also a monostable multivibrator. It supplies two sets of trigger pulses: one set, derived from a fixed reference voltage for the stationary reference bar, and the other set from a variable voltage source which serves as a control voltage for the movable tuning bar. This control voltage varies as the fine-tuning control is adjusted. Both the trigger and the timing pulses are "locked in" with the horizontal retrace pulse.

Control voltage for the movable bar is derived from the position of the video i.f. signal on the slope of the slope detector. A part of the i.f. signal is tapped off the i.f. output stage and fed to the slope detector. The video signal rides up and down the slope of the detector response curve (the detector is peaked at about 46.75 MHz) as the tuning control is varied. (Video i.f. carrier is 45.75 MHz.) The detected video signal (negative-going) varies from about 0.5 to 4 volts p-p as the fine tuner is varied from either side of the correct tuning point. The signal

(*continued on page 91*)

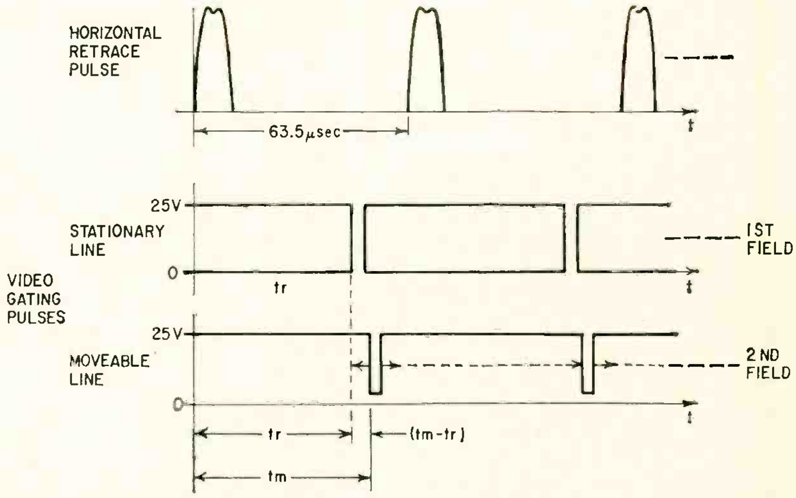
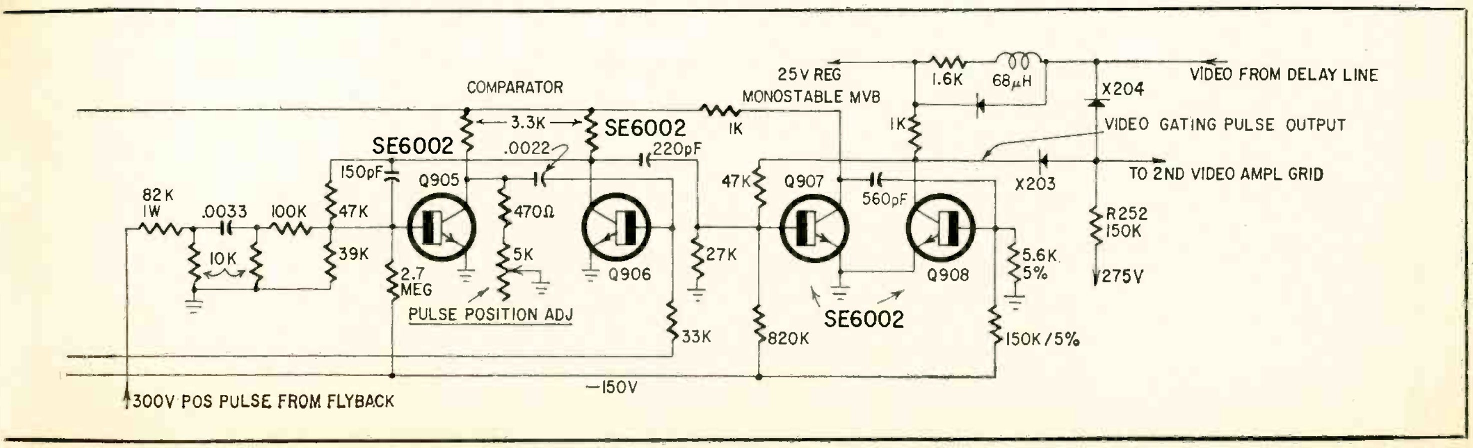


Fig. 3—Video gating pulses are referenced to the horizontal-retrace pulse to determine their relative screen positions. Interval $t_m - t_r$ is zero for correct tuning.



HOW TO SERVICE

Simple procedures you can follow to "tune up" and repair telephone and other type relays

By LEO G. SANDS

MILLIONS OF RELAYS ARE IN USE IN SUCH widely different places as telephone systems, pinball machines, control systems and radio equipment.

A basic relay is actuated by an electromagnet, which pulls in a movable armature. The armature "swings" one or more sets of electrical contacts to switch one or more circuits or devices. Some very simple contact arrangements are shown in Fig. 1. The voltage at which the armature pulls in is the "pull-in" voltage. At a somewhat lower voltage the armature opens or drops out. This is the "drop-out" voltage.

Relays usually suffer from one or more typical types of trouble. They can fail to pull in, they can hang on after the voltage has dropped below drop-out and they can fail to make proper contact.

Failure to pull in can be due to inadequate applied voltage, to dirt, to worn or broken parts and to improper adjustment.

If the armature does not drop out "cleanly" look for voltage that does not drop enough to reach the rated drop-out voltage, sticky contacts, improper adjustment and worn parts.

If the relay does not make proper contact, look for dirty, worn, pitted or burned contact surfaces and improper adjustments. In circuits carrying very little current the contacts are especially likely to become oxidized. Contacts that are seldom used are also more likely to become oxidized.

Use a relay contact burnishing tool to clean dirty or oxidized contacts. A file or sandpaper will remove some of the protective plating material and subject the contact to more rapid deterioration. Carbon tetrachloride should not be used as a cleaning agent. It leaves a film which can adversely affect and in some instances prevent electrical contact. Besides, the fumes can be harmful.

Cleaning

To use the burnishing tool, insert it between the contacts, gently support the armature or contact springs by hand to apply a slight amount of pressure and "wipe" the contacts with the tool. Do not apply enough pressure to distort the springs or contact assembly.

Armature adjustment

Relays do lose spring tension after long periods of use. However, do not be too hasty, do not adjust the armature until you are certain that there is nothing else wrong with the relay or its working voltages.

Don't let the complex appearance of some relays discourage you from working on them. Just don't rough handle them. Consider the telephone relay shown (partially) in Fig. 2.

The first step is to check the *residual* air gap; the gap between armature and core when the relay is energized. If the armature and core (both of magnetic metal) touch they are likely to stick together, therefore a slight air space is normally maintained between them. This air space is determined by the setting of the residual adjust screw on the relay.

The residual adjustment can be used to make the relay drop out at a higher or lower voltage. The wider the gap, the higher the voltage at which the relay will drop out. Use a set of relay contact thickness gauges. In manufacturers' specifications for relays, most residual adjustments in this type of relay call for .001 to .004 inch; most common is .0015 inch.

Note well that the residual screw must be against the core while measuring the residual air gap. Don't let the gauge get under the screw.

The magnetic circuit through the armature is completed by the *heel piece*. Therefore the gap between armature and heel piece must also be adjusted. This, known as the *airline* gap, should be set between .001 and .008 inch, usually around .004. In checking the airline gap, watch that the gauge is not inserted far enough to come between the armature and core. See Fig. 3. To adjust the airline gap loosen the yoke-adjusting screw a little and gently tap the armature to fit snugly up to the gauge. See that the gap is even all the way across the length of the gap before tightening the yoke-adjusting screw.

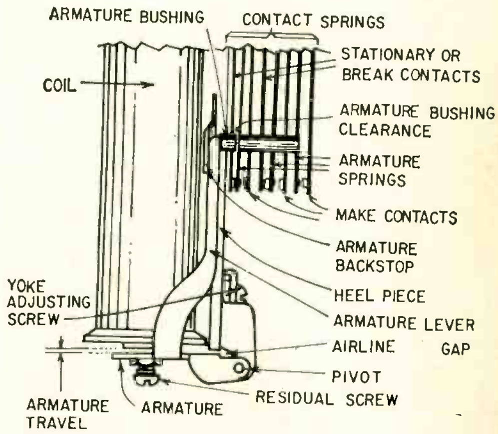


Fig. 2—Typical telephone-type relay.

Contact adjustments

Before adjusting the contact assembly be sure that all springs are straight, aligned and properly tensioned. If springs are bent, straighten them with a relay spring-adjusting tool. Be careful not to make any sharp bends or kinks.

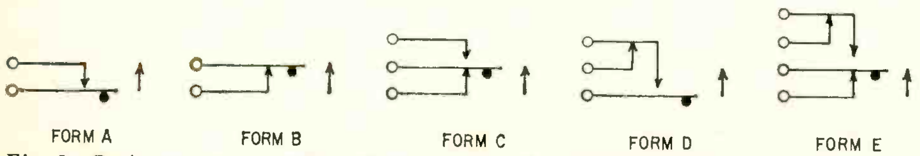


Fig. 1—Basic contact assemblies: Form A, normally open, or make; Form B, normally closed, or break; Form C, double throw, or break and make; Forms D, make-before-break; Form E, break and make-before-break. Sections can be stacked to suit jobs.

I wish to acknowledge special indebtedness to Mr. P. K. Neuses, pioneer in relay adjustment education and the development of relay adjusting tools, from whose little book I obtained most of the information in this article.

AND ADJUST RELAYS

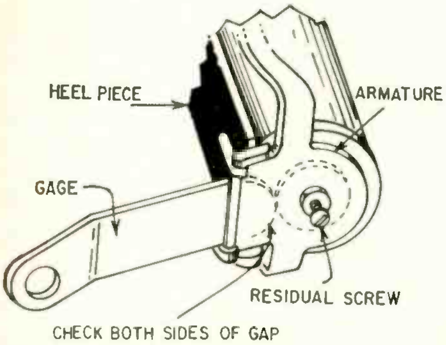


Fig. 3—Airline gap between armature and heel piece should be even and in accordance with manufacturer's specifications.

Tilted bushings due to bent springs can be straightened with a spring-straightening tool, as shown in Fig. 4. Misaligned contacts can be a more serious problem. Sometimes the assembly contact screws can be loosened and the springs shifted slightly to line up the contacts.

If it is suspected that the spring tension is not right, it is important to tension the spring before doing any further adjusting. Use a gram gauge to measure the tension. Each spring should be adjusted to have a tension of 25 to 35 grams, at the point where the contacts just break. Other springs should be lifted off the one being measured.

A spring-bending tool can be used to adjust spring tension. To increase the tension place the tool on the rear portion of the spring, tilt the tool judiciously toward the heel piece and draw slowly along the spring toward the armature bushing, leaving a slight bow (not more than 1/32 inch) in the spring. Apply the spring bender again near the rear and bend until the bow is flattened. Check the spring tension. To reduce spring tension (very rarely necessary) bow the spring slightly in the opposite direction.

Now we come to the actual setting of the contact springs to the proper spacing. Note the specs in Fig. 5. With a .0015-inch feeler gauge between the core and residual screw, a normally closed contact should just break. With a gauge .001 inch thicker it should not break. Contacts that make when the relay is actuated should just make on the specified value and should not make with a .001-inch thicker gauge. The figure .0015 inch is general. If you have exact specifications from the manufacturer, use them for any given relay.

To set the armature lever arm when the first contact breaks in the actuating position, insert the correct feeler gauge between the residual screw and the core as before. With the armature in the energized position, bend the lever arm so the first contact just breaks. Now adjust the armature backstop so that there is .004- to .008-inch clearance between the armature bushing and the first spring when the lever arm is resting against the stop. If the first contact is make, bend the backstop, with the armature in the energized position, .0015″ gauge between core and residual screw) to where it just touches the lever arm.

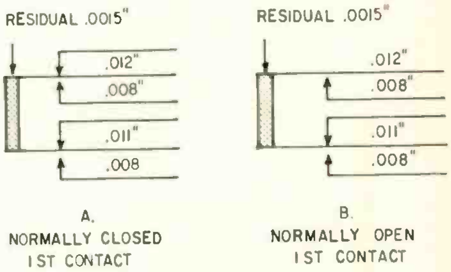


Fig. 5—Typical relay contact settings.

It's better not to try to move the armature by hand—energize the relay electrically for gauging contacts.

Now, having set the armature lever and backstop, you can start with the contacts. With the gauge again set between the core and the residual screw, energize the relay and note the first set of contacts. They should just break or make, as the case may be. If they don't, bend the spring slightly (Fig. 6) until they do. Having adjusted the contacts correctly, try a feeler gauge .001 inch thicker than the one specified for the relay. The contacts should not make or break—as the case may be—with the thicker gauge. (You may have to use a mirror to check the opening and closing of contacts in tight places.)

Remember that, in general, relays fail because of dirty or oxidized contacts. It is usually not necessary to gauge, adjust or bend springs. **R-E**

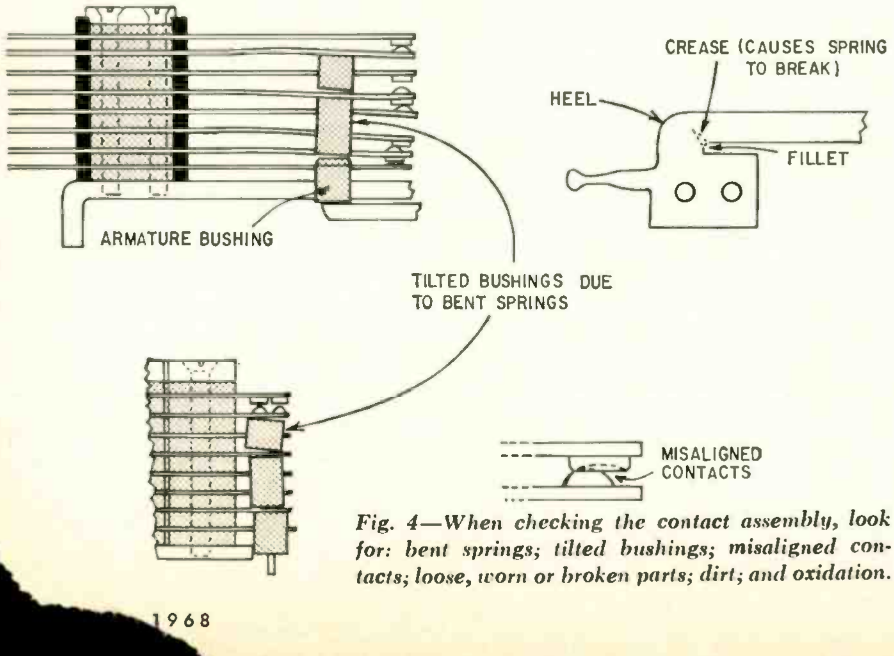


Fig. 4—When checking the contact assembly, look for: bent springs; tilted bushings; misaligned contacts; loose, worn or broken parts; dirt; and oxidation.

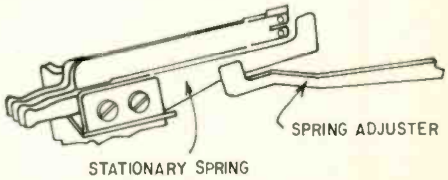
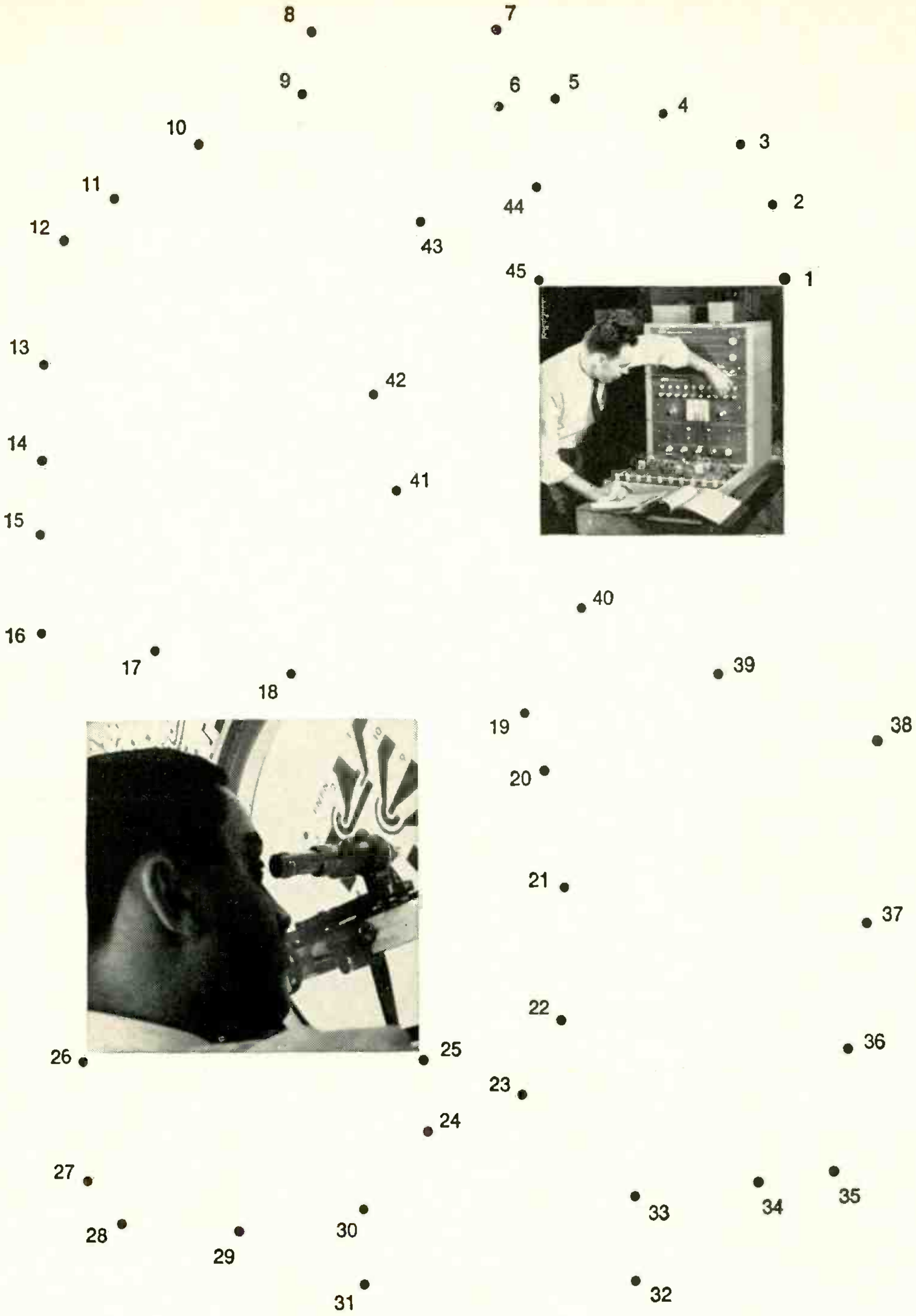


Fig. 6—Use a spring bender carefully to straighten springs and to adjust tension.



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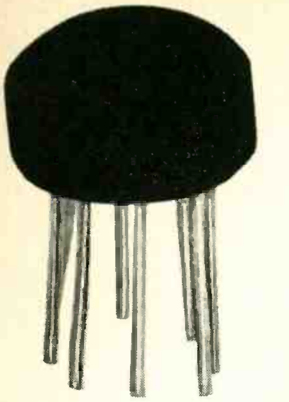


30 BASIC IC PROJECTS

Part 2 of 2 parts to help you to work with IC components and their related circuits.

By R. M. MARSTON

IN PART 1 OF THIS SERIES (DECEMBER, 1967), you were introduced to Fairchild's μL914 integrated circuit. Costing less than a dollar, it has many useful functions in many different applications.

As Fig. 1 shows, the μL914 contains four silicon planar 2N708 transistors and six resistors, all encased in an epoxy block roughly the size of a TO-5 case. The transistors have an f_T of 450 MHz. Lead connections are shown in Fig. 2.

The secret to using an IC is to remember that it's merely a *package of gain;* all you have to do is juggle external components and connections to change circuit function. If you need only two transistors, for example, you short the two others base to emitter, and forget them. Simple, isn't it?

Now, let's check out some more applications.

Pulse inverter and gate circuits

The μL914 can be used as a pulse inverter by cutting out (shorting base to emitter) all transistors except one, and then connecting the input to the base of the remaining transistor and taking the output from its collector. In the absence of a pulse (input grounded) the transistor is cut off and its collector output is fully positive. When a

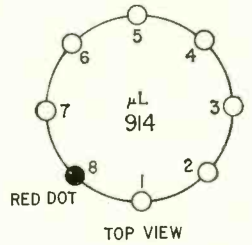


Fig. 2—Base lead connections of μL914.

positive pulse input is applied, the transistor saturates and its collector is grounded.

Fig. 3 shows how to connect the IC as a pulse inverter, using only Q1, and Fig. 4 an alternative connection using Q4. Fig. 5 shows the connections for a dual pulse inverter, using both Q1 and Q4.

Incidentally, the 450-ohm resistors between the base junctions of the IC and the external connecting leads prevent excessive base currents when

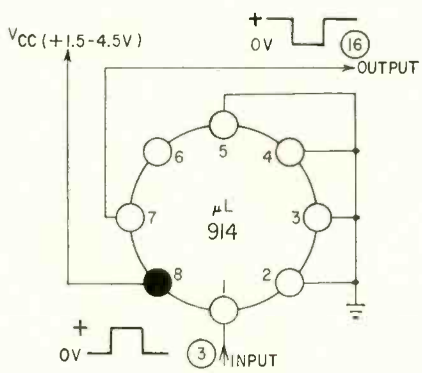


Fig. 3—Pulse inverter using only Q1.

the base leads are shorted to the positive supply line. This feature makes the IC almost indestructible, provided you don't use a supply potential greater than about 6 volts.

Fig. 6 shows how to connect the μL914 as a pulse-disabling gate. Here, Q3 and Q4 are cut out of the circuit, and the output is taken from pin 7. When a pulse train is applied to pin 1 and pin 2 is grounded, an inverted pulse output is available via Q1, just as in Fig. 3. If pin 2 is made positive by a gate signal, Q2 will saturate and pull the output down to ground, so no output will be available from the pin 1 input; the circuit is disabled.

Fig. 7 shows how to connect the IC as a dual pulse-disabling gate, using all four transistors.

The output of Fig. 6 is inverted relative to the signal input at pin 1. If you want a noninverted output, use the connections shown in Fig. 8.

An alternative type of gate circuit is the pulse-enabling gate of Fig. 9. Here, with an input signal applied to pin 1, there is no output if pin 3 is held at ground potential. If a positive gate

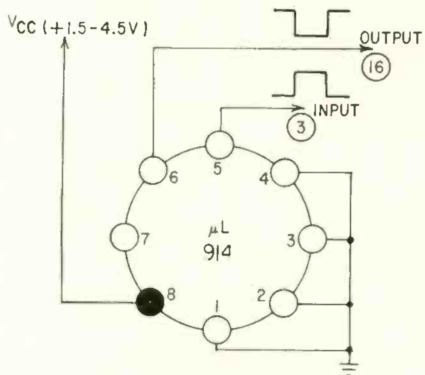


Fig. 4—Pulse inverter using only Q4.

signal is applied to pin 3, the pin 1 signal is made available at the output. The positive gate signal "enables" the gate to open.

The output of Fig. 9 is inverted. It can be made noninverted by wiring a circuit of the type shown in Fig. 3 between the input signal and pin 1.

Linear inverter and gate circuits

The circuits in Figs. 3 to 9 are suitable for use with pulse inputs only —the transistors are used purely as switches. These circuits are, nonetheless, useful to the hobbyist in test-gear circuits, tone generators and musical instruments.

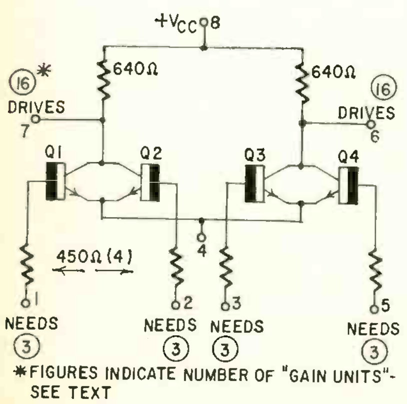


Fig. 1—Internal circuit of μL914.

The usefulness of some of these circuits can be increased by biasing the transistors so that they operate in the linear mode. They then pass sine-wave and other signals with negligible distortion.

Fig. 10 shows how to connect the μL914 as a linear inverter, giving near unity voltage gain between input and output. This diagram, like Fig. 3, shows just one of four alternative ways in which the inverter can be connected. If you want exactly unity voltage gain from this circuit, replace R3 with a 270-ohm resistor and 250-ohm potentiometer in series, and adjust for correct output amplitude.

Fig. 11 shows how to wire the circuit as a linear disabling gate. For a linear enabling gate connect a Fig.-3 type inverter between the gate-pulse input and R4.

Figs. 10 and 11 have useful applications in audio and sound distribution systems, and in oscilloscope trace doublers and various kinds of frequency-measuring gear.

Logic circuits

The μL914 can perform all the basic functions used in computer logic. Before looking at the different IC connections, let's make sure we know what the basic logic terms mean.

In logic work, inputs and outputs are either fully on (positive) or off (zero or grounded). The state of the output depends on the way the different inputs are connected. If a two-input circuit (with inputs A and B) operates so that an output becomes available when either A *or* B is connected, we call that an OR logic circuit. If the output appears only when both A *and* B are connected, we call it an AND logic circuit.

If the gate's inputs and output are in the same state (both positive or both zero) the gate is simply called an AND or an OR logic circuit. If, on the other hand, the input and output state is opposite (input zero and output positive, or input positive and output zero) the name of the gate takes on an "N" prefix and is called a NAND or a NOR logic circuit.

Because each of these four circuits has two variations (an AND circuit, for example, can give a positive output when both inputs are positive, or it can give zero output when both inputs are zero) there are eight variations of logic operation or mode.

Another complication is that each practical circuit can be known by either of two names. If, for example, our AND circuit gives a positive output only when A and B are positive, it follows that the output will be zero when A or B is zero, so the circuit can

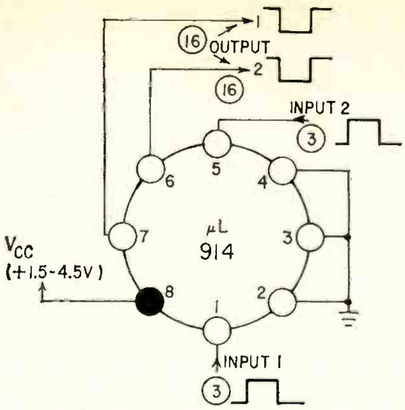


Fig. 5—Dual inverter using Q1 and Q4.

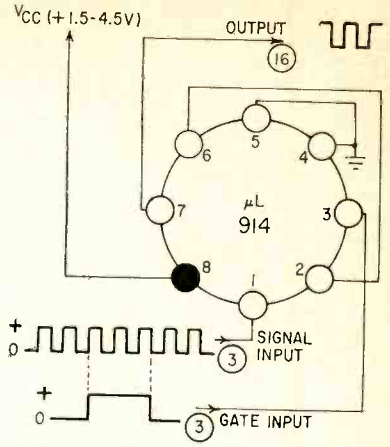


Fig. 9—Pulse-enabling gate (inverting).

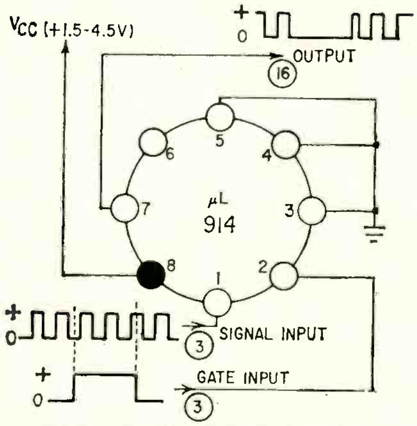


Fig. 6—Pulse-disabling gate (inverting).

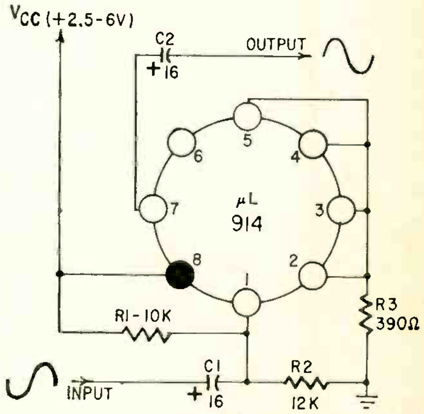


Fig. 10—Linear inverter.

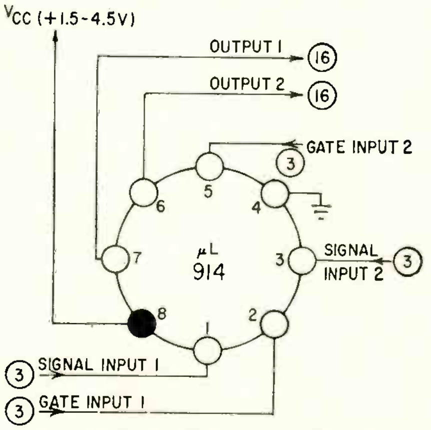


Fig. 7—Dual pulse-disabling gate (inverting).

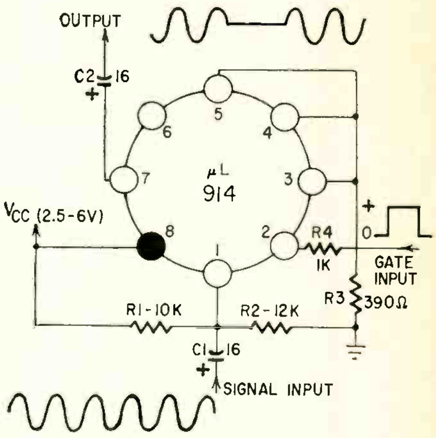


Fig. 11—Linear disabling gate.

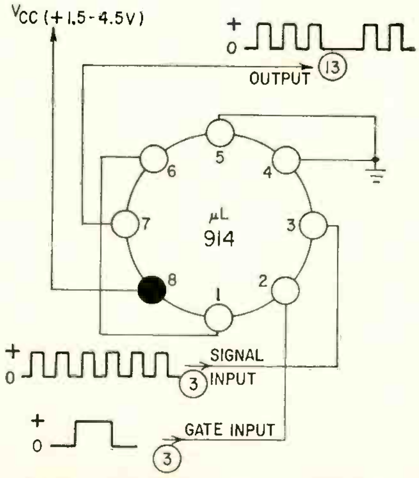


Fig. 8—Pulse-disabling gate (noninverting).

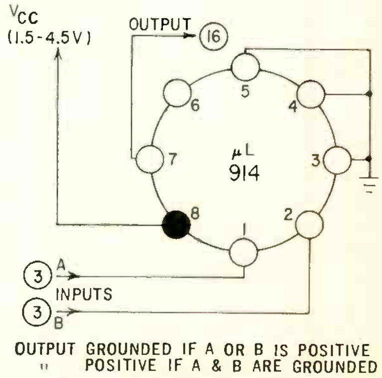


Fig. 12—NOR/NAND logic circuit.

See April p 12

also be used to perform OR logic functions.

This situation can be clarified by looking at Figs. 12 through 15, which show the four circuits that can be used to perform the eight basic logic functions.

Fig. 12 shows a NOR/NAND circuit. Its output is zero if A or B are positive, so NOR logic is performed. The output is positive only if A and B are zero, so NAND logic is also performed.

Fig. 13 performs OR/AND logic, while Figs. 14 and 15 perform AND/OR and NAND/NOR logic, respectively. Both Figs. 14 and 15 require the use of two μL914 IC's.

Multivibrators and trigger circuits

By using only one transistor from each side of the IC and using cross-coupling between these two stages, the μL914 can be made to perform as any one of the three basic multivibrator types. It can work as a free-running or astable multivibrator, as a monostable multivibrator or triggered pulse generator, or as a bistable multivibrator or memory unit.

Fig. 16 shows how to connect the μL914 as a 1-kHz astable multivibrator or waveform generator. Capacitors C1 and C2 are the cross-couplers, and R1 and R2 are the capacitor-discharge resistors. The operating frequency of the multivibrator can be increased by reducing the values of C1 and C2, or reduced by increasing their values.

If the values are reduced by a factor of 10 (to 0.01 μF), the frequency will increase by a factor of 10 (to 10 kHz). The output waveform which can be taken from pins 6 or 7 is approximately rectangular, but has a slightly rounded leading edge.

This rounding of the leading edge, which ocurs with all astable multivibrators, is caused by the fact that, at the moment the circuit switches between one state and the other, the collector of the *off* transistor is pulled down toward the base of the *on* transistor via the cross-coupling capacitor.

This rounding can be eliminated by disconnecting the output from the capacitor at the moment that the circuit changes state. You can do this by using the circuit connections shown in Fig. 17.

The circuit of Fig. 17 generates a near-perfect square wave, with no rounding of the leading edge. Using the component values shown, the circuit operates at a frequency of about 1 kHz. The frequency can be altered by changing the values of C1 and C2.

Fig. 18 shows how to connect the μL914 as a bistable multivibrator or memory unit. If a positive pulse is applied to pin 2, the output at pin 6 will go positive and at pin 7 it will go to zero. Furthermore, the outputs will remain in this state until a positive reset pulse is applied to pin 3. At this point pin 6 will go to zero and pin 7 will go positive, the circuit remaining in this state until another positive pulse is applied to pin 2.

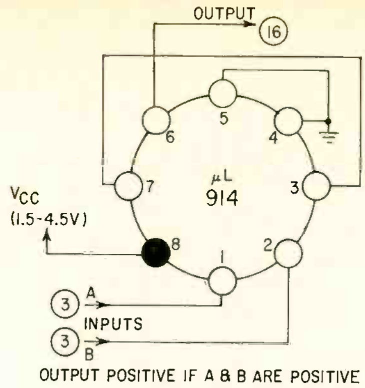


Fig. 13—OR/AND logic circuit.

Fig. 19 shows a monostable multivibrator or triggered pulse generator. The output is normally near ground potential. When a positive pulse is applied to the input, however, the output goes positive and remains in that state for approximately 5 seconds. After that the output automatically returns to zero. The length of the output pulse is controlled by C1, and can be varied from a few microseconds to several seconds by selection of this component.

The monostable multivibrator of Fig. 19 can be used as a noiseless pushbutton by adding R3 and S1 (shown in dashed lines). A normal pushbutton, of course, generates a good deal of noise due to contact bounce, which may be harmful in some applications.

The μL914 can also function as a voltage level or Schmitt trigger. Fig. 20 shows the connections for a direct voltage trigger. Its output goes positive when the input rises to approximately 1.5 volts, and drops to ground again when the input falls to about 1.25. The precise trigger points vary with supply-line potential, and the values quoted apply to a 3.5-volt supply.

The Schmitt trigger can be used as a sensitive sine–square converter by using the connections of Fig. 21. This circuit gives an output of approximately square waveform when a sine wave of amplitude greater than about 150 mV is applied to the input.

Both circuits shown in Figs. 20 and 21 can be operated at frequencies up to several hundred kilohertz. At frequencies above a few tens of kilohertz, the output waveform can be improved by connecting a small capacitor (shown in dashed lines) across R3. The value of this capacitor should be found by trial and error to give the

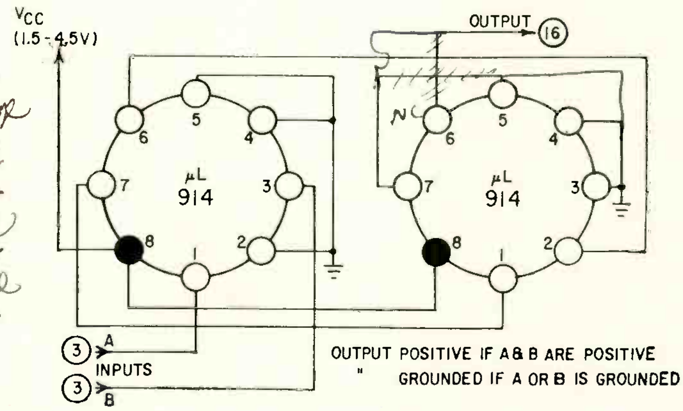


Fig. 14—AND/OR logic circuit.

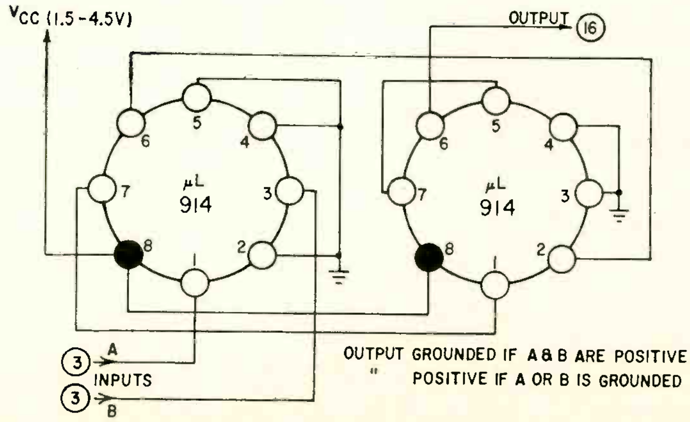


Fig. 15—NAND/NOR logic circuit.

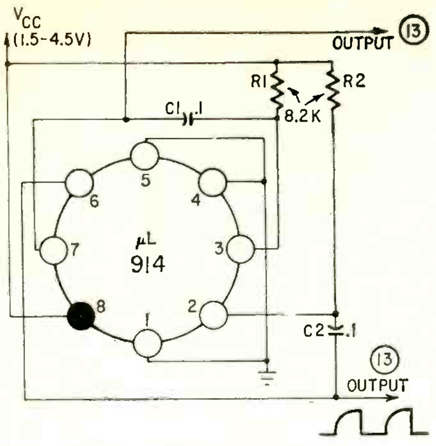
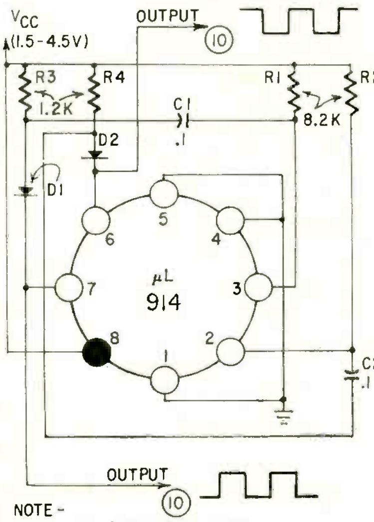


Fig. 16—1-kHz astable multivibrator.



NOTE - D1,D2 = ANY GERMANIUM DIODE

Fig. 17—1-kHz square-wave generator.

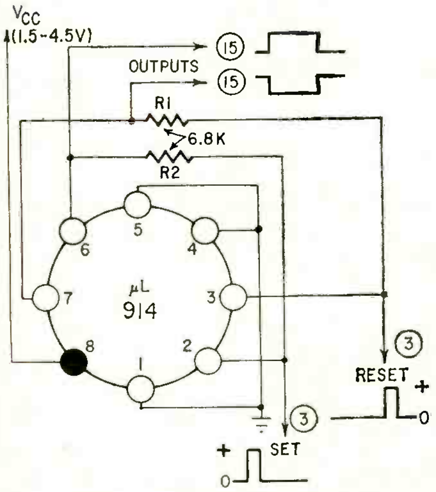


Fig. 18—Bistable multivibrator.

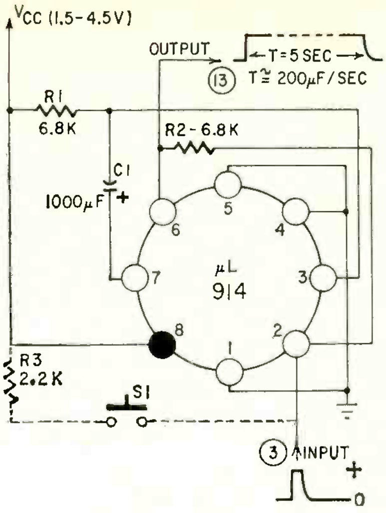


Fig. 19—Monostable multivibrator.

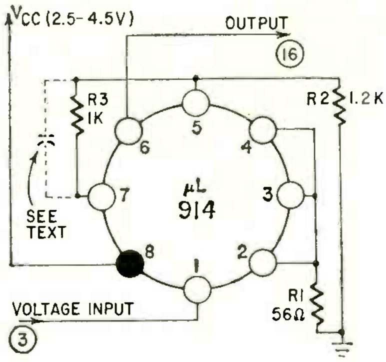


Fig. 20—Schmitt trigger.

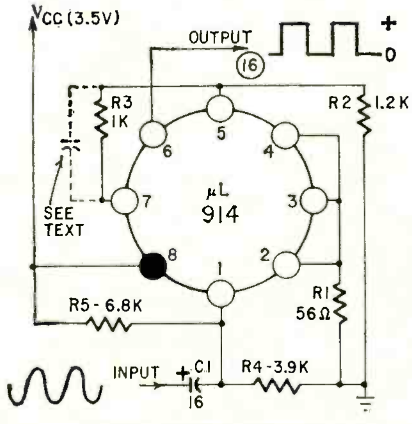


Fig. 21—Sine-square converter.

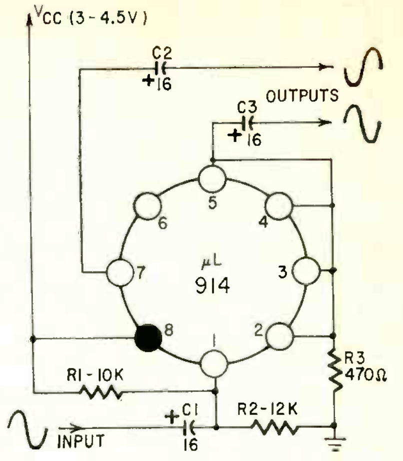


Fig. 22—Phase splitter.

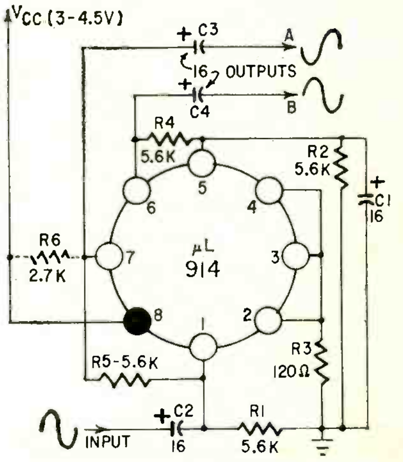


Fig. 23—Balanced (differential) phase splitter.

best output wave shape. Generally you will require a value around 100 pF.

Linear phase splitters

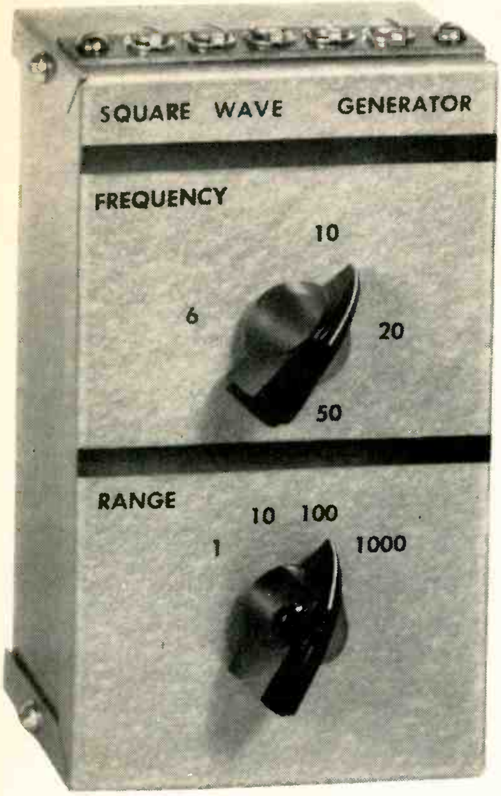
We've already seen that the μL914 can be used as a linear amplifier by applying suitable bias networks to the transistors in the IC. This feature makes the μL914 suitable for many applications in amplifier and oscillator circuits.

Fig. 22 shows how to wire the IC as a simple phase splitter, giving near unity voltage gain. Only one of the internal transistors is used: it is wired as a common-emitter amplifier with emitter degeneration provided by R3. The two output signals of the unit are roughly equal in amplitude and opposite in phase, but different in impedance.

If the two outputs must be exactly equal in amplitude, R3 should be replaced by a 390-ohm resistor and a 250-ohm preset potentiometer in series, the control then being adjusted for an exact output balance. Peak-to-peak input signals of about 1 volt can be handled by this circuit when a 3-volt supply is used.

Fig. 23 shows the connections for a balanced or differential phase splitter, using two of the transistors in the μL914. This circuit gives a voltage gain of about 8. The two output signals have equal impedances, but there is approximately 10% to 15% difference in their amplitudes. If identical output amplitudes are needed, R6 (shown in dashed lines) should be connected as indicated. In this case, however, there will be about 15% difference between the output impedances of the two signals.

We've looked at 31 applications (no charge for extra one)—all using a single low-cost IC. Dozens more exist for this same unit, the final number being limited only by your imagination. **R-E**



BUILD

LOW-COST IC SIGNAL GENERATOR

Using a minimum of components, this signal source provides square waves from 5 Hz to 50 kHz for tests

By JACK ALTHOUSE

INTEGRATED CIRCUITS, IC'S FOR SHORT, are revolutionizing the electronics industry. They've taken over the computer field and are moving into industrial and consumer products faster than anyone dreamed possible. If you are interested in electronics you should be using IC's *now*.

As an example of the ease with which IC's can be used, this wide-range signal generator is built around one 80-cent component. The generator puts out square waves from 5 Hz to 50 kHz and runs from a single 3-volt battery. It's useful for measuring gain and frequency response of audio and ultrasonic equipment, as an interpolation oscillator for checking frequency, and in a host of other lab and workshop applications.

The active component is Fairchild's μL914 . . . a plastic-encapsulated IC in a TO-5 transistor-size case. Inside the case (Fig. 1) you will find (with a microscope) 4 transistors and 6 resistors. The transistors are designed to operate as switches; cutoff or fully-on.

How It Works

Consider pair Q1 and Q2. They form an OR gate. If leads 1 and 2 are left open or are grounded, neither Q1 nor Q2 will draw any current. Thus the voltage at the output lead 7 will be the same as the supply: 3 volts.

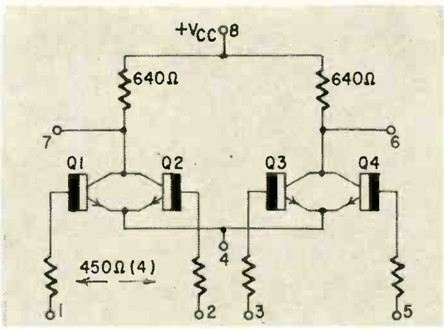


Fig. 1—The μL914 integrated circuit has 4 transistors, 6 resistors and 8 leads.

If lead 1 is connected to 3 volts, Q1 will saturate and the voltage at lead 7 will drop to 0.2. Similarly, if lead 2 is connected to the 3 volts, Q2 will saturate and voltage at lead 7 will drop to 0.2. Furthermore, if both leads 1 and 2 are connected to 3 volts, lead 7 still will have 0.2 volt on it. In one sentence: "If lead 1 *or* lead 2 *or* both are connected to 3 volts, the voltage at lead 7 drops."

Transistors Q3 and Q4 form another OR gate with inputs at 3 and 5 and output at lead 6, which operates identically to the first.

The circuit of Fig. 1 is useful to explain how the IC works but cumbersome to use in ordinary circuit schematics. So it's customary to use the simplified triangular block symbols shown in Fig. 2. Here, the two OR gates of the IC are shown as triangles with their input and output leads numbered.

Fig. 2 is a complete schematic of the IC square-wave generator. Note that leads 2 and 3 of the IC are not used.

At any given time one IC gate is on, the other off. Operation is as follows, beginning from the instant power is applied.

1. IC1-a comes *on*. Its output (lead 7) drops from 3 volts to 0.2.
2. This negative-going pulse couples through C1 to the input (lead 5) of IC1-b and turns it *off*.
3. After a definite length of time, C1 discharges enough through R1 and R2 to let IC1-b turn *on*.
4. The resulting negative pulse at lead 6

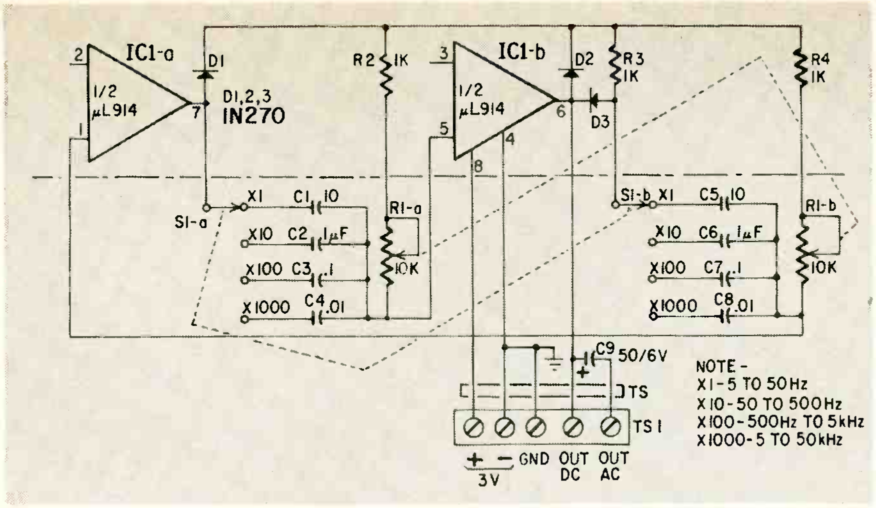


Fig. 2—A single 3-volt battery is all the power supply needed for the generator.

Parts List

C1, C5—10-μF, 6-volt electrolytic capacitor (Sprague TE-1087 or similar)
C2, C6—1-μF, 200-volt metallized paper capacitor
C3, C7—0.1-μF, 200-volt Mylar capacitor
C4, C8—0.01-μF, 200-volt Mylar capacitor
C9—50-μF, 6-volt miniature electrolytic capacitor
D1, D2, D3—1N270 germanium diode
R1—Dual potentiometer, 10,000 ohms each section, linear taper
R2, R3, R4—1000-ohm, 10%, ½-watt, carbon resistor
S1—3-circuit, 4-position, nonshorting switch. Only 2 circuits are used (Mallory 3234J or similar)
TS1—Terminal strip
IC1—μL914 dual 2-input gate (Fairchild)
MISC—Aluminum box (LMB TF-780 or similar); perforated board (Vector 85G24EP or similar); terminals (Vector T-28 or similar).

is coupled through C5 to lead 1 and turns IC1-a *off*.

This entire action keeps on going to produce continuous square waves as long as 3-volt power is applied. Frequency is controlled by the size of the capacitors selected by S1 and by the resistance setting of the two ganged pots R1.

Table I—Frequencies of Some Piano Keys

Key	*Frequency (Hz)*
A above middle C	440
A below middle C	220
2nd A below middle C	110
3rd A below middle C	55

The 3 volts needed at the junction of R2 and R4 to hold one or the other of the gates *on* is supplied from the output of the *off* gate through D1 or D2.

Construction

The square-wave generator fits comfortably into a 5¼ x 3 x 2⅛-inch aluminum box. The first step is to mount the switch and the dual potentiometer as shown in the photograph.

The terminal strip mounts on one end of the box and a soldering lug is placed under one of its mounting screws. Holes must be drilled to accept the soldering lugs on the rear of the terminal strip, so the strip can lie flush across the end of the box.

Next, cut a piece of perforated board 2½ x 1¾ inches and mount it on standoffs inside the box, at the other end. Two screws are adequate to hold it in place in the box.

Capacitors C1 through C8 are wired directly from S1 to R1, supported by their own leads. On each section of dual potentiometer R1, two terminals are jumpered together; these are the center arm and the terminal that the wiper moves to when the front panel knob is turned fully counterclockwise. Similarly, C1 and C5 connect to the switch terminals that are contacted when the switch knob is fully counterclockwise.

After the capacitors are wired, remove the perforated board from the box. It is more easily wired as a separate subassembly. It holds the three diodes, three resistors, and the IC.

The leads of the IC should be bent outward like the spokes of a wheel (Fig. 3). It is best to hold the leads with long-nose pliers when bending them, so the bend starts about $\frac{1}{16}$ inch below the plastic case.

A bottom view of the IC is also shown in Fig. 3. Looking at this end, the leads are numbered clockwise and a flat on the plastic case shows the location of lead 8. Many of these IC's were made without the flat. If yours is one of these, lead 8 is indicated by a dot or strip of brown paint on the side of the case.

Place the IC on the perforated board and mark the locations of the six terminals needed to wire it in to the circuit. Leads 2 and 3 are not used. The IC will be supported by its leads after they are soldered to the terminals. If the leads are left straight and held to the terminals only by solder, it is easy to remove the IC at any time.

Next, mount the other components on the board and complete its wiring. Nine wires come off the board to other parts of the circuit. Be sure they are long enough, and tag them.

Mount the completed board in the box, making certain that none of its leads short to the box. The wiring can now be completed. Capacitor C9 is connected between two pins of the terminal board and is supported by its own leads.

After carefully checking the wiring, connect a 3-volt battery or power supply. Current drain will be about 10 mA. A square wave of about 2.5 volts peak to peak should appear between ground and the dc-coupled output terminal and between ground and the ac-coupled output terminal.

Use the ac-coupled output for calibration. The frequency range depends on the tolerance of the capacitors and resistors but should be close to that shown

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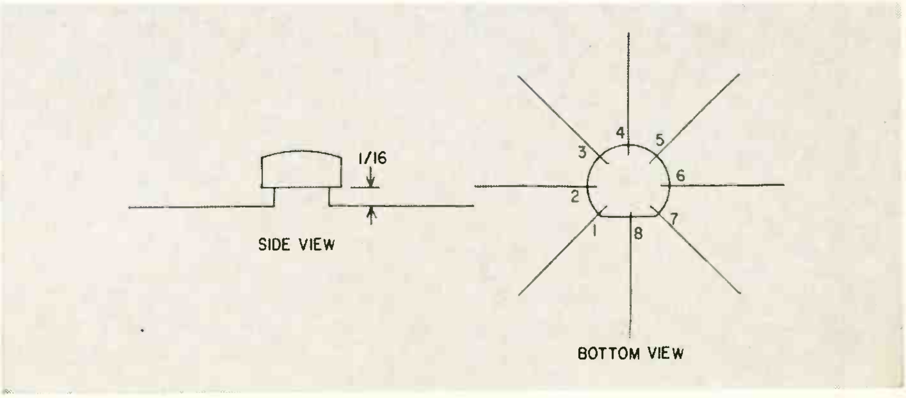


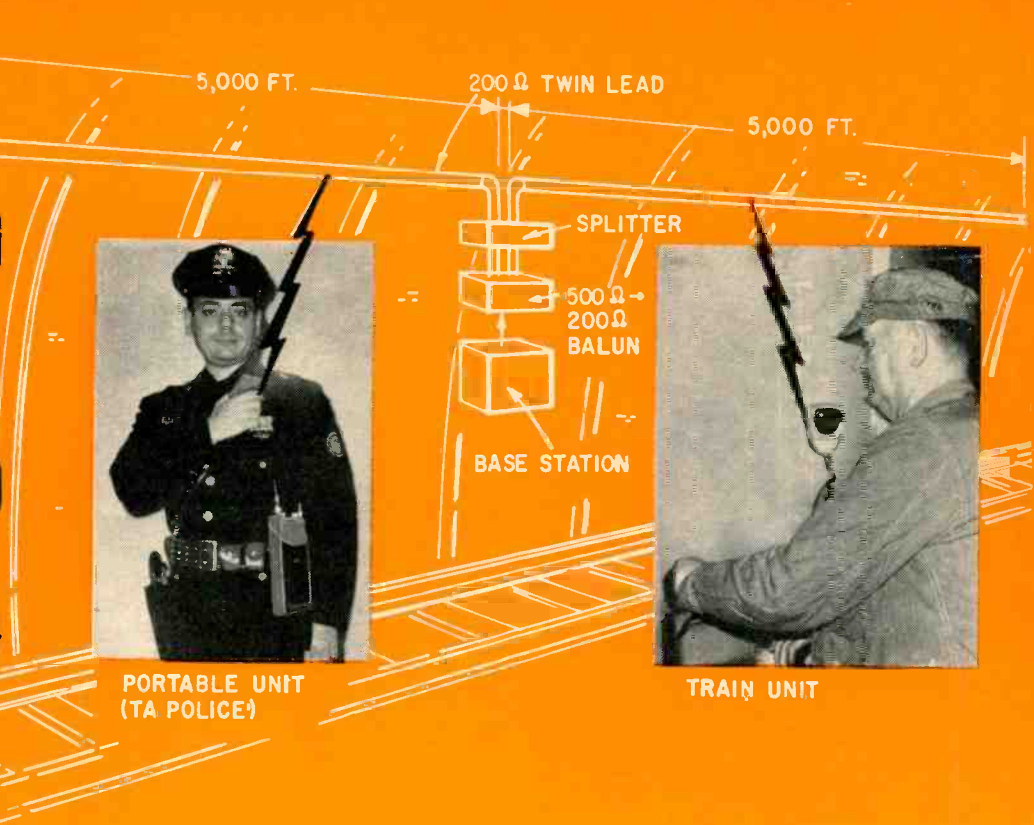
Fig. 3—Basing of the μL914. Be sure to bend the leads carefully as shown, and don't put any strain on the case. Heat sink and avoid overheating when soldering the leads.

N.Y.C. SUBWAY RADIO

KEEPING IN TOUCH UNDERGROUND

What? A two-way radio system in a subway tunnel? Story of rf communications in world's most extensive subway system

By PETER E. SUTHEIM



Photos courtesy New York City Transit Authority

Fig. 1—Basic subway radio system uses a single station driving two lines—in both directions through tunnel. Portables are tuned to one frequency, trains to another.

WITH A LOUD WHOOSH OF ITS AIRBRAKES, A 10-CAR INDEpendent F express shrieked suddenly to a stop between Forest Hills and Jackson Heights. The time was 8:42 on a Wednesday morning. The train was jammed with nearly 1500 passengers bound from the suburbs to their jobs in Manhattan. It was stopped for 15 minutes; nearly all the commuters were late to work. Not one of them knew why the train had been delayed. There was no way to get information to them.

During the great Northeast power blackout in November 1965, subway trains were stalled for hours. Only emergency batteries in each car kept the dim safety lights going. Rumor flew like leaves in a wind. No one knew what had happened.

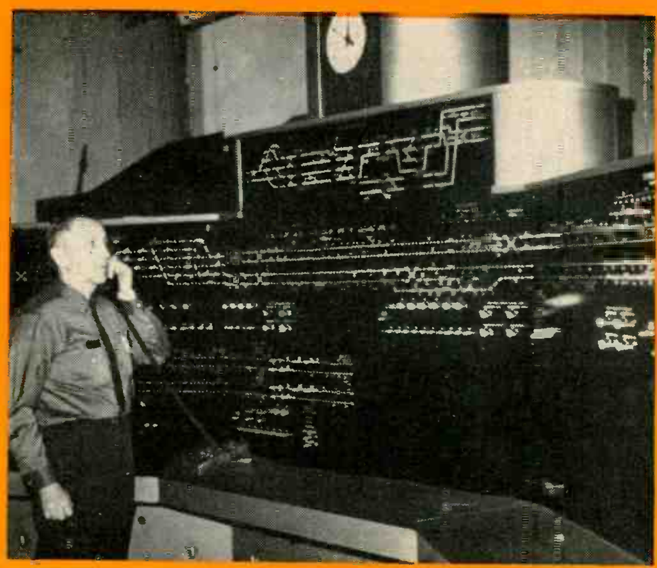
At 1:30 am on a Brooklyn-bound Brighton BMT local, three teenagers began making nuisances of themselves, and 10 minutes later were annoying a few dozen other passengers in one of the six cars. A Transit Authority patrolman assigned to the train ushered the boys off at the Prospect Park station without serious incident. But suppose there had been *six* young hoodlums? Armed? Suppose someone *had* been hurt? The TA cop had no way to send for any help.

Fortunately for us who use the subways in New York, things like that don't happen often. But they do happen, and passengers react with anything from sweaty irritation to anger and panic.

Subway communication problem

Running a city railroad with 6700 cars, some 1.25 billion passengers a year, with a rush-hour train interval of 90 seconds, about 240 route miles of track and 481 stations, is no small job. There has always been a crying need for fast, reliable communications between trains and signal and dispatching towers and, sometimes more important, between Transit Authority policemen along the lines and central control points.

Ever since the first New York subway opened in 1904, transit operations have relied heavily on telephones and intercom systems. Telephones—2000 of them—are spaced about 600 feet apart along every tunnel in the New York rapid-transit system, yet until recently there was no way to communicate with conductors or motormen in moving trains, or to make announcements to passengers.



Grand Central Station interlocking tower is just about the midpoint of the present radio installation on Lexington Avenue subway line. Dispatcher talks to motorman on train.

As long ago as 1950, the Transit Authority experimented with 80-kHz FM carrier-current radio superimposed on the 600-volt dc "third rail" which powers the trains. The equipment was cumbersome (it used vacuum tubes) and the cost of equipping every car in the system would have come to nearly $7 million.

(Trains in the New York subways are made up of single, separate cars, or permanently joined units of two cars. Trains are continually broken up and the cars shuffled. Every car will sooner or later be the lead car of a train, and so every car would have to be equipped with radio. In 1950, vacuum tubes and power supplies made removable, transferable transceivers impractical.)

Transistors and high frequencies

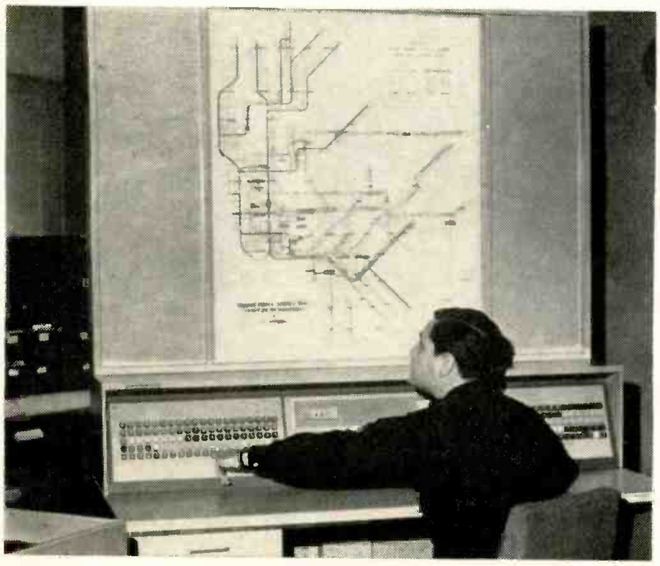
Ten years later, the transistor had come of age. It was now possible to consider using compact, lightweight portable transceivers that a motorman would carry onto his train at the beginning of his run and slip into a bracket in his cab on the lead car. Electrical connections would be made automatically. Power would come from the 28-volt dc system in each car.

Instead of a carrier-current system, it was decided to use conventional narrow-band FM radio, so that transit policemen on foot in station areas well away from the tracks could communicate also, with portable transceivers.

To permit using small antennas (there isn't much clearance between trains and tunnel walls), TA engineers settled on the high vhf land-mobile band (150 MHz). That band is a bit less crowded and less prone to sporadic long-distance "skip" reception than the low vhf band.

Initial experiments turned up an interesting phenomenon. With an omnidirectional antenna, maximum reliable ranges using portable units were only about 500 feet. The steel columns and reinforced-concrete tunnel construction absorbed rf at that frequency at a rate of about 10 dB per 100 feet! Increasing power from 1 watt to 10 watts brought only another 100 feet of range. And 10 watts from a portable transceiver calls for a lot of weight in batteries, so the omnidirectional approach had to be discarded. Directional antennas were obviously out, because it is, in general, impossible to keep a line-of-sight between portable units and a base station.

The solution turned out to be an adaptation of a



At the console in Transit Authority headquarters in Brooklyn, the operator can "punch up" the last reported location of each transit patrolman. At a glance, the entire force is pinpointed.

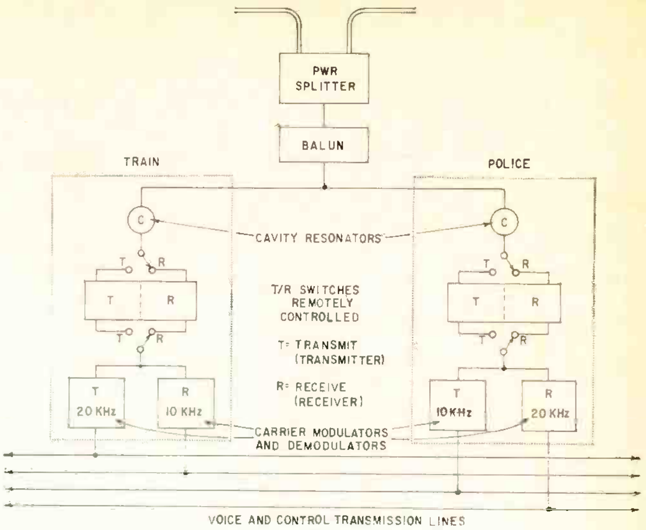


Fig. 2—Block diagram of a single base station in the present subway radio system. Each station consists of two transmitters and receivers, with separate channels for police and trainmen.

method used for vhf paging systems. We might call it the "leaky twin-lead" method. There is a certain amount of radiation from twin-lead—usually an undesirable loss when the twin-lead is used to convey power from a transmitter to an antenna or from an antenna to a receiver. For the Transit Authority's purpose, the radiation from a long run of twin-lead was exactly what was needed.

The twin-lead also acts as a combined receiving antenna and lead-in for picking up signals from the low-powered police and train transceivers and routing the signals to the base-station receivers. In effect, the twin-lead acts as a two-way conductive rf link, guiding the rf energy where it is wanted and keeping undesired radiation and power loss as low as possible.

Tests with this method were conducted during 1961. About 11,600 feet of RG-86/U 205-ohm twin lead was fed at one end by a conventional 25-watt transmitter–receiver unit. That was the base station. The train and portable units were conventional, commercial devices.

To determine the radiation characteristics of the twin-lead, men were assigned to "walk the line" with a portable transmitter and a calibrated receiver. They found "solid" two-way communication possible within 40 feet of the twin-lead antenna at any point up to 6000 feet from the base station. The signal from the base station was readable at 7000 to 8000 feet.

By feeding two diverging transmission lines from the same transmitter, the method could cover a total span of about 2 miles underground (allowing for the 3-dB power loss that results from splitting the signal in two). See Fig. 1.

Working test

It was time for a real working test. TA engineers selected an 8-mile stretch of four-track route on the Lexington Avenue (East Side) line of the IRT division from Bowling Green near the southern tip of Manhattan Island to 125th St. For about half the distance, the two express tracks run side by side in a separate tunnel below the two local tracks. Though that stretch is only about 5% of the total New York transit trackage, it is one of the most heavily traveled lines in the city.

The contract was awarded to Motorola, and construction began. Except for the baluns used to transform the 50-ohm unbalanced outputs of the base stations to 200 ohms

See APRIL - P 6

balanced, and some cavity resonators and power splitters, all the equipment, including the train and portable units, was "stock". Operation was completely satisfactory almost from the very beginning.

Up to this point, the system is pretty straightforward. The only peculiarity is the method of propagating the signals from the transmitters.

One of the principal purposes of the radiocommunications system is to maintain close contact with transit policemen on their beats throughout the trains and stations of the subway. It was decided that police communications could be handled better on a separate channel. As a result, each base station consists of two vhf transmitters and receivers on slightly different frequencies, both feeding the same twin-lead antenna. Resonant cavities isolate all of the units from each other.

The "program"—the intelligence that modulates the transmitters—comes, not from microphones at each base station (except in emergencies), but via lines from TA headquarters in Brooklyn, where train- and police-control facilities are centered, and from a "command post" at the Grand Central Station interlocking tower. A block diagram of the typical base station is shown in Fig. 2.

Transmitter spacing

Six base-station installations are spaced along the IRT stretch from Bowling Green to 125th St. Five are remote-controlled; the sixth, at Grand Central Station, roughly halfway along the line, is part of the control center which commands all six base stations. The trainmaster there can control all six base transmitters if directed to do so by TA headquarters in Brooklyn. Normally, all six base-station transmitters operate simultaneously. They are fed audio in parallel and operated by remote control.

All New York subway cars built since the early 1950's have public-address systems, normally operated by the conductor, who also opens and closes the train doors at each station. Generally the PA system is used to announce stations and to broadcast admonitions like "Please let go of the door!" The motorman and conductor can also intercommunicate via the PA system. In emergencies, it has been used to instruct passengers.

But a PA system is of little use unless the motorman or conductor knows what's happening. Often, he finds himself forced to halt at a red signal and remain there for many minutes without knowing why he had to stop. Red signals are not uncommon during congested rush hours, but passengers in a train that's been waiting in the tunnel for more than, say, 5 minutes, are entitled to know *something*.

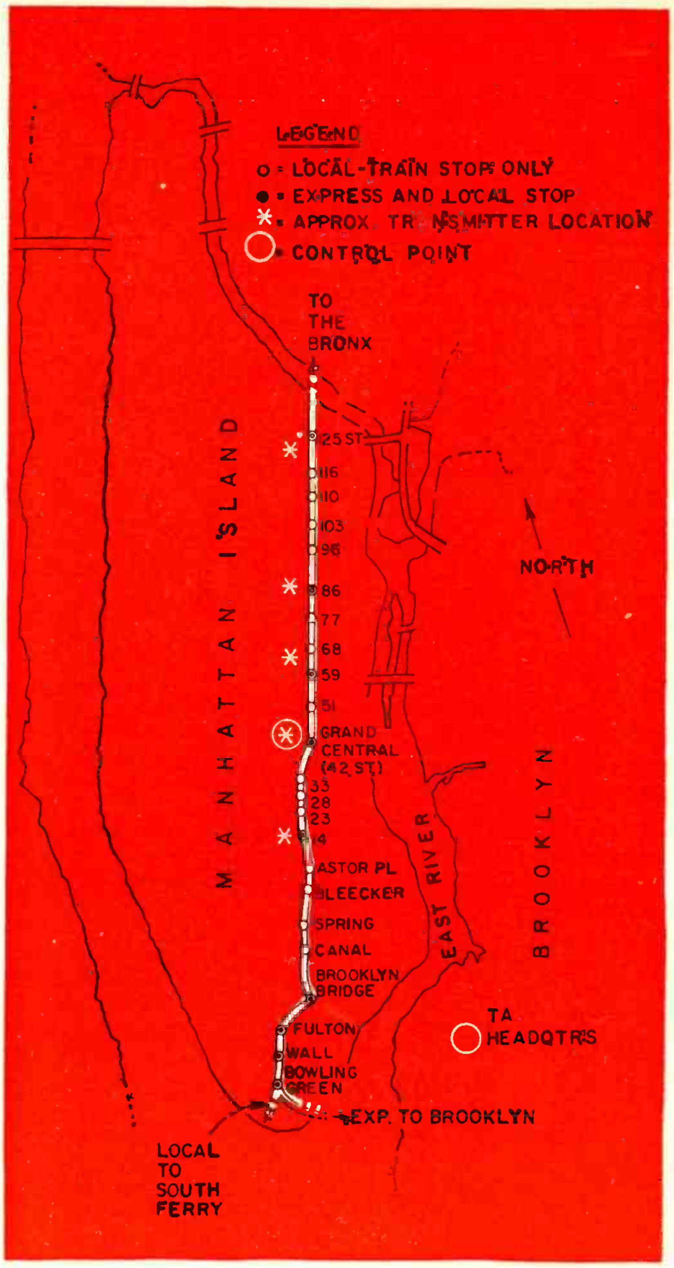
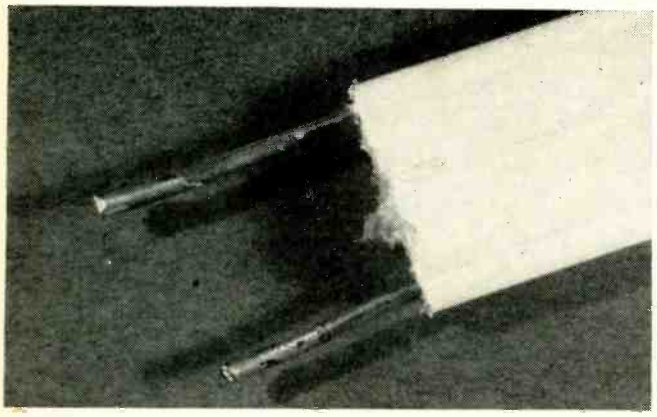


Fig. 3—Simplified map shows location of subway transmitters. Although subway route runs between The Bronx, Manhattan and Brooklyn, present base stations cover only that portion of route in Manhattan. All stations are located below the surface.



The "leaky" antenna/feedline: Rulan-jacketed, foam-filled twin-lead forms the long-line antenna for the New York subway communication system. Wires are No. 8 copper, spaced 1.4 inches. Line is unterminated simply because it works better that way.

Now the motorman can get information from the outside world. If he is ordered to do so—by radio—he can switch the output of his receiver into the train PA system so that an official up the line can make an announcement to all the passengers on the train.

"A train in the 68th St. station is having door trouble. We expect a delay of approximately 10 minutes. Please be patient." An announcement like that from someone in a position to know can do great things for passenger morale. For the first time in more than 60 years of New York subway operation, travelers will feel a little less like isolated inmates of a rumbling, hurtling steel cage. The technology is here; it is now up to harassed subway officials to use the facilities to comfort the passengers.

The radiocommunications system is now being expanded throughout the IRT division, and is expected soon to include the transit system's other two divisions, the BMT and IND subways. **R-E**

Imaginary numbers are a cinch

Part 2 of a series—More about some handy math tools—including operator j—and how they're used to design electronic filters. (Part 1 appeared May 1967)

By NORMAN H. CROWHURST

A FEW DAYS AFTER OUR LAST DISCUSSION, George phoned to ask if I could come over and continue where we left off. I arrived at his lab in time to join him for midmorning coffee.

He had been trying to figure things out himself since our last talk. Remembering that $j \times j$ makes -1, he had deduced that $+j \times -j$ makes $+1$. Was

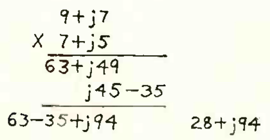


Fig. 1—It's not hard to multiply imaginary numbers; plus j times plus j equals minus 1.

that right? I assured him it was. Then he wrote down a compound multiplication (Fig. 1): $9 + j7$ to be multiplied by $7 + j5$ and came up with the answer: $63 + j94 - 35$.

"You can subtract the 35 from the 63, can't you?" he wanted to know. I nodded. "So the result of multiplying $9 + j7$ by $7 + j5$ is $28 + j94$. Is that right?" he asked.

"Certainly," I said. "I'm surprised you've figured all that out on your own. So why did you call for help?"

"I was following up with what you said about division. I tried to check that multiplication by dividing $28 + j94$ by $7 + j5$, thinking I knew the answer. But I couldn't get very far. Tell me, how do you do it?"

Rationalizing

"Division isn't so easy. But there's a way to make it easier. It's a process called *rationalizing*."

"So show me rationalizing."

"Do you remember what you get by multiplying together A + B and A − B?" I asked him.

"Sure do. That's one bit of algebra I'll never forget. It's A squared minus B squared."

"Good. So now suppose you multiply A + jB by A − jB. What does that make?"

"That would be A squared minus jB all squared." He thought a moment, then went on: "But j squared is minus 1, so that's A squared minus minus B squared. As minus minus makes a plus, I guess it's A squared plus B squared. Is that right?"

"Correct," I assured him. "Now what's happened to the imaginary part of these numbers?"

"There isn't any in the result," he said. "That's interesting, but how does it help with dividing?"

"Let's take that division you wanted to do—what was it, $28 + j94$ divided by $7 + j5$?" I wrote it down as a fraction. "Can you tell me how I could make the divisor, or denominator as it is called in a fraction, just a simple whole number, without changing the final value in any way?"

"Oh!" said George, "light's beginning to dawn. If you multiply $7 + j5$ by $7 - j5$, the imaginary part will disappear. And if you multiply both top and

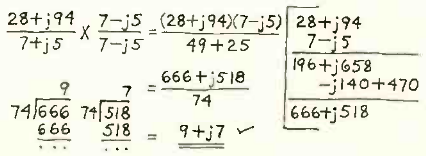


Fig. 2—To divide imaginary numbers, you first write them as a fraction. Then you rationalize the denominator to simplify.

bottom by $7 - j5$, overall value is unchanged. Is that right?" He was already doing it (Fig. 2).

"So now I only have to divide $666 + j518$ by 74." He found it easy, because he knew the answer to expect, which was $9 + j7$. He was delighted.

"Is that rationalizing?" he asked me next.

"*Rationalizing* is the process of making the denominator into a real number, so the numerator can be divided by it to get rid of the complex fraction. What you want is a simple complex number, of the form A + jB."

Vector basics

Then I drew approximate scale sketches (Fig. 3) to show a basic result of vector calculations. In every case, multiplying complex numbers produces an amplitude that is the *product* of the

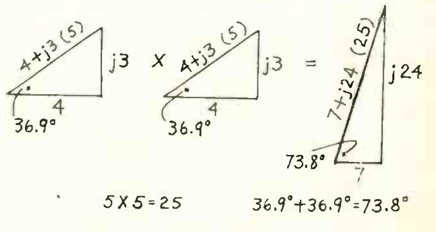


Fig. 3—Vector diagrams show the effects of using operator j. The angles are added, while amplitudes are multiplied.

individual amplitudes. The resultant phase angle is the *sum* of the individual phase angles.

"Hey, that's neat," was his enthusiastic comment.

Then I showed him how division reverses the process: The amplitude of the result follows normal *division*, while

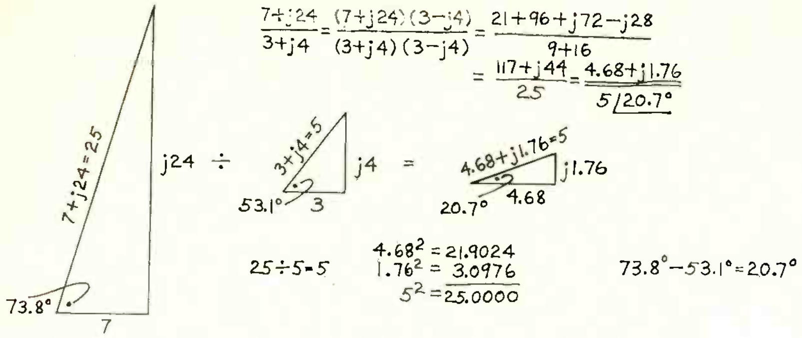


Fig. 4—To divide one vector quantity by another, it's necessary to rationalize the j. Amplitudes follow normal division, but phase angles subtract instead of add.

the phase angles *subtract,* instead of adding.

He worked out an example for himself, using the numbers I picked (Fig. 4). "I'm beginning to see how imaginary numbers will make calculations easier. Now can you give me an example how to use them in a circuit calculation?"

"Right you are. And while we're about it, I'll show you *normalizing,* another trick that makes math easier. Suppose we want to make a low-pass filter of the kind used in crossovers," and I sketched out what I had in mind (Fig. 5). "We normalize to the working impedance and the cutoff frequency."

"Eh? Come again? That sounds awfully complicated."

Normalizing

"Well, instead of putting in values for working impedance and cutoff frequency, you assume for calculations that they are both 1. You can put in the actual figures for frequency and working impedance later. But it's easier to show you than to try explaining what to do.

"First, we assume the filter is terminated with unity impedance. It is shunted by a capacitance that has susceptance of b units and has in series an inductive reactance of a units at cutoff frequency. To design the basic filter, we solve for a and b. Then we can look up values for a particular impedance and frequency on a reactance chart."

"That sounds simple and quick," said George. "Let's try it."

"Working at the output end, we *assume* unity voltage and current are delivered to the unity load impedance. This won't happen in a working filter, it's true; the filter will give full output in the pass range, and diminishing output beyond cutoff. Assuming constant output, we must increase input to maintain it. The increase needed (expressed as a ratio or its logarithm) is the same as the attenuation produced in the output when the input is constant. Do you follow all that?"

"Yes," George said. I wasn't too sure he did, but he was anxious to see what came next.

What susceptance is

"Right. So we have unity voltage across the capacitance of susceptance b," I went on. "What current will go through this susceptance?"

At the word "susceptance" I drew a blank expression from George. I decided to refresh his memory with a few symbols from elementary electronics. I wrote:

$$Z = R + jX$$

$$Y = \frac{1}{Z} = \frac{1}{R + jX} = \frac{R - jX}{R^2 + X^2}$$

Then I reminded him that these 2 components of the admittance (Y) are given the names conductance (G) and susceptance (B).

$$Y = G + jB \quad G = \frac{R}{Z^2} \quad B = -\frac{X}{Z^2}$$

"Now," I asked again, "what current will pass through this susceptance?"

"b units, I suppose," volunteered George.

"That's right, at cutoff frequency. What about at other frequencies? Does the current increase or decrease with changing frequency?"

"Current in a capacitor increases with frequency," George replied. "So the current in the capacitance will be bf. Is that right?"

"Nearly. But if you use f for frequency, you have to remember that cut off frequency is 1, because we're normalizing. You'll avoid confusion if you write x for normalized frequency, which means x is actual frequency divided for the cutoff frequency.

$$x = \frac{f}{f_c}$$

"This makes x = 1 at cutoff frequency. That is what we mean by *normalizing.*"

Putting j in

"So current in the susceptance is bx. Is that right?" asked George.

"Except for one thing—phase angle," I replied.

"Oh. We put a *j* in," he said. "But is it $+j$ or $-j$?"

"The important thing is to be consistent. Assume this one is $+j$. It represents the current in a capacitance. Does this lag or lead the voltage?"

"Let's see. It leads, doesn't it?"

"Right. So $+j$ means leading and $-j$ means lagging, for this calculation. We write current in the capacitor as *j*bx. Add this to the output current and tell me what current must flow through the series inductance?" I asked.

"Is it 1 + *j*bx?" asked George in return.

"Correct. Now, what is the reactance of the inductance?"

"Is it ax?" asked George.

"Yes, because inductive reactance is directly proportional to frequency, or x," I answered. "And the voltage drop due to this reactance will be in quadrature with the current through it. Which way?" I asked further.

"Leading." George was getting more sure of himself by the minute.

"So the voltage drop across the inductance element will be the current through it, multiplied by its reactance," I went on.

"That's (1 + *j*bx) multiplied by *j*ax," cut in George.

"So what's the input voltage required to get unity output voltage, which you remember we assumed as a starting point for our calculation?"

I'd apparently got a little ahead of George, so he waited for me to explain. "You have the unity voltage at the output, plus the drop in the reactance." I wrote it out.

George multiplied this out and re-

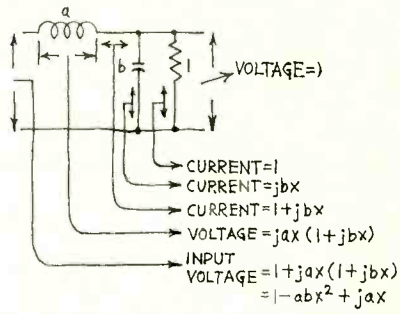


Fig. 5—Operator j and the other math tools become useful when you're designing a low-pass filter for a crossover network. Result is a formula for plug-in values.

arranged it. He was getting the hang of using imaginary numbers. He had even remembered that (jax) multiplied by (jbx) equalled $-abx^2$. "Now, what does all that mean?" he wanted to know next.

Phase angle

"Let's see what the expression tells us about this network," I suggested. "First, what's the phase angle?"

"We did that the last time. It's the ratio of the imaginary part to the real part, and then you find the tangent on the slide rule. Isn't that it?"

"Correct. Now, how does this angle change as frequency, represented by x, varies? At some frequency, when $abx^2 = 1$, the denominator goes through zero. What angle is that?"

"90°," volunteered George, "because the real part is zero—it's all imaginary, or in quadrature."

"How can we make this happen at cutoff where $x = 1$?"

"By making $ab = 1$?" suggested George.

"Right. Now, when x is much smaller than 1, meaning that frequency is well below the reference cutoff frequency, x squared will be a still smaller fraction. For example, if x is half, x squared is quarter; if x is one fifth, x squared is one twenty-fifth."

George was with me. "Now assume that a is slightly larger than unity. Then abx^2 will be much smaller than 1," he said. "The real part will be nearly 1 and positive, and the imaginary part will be smaller than 1, so. . . ." He didn't quite know what this proved.

I said, "Because both real and imaginary parts are positive, the angle is something less than 45°, because the ratio is fractional—less than 1." He saw that (Fig. 6). I went on, "As x approaches 1, abx^2 will still be less than 1, and ax will get bigger than $(1 - abx^2)$, so the angle will approach 90°. Then we pass through 90° when $(1 - abx^2)$ is zero. Beyond that, $(1 - abx^2)$ is negative, so the tangent ratio is negative, indicating an angle over 90°. As x gets larger than 1, x^2 gets much larger than 1, so the ratio is almost the same as x/x^2, or $1/x$."

$$\phi = \text{ARCTAN}\ \frac{ax}{1-abx^2}$$

WHEN $x=1$, & $ab=1$, WE HAVE $1-abx^2=0$

① $x \ll 1 \quad \phi \cong \text{ARCTAN}\ ax < 45°$

② $x \to 1 \quad \phi \to 90°$

③ $x \gg 1 \quad \phi \cong \text{ARCTAN}\left(-\frac{a}{x}\right) \to 180°$

Fig. 6—The phase angle of the circuit changes as the operating frequency does.

George had followed this and saw the value of approximating in this way, to see where the angle "goes" without detailed calculations.

I went on. "Now about amplitude. For the 3-dB point to coincide with the 90° phase point and cutoff or crossover frequency, where x equals 1, what else must we fix?"

"Is this expression," George pointed to $(1 - abx^2 + jax)$ in Fig. 5, "in voltage, current, or power?"

"We decided, when we started, that it represented input voltage needed to produce unity output voltage," I replied.

"So the 3-dB point means we need the input voltage to be root two, or 1.414 times output voltage. Is that right?"

"Yes."

"Then with $(1 - abx^2)$ as zero, the jax part must be 1.414. The j merely identifies the 90° phase shift; also x is 1 at cutoff or crossover, so a must be 1.414. Right?"

INPUT VOLTAGE $= 1 - abx^2 + jax$

REAL PART	IMAG PART
$1-abx^2$	ax
$1-abx^2$	ax
	a^2x^2

$$\begin{array}{l} 1-abx^2 \\ \underline{-abx^2 + a^2b^2x^4} \\ 1-2abx^2+a^2b^2x^4 \\ \underline{\text{add} \to a^2x^2} \\ 1+(a^2-2ab)\,x^2+a^2b^2x^4 = \text{INPUT VOLTAGE SQUARED} \end{array}$$

FOR 3db AT $x=1$, $a=1.414$ & x^2 DISAPPEARS

Fig. 7—When the phase angle is not 90°, figuring the value of input voltage to the filter requires these calculations.

"It certainly is. This means the reactance of the inductor must be 1.414 times the output load impedance at cutoff or crossover frequency."

"Well, that's not too hard to figure," said George. "Now what about the capacitor value?"

"Just remember that b is in susceptance at cutoff frequency. So reactance would be $1/b$."

George was figuring this out. "If ab has to be 1, then b must be $1/a$, or 0.707. But then we'll use a reactance chart to find it, so we'll use $1/b$, which is a, or 1.414. So both a and b are *reactances* of 1.414 times the output load value, at crossover frequency. Is that right?"

I nodded. George was already showing a flair for taking shortcuts, which was fine.

Filter design

"It's beginning to make sense," he said. "But the filter that started all this discussion is much more difficult to figure out, isn't it?"

"Not so hard," I told him. "We've already got the configuration. But before we go further, we should explore the response of this simple filter in a little more detail. In that quick calculation, we did two things for the sake of convenience:

"1. We assumed it is what we call a constant-resistance type—by which we mean, among other things, that the 3-dB and half-phase points coincide at cutoff frequency.

$$\text{VOLTAGE ATTENUATION RATIO} = 1+(a^2-2ab)\,x^2+a^2b^2x^4$$

$$\text{db} = 20\ \text{LOG}\sqrt{1+(a^2-2ab)\,x^2+a^2b^2x^4}$$

$$= 10\ \text{LOG}\left[1+(a^2-2ab)\,x^2+a^2b^2x^4\right]$$

Fig. 8—The product of Fig. 7 can be simplified into this decibel expression.

"2. We considered attenuation only at one frequency. To provide background for more work, we need to figure out more details of the phase and amplitude responses at some other frequencies.

"For example, what is the amplitude of the input voltage, or attenuation factor, when the phase angle is not conveniently 90°, and maybe when this doesn't happen to coincide with the 3-dB point?"

George didn't know where to begin, now, so I continued.

"It's the vector sum of the quadrature components, $(1 - abx^2)$ for the real part and jax for the imaginary or quadrature part. That's the square root of the sum of the squares, remember?"

That set George off, squaring $(1 - abx^2)$ and ax, and adding the parts together, according to terms of x^2 and x^4 (Fig. 7). Then he put the whole thing under a radical sign.

"Actually, if you're working in dB you don't have to go that far," I told him. "The magnitude of the resultant vector is a voltage attenuation ratio, which converts to dB as 20 times the log of this ratio. So don't bother taking the square root. The vector is simply 10 times the log of this sum of the squares." (Fig. 8)

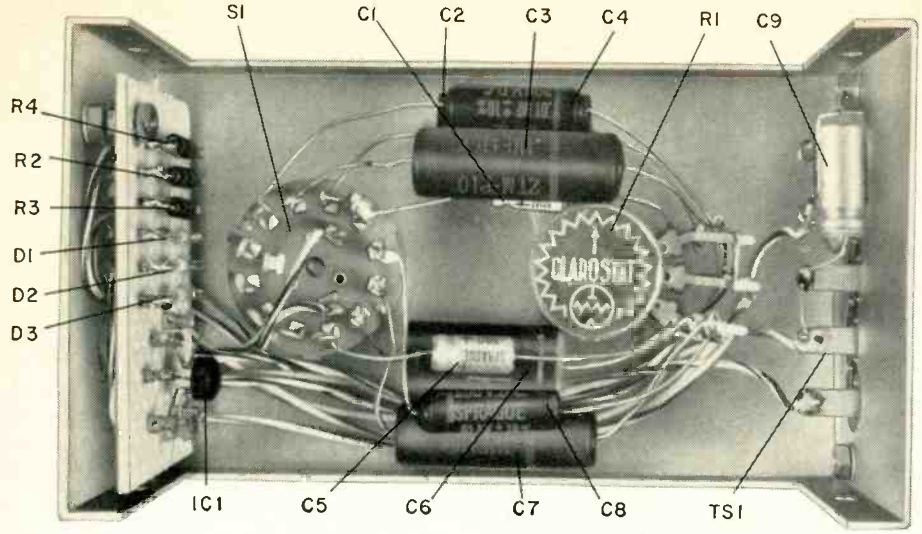
Another problem

I noticed that time was creeping up on us. I had to leave.

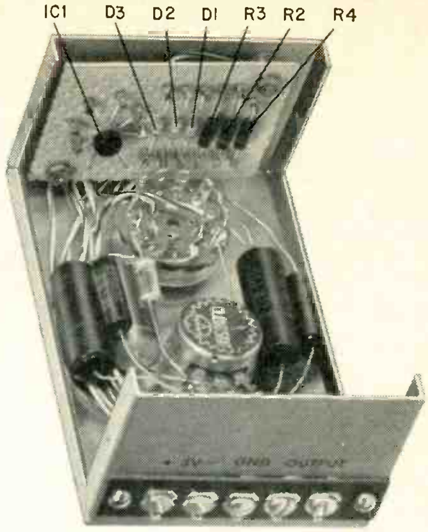
"Time for me to get going, George. See if you can figure out what makes the 3-dB point come at $x = 1$ and also the conditions which would make the response show a peak or a loss greater than 3 dB when $x = 1$. Did you do any calculus in school?"

"Yes, I did," replied George. "It's rusty, because I've never used it since. You mean I'm going to put it to use at last?"

"Yes," I said as I pulled on my coat. "Next time." TO BE CONTINUED



There's plenty of room in the box for all components, including the battery and an on-off switch. Using a perforated board and push-in terminals eases construction.



Terminal strip is convenient, but you can substitute a plug and jack arrangement.

Build Low-Cost IC Signal Generator

(Continued from page 55)

on the schematic.

The easiest way to calibrate is to compare the output of the square-wave generator with that of a calibrated audio oscillator by using Lissajous patterns on an oscilloscope. If you don't have an oscillator and scope available, use a pair of headphones and a piano. Listen to the square-wave generator on the headphones and tune it to several notes of the piano. The table will help.

Calibration on the X10 range will hold reasonably well for the X100 and X1000 ranges. The X1 range, which depends on electrolytic capacitors, may need separate calibration for accuracy.

In using the unit for most audio work, the ac-coupled output is best. No dc flows to the driven circuit.

At frequencies in the X1 range, coupling capacitor C9 may cause the top and bottom of the square wave to tilt. Using dc output corrects this problem.

This square-wave generator is a fast-starting chirp-free oscillator. A key in the 3-volt line turns it into a good code-practice oscillator. **R-E**

How To Fix Intermittent Color TV Sets
(continued from page 39)

tracing and checking were eliminated.

Tube and component checks showed nothing wrong, though a new tube was left in the set to make sure the old one was not at fault. Nevertheless, the noise returned. A universal-type output transformer was hooked to the anode of the output tube, and a test speaker was used. Now the intermittent disappeared, pinpointing the trouble to the output transformer. (It is highly unlikely that the condition could be caused by the speaker.) A replacement transformer cured the trouble.

In a Silvertone color receiver the convergence changed after the set was in operation for an hour, with red fringes overlapping white-to-dark picture areas. After another half hour's operation the convergence would sometimes return to normal. After the set cooled off for about an hour and was turned on again, the intermittent convergence condition would not always return. Obviously the convergence settings need not be reset, because if the misconvergence was corrected, they would not hold when the intermittent condition reversed itself. Certain settings of the BRIGHTNESS control caused picture blooming, indicating trouble in the high-voltage regulator section. A new 6BK4-B shunt regulator tube cured the trouble.

In a Motorola receiver, intermittent loss of color and picture deterioration were traced to a make/break contact at the antenna. One side of the twin-lead was periodically losing contact. This trouble emphasizes the importance of checking the antenna system. Misorientation can also cause color loss—just watch a color picture while an antenna is being rotated.

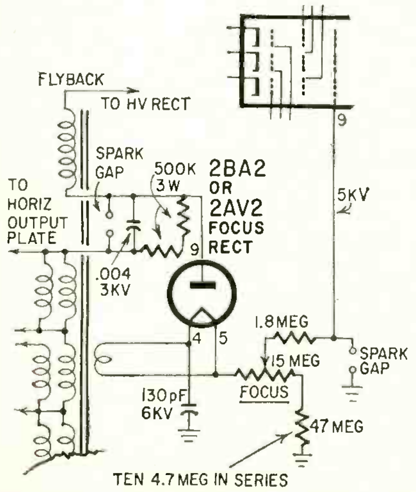


Fig. 5—Complaint was defocusing in this Admiral TV set. Cause was a bad 1.8-megohm resistor connected to CRT pin 9.

In several receivers intermittent color levels were noticed on the high vhf channels (7 to 13), but not on the lower. While a defective oscillator tube in the tuner could cause this, the trouble was traced to intermittent contacts in the station selectors. On occasion the tuner detent failed to position properly and the result was a slight detuning, just as though the fine-tuning control was misadjusted. Cleaning the tuner contacts and adjusting the detent spring cured the troubles.

Logical approach

Because there are so many more circuits in a color set, more intermittent troubles can be expected than in black-and-white receivers. The examples we discussed are, of course, not all-inclusive, but only serve as a guide to the types which might be encountered and the thinking that goes behind the localization procedures. Intermittents can occur almost anywhere in the receiver and each case must be tackled from the standpoint of the circuitry involved and the nature of the symptoms. Each is a different case.

As an electronic technician, what you need most of all to deal with intermittents is *patience!* **R-E**

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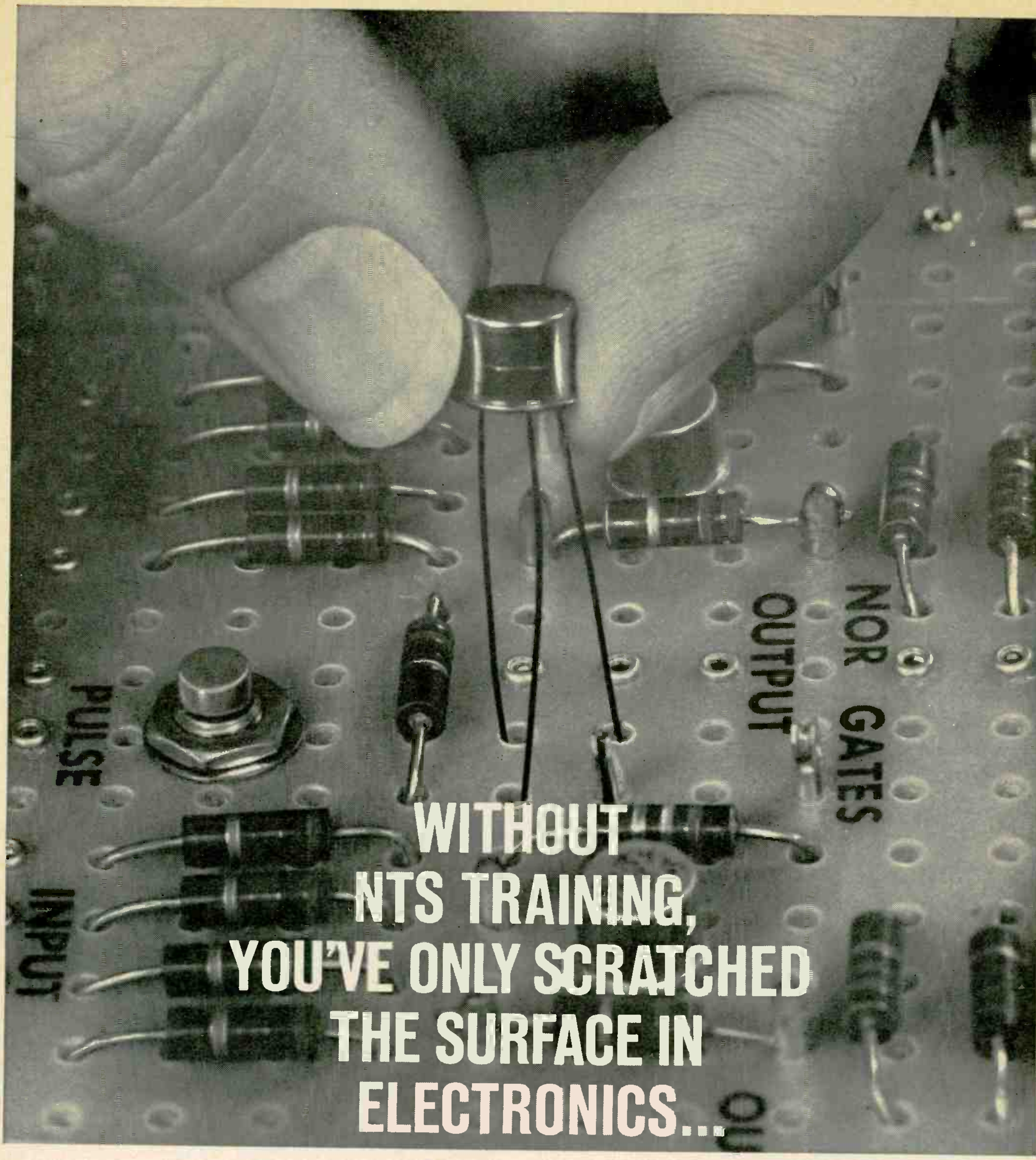

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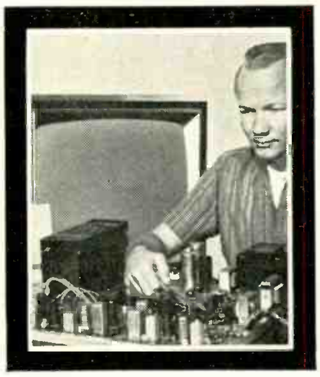

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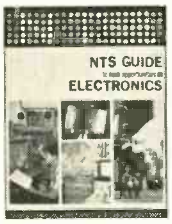

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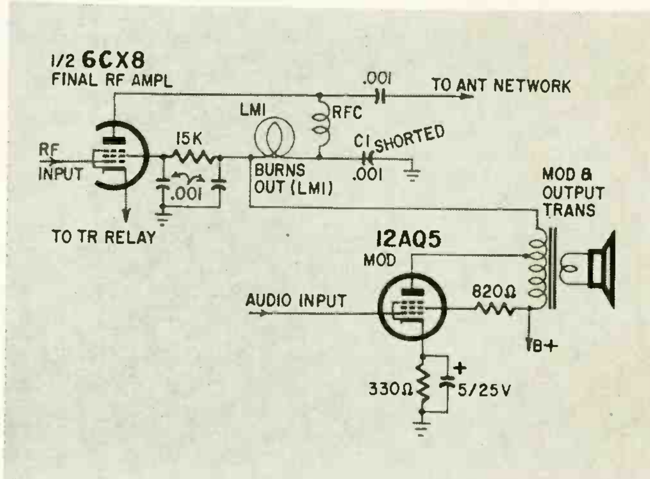
CB Troubleshooter's Casebook

Compiled by Andrew J. Mueller

Case 1: No transmit but receive is okay.

Common to: Knight **C-22.**

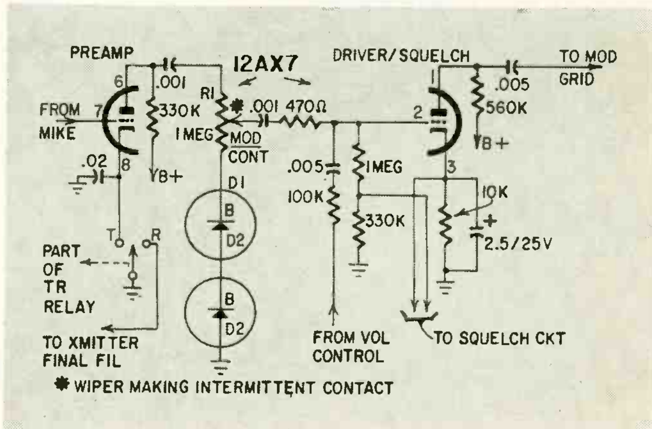
Remedy: Replace shorted rf bypass capacitor C1, lamp LM1 and the 6CX8.



Reasoning: When C1 shorts, a large current is drawn through lamp. This burns out the lamp. If you don't replace or check C1 before replacing the lamp, it will burn out as soon as power is applied to the unit. The pentode section of the 6CX8 will have been damaged due to excessive screen current drawn when the tube was operated with the plate circuit open.

Case 2: Intermittent modulation, receive is okay.

Common to: International **MO-23.**



Remedy: Replace modulation control R1.

Reasoning: With R1 intermittently open, the audio signal will not get from the mike preamp stage to the driver stage. Replacement and proper adjustment of R1 will cure this problem.

EQUIPMENT REPORT

Triplett Model 600
Transistorized Volt-Ohmmeter

Circle 42 on reader's service card

MANUFACTURER'S SPECIFICATIONS

Dc Voltmeter
Ranges: 400 mV to 1600 volts full scale
Accuracy: ±3% of full scale
Input resistance: 2.75 megohms at 0.4 volt; 5.5 megohms at 0.8 volt; 11 megohms other ranges.
Ac Voltmeter
Ranges: 4 volts to 800 volts full scale
Accuracy: ±3% of full scale
Input impedance: 750,000 ohms minimum
Ohmmeter
Ranges: 10 ohms to 1 megohm center scale
Size: 3 3/16" x 5⅛" x 6½"
Weight: 2½ lb
Price: $82.00

WHEN TRANSISTORS CREPT INTO TEST INSTRUMENTS A FEW years ago, they didn't help much in voltmeters. A vom uses no amplifiers, hence can't be transistorized. The vtvm's chief advantage is its high input impedance (a vacuum-tube grid circuit), and the low impedance of a conventional bipolar junction transistor is poorly suited to that application.

Now the field-effect transistor comes along and all of a sudden you have a new kind of voltmeter. Triplett calls their model 600 a TVO—for transistorized voltohmmeter. Self-contained, portable and battery-operated, it's an ohmmeter and ac-dc voltmeter with the input impedance of a vtvm.

Good "human engineering" is evident in the model 600. It uses four batteries (one for the ohmmeter and three for the amplifier power supply). To replace batteries, you need only unscrew a single captive thumbscrew and the chassis slides out of the case. Inside, you find most components are mounted on a rugged, military-type PC board. The ZERO ADJUST control is a geared-down potentiometer, providing greater resolution in adjustment than an ordinary type. Also, the meter movement is protected by a fuse, and a spare is included in a little retaining notch inside the front panel. (But the instruction manual says nothing about either fuse.)

It *is*, however, a nuisance to take the case off, so Triplett has provided an external battery-test procedure. You simply short the test leads and measure the resistance of the 1% precision probe resistor; a meter scale mark lets you know when to replace batteries.

The handle is rigid and can be used to prop the instrument at about a 25° angle for easy viewing on a flat surface. The meter scale is simple to read—red for ohms, black for volts (both ac and dc). The solid-state amplifier is linear, so the voltage scale is, too (no crowded low-voltage ac scale).

Like other Triplett voltmeters, the model 600 has an OFF position which, not only unpowers the amplifier, but also shorts the meter movement. This makes the pointer and coil self-damping, protecting them during transit.

If you have to troubleshoot this instrument, you'll do better to trace out the actual PC board than to refer to the instruction manual. The schematic is nonstandard and hard to understand. But the board and chassis wiring are simple, and parts replacement should be no problem.

I found the model 600 a pleasure to use. It has con-

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venient, well-spaced scale ranges, and it checked out within the specified 3% accuracy. The 0.4-volt dc range is especially useful for troubleshooting transistor circuits.

One caution: Like a vom, the TVO is not shielded. But, like a vtvm, it has amplifiers. This could mean stray pickup if you aren't careful when using it around a transmitter or high rf field. I took the model 600 to a vhf TV station and walked around the transmitter room with it. I could get spurious pickup only by "floating" both test leads; when I shorted them or connected them to a load the TVO worked fine. Still, it's a good idea to remember there's no shield—just in case you get erratic readings.—*Ray Clifton*

Heathkit AR-15 AM-FM-Stereo Receiver

Circle 43 on reader's service card

A COMPLETE STEREO RECEIVER WITH BOTH FM AND AM, an output power of some 70 watts per channel, a full complement of controls and function switches, is no simple little thing. When a machine like that is sold as a kit, it had better be worth the time and effort it takes to assemble.

After living with the AR-15 for a couple of weeks (I didn't build it) I can say quite candidly that I would be pleased and proud to build a stereo system around it. In several ways it is the best-looking, best-performing component (never mind *kit*) of its kind that I have seen for a long time.

The AR-15 is astonishingly sensitive and selective. One of my favorite tests in the New York City area is to wiggle between WQXR-FM on 96.3 MHz and WNBC-FM on 97.1 (both high-power locals) and see how well I can receive the relatively weak 96.7-MHz signal of WSTC-FM—a station in Stamford, Conn., about 35 air miles from where I live. (All this with indoor rabbit-ears on the ground floor.) Not many tuners come off well on *that* test. The AR-15

MANUFACTURER'S SPECIFICATIONS

AMPLIFIER SECTION

Continuous power output, per channel: 8-ohm load, 50 watts.
Power bandwidth for constant 0.5% total harmonic distortion: 6 Hz to 25 kHz.
Frequency response (1-watt level): ±1 dB, 6 to 50,000 Hz, ±3 dB, 4 to 70,000 Hz.
Harmonic distortion: Less than 0.5% from 20 to 20,000 Hz at 50 watts output; less than 0.2% at 1000 Hz with 50-watts output; less than 0.2% at 1000 Hz with 1-watt output.
IM distortion: (60 Hz: 6000 Hz, 4:1): Less than 0.5% with 50 watts output; less than 0.2% with 1 watt output.
Damping factor: 45
Hum & noise: Volume control at minimum position, —80 dB. PHONO (10-mV reference) —60 dB. TAPS and AUX (200 mV reference) —65 dB.
Channel separation: PHONO, 45 dB; TAPE and AUX, 55 dB.

FM SECTION (MONO)
Selectivity: 70 dB
Image rejection: 90 dB
I.f. rejection: 90 dB minimum
Capture ratio: 1.5 dB
AM suppression: 50 dB
Sensitivity: 1.8 μV

FM SECTION (STEREO)
Separation: 40 dB or greater.
19- and 38-kHz suppression: 55 dB or greater.
SCA suppression: 50 dB

AM SECTION
Sensitivity. 12 μV at 1000 kHz
Image rejection: 60 dB at 600 kHz; 40 dB at 1400 kHz.
I.f. rejection: 70 dB at 1000 kHz.
Power: 105–125 or 210–250 volts, 50/60-Hz ac.
Size: 16⅞" x 4¾" x 14½"
Price: $329.95 kit, $19.95 for cabinet.

received WSTC-FM almost perfectly, with no hiss and only an occasional faint crackle from the ignition of a passing car. There was no breakthrough from the neighboring New York stations.

This performance is due partly to the use of low-cross-modulation FET's in the AR-15 front end, and to the excellent limiting provided by the integrated-circuit i.f. amplifiers and their crystal filters.

The muting system is not completely satisfactory. If you adjust it so that it cuts out only interstation hiss, but not weak signals, there is a jarring burst of badly distorted sound-plus-hiss as you tune from between-station silence into the center of a channel. To eliminate that, you have to turn the squelch threshold higher, and then the tuner will pass over some weak signals without a peep. The muting works at least as well as on most other tuners, but there are designs in which stations emerge smoothly from complete silence after you have tuned to the center of the channel.

The AR-15 has two tuning meters—one is a relative-signal-strength indicator, which can be helpful in orienting an antenna, and the other is a center-of-channel indicator, which is more useful for precise tuning. Only the signal-strength meter operates on AM. These meters are used during assembly to check voltages and resistance as construction moves forward. The AR-15 does about the best it can with AM reception, although it compromises between wide bandwidth (nice for good-quality local stations, of which there are few), and really sharp selectivity (necessary for distant stations with considerable interference).

There are screwdriver-adjustable level controls for each program source. That such controls were included at all is nice enough, but to have them accessible from the front is marvelous. The level trimmers are separate for left and right, so you can feed the remainder of the receiver's audio circuitry with a perfectly balanced stereo signal.

Heath gives unusually complete specifications for the AR-15. Almost everything that can be measured and stated in numbers has been included, which is a healthy sign. For example, along with sensitivity figures for various inputs, the overload levels are given. There's a margin of some 20 dB between the input level that produces full output and the level at which the *input* stages overload. Very good.

FM sensitivity and capture ratio are as good as those of any tuner available. The Heath AR-15 is well worth what it costs—in money and in time, unless you need to measure your time as money. It may well be the best receiver on the market now, kit or wired.—*Peter E. Sutheim*

Knight-Kit KG-663 DC Power Supply

Circle 44 on reader's service card

TODAY'S EXPERIMENTERS AND HOBBYISTS—NOT TO MENTION service technicians—work with transistors, IC's, SCR's and Zeners. When you breadboard a circuit or troubleshoot a chassis, you need a low-voltage, high-current bench supply. Here's one that's versatile and protective.

Being slow and careful, I took nearly 12 hours to assemble the KG-663. Components are easily mounted on tie strips, and the hookup wires furnished are color-coded and sized for each specific job. The construction manual is easy to follow; parts are conveniently identified.

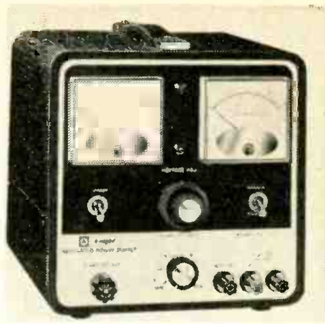
This power supply is useful in several ways. It can furnish either voltage or current regulation, depending on what you need for a particular application. You can connect two or more KG-663's in series (for higher voltage) or in parallel (for higher current). Put the supply on a bench and, with its remote-control facility, you can control it from across the room. There's also provision for remote error sensing—to overcome voltage drop in long test leads.

I said the KG-663 is protective. True—you can't damage anything by putting a dead short on the output terminals; a monitor circuit limits short-circuit current to a safe value.

Two meters monitor output voltage and current. In the STANDBY mode a red panel lamp comes on; in OPERATE a green one lights. Oh yes—the output floats above ground —with the chassis brought out to a separate binding post.

The KG-663 is easy to build, useful and worth the price.—*Thomas R. Haskett* **R-E**

MANUFACTURER'S SPECIFICATIONS



Output Voltage: 0–40 volts
Output Current: 0–1.5 amps
Input Voltage Range: 110–130 volts, 50/60 Hz
Output Load Regulation: Less than 0.06 volt from no load to full rated load.
Line Regulation: Less than 0.3 volt change under all load conditions.
Current Limiting: Continuous, adjustable from front panel.
Short-Circuit Protection: Continuous dissipation type.
Output Impedance: Less than 0.1 ohm from dc to 10 kHz; less than 0.5 ohm to 100 kHz.
Power: 110–130 volts, 50/60 Hz; 20 watts no load; 110 watts at full rated load.
Ripple (full load): Less than 0.6 mV rms
Semiconductors: 11 diodes and 6 transistors
Size: 7¾" x 7½" x 10¾"
Weight: 16 lb
Price: $94.50 kit, $140.00 wired

Shunt Regulators

(continued from page 37)

1) See if the set has too much brightness and possibly blooms, or retrace lines appear.
2) Set the CRT controls as outlined previously.
3) Check the boosted B+ and set the HV ADJ for proper current through the 6BK4 with a black screen.
4) Check the 400-volt supply and the cathode voltage of the shunt regulator.
5) Replace the 3A3 and 6BK4.

If the 6BK4 current is too high—more than 1 volt drop across the cathode resistor:

1) See if the set has adequate brightness.
2) Set the kinescope controls as outlined previously.
3) Dip the horizontal-output current with the HORIZONTAL EFFICIENCY coil.
4) Next see *which* part of the 6BK4 circuit—grid or cathode—has upset the bias. Check both the 850-volt boost and the 400-volt B+ source. Next check the resistor divider network (be careful of any resistor above 1 megohm). Set the HV ADJ control for the proper current flow through the 6BK4.

At no time is it absolutely necessary to measure the high voltage. The time and small effort, if taken, would give a valuable secondary check. If you have a vtvm and an HV probe, by all means, use them. Note that this is a secondary measurement; the amount of 6BK4 current is more important.

Points to watch

Anytime the picture tube blooms—the set is *misadjusted* and high-voltage failures begin.

Anytime the CRT blooms—the shunt regulator has lost control, and the HV is unregulated.

The 1-volt minimum reading across the regulator cathode resistor is with a black screen.

Any of the CRT controls could cause the picture to bloom:

1) The RED, GREEN and BLUE SCREEN controls—Set for a *dim* white line.
2) The customer brightness control—Set at 75% to 90% of full clockwise rotation, then set screens.
3) The CRT bias or picture bias control—Set *only* high enough to bring in the least dominant gun with *full screen* on that gun.

Know the high-voltage and shunt-regulator circuits, and you'll find them easy to troubleshoot. Makes the difference between doing a good job and just a mediocre one. **R-E**

COMING NEXT MONTH

BUILD–Inexpensive but reliable scope and voltmeter calibrator to keep tabs on drift, deviation and other test equipment inaccuracies. Has calibration points of 1, 10 and 100 volts of ac and dc, with accuracy between 1% and 3%. Employs a neon lamp as a voltage reference.

SERVICE–Learn how to service solid-state TV receivers. Transistor circuits require logical, nondestructive trouble-shooting techniques. Stay out of trouble —read about these practical tips.

AUDIO–Large convention halls and auditoriums present feedback and reverberation problems galore. Learn how an "impossible" problem was solved with new techniques.

YOU ASKED FOR IT—Build a Mini-Tenna, a solid-state FM antenna that fits into the palm of your hand. (This 4-transistor construction project was inspired by the Subminiature Integrated Antenna (SIA) which was designed for military use. The editors challenge you to have better luck with it than they did.

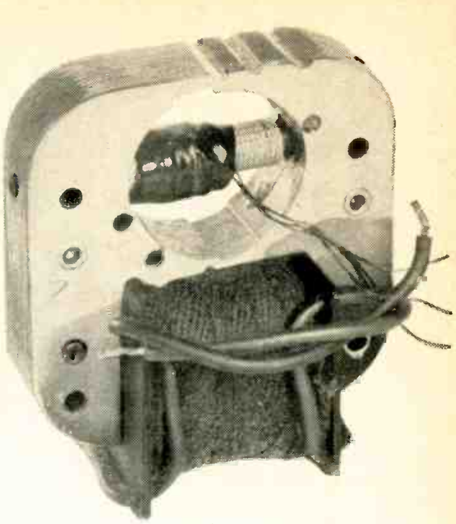
AUDIO–Recording live music on your stereo tape machine? Find out about "curtain-of-sound" miking techniques to achieve best stereo effect.

SERVICE–Ultrasound equipment is used for cleaning and other manufacturing processes. Learn how the equipment works and how to troubleshoot it. It isn't that much different from certain home type electronic equipment you've already worked with.

AND . . . an electronic tremolo you can build for guitar or organ . . . how to set up remote audio lines for a two-way radio system . . . tips on trouble-shooting color TV picture tubes. Yes, all this and more . . . in the next issue

of RADIO-ELECTRONICS.

Build



Quickie Spectrum Sweeper

Phono motor drives local oscillator in AM radio . . . all over the band

By **FRED W. RODEY**

WOULD YOU BELIEVE THAT YOU CAN mix an old phono motor with an old radio and come up with a spectrum sweeper? You can sweep the broadcast band or produce a single 455-kHz i.f. signal. You can also modify the Spectrum Sweeper to work other frequencies.

A recent problem made necessary a spectrum analyzer that would cover a wide band of frequencies in the broadcast band to check harmonic sidebands on a 50-kW transmitter. Voltage-variable capacitors were tried, but their low Q and small capacitance change was a handicap.

Saturable-core inductors have been used to solve this problem, but none could be found on the dealer's shelves to satisfy me; so I decided to construct one. A saturable-core device can be made to work by passing both ac and dc through a control coil on the core. The dc level establishes the average inductance and the ac varies the inductance (at a 60 Hz rate). See Fig. 1. While both currents run through this coil, two separate transformers should be used.

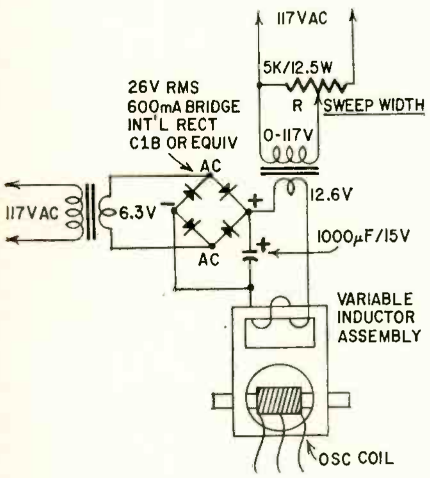


Fig. 1—Direct current establishes the average inductance and ac varies it. Both transformers are connected to the line.

Parts List
Silicon rectifier bridge, 600 mA, (International Rectifier C1B or similar)
Capacitor, 1000 μF, 15 volts
Potentiometer, 5000 ohms, 12.5 watts, (Ohmite Type E-0123 or similar)
Transformers (2): Both with 117-volt primaries, one with 6.3-volt secondary, the other with 12.6-volt secondary.
Phonograph motor: 117 volt, 60 Hz, ac, 2 pole

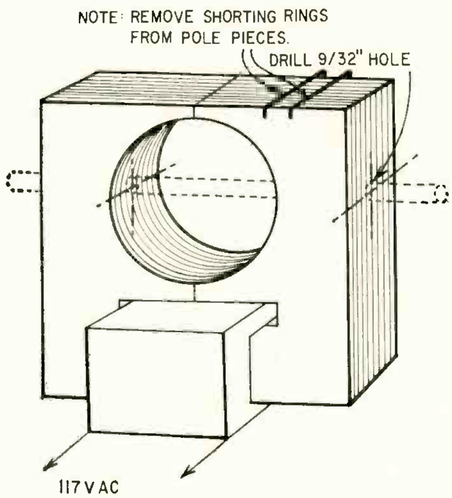


Fig. 2—Salvage the stator coil and frame from a phonograph motor. Discard the rotor and shorting rings and drill the holes.

The unit I built proved to be a very successful sweeper. It can be adapted to any variable-frequency application, so only the general details of construction are given.

The magnetic coil and frame are taken from a 117-volt 2-pole shaded-pole phonograph motor. Only the coil and frame are used. Discard the rotor assembly. Select a motor with a large diameter rotor (about 1 inch).

Mark off center lines and drill 9/32-inch holes through both pole ends.

The holes must be in line (Fig. 2). Clamp or bolt the pole ends together tightly while drilling, to hold the laminations in place.

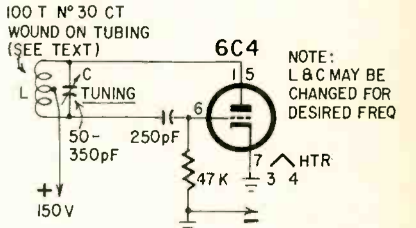


Fig. 3—A suggested oscillator circuit for use with the variable sweep device.

To make the rf coil, use a ¼-inch ferrite rod 2½ or 3 inches long. This is not critical. Cut a length of nonmetallic tubing that will slip easily over the ferrite rod. It should be just long enough to fit inside the motor frame between the poles. The rf coil is then wound on the tubing. Additional coils can be wound on similar pieces of tubing to cover other portions of the spectrum.

To assemble the unit, insert the ferrite rod into the holes in the pole ends and through the rf coil tubing.

Any type of oscillator circuit can be used. A center-tapped coil makes a simple arrangement, and eliminates the need for the rf chokes required in the usual two-terminal configuration. The oscillator in Fig. 3 has a center frequency of 1,150 kHz, ±50 kHz, with 12 volts ac on the control coil. By varying the Sweep Width control (Fig. 1) to reduce the control voltage to 6 volts, the circuit will sweep ±25 kHz. Check the oscillator with a wideband oscilloscope to be sure its output is flat over the entire range swept.

The sweep oscillator was used to replace the local oscillator in a receiver to sweep a spectrum. The rf stage had to be made broad enough to pass the entire band of frequencies to be observed.

You can broaden the passband simply by disconnecting the variable capacitor in the rf stage. If too much sensitivity is lost, reconnect the capacitor, tune it to the center frequency and shunt the circuit with a resistor. The lower the value of the resistor, the broader the band, and the lower the gain. **R-E**

√ Page file

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More information on new products is available free from the manufacturers of items identified by a Reader's Service number. Turn to the Reader's Service Card facing page 74 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

CB BATTERY PACK, *Model PAP-1, Port-A-Pak* features a rechargeable battery which operates most solid-state CB rigs in receive position for 8 hours. Can be recharged while in standby position. In-

cludes a collapsible antenna, battery and battery meter, durable case, charging connector, mounting hardware, shoulder strap and microphone bracket. $12.95—**Courier Communications, Inc.**

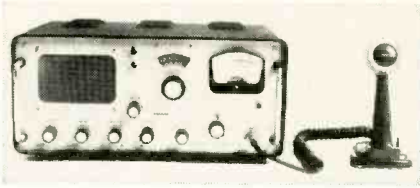
Circle 46 on reader's service card

CB AND MOBILE MICROPHONE, *Model + 350.* Contains a transistorized preamplifier which provides improved transmission quality compared to carbon

microphones. Output level is — 38 dB below 1 volt per dyne per square centimeter. Response is 350–4,000 Hz. $35.00—**Turner Microphone Co.**

Circle 47 on reader's service card

BASE STATION, *Titan II.* It is a single-sideband receiver and a double-sideband suppressed-carrier transmitter. Mechanical filter produces 90-dB adja-



cent-channel selectivity. Input for 10 dB signal-plus-noise-to-noise ratio is 0.15 μV, delivers 4 watts maximum output. Contains 23 transmit crystals. $482.—**Tram Corp.**

Circle 48 on reader's service card

WIRELESS INTERCOM, *Model AM-340.* Hold in hand or hang on wall. Solid-state unit works between rooms,

apartments, offices or adjacent buildings. To operate, units are plugged into 117 Vac outlet. $29.98—**Olson Electronics, Inc.**

Circle 49 on reader's service card

FM MONITOR RECEIVERS. *Model FR-104* and *Model FR-105.* Adaptable for commercial and industrial applications, these solid-state units operate on 117 Vac, 50/60 cycles and 12 Vdc. Plug-in channel crystals allow instant frequen-

cy change. Model FR-104 operates in the 25–50 MHz band, sensitivity is 0.3 μV, and selectivity 6 dB and model FR-105 (shown) operates in the 150–175 MHz band, sensitivity is 0.8 μV, and selectivity 60 dB. $140.—**Sonar Radio Corp.**

Circle 50 on reader's service card

2-WAY MOBILE RADIO, *PACE 2000.* Comes in 3 frequency ranges: 25–35, 35–45, and 45–50 MHz and can be used as a base station or mobile installation. Features lifetime-guaranteed glass-

fiber circuit boards, double-conversion receiver, 12 Vdc or ac operation, full diode protection and Zener regulation. Use of silicon transistors permits operation in temperatures from −40°F to +155°F. **Pace Communications Corp.**

Circle 51 on reader's service card

MARINE RADIOTELEPHONE. Operates with static-free clarity in vhf bands. Can transmit at full power with an antenna as short as 20 inches and needs no ground plate attached to the boat's

hull. This 12-channel two-way radio can be used to talk with other boats, call for assistance, or talk with anyone ashore through a telephone company operator. 40–50-mile range. $595.—**Raytheon Company**

Circle 52 on reader's service card

BASE STATION, *Model DJ95.* Operable on one to six channels in the 148–174 MHz band. Power output is 30 watts and receiver sensitivity is 0.35 μV for 12

dB SINAD. Adjacent-channel selectivity is −70 dB and bandwidth is 13 kHz. Spurious response is down 100 dB. Three other Models also available.—**Kaar Electronics Corp.** **R-E**

Circle 53 on reader's service card

14 NEW KITS FROM HEATH...

For The Whole Family . . .
New Deluxe "227" Color TV

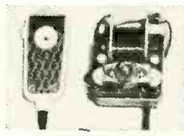
Kit GR-227
$419.95 (less cabinet) $25 mo.

Exclusive Heathkit Self-Servicing Features. Like the famous Heathkit "295" and "180" color TV's, the new Heathkit "227" features a built-in dot generator plus full color photos and simple instructions so *you* can set-up, converge and maintain the best color pictures at all times. Add to this the detailed trouble-shooting charts in the manual, and you put an end to costly TV service calls for periodic picture convergence and minor repairs. No other brand of color TV has this money-saving self-servicing feature.

Advanced Features. Boasts new RCA Perma-Chrome picture tube for 38% brighter pictures . . . 227 sq. in. rectangular viewing area . . . 24,000 v. regulated picture power . . . improved phosphors for brilliant, livelier colors . . . new improved low voltage power supply with boosted B+ for best operation . . . automatic degaussing . . . exclusive Heath Magna-Shield to protect against stray magnetic fields and maintain color purity . . . ACC and AGC to reduce color fade and insure steady, flutter-free pictures under all conditions . . . preassembled & aligned IF with 3 stages instead of the usual 2 . . . preassembled & aligned 2-speed transistor UHF tuner . . . deluxe VHF turret tuner with "memory" fine tuning . . . 300 & 75 ohm VHF antenna inputs . . . two hi-fi sound outputs . . . 4" x 6" 8 ohm speaker . . . choice of installation — wall, custom or optional Heath factory assembled cabinets. Build in 25 hours.

Kit GR-227, (everything except cabinet) . . . $42 dn., as low as $25 mo. . . 114 lbs. **$419.95**
GRA-227-1, Walnut cabinet . . . no money dn., $6 mo **$59.95**
GRA-227-2, Mediterranean Oak cabinet (shown above) . . . no money dn., $10 mo. **$94.50**

New Remote Control For Heathkit Color TV



Kit GRA-27
$19.95

Now change channels and turn your Heathkit color TV off and on from the comfort of your armchair with this new remote control kit. Use with Heathkit GR-227, GR-295 and GR-180 color TV's. Includes 20' cable.

Kit GR-295
$479.95
(less cabinet)
$42 mo.

Deluxe Heathkit "295" Color TV

Color TV's largest picture . . . 295 sq. in. viewing area. Same features and built-in servicing facilities as new GR-227. Universal main control panel for versatile in-wall installation. 6" x 9" speaker.

Kit GR-295, (everything except cabinet), 131 lbs. . . . $48 dn., $42 mo. **$479.95**
GRA-295-1, Walnut cabinet (shown above), 35 lbs. . . no money dn., $7 mo. **$62.95**
Other cabinets from $94.50

Kit GR-180
$359.95
(less cabinet & cart)
$31 mo.

Deluxe Heathkit "180" Color TV

Same high performance features and exclusive self-servicing facilities as new GR-227 (above) except for 180 sq. in. viewing area.

Kit GR-180, (everything except cabinet), 102 lbs. . . $36 dn., $31 mo. **$359.95**
GRS-180-5, table model cabinet & mobile cart (shown above), 57 lbs. . . . no money dn., $5 mo. **$39.95**
Other cabinets from $24.95

FREE... 40-Lesson Record Course With Either Heathkit/Thomas Organ! A $50 Value! Includes four 33⅓ rpm records, music book & leatherette album.

Kit TO-67
$995
(including bench)
$200 dn.,
as low as $29 mo.

Heathkit® /Thomas "Paramount" Theatre Organ

Save Up To $500! Build in 80-100 hours. All Thomas factory-made parts . . . 15 manual, 4 pedal voices; instant-play Color-Glo; all-transistor circuit; 200 watts peak power; 2-speed rotating Leslie plus main speaker system with two 12" speakers; 44-note keyboards; horseshoe console with stop tablets; 28-note chimes; 13-note bass pedals; repeat & attack percussion; reverb; headset outlet; assembled walnut finish hardwood cabinet & bench; and more. 265 lbs. 7", 33⅓ rpm demonstration record 50c.

America's Lowest Cost Solid-State Organ

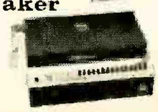
Kit GD-325B
$394.90
$40 dn., $34 mo.

Save Up To $205! Instant-play Color-Glo; 10 voices; 13-note bass pedals; repeat percussion; 37-note keyboards; 75-watt peak power; vibrato; assembled walnut cabinet & bench. 172 lbs. 7", 33⅓ rpm demonstration record 50c.

Exclusive Band Box Percussion

Automatically or manually adds 10 percussion voices to any Heathkit/Thomas organ. Build & install in 12 hours.
Kit TOA-67-1, no money dn., $14 mo. **$145.00**

Exclusive Playmate Rhythm Maker



Adds 15 fascinating rhythms to any Heathkit/Thomas Organ. Requires Band Box percussion (above) for operation.
Kit TOA-67-5, no money dn., $18 mo. **$189.90**

Circle 106 on reader's service card

USE COUPON BELOW TO ORDER NOW

NEW! VOX "Jaguar" Transistor Combo Organ By Heathkit

Kit TO-68
$349.95
$35 dn., $30 mo.

Save Up To $150 on the world's most popular combo organ with this new Heathkit version. Features the most distinctive sound of any combo organ. Has a special bass output that gives a brilliant stereo bass effect when played through a separate or multi-channel amplifier, 4 complete octaves, vibrato, percussive effects and reversible bass keys. Includes hand crafted orange and black cabinet, fully plated heavy-duty stand, expression pedal and waterproof carrying cover and case for stand. Requires a bass or combo amplifier like Heathkit TA-17 (opposite page).

Kit TO-68, 80 lbs.... $35 dn., $30 mo. **$349.95**

NEW! Deluxe Solid-State Combo Amplifier & Speaker System ... Choose Kit Or Factory Assembled

Amplifier Kit TA-17
$175
$17 mo.
(Assembled TAW-17 $275)

Speaker System Kit TA-17-1
$120
$11 mo.
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Special Combination Offer
Amplifier & Two Speaker Systems
Save $20
Kit TAS-17-2
$395
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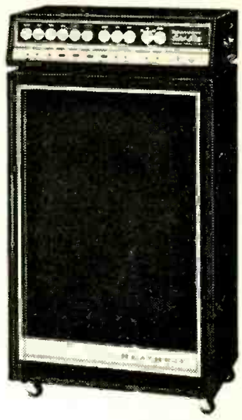


All the "big sound" features every combo wants . . . tremolo, built-in "fuzz", brightness, reverb, separate bass and treble boost and more. Delivers a shattering 120 watts EIA music power (240 watts peak power) through two TA-17-1 speakers . . . or 90 watts through one TA-17-1 speaker. Features 3 independent input channels, each with two inputs. Handles lead or bass guitars, combo organ, accordion, singer's mike, or even a record changer. All front panel controls keep you in full command of all the action.

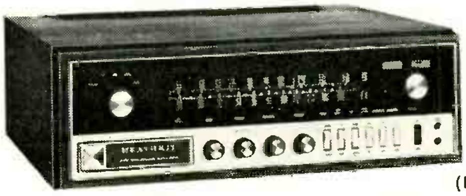
Speaker system features two 12" woofers, special horn driver and matching black vinyl-covered wood cabinet with casters & handles for easy mobility.

NEW! Lowest Cost Solid-State Stereo Receiver

Kit AR-17
$72.95
(less cabinet)
$8 mo.

Features wide 18-60,000 Hz response @ ±1 db at full 5 watts RMS power per channel . . . 14 watts music power . . . inputs for phono and auxiliary . . . automatic stereo indicator . . . outputs for 4 thru 16 ohm speakers . . . adjustable phase for best stereo . . . flywheel tuning . . . and compact 9¾" D. x 2⅞" H. x 11⅞" W. size. 12 lbs. Optional factory assembled cabinets (walnut $7.95, beige metal $3.50).

Kit AR-17, (less cab.) 12 lbs. . . . no money dn., $8 mo. . . **$72.95**
Kit AR-27, 7-Watt FM Mono Only Receiver (less cab.) 9 lbs. . . . no money dn., $5 mo. **$49.95**



Kit AR-15
$329.95
(less cabinet)
$28 mo.

Assembled
ARW-15 $499.50
(less cabinet) $43 mo.

World's Most Advanced Stereo Receiver

Acclaimed by owners & experts for features like integrated circuits & crystal filters in IF amplifier; FET FM tuner; 150 watts music power; AM/FM and FM stereo; positive circuit protection; all-silicion transistors; "black magic" panel lighting; and more. Wrap-around walnut cabinet $19.95

Kit AR-15 (less cab.), 34 lbs. . . . $33 dn., $28 mo. **$329.95**
Assembled ARW-15, (less cab.), 34 lbs. . . . $50 dn., $43 mo. **$499.50**

Professional 10-Band Shortwave Receiver

Kit SB-310
$249
$23 mo.

Covers 49, 41, 31, 25, 19 & 16 meter shortwave . . . 80, 40 & 20 meter ham . . . 11 mete CB Includes 5 kHz crystal filter for AM, SSB and CW listening. Features selectivity that slices stations down to last kHz; 11-tube circuit; crystal-controlled front-end and more. 20 lbs. SB-600 8 ohm 6" x 9" speaker in matching cabinet $18.95.

NEW! Solid-State Portable Volt-Ohm-Meter

So Handy, So Low Cost we call it "every man's" meter. Just right for homeowners, hobbyists, boatowners, CBer's, hams . . . it's even sophisticated enough for radio & TV servicing! Features 12 ranges . . . 4 AC & 4 DC volt ranges, 4 ohm ranges; 11 megohm input on DC, 1 megohm input on AC; 4½" 200 uA meter; battery power; rugged polypropylene case and more. Easy 3 or 4 hour kit assembly. Ideal gift for any man! 4 lbs.

Kit IM-17
$19.95

NEW
FREE 1968 CATALOG!
Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, electric guitar & amplifier, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

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Please send model (s)__________
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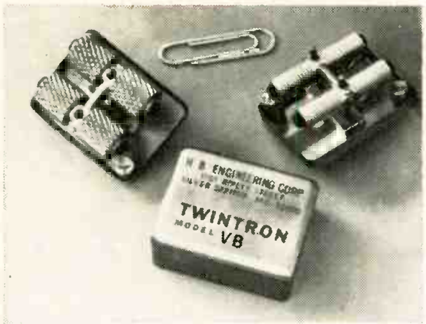
Name__________
Address__________
City__________ State__________ Zip__________
Prices & specifications subject to change without notice. CL-310R

NEW PRODUCTS

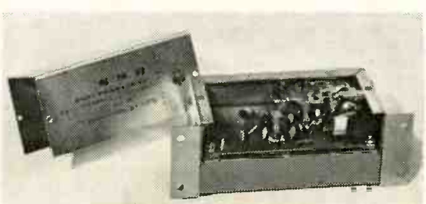
AF RESONATOR. *Twintron*, a tunable electromechanical resonator available in 100–700 Hz, 300–3000 Hz and 700–8000 Hz frequency ranges. The Q is adjustable from approx. 50 to over 200. Thermal stability is 0.05% from —30 to +60° C. It can be used by experimenters and builders of radio controls for model aircraft and boats and as audio oscillators, narrow-band pass or reject filters and tone echo reflectors.—**H. B. Engineering Corp.**



Circle 54 on reader's service card

AM/FM TABLE RADIO, *Model S-214.* Covers the 19-, 25-, 31- and 49-meter overseas bands plus standard AM/FM broadcasts. Uses 10 transistors and 6 diodes. Has only 5 controls for simple operation. Automatic gain control reduces fading and blasting. Tuning range is 540–1600 kHz, 5.9–6.25, 11.5–12.0, 15.05–15.55 and 88–108 MHz. There are 3 separate antennas for AM, FM and SW. Encased in a die-cast chromed front and walnut grained-vinyl-covered metal cabinet. $89.95—**Hallicrafters Co.**

Circle 55 on reader's service card



SSB-1 RADIO ADAPTER. Designed for one-way mobile communication, the unit is applicable to fire, police, civil defense, marine and commercial uses. A complete FM communications tuner that feeds an af signal to the automobile radio. Incorporates a squelch system which eliminates all noise. Features FM limiters, advances circuit design and simple mounting. This compact unit has 7 transistors and 5 diodes and is available from 30 through 175 MHz range. Technical data sheet available.—**SSB Electronics Co., Inc.**

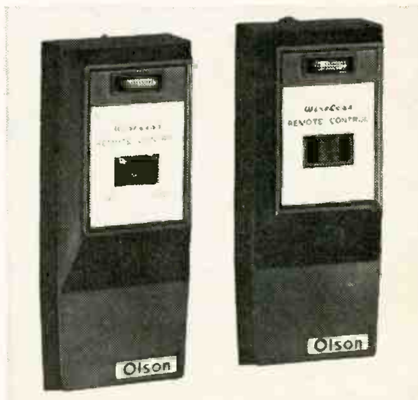
Circle 56 on reader's service card

VHF CONVERTER, *Weather Watcher.* Receives U.S. Weather Bureau forecasts on 162.55 MHz and converts them to play through an AM radio, either

battery or ac-powered. No wired connections are necessary. Kit, $14.95; finished set, $18.95.—**Executive Research, Inc.**

Circle 57 on reader's service card

WIRELESS REMOTE CONTROL SWITCH, *Model SW-394.* Turn any electric appliance up to 500 watts off and on from anywhere in your home. Appliance is plugged into the receiver



and receiver is plugged into wall outlet. The remote control transmitter plugs into any other outlet in the house. No wires are used. Operates on 110 to 120 volts ac. Transmitter and receiver $14.95.—**Olson Electronics, Inc.**

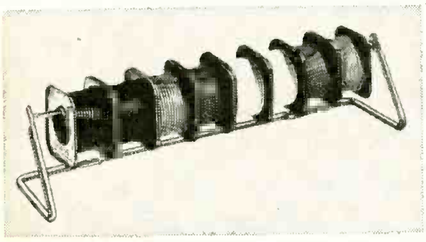
Circle 58 on reader's service card

COLOR TV RECEIVER KIT, *Model 600.* Table model has a 180-sq.-in. picture area and comes with a woodtone vinyl-clad steel cabinet. Designed for training use, printed circuit boards are used throughout. Incorporates 21

tubes, solid-state uhf tuner and noise cancellation circuit and 16 diodes. Separate gun killer switches and a cross-hatch generator are built in for easy maintenance.—Conar Div. of National Radio Institute.

Circle 59 on reader's service card

8-SPOOL HOOK-UP WIRE KIT, *No. 8816.* Features eight spools of 18-gauge stranded vinyl wire on a portable metal rack dispenser, which is easily



mounted on workbench or wall. Each spool holds 25′ of wire. Available in brown, red, orange, yellow, green, light blue, white and black.—Belden Corp.

Circle 60 on reader's service card

VARIABLE SPEED SABRE/JIG SAW, *Model 521.* Thumb pressure controls speed from 0 to 2800 one-inch strokes per minute. Features retractable

shoe plate and man-size handle. Powered by ⅓-hp 4-amp ac motor and weighs 4⅓ lbs. Operates on 110–120 Vac. Comes with seven cutting blades. Guaranteed 1 year. $34.95.—Wen Products, Inc.

Circle 61 on reader's service card

COMMUNICATIONS RECEIVER, *DX-150.* Operates on either 117 Vac or 12 Vdc. Covers shortwave, ham and CB frequencies from 535 kHz to 30 MHz. Provides AM, SSB and CW reception. Features a product detector, variable pitch bfo, fast/slow avc, built-in monitor speaker, 11 front-panel controls including rf gain control and antenna trimmer. Sensitivity is 0.5 μV at 30 MHz. Uses 19 transistors, 13 diodes and 3 thermistors. Enclosed in a silver-grey metal cabinet. A 12-volt dc portable power pack and exact-match external communications speaker (SP-150) are optional, $7.95 each. Receiver is $119.95. Additional information available.—Radio Shack Corp.

R-E

Circle 62 on reader's service card

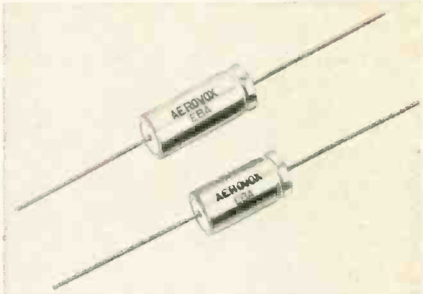
Circle 108 on reader's service card

81

NEW COMPONENT PRODUCTS

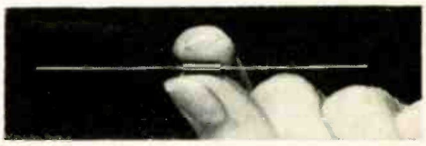
MINIATURE ELECTROLYTIC CAPACITORS. Cased in aluminum and reduced in size, these capacitors are suitable for use in personal radios, microphones, wire recorders, miniature TV receivers and tape recorders. Eliminate variable or high-resistance connections. 32 types available with ratings from 1 to 1000 μF, and dc ratings of 3, 6, 10, 15, 25, 35, 70, and 100 volts.—**Aerovox Corp.**

Circle 63 on reader's service card



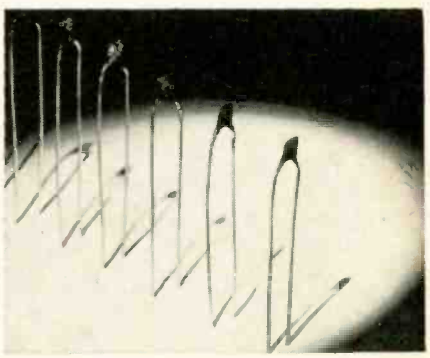
METAL FILM RESISTORS. *MAF-60 Series.* ¼-watt (at 70°C) and ⅛-watt (at 125°C) precision. Change in resistance after 1000-hr. load life is less than ±0.5%. Standard temperature coefficient is 100 PPM/°C. Undercoated with silicone and final-coated with molded epoxy resin. Solder-coated copper axial leads are standard.—**P. R. Mallory & Co. Inc.**

Circle 64 on reader's service card



SMALL CERAMIC CAPACITORS, *Types TMD5 and TMD6.* Phenolic-coated with radial-lead construction. Combines multilayer technology with dipped encapsulation. For conventional or printed wiring assemblies in tuned circuits, delay lines and filter circuits. Standard ratings are from 10 to 100,000 pF.—**Cornell-Dubilier Electronics** R-E

Circle 65 on reader's service card



82

THE COLOR TV SERVICING BOOM IS ON!

BE IN ON THE PROFIT PICTURE *with the know-how you get in* COMPLETE PHOTOFACT® COLOR TV COVERAGE

283 ***Here are the PHOTOFACT sets with Color TV coverage from the beginning in 1954 through 1967:***

1	31	61	91	121	151	181	211	241	271	301	331	361	391	421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871	901
2	32	62	92	122	152	182	212	242	272	302	332	362	392	422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872	902
3	33	63	93	123	153	183	213	243	273	303	333	363	393	423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873	903
4	34	64	94	124	154	184	214	244	274	304	334	364	394	424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874	904
5	35	65	95	125	155	185	215	245	275	305	335	365	395	425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875	905
6	36	66	96	126	156	186	216	246	276	306	336	366	396	426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876	906 Sept.
7	37	67	97	127	157	187	217	247	277	307	337	367	397	427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877	907 Sept.
8	38	68	98	128	158	188	218	248	278	308	338	367	398	428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878	908 Sept.
9	39	69	99	129	159	189	219	249	279	309	339	369	399	429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879	909 Sept.
10	40	70	100	130	160	190	220	250	280	310	340	370	400	430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880	910 Sept.
11	41	71	101	131	161	191	221	251	281	311	341	371	401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851	881	911 Sept.
12	42	72	102	132	162	192	222	252	282	312	342	372	402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852	882	912 Oct.
13	43	73	103	133	163	193	223	253	283	313	343	373	403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853	883	913 Oct.
14	44	74	104	134	164	194	224	254	284	314	344	374	404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854	884	914 Oct.
15	45	75	105	135	165	195	225	255	285	315	345	375	405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855	885	915 Oct.
16	46	76	106	136	166	196	226	256	286	316	346	376	406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856	886	916 Oct.
17	47	77	107	137	167	197	227	257	287	317	347	377	407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857	887	917 Oct.
18	48	78	108	138	168	198	228	258	288	318	348	378	408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858	888	918 Nov.
19	49	79	109	139	169	199	229	259	289	319	349	379	409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859	889	919 Nov.
20	50	80	110	140	170	200	230	260	290	320	350	380	410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860	890	920 Nov.
21	51	81	111	141	171	201	231	261	291	321	351	381	411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861	891	921 Nov.
22	52	82	112	142	172	202	232	262	292	322	352	382	412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862	892	922 Nov.
23	53	83	113	143	173	203	233	263	293	323	353	383	413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863	893	923 Nov.
24	54	84	114	144	174	204	234	264	294	324	354	384	414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864	894	924 Dec.
25	55	85	115	145	175	205	235	265	295	325	355	385	415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865	895	925 Dec.
26	56	86	116	146	176	206	236	266	296	326	356	386	416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866	896	926 Dec.
27	57	87	117	147	177	207	237	267	297	327	357	387	417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867	897	927 Dec.
28	58	88	118	148	178	208	238	268	298	328	358	388	418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868	898	928 Dec.
29	59	89	119	149	179	209	239	269	299	329	359	389	419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869	899	929 Dec.
30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870	900	930 Jan.

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Circle 110 on reader's service card

NEW TEST EQUIPMENT

COLOR GENERATOR, *Model 680.* Four crystal-controlled oscillators can be operated on ac or battery. Compact, solid-state and portable, it incorporates a wide range of test patterns, including sin-

gle and multiple vertical bars. Uses 26 semiconductors and features nine video patterns and printed circuitry. Available in kit and wired versions.—**Conar Instruments**

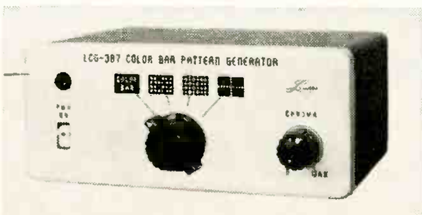
Circle 66 on reader's service card

TRANSISTOR ANALYST, *Model 161.* Checks transistors, diodes and rectifiers out-of-circuit for ac beta and I_{cbo} leakage. Beta ranges are 2 to 100 and 10

to 500, and leakage range is from 0 to 5000 μA. Comes with transistor spec handbook and an instruction manual. $89.95. —**B & K Div., Dynascan Corp.**

Circle 67 on reader's service card

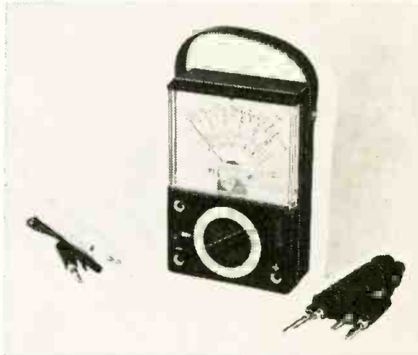
COLOR-BAR PATTERN GENERATOR, *LCG-387.* Rf output: channels 5 and 6, selectable; 10 mV open circuit from 300-ohm source. 10 color bars; chroma level 0% to 200% of sync-pulse



amplitude, continuously adjustable. Crosshatch: vertical: 14 lines, 0.2-μsec width and 4-μsec spacing. Horizontal: 11 lines, 1 scan line with return trace blanking; 24H spacing (1H = 63.5 μsec.). Dots: at intersections of crosshatch. Single cross: centered on standard raster. Comes with carrying case, 300-ohm cable with connector and insulated clips. $140.—**Leader Electronics Corp.**

Circle 68 on reader's service card

MULTITESTER, *Speco Model P-100-L.* Includes ample ranges in dc voltages (10,000-ohms/volt sensitivity), ac voltage (5000-ohms/volt sensitivity), direct current and resistance, all selected with one knob. Features carrying strap,



1% precision resistors, printed-board construction and meter fuse protection. Comes with batteries, test leads and instruction manual. $21.95. Model LP-1 probe with light available for $2.69.—**Components Specialties, Inc.**

Circle 69 on reader's service card

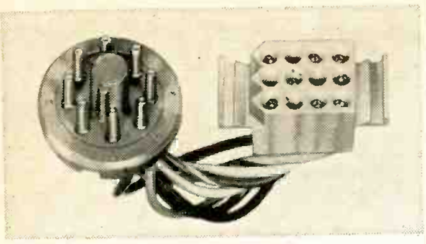
MULTIMETER, *Model TE-216.* 100,000 ohms/volt. Dc volts; 0.3, -12, -60, -120, -300, -600, and -1200. Ac or output voltage: 0-6, -30, -120 and -300

volts. Dc resistance: 0-2000, 200,000, 2 meg and 200 meg. Direct current: 0-12 mA, 6 mA, 60 mA, 300 mA, and 12 amps. $39.98.—**Olson Electronics, Inc.**

Circle 70 on reader's service card

84

UNIVERSAL YOKE ADAPTER, *YA Series*. Makes possible the replacement of yokes for various TV makes and models. The various adapter combina-



tions substitute the *DY 91-AC* yoke and four adapter plugs (*YA-1, YA-2, YA-3* and *YA-4*) for the five yokes previously needed on hand.—**Stancor Products, Essex Wire Corp.**
Circle 71 on reader's service card

DIGITAL VOLTMETER, *Model 304*. Polarity is automatically selected and displayed. Overload protection to 100 volts on the 100-μV, 1- and 10-volt ranges, and to 1200 volts on the 100- and

1000-volt ranges is provided. Input resistance is 10 megohms (1 meg on the 100-volt and 1000-volt ranges). Power rating is 115/230 volts ±10%, 50–400 Hz, 22 watts. $375.—**The Roback Corp.**
Circle 72 on reader's service card

TROUBLESHOOTING TESTER, *Trantracer*. Low current enables the tester to locate open transistors quickly and to determine diode polarity in circuit

boards and assemblies. Can be used as a continuity tester for circuits up to 400,000 ohms resistance and is unique in that the current through the circuit is less than 50 μA.—**Desco Manufacturing Co.** **R-E**
Circle 73 on reader's service card

85

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 74 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

SPEAKER CATALOG, 12 pages. Comments of well-known authorities and specs on AR-2, AR-2a, AR-3, AR-4 and AR-4x speakers. Also includes AR line of 33⅓ and 45-rpm turntables and other components and guides. Prices and order blank provided.—**Acoustic Research, Inc.**
Circle 74 on reader's service card

STEREO COMPONENTS. 20-page 1968 brochure covers components and speaker systems, including new furniture styles for cabinets and speaker systems. *Brochure AL-1368* gives specs and features of all equipment.—**Altec Lansing**
Circle 75 on reader's service card

INSTRUMENT MOTORS. 8-page catalog covers servo-control, induction, reluctance and hysteresis synchronous motors. Each of the four types of motors are available with one of 20 gear trains from 0.67 to 1800 rpm, dual bearing-shaft support and epoxy-insulated stator.—**Amphenol Controls Div., Amphenol Corp.**
Circle 76 on reader's service card

PLASTIC POWER TRANSISTOR, *Engineering Data Sheet B-5001.* 6 pages. Provides technical specs, safe operating area (SOAR) charts and engineering parameters. Electrical characteristics are also given for this silicon npn transistor type B-5001, along with a list of area stores for easy ordering.—**Bendix Semiconductor Div.**
Circle 77 on reader's service card

TECHNICAL BOOKLET, *Recording High Off-Ground Signals,* 20 pages. Gives solutions to problems encountered in recording test or troubleshooting data from automatic systems in which dc voltages of 500 to 1000 are operational, or where control-loop signals are maintained at high off-ground potential.—**Clevite Corp.**
Circle 78 on reader's service card

"10 WAYS TO INCREASE PROFITS *with Concord Video Tape Recorders"* is an 8-page booklet that tells how profit results from use of video tape recorders in business. It gives features and names applications in which this instrument can be useful.—**Concord Electronics Corp.**
Circle 79 on reader's service card

SCIENCE CATALOG, *No. 681.* Pages of good reading for people in engineering, design, production and research and development. More than 4,000 items cover the fields of science, math and optics for hobbyists, schools and industry. 147 pages chock full of bargains.—**Edmund Scientific Co.**
Circle 80 on reader's service card

1968 CATALOG is a 108-page kit-builder's treasure listing over 300 kits for every interest, every budget. All are available at 50% savings over comparable factory-built models. There is something for the music enthusiast, shortwave listener, camera bug, car fan and many more.—**Heath Co.**
Circle 81 on reader's service card

SLIDE RULE AND CALCULATOR CATALOG. 16 pages of special-purpose slide rules, calculators, slide charts, and kits geared to the fields of electronics and mechanics. Features two new calculators. Prices and order information included.—**Info Inc.**
Circle 82 on reader's service card

BELLS, BUZZERS AND CHIMES, a 19-page catalog including audible signals, transformers, pushbuttons, electrical specialties, fire and burglar alarm systems and other devices. Gives specs, features and use.—**Lee Electric, Inc.**
Circle 83 on reader's service card

RECHARGEABLE ALKALINE BATTERIES. Batteries can be recharged 50 times and require no water. Used in TV receivers, ac/dc radios, portable phonos, tape recorders, cameras, small appliances, flashlights, etc., these D, C and AA size batteries can be stored for 2 years under normal temperatures. They are capable of giving full primary capacity and have a large reserve for emergency use. 5-page booklet gives specs and information.—**Mallory Battery Co., Div. P.R. Mallory & Co., Inc.**
Circle 84 on reader's service card

1967/68 ANTENNAS, *No. AT-218.* 16-page catalog describes TV/FM antennas and audio accessories. Gives specs, features and model numbers and lists nearest stores for ordering convenience. Flyers also available.—**Mosley Electronics Inc.**
Circle 85 on reader's service card

TUBE BRITENERS, *LCB 68.* 4-page catalog covers and TV Briteners for b-/w and color TV, automatic voltage regulators and service products and accessories. Quick selector chart shows at a glance which Briteners are right for any given tube. Includes *model C-502* for cathode-to-heater shorts in round tubes, *model C-512* for rectangular tubes and *model D-210* automatic voltage regulator for color sets and other appliances.—**Perma-Power Co.**
Circle 86 on reader's service card

STEREO BULLETINS (two) which describe stereo components, stereo compacts and stereo consoles. Both give specs and model numbers. Charts provide features and specs of all models at a glance.—**H. H. Scott, Inc.**
Circle 87 on reader's service card

SEMICONDUCTORS, *Catalog B-9418.* 16 pages. Describes semiconductor devices ranging from the largest commercially available transistor (250 amps) to a line of low-cost plastic-case rectifiers. Includes spec charts and dimensional diagrams for transistors, thyristors and rectifiers. **Westinghouse Semiconductor Div.**
Circle 88 on reader's service card

NUTDRIVER SET, *Bulletin N867.* Describes hollow-shaft nutdriver set *No. HSC-1* which features a drilled handle and speeds lock-nut/screw adjustments. Gives specs for the 8 shafts with hex openings from 3/16" through 9/16".—**Xcelite Inc.**
Circle 89 on reader's service card

Write direct to the manufacturers for information on the item listed below:

SHIELDING FOR ELECTROMAGNETIC COMPATIBILITY. 40-page design manual gives basic information including permeability and attenuation curves for commonly used ferromagnetic alloys. Provides design data on selection of materials, heat treatment, effect of shield configuration and thickness on magnetic shielding performance, and formulas for calculation of field attenuation in decibels. $1.50 per copy.—**Magnetic Metals Co.** 2108 Hayes Ave., Camden, N. J. 08101

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Handbook for Electronic engineers — Huge encyclopedia packed with electronics information. Hundreds of diagrams and drawings. Over 400 pps. List price $16.00. No. G-29.

Probes for Test Instruments — Shows how to use probes for quicker, more accurate testing and servicing. Fully illustrated. 224 pps. List Price $4.60. No. G-54.

Industrial Electronics Made Easy — Crystal-clear data on operation and maintenance of all types of industrial equipment. 228 pps. List Price $5.95. No. G-99.

New Skill-Building Transistor Projects & Experiments — Learn about transistors by actually doing things with them. Scores of projects. 192 pps. List Price $4.95. No. G-129.

Electronic Engineering Measurements Filebook — A single source of measurement principles and practices; over 60 complete "How to Measure" sections. Newly revised. 256 pps. List Price $9.95. No. T-131.

Test Instruments for Electronics — Shows how to get the most out of your test equipment; how to modify, improve, and make it do more than designed to do. 192 pps. List Price $4.95. No. G-131.

TV Troubleshooter's Handbook — Carefully-planned reference source of over 350 different, tried and tested solutions to B&W and Color "tough dogs". 192 pps. List Price $6.95. No. 401.

Ten-Minute Test Techniques for Electronics Servicing — Brand new practical handbook describes how trouble in any piece of electronic equipment can be pinpointed quickly and easily. 176 pps. List Price $6.95. No. 424.

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THIS ENTIRE FOLD-OVER COUPON FORMS A NO-POSTAGE-REQUIRED BUSINESS REPLY ENVELOPE

Circle 115 on reader's service card

TECHNOTES

ADMIRAL RECORD CHANGERS

Complaint: Changer stalls in cycle.

Remedy: A thorough cleaning.
1. Wipe the entire inside flange of the turntable with a clean white cloth wet with trichlorethane (you can use carbon tetrachloride in a well-ventilated area). Do *not* use any other solvent.
2. With the idler wheel lightly pressed against the rotating motor shaft, clean its rim with 400-grit sandpaper until its working surface is uniformly black.
3. Use a clean white cloth wet with trichlorethane to wipe all surfaces of the motor shaft that contact the idler wheel in any function.
4. Carefully replace the turntable, rotating it clockwise to ease installation.—*Admiral Service News Letter*

SYLVANIA DO1-2 COLOR CHASSIS

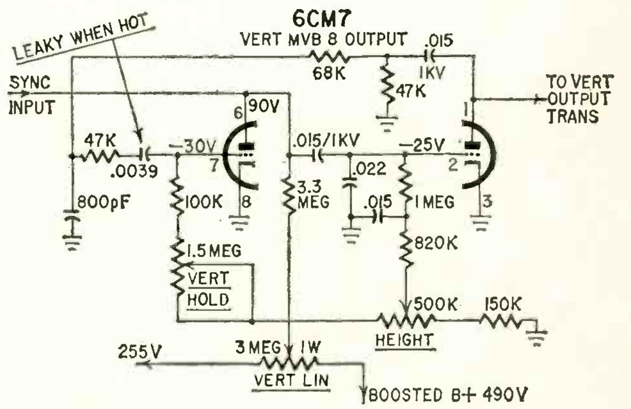
Complaint: Insufficient width.

Remedy: Replace horizontal-oscillator coupling capacitor C420 (.0015 μF). It is probably shorted. When it shorts it produces the following symptoms:
1. High-voltage adjustment control inoperative.
2. High voltage only 23 kV; should be 25 kV.
3. High-voltage regulator inoperative.
4. Horizontal output tube bias low.—*Sylvania Service Notebook*

HAIR DRYER FINDS LOST VERTICAL SYNC

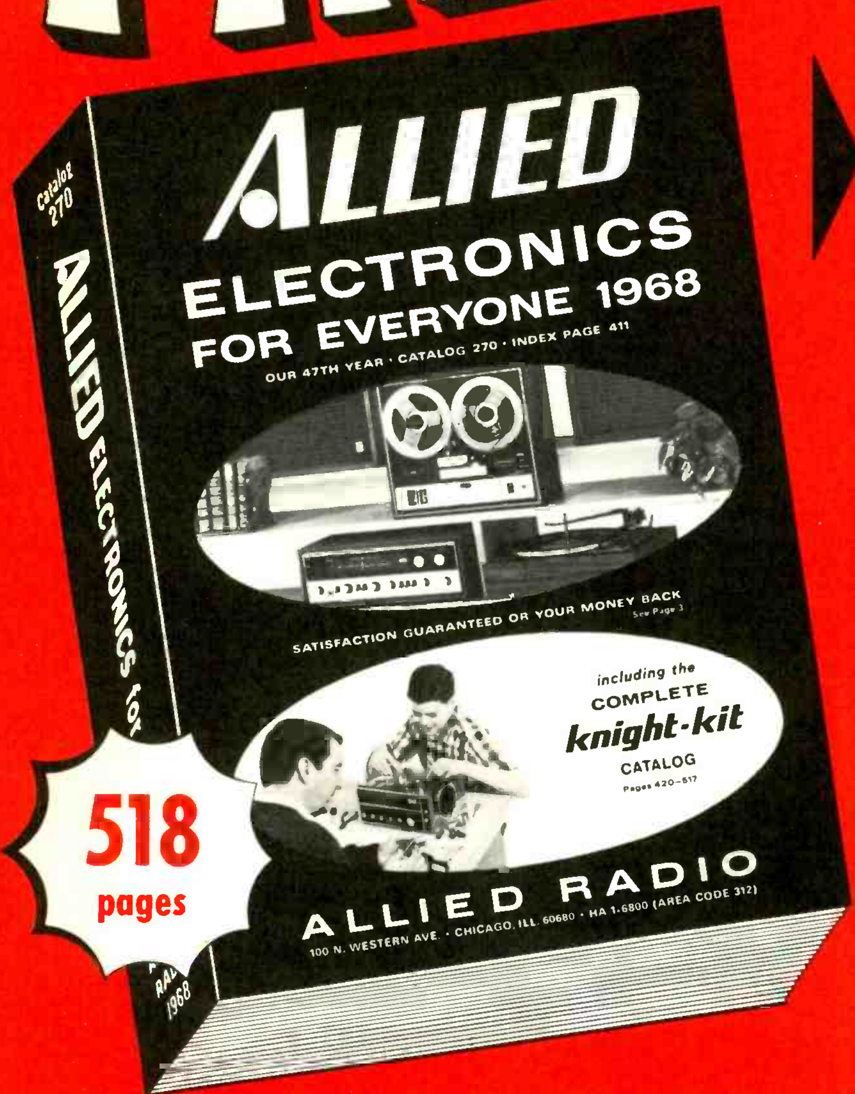
Complaint: The vertical-hold control had to be readjusted several times to maintain sync during the first 45 minutes or so after the set was turned on. Soon the end of the control range was reached and sync was lost.

Symptoms: All parts in the vertical oscillator and sync circuits checked OK. The set worked OK with the back off but soon lost sync when the back was replaced.



Remedy: The problem was obviously caused by a temperature-sensitive component. I used a small hair dryer to direct a stream of warm air over the various parts in the vertical oscillator circuit. The culprit was the .0039-μF capacitor connected to the grid of the input section of the 6CM7 (see diagram). When heated, it became leaky and provided a temperature dependent resistive path in parallel with the vertical hold control to ground. Replacing this capacitor cured the trouble.—*Stan Thomas* **R-E**

FREE



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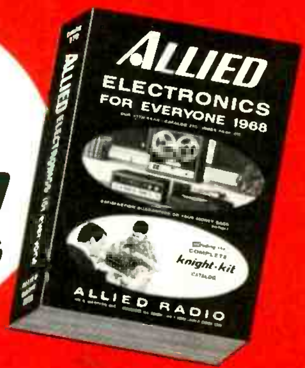

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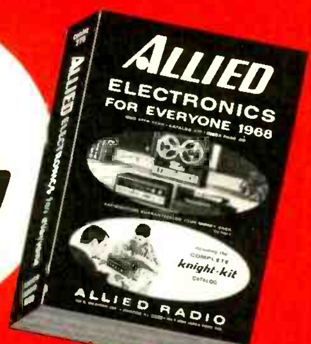

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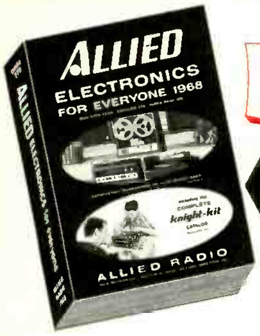

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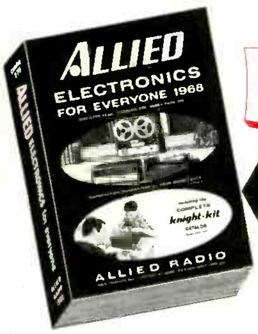

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New Color TV Tuning Indicator

(*continued from page 43*)

across R905 is about 3 volts p-p when the tuning is correct.

Video peak detector Q900, buffer amplifier Q901, and peak detector Q902 circuits insure that the control voltage level for correct tuning remains constant and "tracks" the incoming signal regardless of its strength. The dc control voltage at the emitter of the peak detector is a constant 4 volts at the correct tuning point and "swings" above or below this level when the set is mistuned. This control voltage is applied to diode X904 in the gate circuit.

Gate circuit X903 and X904 and bistable multivibrator circuit Q903 and Q904 allow the comparator to monitor 2 different signals in a particular time-sharing mode. During the first time period (1 picture field) the gate "passes" the reference voltage, and during the next field it "passes" the control voltage. The bistable multivibrator changes state on each vertical pulse so that the switching rate for each gate signal is 30 Hz, as shown in Fig. 4.

Assume for the moment that Q903 of the bistable multivibrator is on. Its collector is essentially at ground potential and therefore grounds R920 going to the junction at the gate diodes. Since Q904 is off, its collector is close to 12 volts. Also, the control voltage input (when turning is correct) is nominally about 4 volts. Both diodes are forward-biased. The gate output voltage is essentially the same as the control voltage input to the bottom diode because the control voltage is fed from a low-impedance source and the diode voltage drops tend to cancel out because the diodes are connected in opposite polarity.

When the bistable multivibrator changes state so that Q903 is off, both diodes become biased off; the junction of their cathodes goes close to 12 volts. The gate output voltage is now determined by the resistance divider R921, R922 and R923.

Finally, the video gate circuit consists of fast-switching diodes X203 and X204 and biasing resistor R252. This resistor feeds a positive voltage (somewhat less than 25 volts) to X204's anode and keeps it forward-biased when no gating pulse is applied to X203. This permits the transmitted video signal to reach the grid of the second video amplifier. Diode X203's cathode is at +25 volts so it is reverse-biased. When the negative-going gating pulse arrives, X203 conducts and X204 cuts off. The gating pulse passes through X203 and cuts off the video amplifier and picture tube just long enough to make the bars on the screen. **R-E**

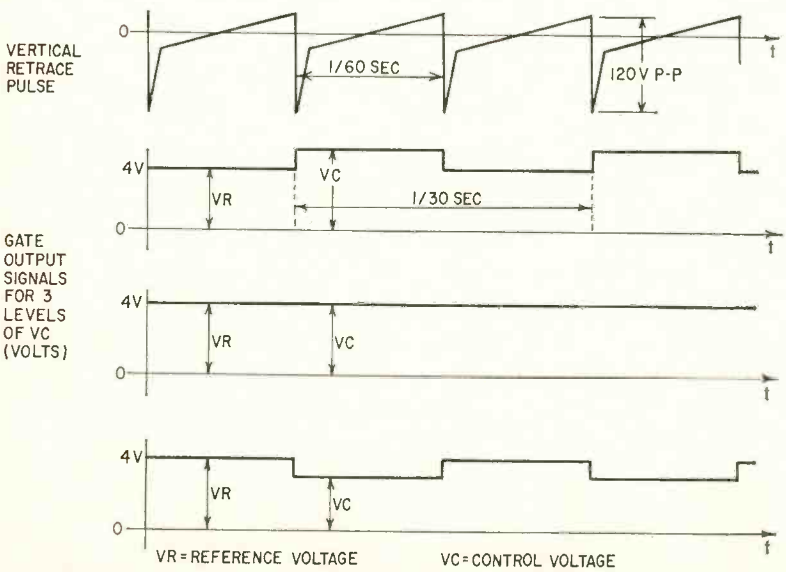


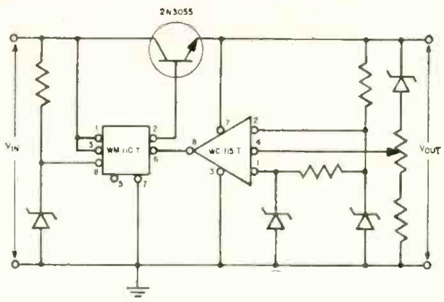
Fig. 4—Gate output voltages V_c and V_r are developed during alternate fields. The second thru fourth drawings show how V_c varies as set's fine-tuning control is adjusted.

91

NEW SEMICONDUCTORS

NEW IC 350-WATT VOLTAGE REGULATOR

The Westinghouse WM 110 T integrated-circuit voltage regulator combines in a single TO-3 package a reference diode and sensing amplifier followed by Darlington-connected series regulator power transistors, all on a single silicon chip.



The regulator provides regulation within 2% over a range of 8 to 48 volts output at currents up to 2 amps. When fed from a constant-current source, regulation is within 0.2% and is further improved when the low-cost WC 115 T IC differential amplifier is used as a feedback element.

The diagram shows a typical 350-watt power supply using the WM 110 T driven by the differential amplifier. The regulated output of the WM 110 T is fed to the base of a 2N3055 series regulator transistor which delivers up to 350 watts of clean power to the load.

The IC voltage regulator is ideally suited to aircraft/aerospace, mobile and fixed applications requiring clean power in the 1–10-amp range from electromechanical, solid-state or battery sources. Its self-contained error-signal feedback loop has a gain greater than 10,000. This permits operation without external amplifiers. Further information can be obtained from Westinghouse Molecular Electronics Div., Elkridge, Md. 21227.

AND MICROCIRCUITS

TWO NEW TUBES FOR COLOR TV

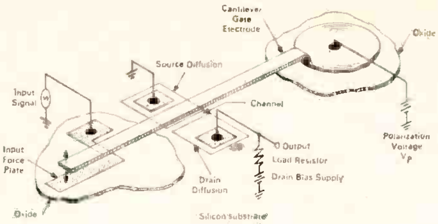
The General Electric 6JE6-B is an improved version of the 6JE6 designed for cooler operation and a lower primary beam-plate emission.

The 3BS2-A is a new compactron high-voltage rectifier with a 4-second warm-up time which makes it ideal for use in color sets designed to start operating within seconds after being turned on. The output current rating of this G-E tube is 2.2 mA. Heater current is 480 mA at 3.15 volts with a steady-state peak plate current rating of 110 mA.

RESONANT-GATE TRANSISTOR

The resonant-gate transistor (RGT)—until now, a laboratory curiosity—is now available for evaluation. It is a frequency-selective device with Q's ranging from 20 to 200.

Its operation results from a mechanical resonating beam or "tuning fork" set in motion by electrostatic forces produced by the input signal voltage. Vibration of the cantilever beam is



sensed by a conventional MOSFET for which the beam serves as a gate.

At present, the frequency range is limited to about 3 kHz to 30 kHz but higher frequencies can be obtained by using an overtone mode of vibration.

The RGT's are available for $67 each from Westinghouse Molecular Electronics Division, Elkridge, Md. 21227. **R-E**

(continued from page 33)

cific channels. A slanting frequency response across a TV channel can cause trouble to a color signal. For example, Fig. 6 shows the response of a poor b-w antenna to channel 6. The color information is received at unequal amplitudes by this antenna. This causes unequal phase delay over the range of color information, producing incorrect colors.

A modern color antenna is designed for maximum frequency flatness rather than maximum gain. A color antenna should be flat within 2 dB per TV channel and 1 dB is required for really excellent color pictures.

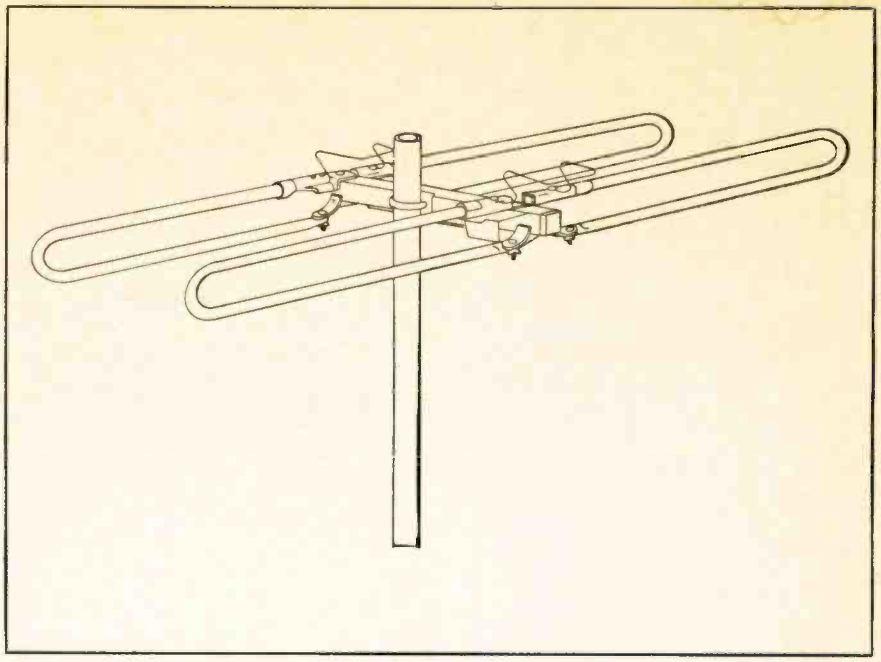


Fig. 4—Antenna elements can be connected or arranged to reduce sidelobes to reject multipath signals. Antenna has low gain but is useful for avoiding ghost pickup.

One way to minimize ghosts—use a flat-response directional antenna with a rotator. Then aim for the best picture.

Uneven frequency response can also be caused by lead-in, matching transformers or multiset couplers, but this is rare. More common is tilted response in the tuned circuits of the TV receiver. Technicians sometimes deliberately misalign certain receiver circuits in an effort to compensate for poor antenna response or for tilts caused by lead-in standing waves.

Misalignment is a poor compromise solution. For one thing, it's almost impossible to make all colors true at the same time. Generally, you can make the flesh tones look real, but the yellows or the greens will be a little off.

The best solution is to align the color receiver properly, according to the manufacturer's instructions, with a good color-bar generator. Use an antenna with flat frequency response. Lead-in should be carefully installed away from ac lines and metal elements. The type of lead-in depends on your location. For suburban locations without much interference, ordinary twin-lead will do. Near the ocean where salt spray corrodes rapidly, a heavy-duty twin-lead is needed.

If noise pickup is a problem, you will need shielded lead-in. Two types are available: 72-ohm coax, and 300-ohm shielded twin-lead. Depending on the antenna and receiver, you may need baluns (matching transformers) with 72-ohm coax. Any balun used must have flat frequency response to preserve the color phase values.

With good quality equipment and a careful installation, you should be able to get faithful, ghost-free color reception on all channels—except possibly in the most unusual of reception conditions. **R-E**

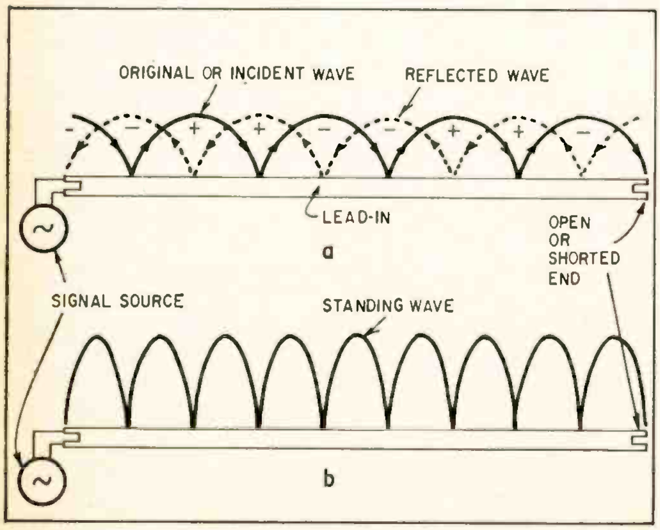


Fig. 5—Under certain conditions, the incident and reflected waves on the lead-in cross at the same points (a). The result is a series of standing waves (b) which usually cause ghosts.

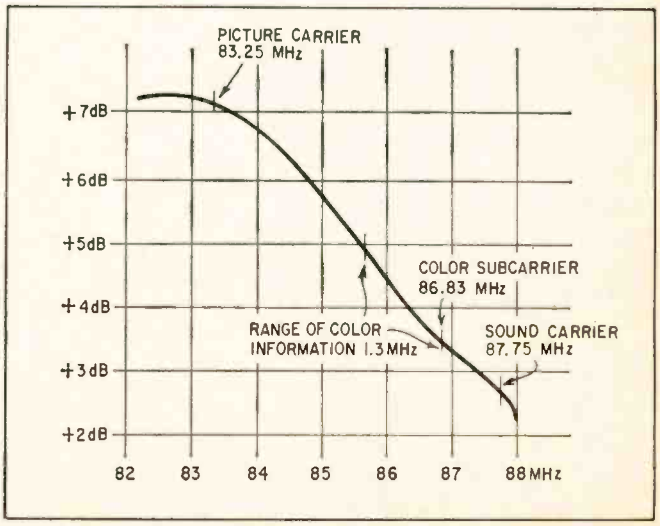


Fig. 6—Uneven frequency response across a TV channel (by an antenna) can cause undesirable color changes in the picture. Antenna should be flat within 2 dB across TV channel.

NEW BOOKS

ELECTRONICS MATHEMATICS, by Gregory J. Nunz and William L. Shaw. *McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. 10036. 9 x 6 in., 418 pp. Cloth, $9.95*

Two volumes in one book: Vol. I is designed for use either in a first course in electronics or concurrently with a nonmathematical introductory electronics course; Vol. II can be used concurrently with study of ac circuit fundamentals involving trigonometry and vector notation. Prepares the student for subsequent courses in active circuit devices, computer fundamentals, and other electronic equipment. Features slide-rule instruction as part of the text and computation tables in the appendix.

UNDERSTANDING SCHEMATIC DIAGRAMS, edited by Julian M. Sienkiewicz. *Allied Radio Corp., 100 N. Western Ave., Chicago, Ill. 60680. 5½ x 8½ in., 112 pp. Paper, $0.75*

An introduction to electronics, this book explains in nontechnical language the functions of components, their uses in electronic circuits, and the symbols and techinques of schematic diagrams. The chapters cover such subjects as tubes and semiconductors, connecting devices and fundamental components. Material is made easy to understand with generous use of illustrations and diagrams. Two pages are used for drawings of the most commonly used schematic symbols.

LASERS AND MASERS, by Charles A. Pike. *Howard W. Sams & Co., Inc., 4300 W. 62nd St., Indianapolis, Ind. 46206. 5½ x 8½ in., 176 pp. Paper, $4.95*

Presents the fundamentals of both gas and solid-state laser and maser devices. Also covers the early history and development of atomic structure and provides the framework on which laser and maser devices have been built. At the end of each topic and chapter is a set of questions and answers designed to help you learn by reinforcing the facts presented in the text. A final examination at the end of the book serves as a review and tests your comprehension. Fully illustrated and easy to understand.

YOUR FUTURE IN THE HIGH FIDELITY INDUSTRY, by Bernard Newman. *Richard Rosen Press, Inc., 29 E. 21 St., New York, N. Y. 10010. 8½ x 6 in., 128 pp. Cloth, $4.00*

A definitive study of the field to help you select your life's work, this book will enable you to weigh your own capabilities and ambitions in light of the requirements, the advantages and the drawbacks of such a career. It is hoped that the book will attract the most capable young people to the challenging and rewarding career opportunities in the high-fidelity components industry. The book covers all phases of the art—origins, trends, factory, sales and retail operations, warranties and repairs, available jobs and financial rewards. **R-E**

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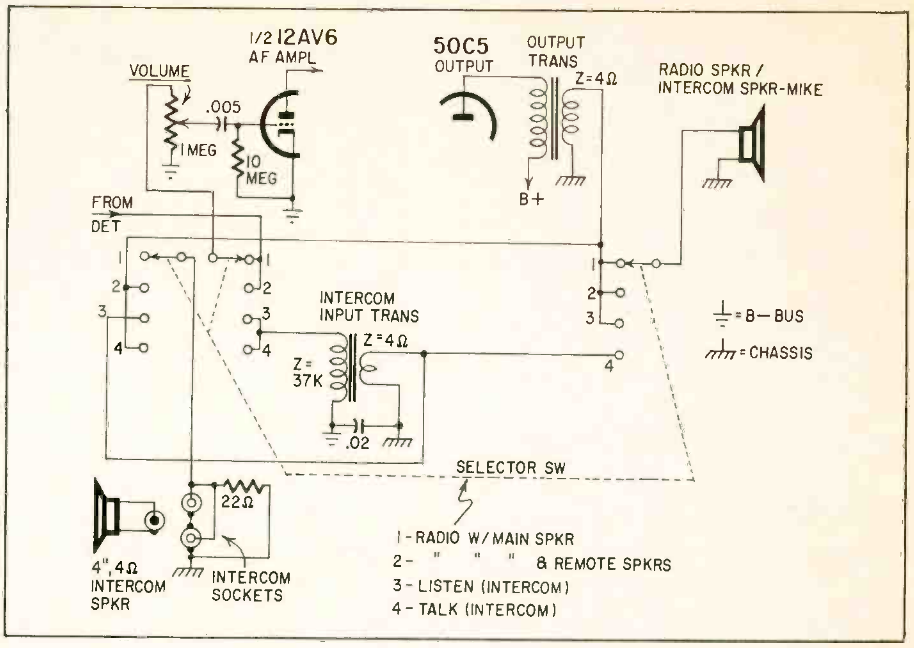
NOTEWORTHY CIRCUITS

UNUSUAL CIRCUIT

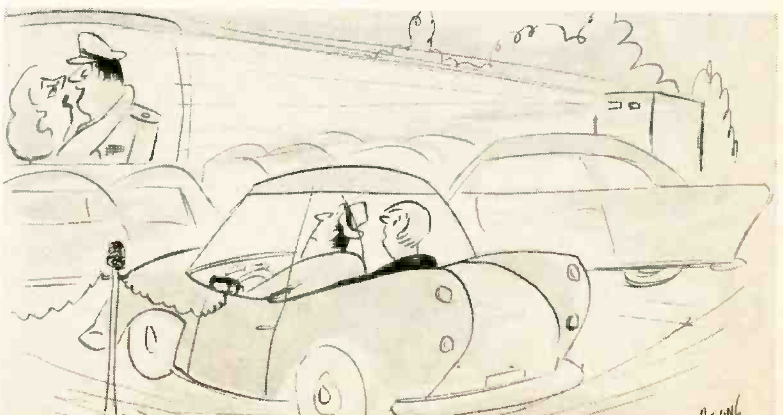
(Radio–Intercom)



A radio that can be used as an intercom is very useful in any home. Programs can be piped into distant rooms so the volume at the set does not have to be pushed up to an uncomfortable level. A mother can call the kids up from the basement playroom or her husband from the garage. The intercom is useful also as a remote babysitter. Place a speaker near the crib, lock the master selector switch in the listen position and you are in business.

One of the simplest radio–intercom setups was that used in Sears' model 3039 Silvertone radio (a 1963 model). The diagram shows the set's audio circuitry. The input transformer matches the voice coil to the af amplifier grid when the unit is used as an intercom.

(Gather up a 3-pole, 4-position switch, input transformer and a couple of small PM speakers and you are ready to hook up your radio as an intercom. Be sure to shield the high-impedance leads from the detector and to the high end of the volume control to minimize hum and feedback. The switch should have positive detents in the RADIO and LISTEN positions with a spring to return it to LISTEN.)—*E. Wilhelm* **R-E**



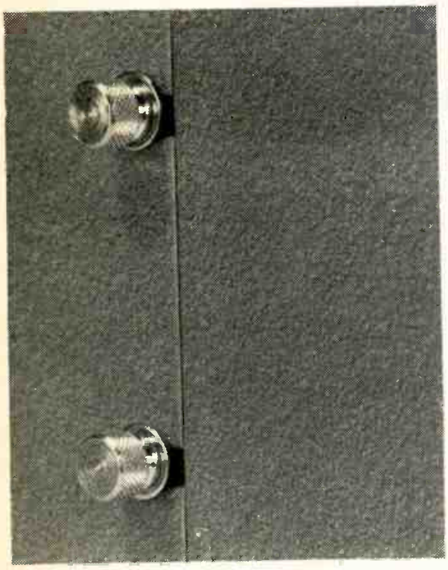
"No wonder the picture is confusing . . . you didn't turn on the sound and you forgot to turn your radio off."

TRY THIS ONE

RACK SCREW REPLACEMENT

Relay panels have been held in relay racks with oval-head machine screws and cup washers since Western Electric adopted the method about a half-century ago. This method of mounting is mechanically very satisfactory, but the sharp edges of the cup washers chew the finish of the panels, making equipment look old quite rapidly and reducing its salvage or trade-in value. This is particularly annoying with rack panels that must be removed and replaced periodically.

The conventional rack screw-and-cup-washer combination may be re-



placed conveniently with a thumb screw and flat washer as shown in the photo. This retains the mechanical strength of the older method, makes removal and replacement more convenient and eliminates panel scarring produced by cup washers.

I use 10-32 nickel-plated thumb screws (Herman H. Smith No. 2368). The washers are ½ in. in diameter, .049-in.-thick nickel-plated steel with a 13/64 in. hole (General Cement No. 6157-C). Similar parts from other manufacturers will work equally well.—*Ronald L. Ives* R-E

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• Transistorized U.H.F. Tuners used in 1965 to 1967 TV sets made by Admiral, RCA, Motorola, etc. Removable gearing may vary from one make to another. Need only 15 volts d.c. to function. No filament voltage needed. Easy replacement units. Cat. # U.H.F. 567, $4.95.

• General Electric U.H.F. miniature Transistorized Tuner. G.E. Part # ET85X-33. Cat. # GE85, $4.95.

• F.M. Tuner, Hi-Fi amplifier tuning unit complete with diagram. 2 tubes. Sam's Photofacts # 620 lists 2 applications. Cat. # FM20. $3.98.

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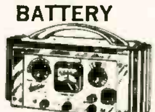

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400	.12
600	.18
800	.22

PRV	AMP
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1600	.80
1800	.90

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TO-66
5 AMPS

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600	.30	1.00	1.20	1.80
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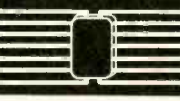

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300	.90	1.25	1.70
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MARKET CENTER

Circle 146 on reader's service card

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Circle 147 on reader's service card

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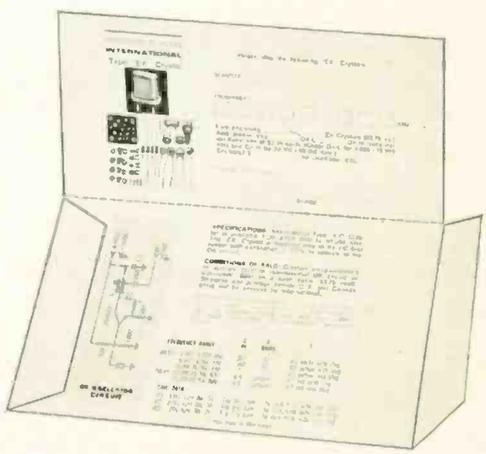

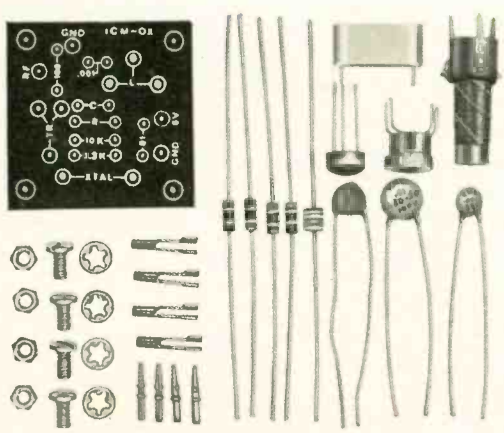

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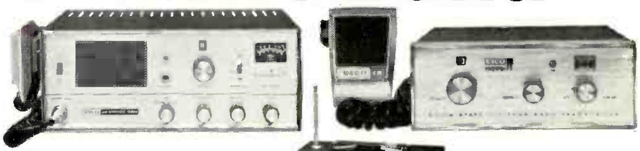

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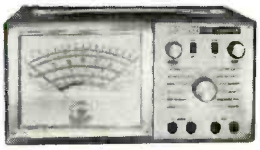

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